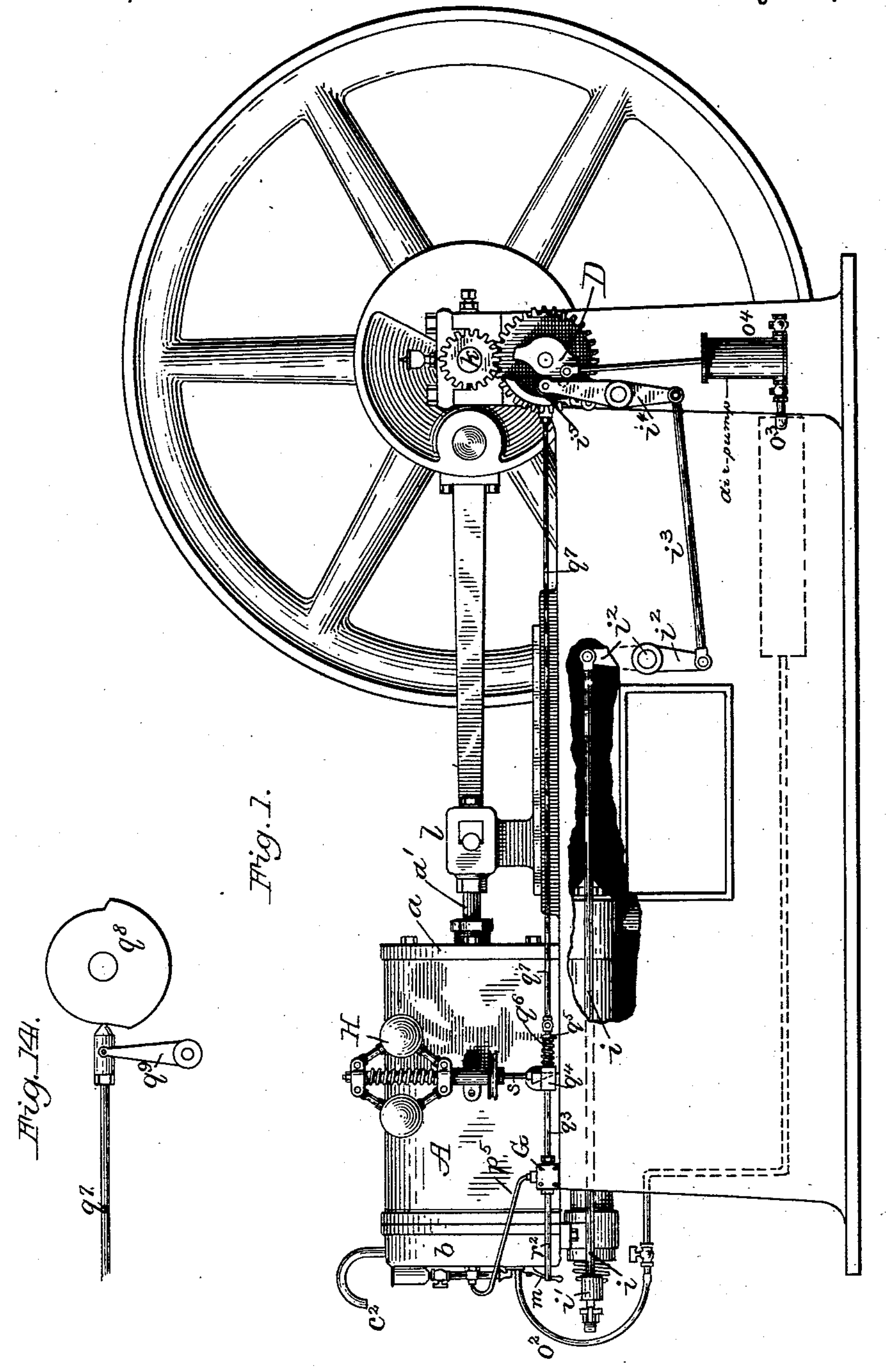
(No Model.) 5 Sheets—Sheet 1.

# G. B. BRAYTON.

## GAS AND AIR ENGINE.

No. 432,114. Patented July 15, 1890.



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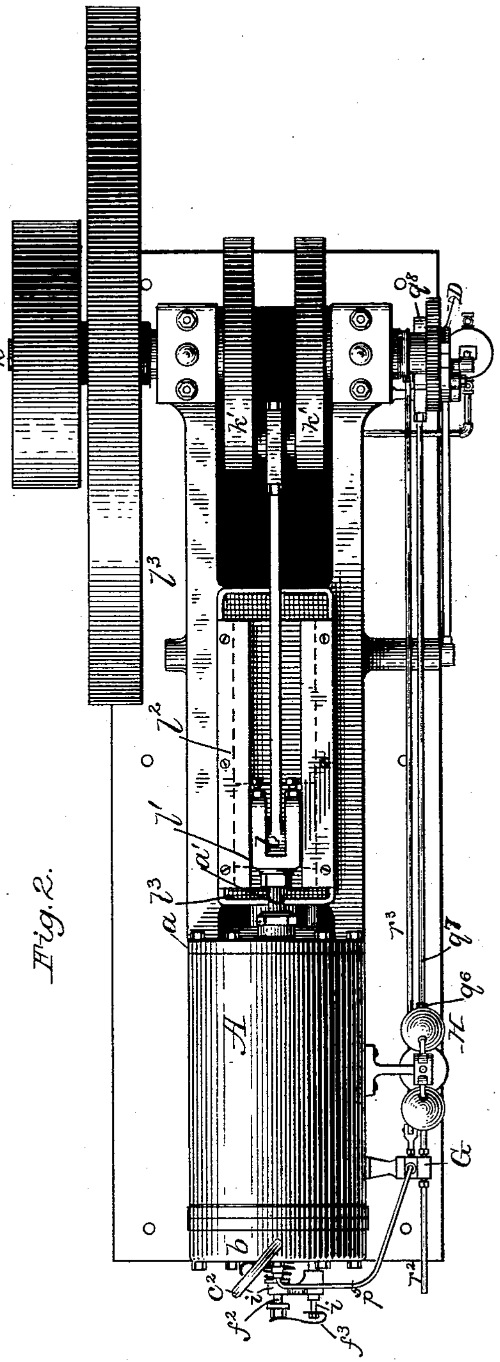

Fig. 2.

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# G. B. BRAYTON.

## GAS AND AIR ENGINE.

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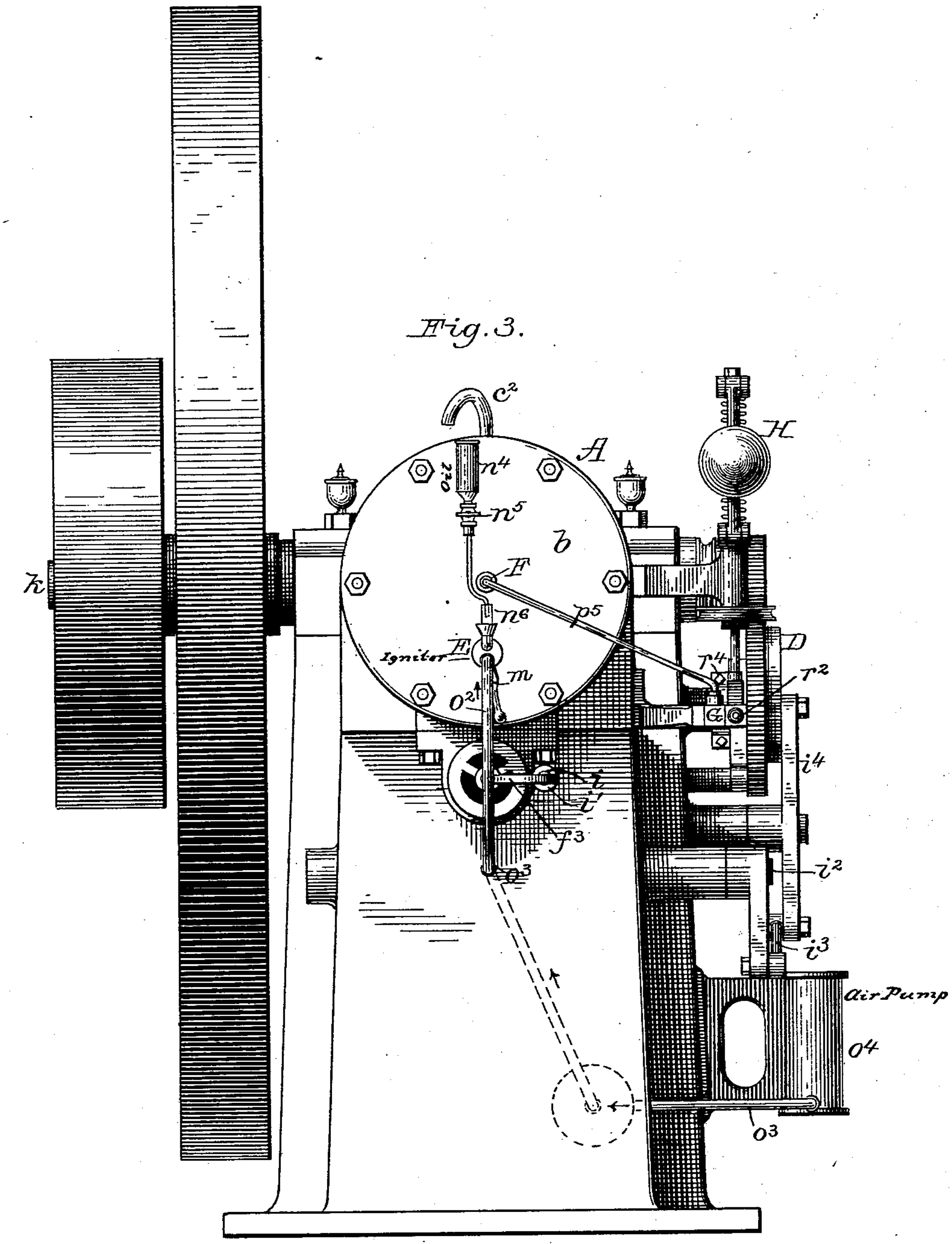
Fig. 3.

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(No Model.) 5 Sheets—Sheet 4.

# G. B. BRAYTON.

## GAS AND AIR ENGINE.

No. 432,114. Patented July 15, 1890.

Fig. 4.

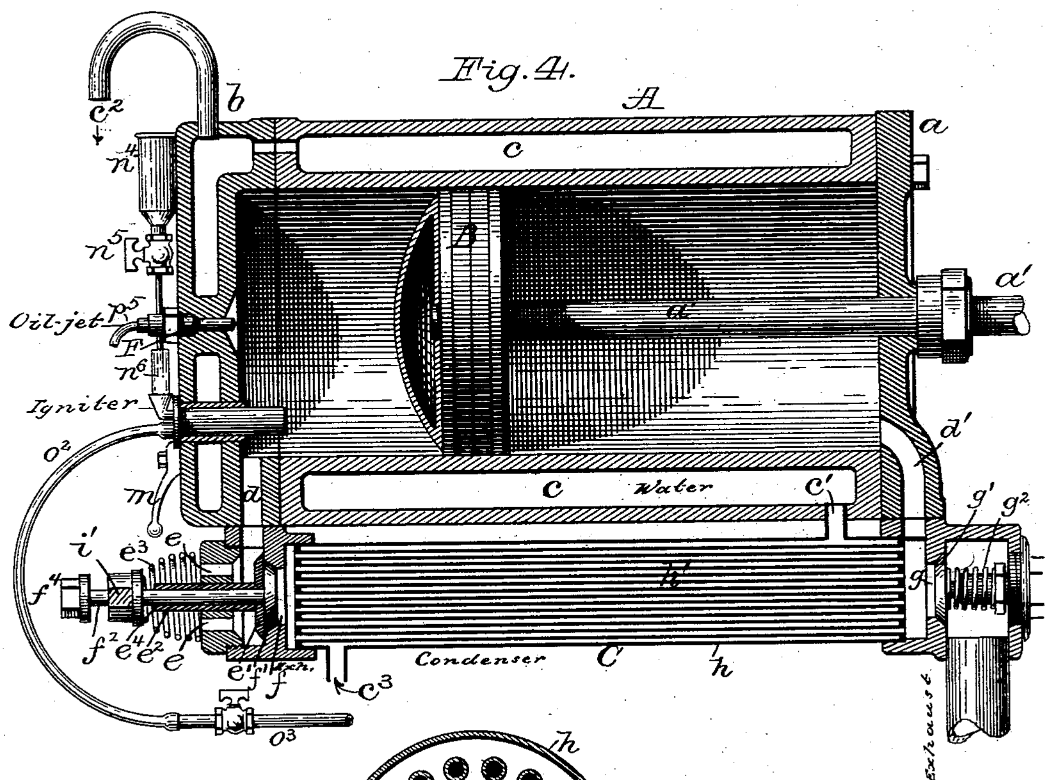
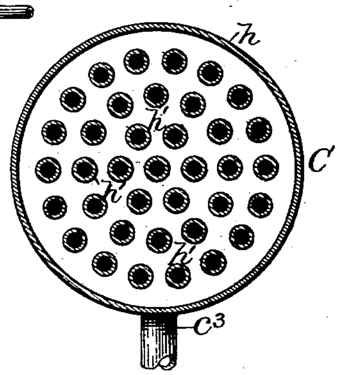



Fig. 5.



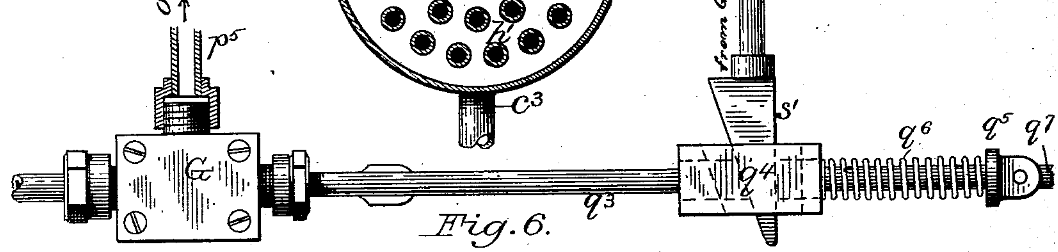
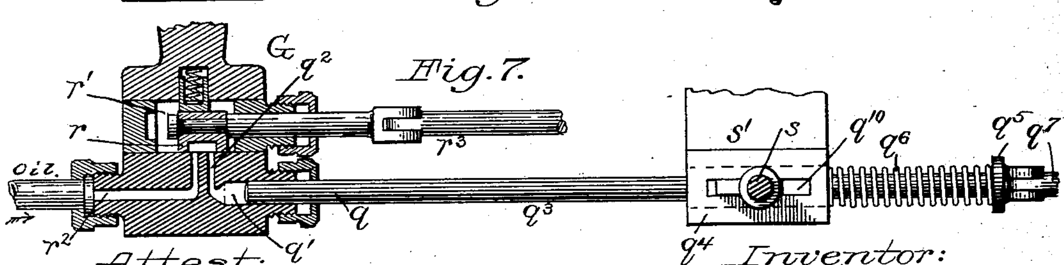




Fig. 6.

Fig. 7.

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5 Sheets—Sheet 5.

# G. B. BRAYTON.

## GAS AND AIR ENGINE.

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Fig. 8.

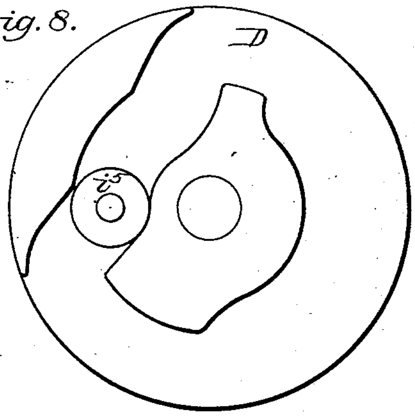



Fig. 9.

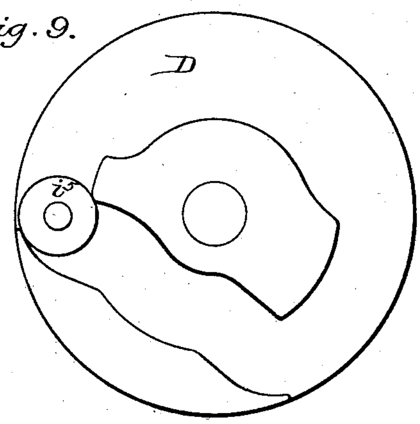



Fig. 10.

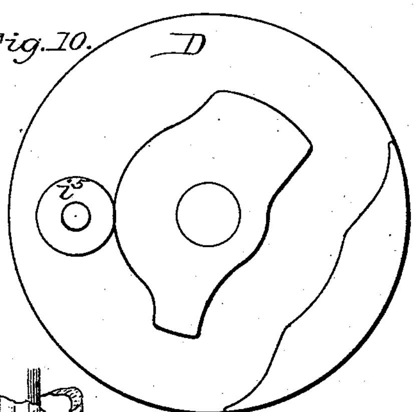



Fig. 11.

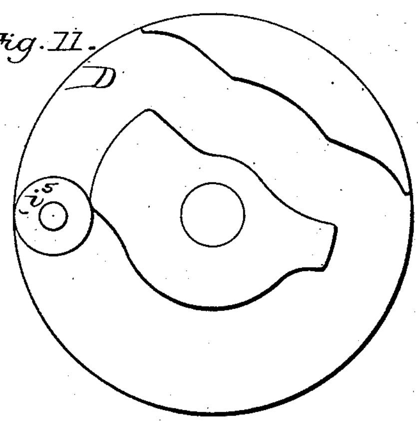



Fig. 12.

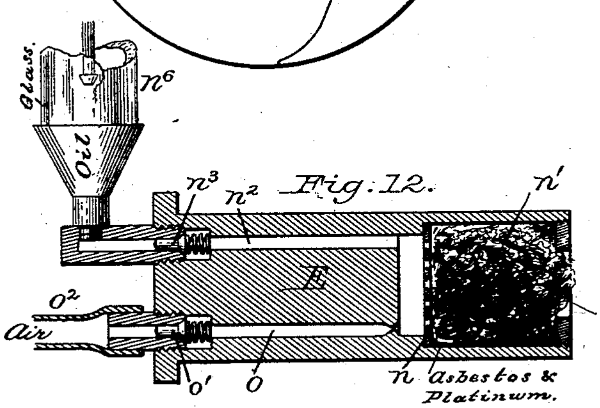
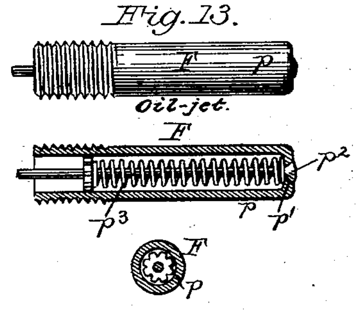



Fig. 13.

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# UNITED STATES PATENT OFFICE.

GEORGE B. BRAYTON, OF EXETER, NEW HAMPSHIRE.

## GAS AND AIR ENGINE.

SPECIFICATION forming part of Letters Patent No. 432,114, dated July 15, 1890.

Application filed September 15, 1887. Renewed December 16, 1889. Serial No. 333,846. (No model.)

*To all whom it may concern:*

Be it known that I, GEORGE B. BRAYTON, of Exeter, in the county of Rockingham and State of New Hampshire, have invented certain new and useful Improvements in so-called "Gas and Air Engines;" and I do hereby declare that the following specification, taken in connection with the drawings furnished and forming a part of the same, is a clear, true, and complete description of the several features of my invention.

Engines or motors of the class referred to involve a rapid combustion of fuel, either directly within the cylinder or in a combustion-chamber communicating therewith, power being developed not only from force exerted on the piston directly incident to the prompt or explosive burning of the fuel, but also to the accompanying expansion of the air within the cylinder.

One portion of my invention is applicable to and of value in any engine of this general type in which fuel is burned at only one side of the piston, provided that the opposite end of the cylinder be so closed that a partial vacuum may be induced therein on the side of the piston opposite to that at which the firing occurs, and also provided that said fuel be burned at strokes of the piston which intervene with strokes during which no burning occurs, and still further provided that atmospheric pressure can be permitted to act upon the firing side of the piston during those strokes thereof which alternate with the firing strokes.

The object of this portion of my invention is to supplement the power due directly to the burning of the fuel with power due to an atmospheric pressure corresponding more or less closely with the degree of vacuum induced in the non-firing or cool end of the cylinder, and thus render the non-firing piston-strokes dynamically effective to a practically valuable extent. For attaining this end I have for the first time, as I believe, applied a condenser communicating with both ends of the cylinder, a port which is valve-guarded for controlling the intermitting or main exhaust communication between the firing end of the cylinder and said condenser, means for intermittingly supplying the firing end of the cylinder with fresh air, and a weighted auxiliary exhaust-valve guarding an exit common to both the cool end of the cylinder and the adjacent portion of the condenser. These elements are so organized that in regular operation during a large portion of a non-firing stroke of the piston fresh air is freely admitted to the firing end of the cylinder, the main exhaust being closed meantime, thus freely charging the firing end or combustion-chamber of the cylinder with an abundance of atmospheric oxygen. After this the air-induction closes and the piston makes its return-stroke, compressing the air in the firing-chamber, the main exhaust being open during a portion of said stroke and then closed. The fuel being next supplied and then ignited, the piston is driven by the explosive force, and such air as may then be at the opposite side of the piston is discharged by way of the auxiliary exhaust-valve, which, being light-weighted or provided with a spring, opens under slight internal pressure. The main exhaust then opens, and as the piston moves back toward the firing-chamber the heated contents of the latter pass through the condenser and into the forward end of the cylinder and are suddenly cooled, and an appreciable vacuum is induced within the condenser in the cool end of the cylinder communicating therewith, and also in the combustion-chamber, drawing from the latter a large portion of the foul air resultant from combustion. The main exhaust is then closed, fresh air is again freely admitted to the firing-chamber, and upon the firing side of the piston atmospheric pressure is exerted to a degree appropriately corresponding to the partial vacuum induced in the cylinder at the non-firing side of the piston. Inasmuch as the auxiliary exhaust-valve is so weighted as to open readily in response to slight internal pressure and to close promptly when said pressure ceases, the exhaust into the open air occurs only at such intervals and during such time as the pressure within the condenser and the non-firing or cool end of the cylinder is greater than atmospheric pressure. This feature of my invention is wholly independent of the particular character of the fuel employed—*i. e.*, whether it be ordinary service-gas or carbureted air, or liquid hydrocarbon supplied in any manner, either to the firing end of the cylinder or to a firing-chamber communicating therewith, and whether said liquid fuel be sprayed, as heretofore, by means of an air-jet or converted into an explosive gas by being sprayed upon hot plates, as heretofore, or in a novel manner and by means devised by me. In this connection I have sought to avoid the use of light volatile hydrocarbon liquids—such as naphtha or gasoline—thereby obviating the dangers incident thereto both in use and storage, and to employ in lieu thereof such safe, heavy, high-test oils as are always readily available from the ordinary market stocks of oil universally carried in large quantities for household uses. Moreover, the light hydrocarbons now enter so largely into various arts that their market value has been greatly enhanced, and to such a degree as to render them unprofitable for use as fuel in any connection wherein the heavy oils can possibly be employed.

I have discovered that heavy oils can be mechanically converted into a finely-divided condition within the firing portion of a cylinder or in a communicating firing-chamber, and I now employ for the first time an oil-jet pipe and a prompt, quick-acting forcing-pump, which delivers into the cylinder proper charges of oil in an atomized or finely-divided condition well fitted for explosive combustion, whether said oil be so injected in the presence of air at atmospheric pressure or air in a compressed condition, although this latter is specially desirable in view of the abundance of oxygen thereby afforded and facilitating prompt combustion with increased dynamic energy. I have also combined with said quick-acting oil-forcing pump and the jet-pipe a regulator which varies the capacity of said pump to charge itself with oil, thus immediately varying the volume of the finely-divided liquid fuel forced into the combustion-chamber, and thereby regulating the speed of the engine. This organization involves what I believe to be a novel mode of regulating the speed of engines operated by the explosive combustion of liquid fuel within the cylinder in that, instead of regulating an exact supply of air needed with combustible gases to afford a combustible gaseous mixture, or of regulating the supply of liquid fuel to a chamber, wherein it is taken up by air to form a gaseous or carbureted mixture afterward fed to the cylinder, or of varying a supply of liquid fuel to hot plates or bodies of metal or stone for converting it into a gaseous combustible condition, I have for the first time, so far as my knowledge extends, regulated speed by variably controlling the direct discharge of liquid fuel into the combustion chamber or cylinder in a finely-divided condition highly favorable to immediate combustion. As compared with said prior methods, mine obviously affords a more prompt, immediate, and direct connection between the controlling-power of the governor and the explosive action, and hence an extraordinary uniform action on the part of the engine is assured, because for the first time I discharge the liquid fuel for immediate combustion in such variable quantities as are required for maintaining a uniform speed under the variable conditions ordinarily involved in the operation of such engines. These features of my invention are obviously wholly independent of any special form of ignitor for firing the fuel, and any of the well-known types of ignitors or "lamps," as they are sometimes termed, will serve the purpose, provided always that they are so organized in connection with the cylinder that air may be compressed within the cylinder, and also of such a character as will insure a successful firing of the sprayed or atomized liquid fuel. I have, however, devised what I deem to be a novel ignitor, which has performed good service in my engine. This ignitor is readily applied to and detached from the cylinder, and consists of a cylindrical chamber loosely filled with an incandescing material—such as asbestus or platinum wire, or both—and provided with separate ducts leading from its outer end to said chamber, respectively, for supplying fuel and air. Each of said ducts is provided with a spring-weighted valve, which opens toward the incandescing material, and the oil-valve is so lightly closed by its spring that it will open during the slightest tendency to vacuum within the cylinder, while the air-valve remains open under pressure from the blast derived from a chamber into which the air has been forced, thus affording a free combustion in the presence of the incandescing material, which is therefore maintained in good firing condition, even when said air and said oil valves are intermittently closed by reason of pressure within the cylinder.

Without departure from certain portions of my invention the incandescent-chamber may be supplied through one duct only with air and fuel by mixing in proper proportions to form a combustible compound the air and service-gas or the vapor of light hydrocarbons in an outside chamber or conductor.

Certain other minor features of invention will be hereinafter referred to in connection with the detailed description of the drawings, and all of said features will be duly specified in the several clauses of claim hereunto annexed.

Referring to the five sheets of drawings, Figure 1 is a side elevation of an engine embodying all of the features of my invention, organized in what I deem a specially-desirable form. Fig. 2 is a top or plan view of the same. Fig. 3 is an end view thereof. Fig. 4 is a central longitudinal vertical section of the cylinder, the condenser, and accompanying valves. Fig. 5 illustrates the condenser in cross-section. Figs. 6 and 7 respectively illustrate the oil spraying or forcing pump in side view and longitudinal horizontal central section, and they also show the connection of the governor-rod with the oil-pump rod. Figs.

8, 9, 10, and 11 illustrate the cam which operates the main exhaust and the air valve, and they exhibit its various positions while in service. Fig. 12 illustrates my ignitor in longitudinal central section. Fig. 13, in three views, illustrates my jet-pipe and its several parts on an enlarged scale. Fig. 14 illustrates the oil-pumping cam and the adjacent portion of the pump-rod.

The cylinder A has a head $a$, provided with a stuffing-box or gland for packing the piston-rod $a'$, thus closing that portion of the cylinder which may be termed its "non-firing or cool end." The opposite cylinder-head $b$ is suitably perforated for receiving the fuel-supply pipe and also an igniting device, these being located with reference to each other as may be deemed most desirable. The head $b$ is at what may be termed the "firing end" of the cylinder, the interior space between it and the piston constituting a combustion-chamber; but a separate chamber communicating with the interior of the cylinder might be employed, as in some forms of engines. The cylinder is annularly jacketed to afford a water-space $c$, having its inlet at $c'$ and outlet at $c^2$.

The piston B is of the ordinary character and is provided with a hollow shield on its firing side to protect it from becoming unduly heated, as would result from a direct contact with the burning fuel.

At the firing end of the cylinder there is a port $d$, which serves both for the induction of air and for exhausting from the cylinder, and it is valve-guarded for properly opening and closing passages which respectively lead to the open air and to the condenser C, which underlies the cylinder and is parallel therewith. The valve-gear and the character of the port-controlling devices may be widely varied without departure from the main features of my invention. As here shown, the air passage or port $e$ is guarded by a valve $e'$, opening inward, mounted upon a sleeve $e^2$, and held to its seat by an expansive spiral spring $e^3$. The exhaust port or passage $f$ is at the adjacent end of the condenser C, and this is guarded by a valve $f'$, mounted on a valve-spindle $f^2$ within the sleeve $e^2$ and projecting beyond its rear or outer end, said sleeve affording a guide-bearing therefor, the latter being in turn provided with a suitable guide-bearing of its own, and at the outer end of the valve-spindle $f^2$ a bent spring $f^3$ is applied for normally holding the valve in a closed position. This spring $f^3$ may be variously applied; but it is here shown as mounted at the end of and carried by a sliding valve-rod, which will be hereinafter further described. These valves are positively operated as to their opening movements by valve-gear to be hereinafter described. At the opposite or cool end of the cylinder there is a port $d'$, communicating with a passage common to the interior of the condenser, which at that end is open, and opposite this end of the condenser there is an auxiliary exhaust-port $g$, guarded by an auxiliary exhaust-valve $g'$, opening outward, mounted on a rod sliding in suitable bearings, and held to its seat by means of a weight or spring $g^2$, which may be adjustable for so graduating it that the valve will freely open whenever the internal pressure exceeds that of the atmosphere, but causing it to promptly close and to exclude air when a partial vacuum has been induced within the condenser and within the cool end of the cylinder.

The condenser C may be widely varied in its construction without departure from my invention, although I prefer a surface-condenser, as shown, consisting of an inclosing-shell $h$ and numerous thin longitudinal tubes $h'$, composed of good heat-conducting metal and supplied with cold water, which, entering at $c^3$, passes out of the condenser by way of the pipe-connection at $c'$ into the water-space of the cylinder.

Now, regardless of the character of the explosive or prompt-burning fuel employed, or the form of ignitor or lamp relied upon, this portion of the engine operates as follows: Assuming the engine to be in service and the piston just moving forward on its non-firing stroke, the main exhaust-valve being tightly closed, the air-port is opened and air is drawn into the cylinder during a large portion of said movement of the piston, whereupon said port is closed and the main exhaust opened and then closed, so that the piston in moving back toward the firing end of the cylinder compresses said air during about one-half of its stroke; but the efficiency of the engine may be increased, however, by a higher rate of compression, desirable in some cases. Fuel is then supplied to the cylinder and ignited, driving the piston to the opposite end of the cylinder, the auxiliary exhaust-valve $g'$ then opening for the relief of any pressure which may have occurred in the cool end of the cylinder. Then, as the piston next moves backward, the air-valve being still closed, the main exhaust-valve $f'$ opens and the heated contents of the combustion-chamber pass into and through the condenser and are suddenly cooled, thus inducing a partial vacuum throughout the internal communicating spaces. The air-valve then again opens, and atmospheric pressure instantly occurs within the combustion-chamber, and its force is exerted upon the firing side of the piston during its next or non-firing stroke, and so on, the firing strokes alternating with the non-firing strokes, and during the latter the atmospheric pressure on the piston will vary in accordance with the efficiency of the condenser under the varying conditions as to speed and the quantity of fuel burned in the cylinder. These valves $e'$ and $f'$ are operated by a single valve-rod $i$, having an arm $i'$, provided with a hole freely occupied by the valve-spindle $f^2$ of the valve $f'$; said spindle having near its outer end a nut $f^4$, and the sleeve-spindle $e^2$ of the valve $e'$ has at its outer end an abutting surface at $e^4$, and between said nut and said sleeve said arm $i'$ moves with proper lost motion; but during a portion of the final movement of said valve-rod in one direction said arm forces the sleeve of valve $e$ inward against its spring, and during a corresponding portion of its opposite movement said rod draws the spindle of valve $f'$ outward, thus positively actuating both valves, the exhaust-valve being opened twice to each opening of the air-valve. For securing the proper time for the operation of these valves the valve-cam D is geared to the crank-shaft $k$, so as to make one revolution to every two revolutions of said shaft, and the valve-rod is coupled to said cam by means of a rock-shaft and lever or arms at $i^2$, a link $i^3$, and a rocking lever $i^4$, carrying at one end a friction-roll $i^5$, engaging with the cam. In Fig. 8 said cam and roller are indicated in positions occupied by them at the beginning of a non-firing stroke of the piston and while fresh air is being admitted to the cylinder. In Fig. 9 the positions of said cam and roller are indicated at the beginning of the return non-firing stroke, during a part of which the exhaust-valve is opened, then closed, and the air compressed within the cylinder. In Fig. 10 their positions are shown at the beginning of a firing stroke, during which the air-valve and exhaust-valve are both closed. In Fig. 11 their positions are shown at the beginning of the return firing stroke of the piston, during which the heated contents of the combustion-chamber are delivered through the main exhaust-valve into the condenser, and which, when cooled, pass into the cool end of the cylinder.

The piston-rod $a'$ is coupled to the crank-shaft $k$ by a pitman and cross-head $l$, the latter being a sliding block provided with side flanges $l'$ at its base, occupying guide-bearings $l^2$ and arranged to wipe at each end into the oil-pans $l^3$, thus providing for perfect lubrication of the slide-bearings of the cross-head. As here shown, the pitman is coupled to two crank plates or disks $k'$; but other forms of crank may be employed.

The ignitor E as devised by me is specially illustrated in Fig. 12. It is a cylindrical structure snugly fitting a hole in the cylinder-head $b$, wherein it is securely confined by a locking-lever $m$. At its inner end it is chambered for the reception of a perforated disk $n$ and incandescing material $n'$, usually asbestus and platinum wire in a loose open mass. At the rear of said perforated disk there is an oil or fuel duct $n^2$, guarded near its outer end by a spring-valve $n^3$, which opens toward the incandescing material. An annular plate is inserted in the mouth of the incandescent chamber for properly confining the incandescing material in place and restricting or consolidating the protruding flame. Another duct $o$, parallel with the other, is for supplying air to the ignitor from any suitable source, and preferably under pressure, and this duct near its outer end is also guarded by a spring-valve $o'$. This combination of the chamber and its incandescing matter, the valve-guarded fuel-duct, and the valve-guarded air-duct I believe to be novel whether it be organized to operate with inflammable gases or liquid fuel; but as here shown it is supplied from an oil tank or cup $n^4$, provided with a cock $n^5$, for graduating the supply of fuel, drop by drop, and a glass tube $n^6$, connecting said cup with the outer end of the duct $n^2$, thus enabling the feeding operation to be readily observed and excluding obstructive matter from the oil-duct. The valves of both ducts are effectually closed against any back-pressure in the engine-cylinder, the air-duct valve being at all other times open to air supplied under pressure by way of a flexible pipe $o^2$, coupled to pipe $o^3$, leading from an air-tank which is within the bed-plate and charged with air by the air-pump $o^4$.

It will be observed that the incandescing material is well housed by its chamber against the cooling influences of the fresh air entering the cylinder during the non-firing strokes, and that during that time the air-duct delivers, under a pressure of from twenty to forty pounds, a blast of air within the ignitor, which secures perfect combustion of the oil in the presence of the incandescent. With this ignitor I have used ordinary high-test oil in exceedingly small quantities with good results and maintained a degree of incandescence which has never failed to result in properly firing any charge of fuel used in the presence of compressed air, and even if the air-duct be closed because of pressure within the cylinder.

It is to be understood that the air-duct where it discharges into the ignitor need not be greater than one one-hundredth of an inch in diameter. I have never known it to be clogged in practice, nor the perforations in the ignitor-disk to become clogged, although they are very fine, but are countersunk from each side to a knife-edge at the aperture.

I will next describe the fuel jet-pipe F, which I believe to be wholly novel as a means for delivering liquid fuel in fit condition for prompt or explosive combustion.

This jet-pipe, as illustrated in Fig. 13, includes a small tube $p$, having at its inner end a conical valve-seat, as at $p'$, a valve-spindle having a tapering head $p^2$, which fits said seat, and a comparatively strong spring $p^3$, which normally closes the valve. The interior of the tube is of small sectional area, and the spring-spindle carries a guide loosely occupying said interior and serving as one abutment for the spring, its other abutment being a shoulder afforded at the contracted end of the tube in which the valve-seat is located. The charges of oil are delivered through this jet-pipe for an engine with, say, a seven-by-ten-inch-cylinder range—say from one-half a drop to five or six drops—and when the oil therein is suddenly subjected to pressure it flies from the valve-seat in a finely-divided condition, so that if a means of ignition be present explosion will follow. The liquid fuel is driven to the jet-pipe by the forcing-pump G through a small metal tube $p^5$, sufficiently flexible to admit of its being conveniently attached to or detached from the jet-pipe by means of suitable couplings. This pump is shown in side view and in longitudinal horizontal section in Figs. 6 and 7. It includes a pump-plunger $q$ and its barrel $q'$ and a slide-valve $r$ and its chamber $r'$. An oil-duct $q^2$ connects said barrel $q'$ with the valve-chamber $r'$, and another duct $r^2$ conveys oil from a suitable supply-tank preferably slightly elevated above the pump. The jet-pipe tube $p^5$ also communicates with the interior of said valve-chamber, and said chamber and tube are normally filled with oil. The two ducts $q^2$ and $r^2$ are at intervals practically connected within the chamber by the slide-valve, which is of a well-known form, backed by a spring, as shown, and in sliding to and fro it enables the pump-plunger $q$ to draw inward a charge of oil and then force it into the valve-chamber, and to thereby cause a corresponding charge of oil to be discharged in a finely-divided condition from the jet-pipe. The slide-valve is actuated in a regular and uniform manner by its rod $r^3$ and an eccentric $r^4$ on the counter-shaft, which carries the valve-cam D. The plunger $q$ has a rod $q^3$, sliding in a guide-block $q^4$ and provided with a collar $q^5$, and the plunger is maintained in a normally-retired position by means of an expansive spiral spring $q^6$, encircling said rod and having its abutments against said collar and block. A link or pitman $q^7$ is jointed to the pump-rod and extends from there to near the shaft of the cam D, where it is supported on a vertical arm $q^9$, pivoted at its foot to the bed-plate. A cam or tappet $q^8$ (see Fig. 14) on the cam-shaft in each revolution so strikes the end of the link or pitman $q^7$ as to promptly force the pump-plunger $q$ inward for supplying liquid fuel to the cylinder. This cam or tappet $q^8$ is essentially quick-acting in its operation, and in fact it strikes a prompt quick blow against the pitman $q^7$, overcoming the spring $q^6$, but permitting the latter to cause the proper retractile movement. The guide-block $q^4$ is slotted on top, and the part of the pump-rod which slides in said block is also slotted longitudinally at $q^{10}$, affording a vertical opening downward through said block and rod.

The governor H has, as usual, a vertically-reciprocating well-guided governor-rod $s$, having at its lower end a wedge $s'$, straight at one side and inclined at the other, the inclined side being toward the pump. When the engine is running slow, the pump-rod is retracted by its spring to its fullest extent, and the pump delivers maximum charges of oil to the cylinder; but as speed increases the governor-wedge is lowered, and its inclined edge affords an abutment for the adjacent end of the slot in the pump-rod and restricts its rearward movement and correspondingly restricts the charge taken into the pump to be supplied to the combustion-chamber. The pump cam or tappet is incapable of striking the pump-rod whenever the governor prevents any retractile movement of said rod, and therefore the pump varies in its action and apportions each charge from no oil at all to fractions of a drop and upward to the maximum charge, which, as before stated, in a small engine need seldom exceed five or six drops. Other combinations of the regulator with the means for affording the quick stroke of the pump-plunger may be devised; but the essential feature of this part of the invention is regulating the speed of the engine by a variable direct supply of liquid fuel to the cylinder. The action of the governor is so direct and effective that the speed of my engine is as regular and even under extraordinary varying conditions as in the best steam-engines with which I am familiar.

In operation I find that special lubrication of the cylinder-piston is wholly unnecessary, and that a comparatively small bulk of water is required for condensing purposes, and the water leaving the condenser prevents the cylinder from becoming unduly heated.

The taking of a full charge of air into the cylinder, then discharging a part thereof between each firing stroke, together with the effective exhaust incident to the use of the condenser, and with the fact that the atmospheric oxygen is compressed previous to the introduction or the firing of the fuel, all tend to as perfect and effective explosive combustion as I believe it to be possible to attain with heavy oils.

The effective value of the atmospheric pressure upon the piston during the non-firing stroke will be obvious when I state that upward of nine pounds to the square inch has been at times indicated during many carefully-conducted tests of my engine.

As to economical use of fuel, it can fairly be indicated when I state that a seven-by-ten cylinder engine constructed as herein shown and described has been speeded to two hundred turns a minute and made to drive a thirty-inch fan fifteen hundred revolutions a minute for ten hours on three and one-half gallons of ordinary high-test kerosene.

In starting my engine the ignitor is removed from its position, heated, and the oil lighted and then replaced. The crank-shaft is then rotated by hand or by air pressure until the first explosive burning of the fuel occurs, after which speed and power will be rapidly developed. The engine may, however, be started by working the fuel-injecting pump by hand after placing the engine in position to act from explosion, the ignitor being then already in position and in operation.

The method herein described of operating and regulating the speed of an engine in which liquid fuel is explosively burned within a cylinder or combustion-chamber communicating therewith will form the subject of a separate application for Letters Patent.

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

1. The combination, substantially as hereinbefore described, of a cylinder closed at both ends, a piston, appliances for supplying fuel to said cylinder and igniting it at one side of said piston, a condenser communicating with both ends of the cylinder, a valved air-inlet for supplying air to the firing end of said cylinder, a valved exhaust-port at said firing end of the cylinder and between the latter and said condenser, positively-actuated valve mechanism by which said air-inlet port is opened during portions of the alternating non-firing forward strokes of the piston, and also for intermittingly opening said exhaust-port, and an auxiliary exhaust-port, which is located at the opposite or non-firing end of the cylinder and guarded by a valve so weighted as to freely open to pressure within the condenser and within the communicating non-firing end of the cylinder.

2. The combination of a cylinder provided with a valve-guarded air-inlet, a piston which moves forward while said inlet is open and then rearward after it is closed for compressing air thus supplied to the cylinder, a spraying jet-pipe within the cylinder, and a pump which forces a charge of liquid fuel through and from said jet-pipe into said cylinder in a finely-divided condition and fitted for immediate combustion in the presence of the compressed air, substantially as described, whereby abundant oxygen is afforded for securing a favorable prompt combustion of the liquid fuel when ignited and the compressed air efficiently expanded.

3. In an engine organized to be operated by the combustion of fuel within the cylinder or in a chamber communicating therewith, the combination of an intermittingly-operated oil-forcing pump, an oil-duct leading to the firing end of the cylinder, and a spraying jet-pipe which delivers the liquid fuel in a finely-divided condition within the firing portion of the cylinder and communicating with said duct, substantially as described, whereby as a result of each forcing stroke of said pump liquid fuel is mechanically sprayed within the firing-chamber in a condition favorable to prompt and practically instantaneous combustion upon igniting any portion thereof.

4. The combination, substantially as hereinbefore described, with an engine-cylinder and a piston, of a liquid-fuel jet-pipe projecting into the cylinder, composed of a nozzle and a spring-actuated valve by which said nozzle is normally closed, but which responds to sudden pressure of the liquid fuel within the nozzle and discharges said liquid in a finely-divided condition highly favorable to practically instantaneous combustion on being ignited.

5. In an engine operated by means of fuel pumped to and burned within the cylinder or its firing-chamber, the combination, substantially as hereinbefore described, of a pump having a longitudinally-slotted pump-rod, a spring which imparts to said rod a retiring movement for charging the pump, a quick-striking cam or tappet for driving said rod forward for discharging the contents of the pump, and a governor-rod provided with a wedge sliding at right angles to and in the slot of said rod, whereby the extent of the rearward or charging movement of said rod is restricted by said wedge and varied according to the positions at which said wedge may be placed from time to time by the governor and the charges of fuel forced to the cylinder correspondingly varied, and thereby regulating the speed of the engine.

6. The combination, substantially as hereinbefore described, of the engine-cylinder or its firing-chamber, a jet-pipe or nozzle therein for discharging liquid fuel in a sprayed or finely-divided condition, a fuel-forcing pump communicating with said jet-pipe, a slotted pump-rod retracted by a spring and forced forward at intervals by a quick-acting cam or tappet, and a governor-rod provided with a wedge sliding in the slot of said pump-rod, whereby the retiring or charging movement of the pump-rod is varied by the governor and the sprayed charges of liquid fuel delivered into the cylinder correspondingly varied for regulating the speed of the engine.

7. The combination, with the cylinder and its piston, of an engine operated by the combustion of fuel within the cylinder or its communicating firing-chamber, a detachable ignitor provided with a fuel-supply nozzle, an air-supply nozzle, a spring-actuated valve in each of said nozzles permitting them to freely open toward the cylinder during portions of the forward movements of the piston, but effectually closing them against pressure in the cylinder, and a loose mass of incandescing matter, such as asbestus or platinum wire, substantially as described.

GEO. B. BRAYTON.

Witnesses:

ENOS PARSONS,

WALTER M. KIDDER.