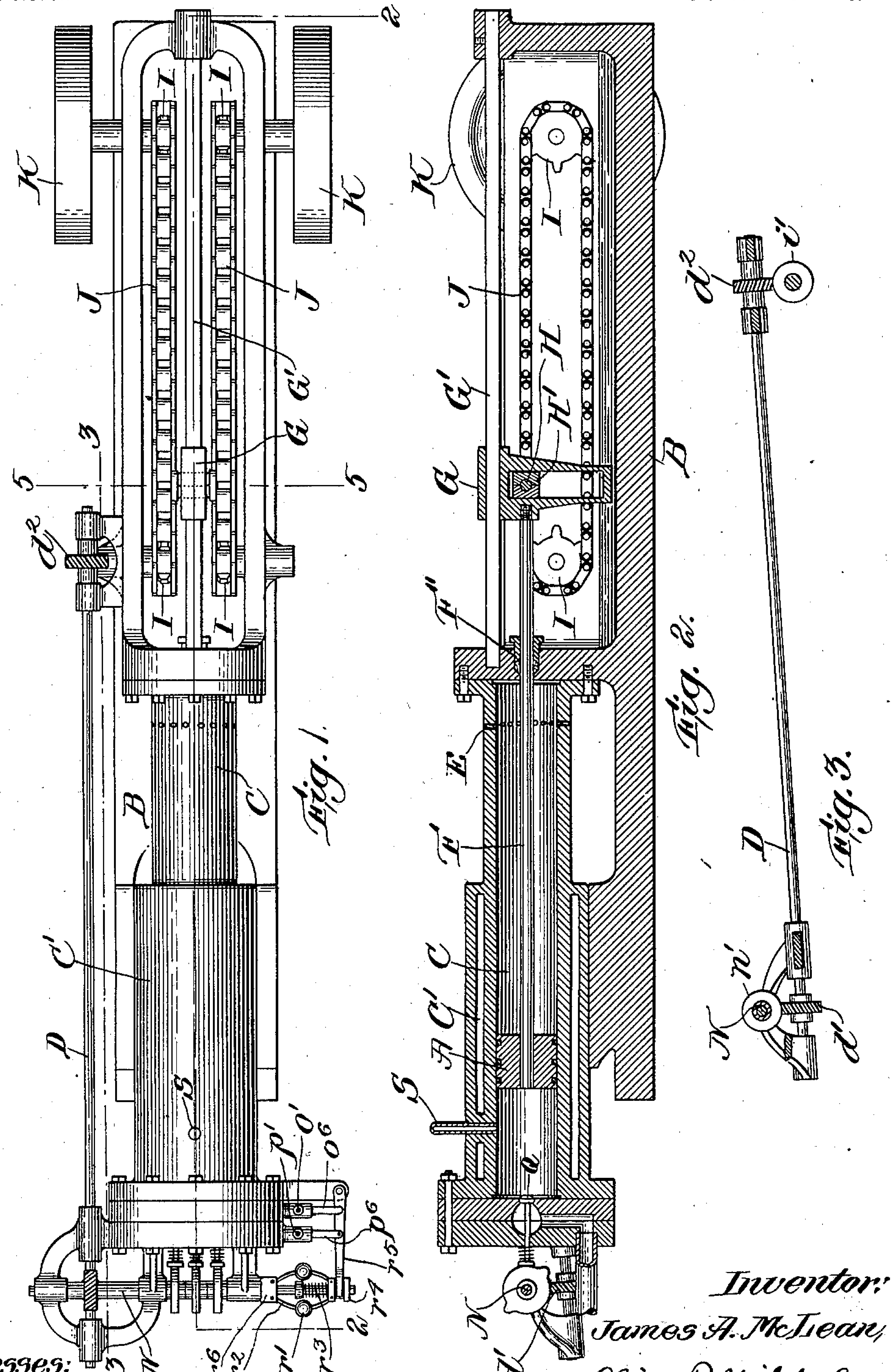
No. 670,997. Patented Apr. 2, 1901.

J. A. McLEAN.

INTERNAL COMBUSTION ENGINE.

(Application filed Oct. 19, 1900.)

(No Model.) 2 Sheets—Sheet 1.



Witnesses:
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Joseph T. Brennan

Inventor:
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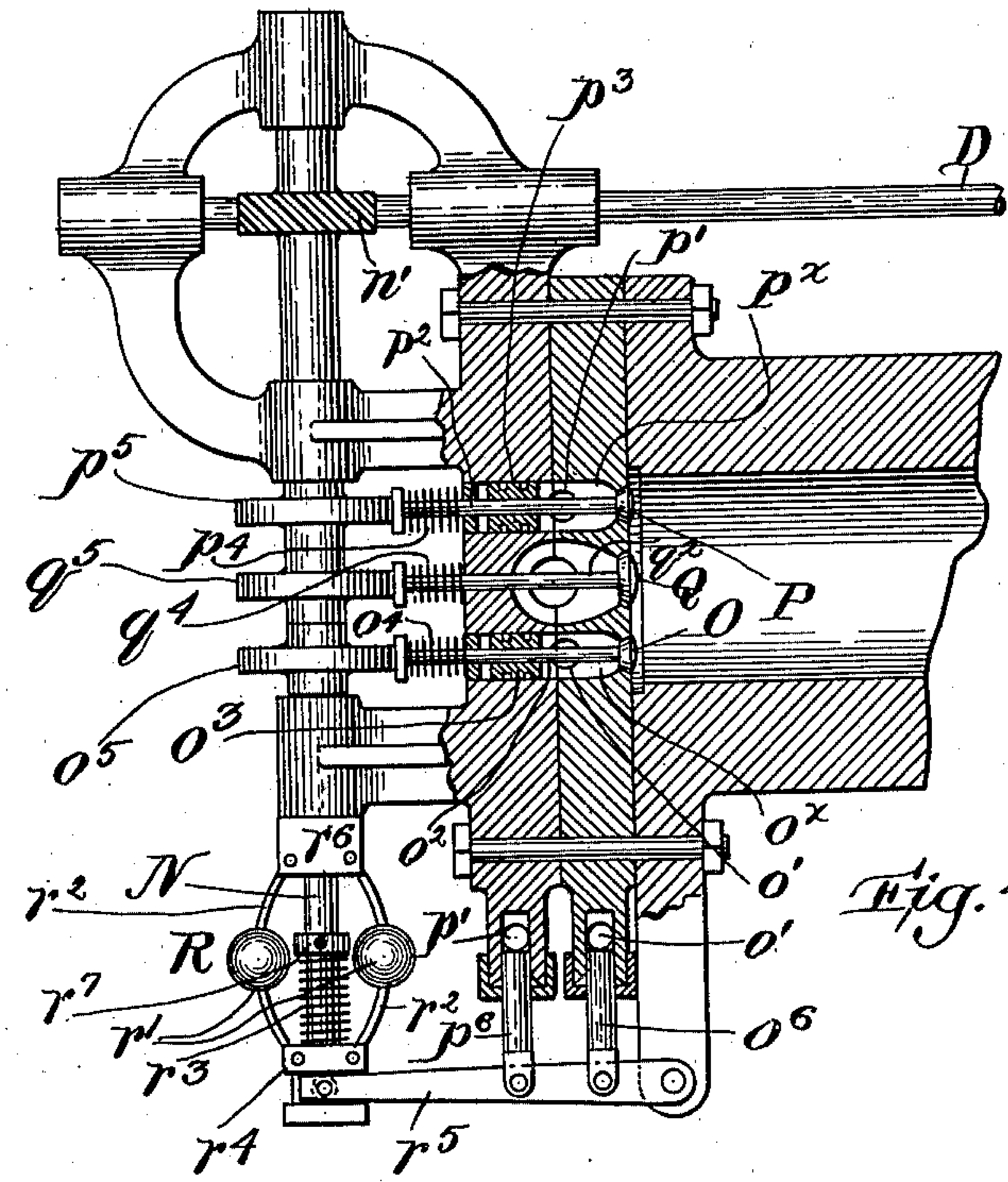

Fig. 4.

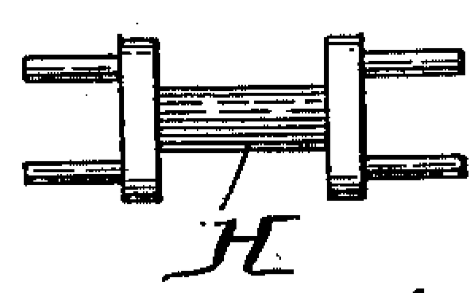

Fig. 6.

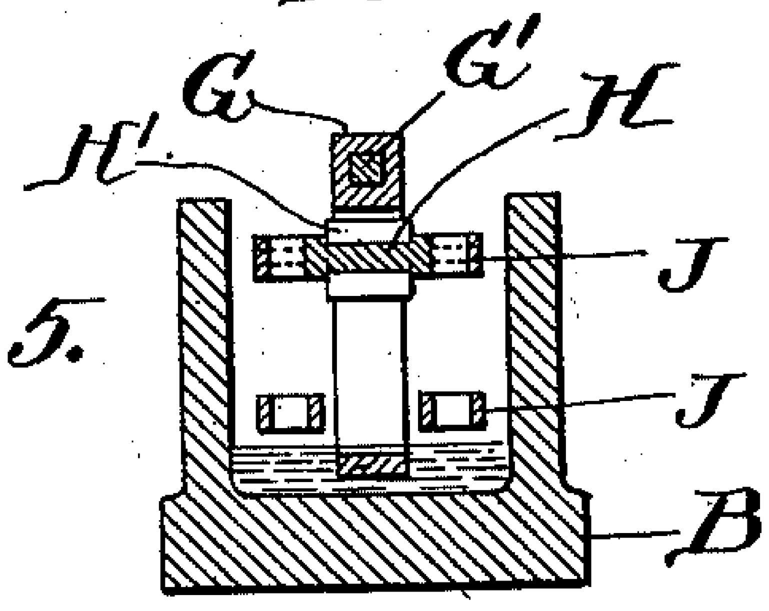

Fig. 5.

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UNITED STATES PATENT OFFICE.

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INTERNAL-COMBUSTION ENGINE.

SPECIFICATION forming part of Letters Patent No. 670,997, dated April 2, 1901.

Application filed October 19, 1900. Serial No. 33,627. (No model.)

To all whom it may concern:

Be it known that I, JAMES A. McLEAN, a subject of Victoria, Queen of the United Kingdom of Great Britain and Ireland, and a resident of Boston, in the county of Suffolk and State of Massachusetts, have invented a new and useful Improvement in Internal-Combustion Engines, of which the following is a specification, reference being had to the accompanying drawings, in which—

Figure 1 is a plan view of my improved engine. Fig. 2 is a side elevation representing a vertical section on the line 2 2 through the center of Fig. 1. Fig. 3 is a sectional elevation of a detail of the valve-operating device sectioned on the line 3 3 of Fig. 1. Fig. 4 is a plan of the valve mechanism and cylinder-head, partly in section, enlarged. Fig. 5 is an end elevation of a section on line 5 5 of Fig. 1. Fig. 6 is an elevation of a detail.

In most types of internal-combustion engines at present used there is great waste of energy by radiation or conduction of heat from the cylinder-walls into the air or jacket-water and by the expulsion of unburned or incompletely-burned fuel in the exhaust.

The objects of my invention are to attain a greater economy of transformation in changing the energy of fuel into useful work, particularly by reducing the amount of heat lost through cylinder-walls by providing for complete combustion of the fuel charge before the cylinder contents escape into the exhaust by widening the temperature and pressure limits between which the engine works and by relieving the piston of friction against the walls of the cylinder; also, to do away with the noise and offensive odor that characterize the exhaust of most internal-combustion engines now known.

Other objects are to provide an engine that can be regulated closely, that will require less water in the jacket to keep the cylinder at a proper temperature, that is light in weight compared to its capacity, and requires no heavy fly-wheel—in short, to provide a light neat engine of high efficiency.

My invention is applicable to any type of internal-combustion engine. In the following description and drawings I show it as applied to a single-acting horizontal gas-engine working on the two-cycle system, in the normal operation of which an explosion occurs at every outward stroke of the piston.

Referring to the drawings, A is a piston traveling in the combustion-cylinder C, which is supported on the engine frame or bed B. A portion of the cylinder is surrounded by a jacket C′.

O is an admission-valve for air, P an admission-valve for gas or vapor, and Q the exhaust-valve.

Toward the outer end of the cylinder, which is closed, is a circle of holes E, adapted to be closed by the piston as it approaches the end of its outward stroke, thus forming a cushion for the piston. A piston-rod F passes through a stuffing-box F′ in the cylinder end and terminates in the yoke G, which is rigidly secured thereto and is adapted to reciprocate therewith, being guided and kept in alinement by the guide-rod G′, on which it slides. This guide-rod is supported rigidly in the engine-frame. It is represented in the drawings as square. It might be round or any other suitable shape or ways might be substituted for it without departing from the essence of my invention, the function of this guide-rod being merely to support and keep the yoke in alinement with the piston travel and to prevent it from swaying or twisting sidewise. Within the yoke is a pin-box H′, adapted to slide up and down therein, as required by the travel of the pin H, which is journaled in the box, as will be presently described. On each side of the piston-rod are two sprocket-wheels I, pivoted on studs projecting inwardly from the engine-frame toward the line of travel of the yoke G, one located near the outer and one near the inner limit of the yoke's travel. Sprocket-chains J run over the sprocket-wheels, one on each side of and parallel with the yoke's line of travel. They are connected by a pin H so as to travel in unison. The pin H being journaled in the box H′ in the yoke G on the end of the piston-rod F travels to and fro in harmony with the out and in strokes of the piston. The sprockets being set so that the pin H is at the outmost end of the horizontal diameter of the most distant sprocket-wheels at the time the piston is at its outer limit of stroke and is at the inmost end of the horizontal diameter of the nearer sprocket-wheels when the piston is at its inner limit of travel, it will be seen that the successive explosions of charges in the cylinder and ensuing outstrokes of the piston will drive the chain continuously in one direction around the sprocket-wheels, causing them to rotate. The studs on which two of the sprockets are mounted are shafts journaled in and extending through the engine-frame and carrying on their other ends, outside the frame, fly-wheels K K, which also serve as driving-wheels for delivering the power produced by the engine. When on starting the engine the first explosion occurs and drives the piston out, the momentum of parts is such that the pin H is carried past the dead-center and driven back on the inward stroke, moving the piston with it.

I prefer to make the sprockets of small diameter compared with the length of stroke. I have found it a suitable ratio of dimensions to make each single outward stroke of the piston correspond to three complete revolutions of the sprockets and fly-wheels. In the engine represented in the drawings the chains have thirty-six links each and the sprockets six teeth each. This engine being single-acting, the sprockets are so placed that the path in which the pin H travels during the greater part of the working or outward stroke will be approximately in line with the thrust of the piston-rod. There is therefore no sidewise pressure between the piston and cylinder to cause friction, except the weight of the piston itself, and even that would be avoided by building my engine vertical instead of horizontal. Thus without the use of a cross-head and ways I avoid a difficulty inherent in all engines in which the power is transmitted from the piston through a crank to the driving-wheel. In such engines if a trunk-piston is employed there is a resultant side pressure of the piston on the cylinder-walls, greater or less in amount, that depends directly upon the angle between the piston-rod or connecting-rod and the axis of the cylinder and varies with the cylinder-pressure. By avoiding this without the use of a cross-head and ways I secure simplicity and cheapness of construction and save power that would otherwise be consumed in overcoming the friction of the cross-head on the ways. The pin H and the link of each chain to which it is to be secured may conveniently be made all one piece, Fig. 6, thus giving greatest strength and simplest construction. It will be evident that as the pin travels along with the chain—say upon an outward stroke—when the links to which it is attached reach the outer sprocket they will turn downward out of the plane of thrust of the piston in order to pass around the outer circumference of the sprocket-wheel and start back on the inward stroke. The mounting of the pin-box H′ movably in the yoke G enables the pin to remain in engagement with the yoke and piston-rod while following the chain in that movement. In the hollow under the chain formed by the bottom of the engine-frame is a bath of oil for lubricating the chain and related parts by the splashing of the yoke G in it as it travels to and fro.

The valve mechanism is as follows: O is the air-admission valve. P is the gas or vapor admission valve. Q is the exhaust-valve. All are puppet-valves adapted to open toward the cylinder, so that the pressure from within will force them upon their seats. The air and gas valves O and P open into their respective valve-chambers $o^\times$ $p^\times$, which communicate through supply-pipes o' p' with supply-tanks (not shown in the drawings) for air and gas, respectively, in which tanks air and gas are kept at suitable pressure. I have found seventy-five pounds per square inch suitable. This pressure may be maintained by any ordinary pump driven by power from the engine itself or from any other suitable source. Upon the valve-stems o^2 and p^2 are mounted equilibrium-pistons o^3 and p^3 of such area as compared with the area of the valves that the pressure of the supply of air and gas from the supply-tanks upon them is greater than upon the valves, and therefore tends to keep the valves closed. Springs o^4 and p^4 are also mounted upon the valve-stems and a spring q^4 upon the valve-stem q^2 of the exhaust-valve Q to keep the valves normally closed. Cams o^5 p^5 q^5, mounted on a valve-operating shaft N, are adapted to press against the several valve-stems to open the valves at the proper point of stroke. The valve-operating shaft N is connected by intermediate gearing with one of the sprocket-wheels I and is driven thereby. A spiral gear n' on the shaft N engages with a spiral gear d' on the connecting-shaft D, the shaft D also carrying a spiral gear d^2, that engages with a gear i', mounted on a stud-shaft driven by one of the sprocket-wheels I, preferably one of the nearer pair. These gears are proportioned so as to compensate for the difference between the rate of revolution of the sprocket-wheel and rate of piston-strokes. In the engine represented in the drawings accordingly the shaft N makes one complete revolution to each six of the sprocket.

A governor R is mounted on the shaft N and is adapted to operate throttle-valves o^6 p^6, set in the air and gas supply pipes o' p'. This governor may be of any suitable construction. As represented in the drawings it consists of two ball-weights r', supported by springs r^2, which are balanced by a third spring r^3, all three springs being attached at one end to a sleeve r^4, adapted to slide on the shaft N, the other ends of the springs r^2 being fast to collars r^6 r^7, fixed to that shaft. The collar r^7, to which the end of the balance-spring r^3 is attached, is adjustable upon the shaft, thereby allowing the balance-spring to be made weaker or stronger at pleasure to adjust the governor. Increase of speed of the shaft N throws the balls outward, thereby moving the sleeve inward and closing proportionately the throttles o^6 p^6, which are connected to a lever r^5, that is fulcrumed to the frame and engaged at its free end in a groove in the sleeve r^4. An ignition-tube S is set in the cylinder-wall at a point a little way from the inward end of piston travel. Any other suitable means of igniting the charge might be used without departing from my invention. The igniting device is preferably located so the explosion will occur when the pin H has about completed its arc of travel around the sprocket I and has a straight path before it.

The operation of my engine is as follows: Assuming that the piston is approaching the end of its inward stroke, all valves being closed, the gas-valve P is opened by the cam p^5, and after remaining open the proper length of time to admit the desired quantity of gas as fixed by the length of the projection on the periphery of the cam is closed by the combined action of its spring p^4 and equilibrium-piston p^3. The air-valve O then opens, admitting air under pressure from the air-tank. The pressure at which this gas and air is admitted helps to cushion the piston at the end of stroke and start it back on its outward stroke. By the time the piston approaches the ignition-tube on its outward stroke it is well under way, the air-valve closes, ignition occurs, and the piston moves on, impelled by the explosion and ensuing combustion. Air in front of the piston is driven out of the cylinder through the holes E until the piston reaches and closes them, thereby imprisoning some air in the cylinder end. Then the exhaust-valve opens and the piston is stopped and started on its return stroke by the joint action of the air-cushion formed by closing the holes E and of the pin H, which reaches the outer limit of its travel and passes around the outer sprocket I. Energy stored in the moving chain and fly-wheel carries the piston in again, the exhaust remaining open until near the end of stroke, when it closes and the gas-admission valve opens as before. The work done by the piston on its outward stroke is transmitted, through the piston-rod, yoke, and pin H, to the chains, and by the chains, through the sprocket-wheels, to the main driving-shafts, on which are mounted the fly-wheels K. Inasmuch as the main shafts may revolve several times during each complete out and in stroke of the piston, which strokes are preferably quite rapid in order to take most advantage of the expansive energy in the cylinder, the fly-wheels may be made very light and of small diameter, the deficiency in weight being made up by their great velocity of revolution. It is probable that in some cases the fly-wheels can be dispensed with altogether, the momentum of the chains and sprockets performing their function. The air-cushions at each end of stroke prevent the engine from pounding and at the same time waste no energy, for on the return stroke they give up all they have absorbed. The amount of gas and air to be admitted for each charge and the proportion of each to the whole are determined by the length of time the respective admission-valves remain open, which in turn depends upon the shape and adjustment of the cams that operate them. The proper relative quantities of gas and air depend upon the fuel used. They should be in the proportions known to be best for complete combustion, with a slight excess of air added to insure the presence and sufficient distribution of enough oxygen to burn all the fuel. While the piston is traveling toward the ignition-point after admission the recently-admitted gases absorb some heat from the cylinder-walls and the pressure rises a little. The instant the charge begins to burn upon ignition the piston leaps forward, responding freely to the increase of pressure except as it may be hampered by the brake-load on the engine. I have discovered that by causing the ignition to be delayed until the pin H has completed its travel around the sprocket I instead of allowing ignition to occur shortly after the dead-center is passed, as is usual in crank-engines, enormous gain in efficiency is secured. In all crank-engines of which I have knowledge the parts are organized for the explosion to occur shortly after the dead-center is passed, and the explosion occuring at that time finds the crank-pin in a position unfavorable for transmitting the energy of the pent-up products of explosion. The crank-pin reaches a favorable position in due course, but not until a considerable portion of the energy liberated in the cylinder having been unable to find an immediate outlet by expansion has passed out in the form of heat by conduction through the cylinder-walls. By my invention I locate the ignition device so that the explosion is delayed until the pin H is in its most favorable position for receiving and transmitting the thrust of the piston. Then I produce the explosion, with the result that an outlet being ready open for the energy to escape in the form of mechanical work by expansion a larger portion of it does escape in that way, and a smaller portion escapes in the form of heat conducted through the cylinder-walls than if the explosion had occurred sooner. This great advantage results from two things—from my use of a chain and sprocket to transform the reciprocating motion of the piston into the rotary motion of the driving-shaft and from my organization of parts by which the explosion is delayed, as described.

Another great advantage is that in building my engine I am not restricted to the use of a short stroke, but can make it as long as I desire and may cover several revolutions of the driving-shaft with one stroke. This enables me to delay opening the exhaust until the gases in the cylinder are fully burned and until they have expanded to as low a pressure as I desire. Thus I succeed in liberating within the cylinder all the energy of the fuel and in utilizing a very large part of the energy thus liberated. By securing complete combustion of fuel I do away with the offensive odor frequently noticed in the exhaust of gas-engines. By exhausting at a low pressure I do away with the noise.

It will be apparent that all the benefits of my invention might be secured by the substitution of equivalent mechanical devices for the sprocket chain and wheel I have shown in the drawings—for example, by the use of a cable making frictional contact with grooved sheaves. I consider the use of a sprocket chain and wheel the best mode of applying my invention, and therefore have shown that form in the drawings. I do not, however, by the use of the word "chain" mean to limit myself to a sprocket-chain, but include a cable or any other equivalent device.

What I claim is—

1. In an internal-combustion engine, a combustion-cylinder; a piston, adapted to reciprocate therein and continuously in engagement with a chain; that chain; a wheel in engagement with the chain; valve mechanism to operate the engine; all organized and arranged substantially as described, so that the force of the explosion is immediately transmitted to the chain and wheel, to transmute the reciprocating motion of the piston into rotary motion.

2. In an internal-combustion engine, a combustion-cylinder; a piston adapted to reciprocate therein and in engagement with a chain during the explosion-stroke of the piston; that chain; a wheel in engagement with the chain; valve mechanism to operate the engine; all organized and arranged substantially as described, so that the force of the explosion is immediately transmitted to the chain and wheel to transmute the reciprocating motion of the piston into rotary motion.

3. In an internal-combustion engine, a combustion-cylinder; a piston adapted to reciprocate therein and continuously in engagement with a chain, that part of the chain with which the piston is engaged being approximately in the line of thrust of the piston during the working stroke; that chain; a wheel in engagement with the chain; and valve mechanism to operate the engine, substantially as described.

4. In an internal-combustion engine, a combustion-cylinder; a piston adapted to reciprocate therein; a chain; a wheel in engagement with the chain; a pin held in the chain and projecting therefrom; a yoke, adapted to be engaged by said pin and also by the piston, whereby the reciprocating motion of the piston is transmitted and transmuted into rotary motion through the yoke, pin, chain and wheel.

5. In an internal-combustion engine, a combustion-cylinder and a piston adapted to reciprocate therein; a main driving-shaft; means connected to the piston and to the main driving-shaft to transmit motion from the one to the other, the point of connection between the piston and said transmitting means being adapted to follow a curved path in reversing its motion preliminary to beginning its working stroke; an igniting device for the fuel charge; and valve mechanism for the igniting device; all organized and arranged so that the igniting device shall not operate until said point of connection between the piston and the transmitting means has approximately completed said reversal of motion and is traveling in a direction approximately parallel to the thrust of the piston.

6. In an internal-combustion engine, a combustion-cylinder and a piston adapted to reciprocate therein; a main driving-shaft; means connected to the piston and to the main driving-shaft to transmit motion from the one to the other; means to conserve in the engine surplus energy between the impulses of the piston; an igniting device for the fuel charge; valve mechanism for the igniting device; all organized and arranged so that the igniting device shall not operate until the piston has attained on its working stroke approximately the full velocity which the conserver of energy can give it.

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