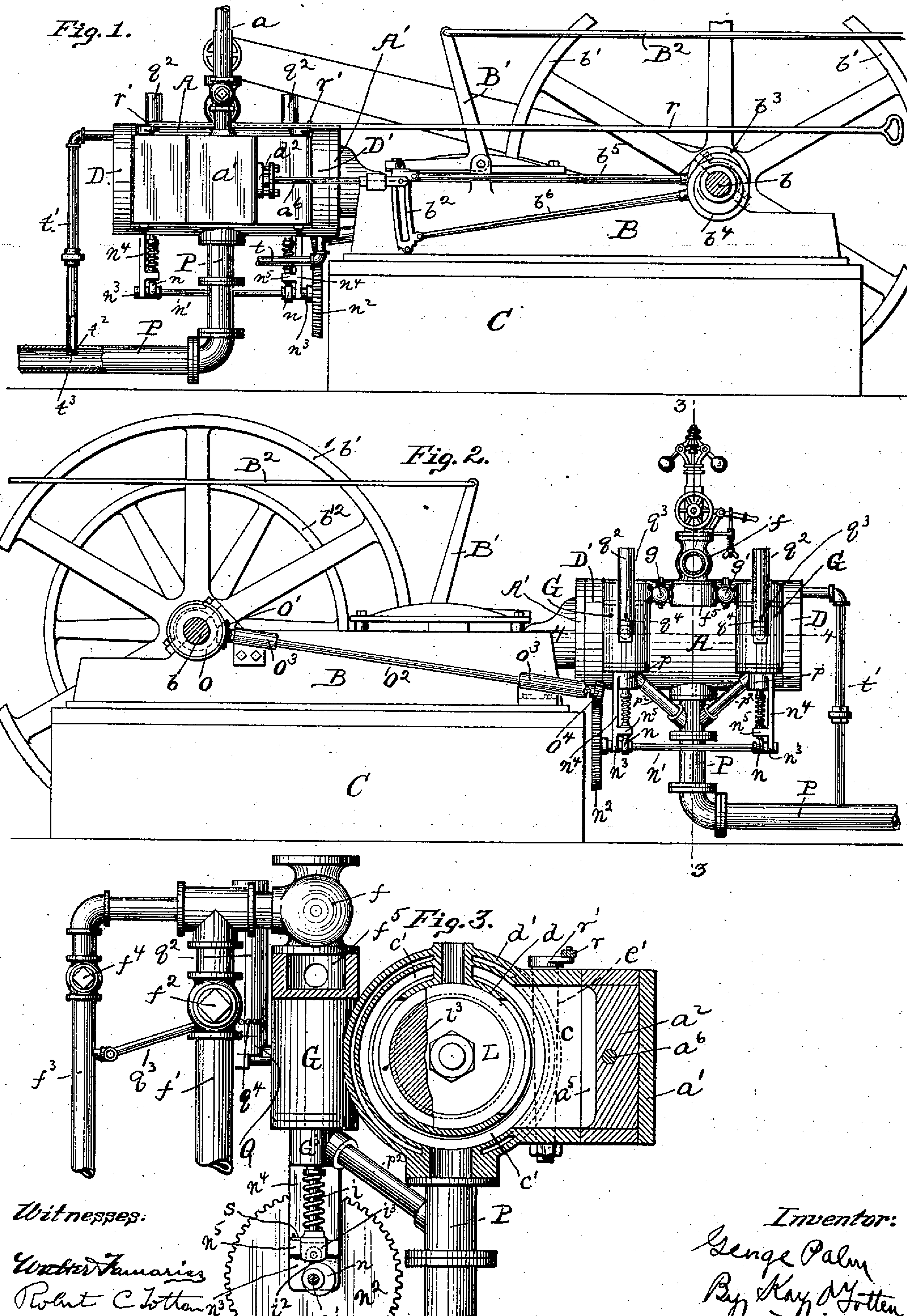
No. 654,761. Patented July 31, 1900.

G. PALM.

COMBINED STEAM AND EXPLOSIVE ENGINE.

(Application filed Dec. 18, 1897.)

(No Model.) 3 Sheets—Sheet 1.



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

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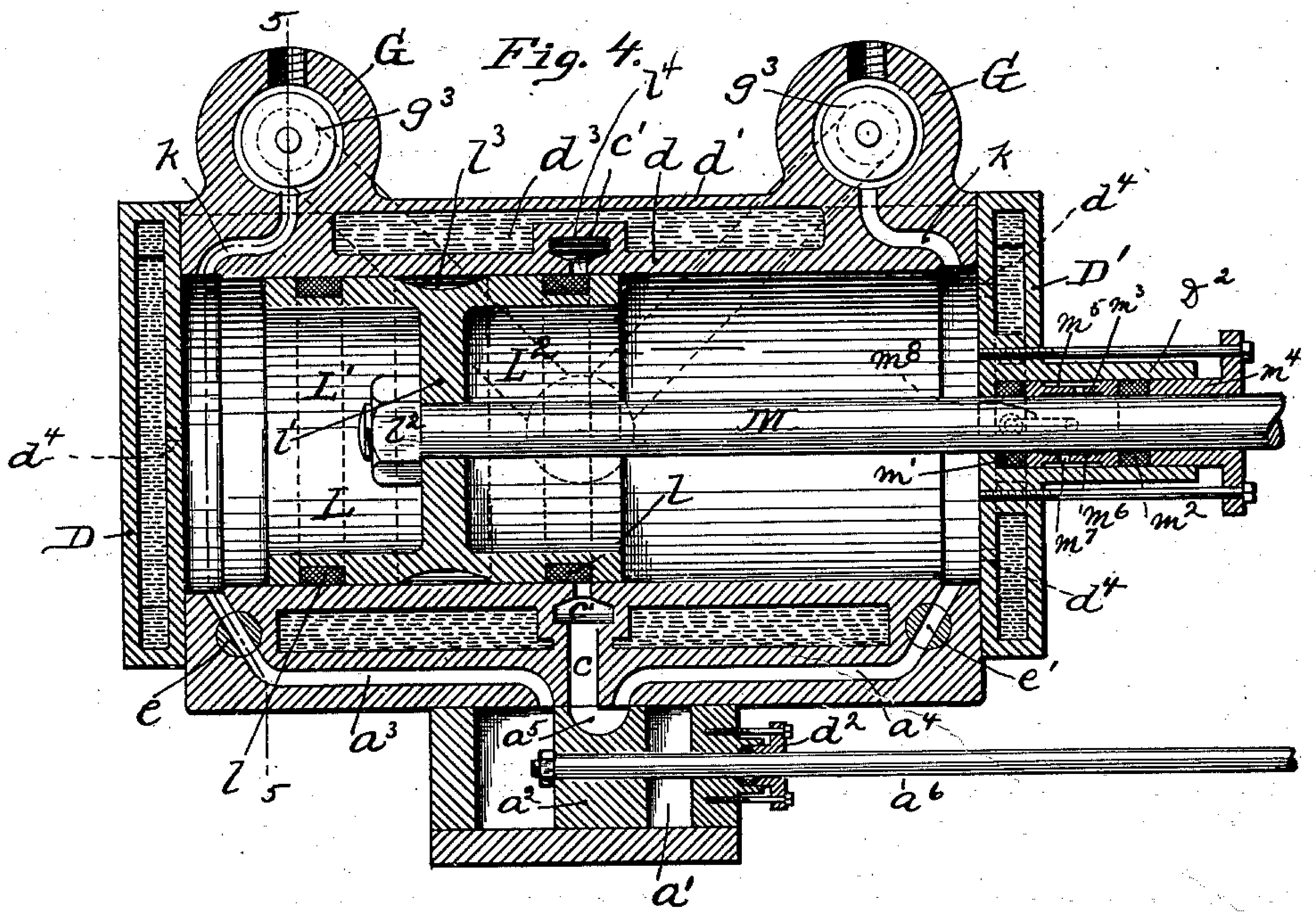

Fig. 4.

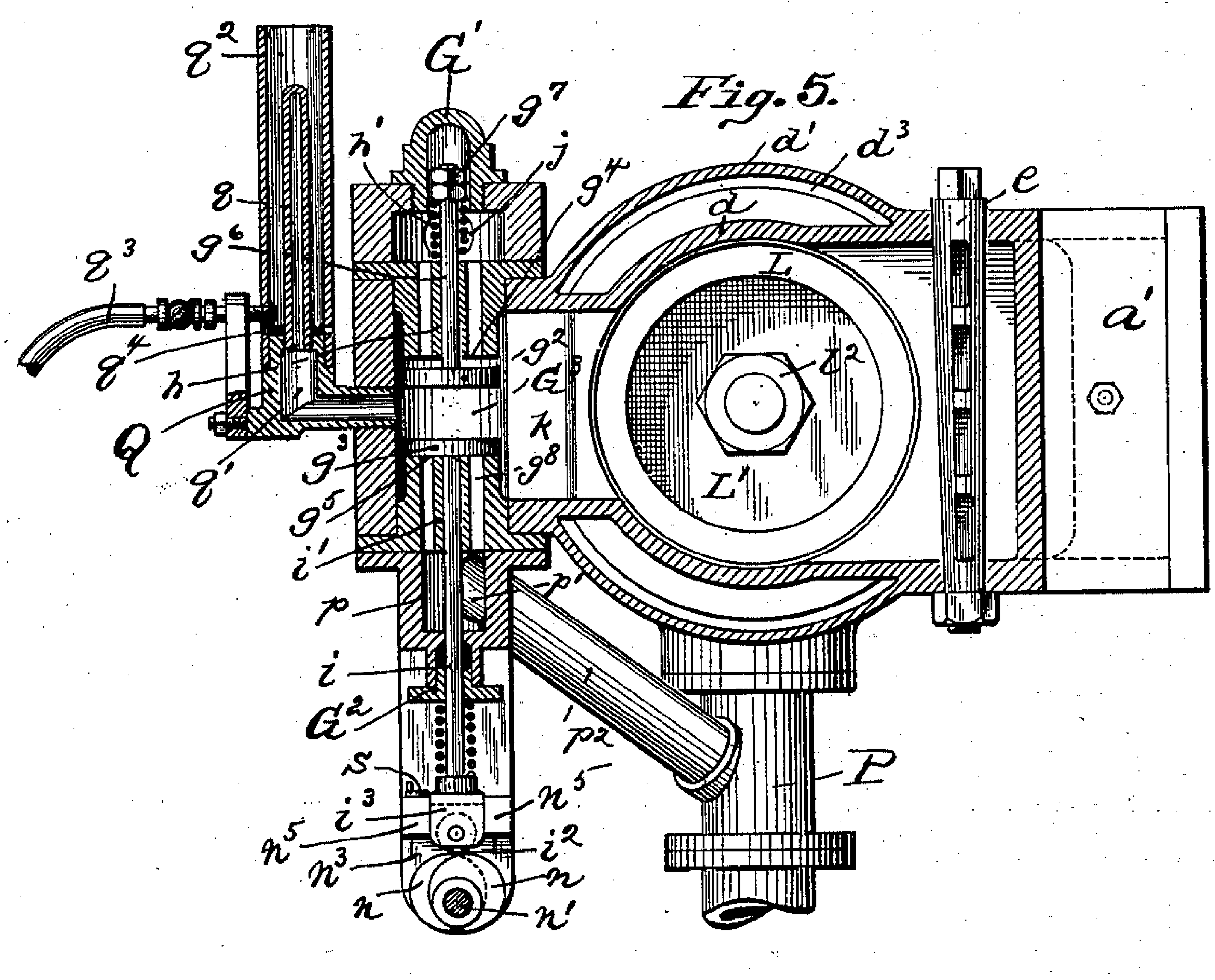

Fig. 5.

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Fig. 6.

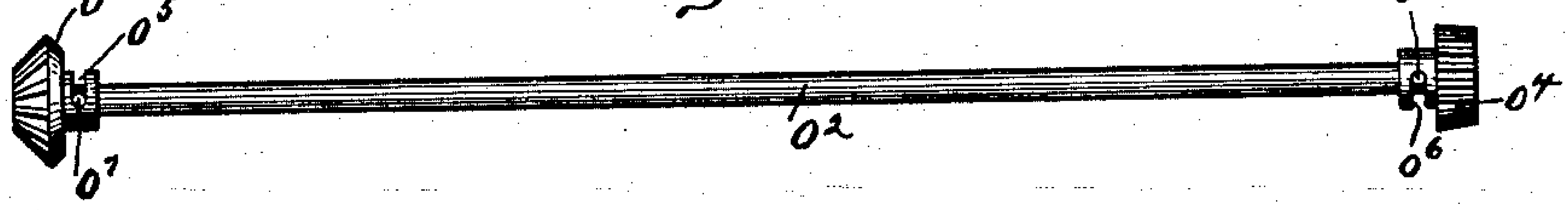


Fig. 7.

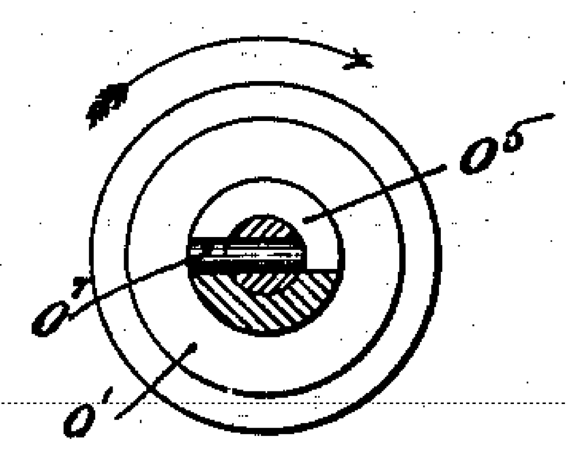


Fig. 8.

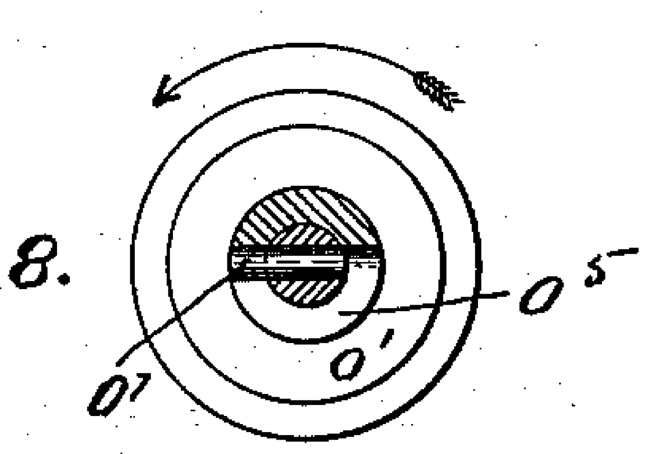
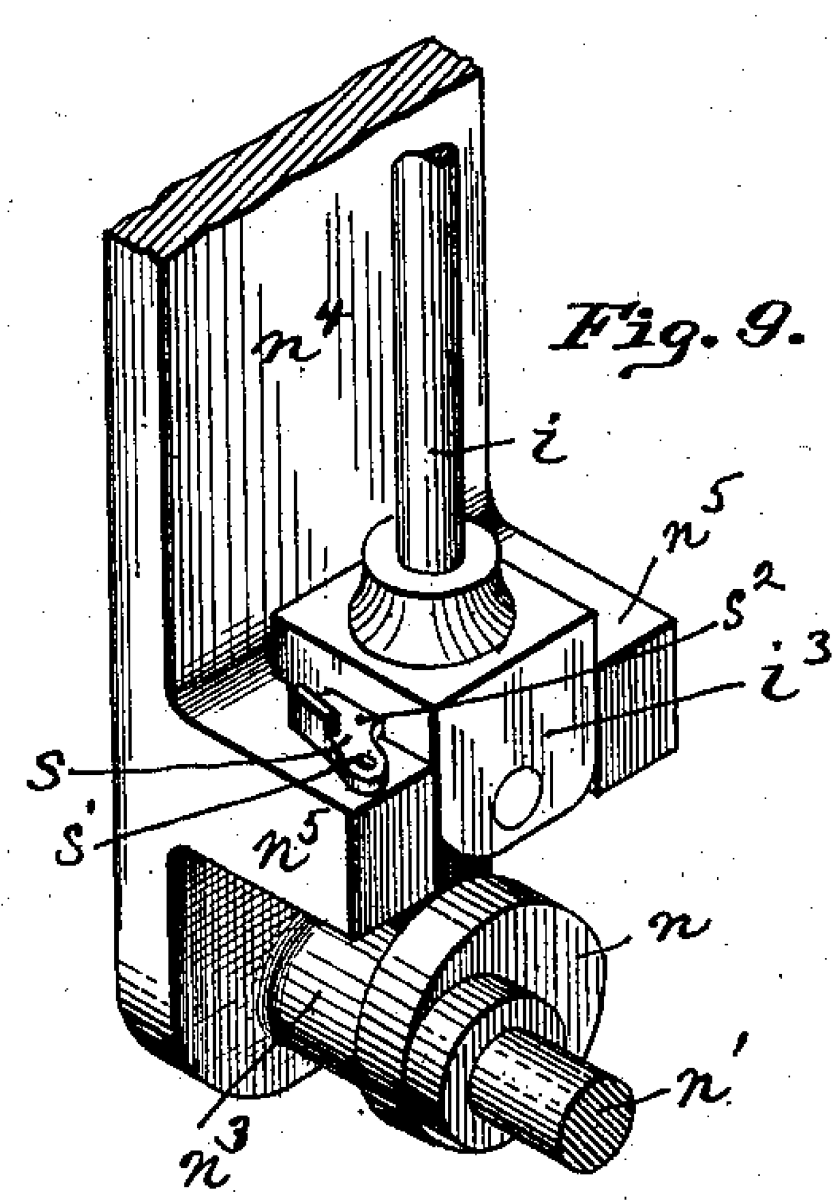


Fig. 9.



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UNITED STATES PATENT OFFICE.

GEORGE PALM, OF BUTLER, PENNSYLVANIA.

COMBINED STEAM AND EXPLOSIVE ENGINE.

SPECIFICATION forming part of Letters Patent No. 654,761, dated July 31, 1900.

Application filed December 18, 1897. Serial No. 662,402. (No model.)

To all whom it may concern:

Be it known that I, GEORGE PALM, a resident of Butler, in the county of Butler and State of Pennsylvania, have invented a new and useful Improvement in Engines; and I do hereby declare the following to be a full, clear, and exact description thereof.

My invention relates to engines.

The object of my invention is to provide an engine so constructed that it may be operated either by steam, compressed air, or gas or by steam or compressed air and gas.

My invention comprises certain novel features, among them that of a cylinder having inlet-ports on the one side entering from an ordinary steam-chest, through which steam or compressed air may be admitted to operate the piston within said cylinder, the steam-ports having valves therein by means of which steam may be shut off from one end or both ends of the cylinder and ports adapted to admit an explosive mixture to each end of said cylinder from the opposite side to the steam-ports, whereby the said engine may be started by means of steam or compressed air or operated entirely by the same or by the explosive mixture or by steam and the explosive mixture acting upon opposite ends of the piston.

In the drawings, Figure 1 is a side view of my engine, showing the side from which the engine is operated by means of steam or compressed air. Fig. 2 is a similar view showing the opposite side of the engine from that shown in Fig. 1 or the side from which the air and gas inlets are controlled. Fig. 3 is a cross-section on the line 3 3, Fig. 2. Fig. 4 is a horizontal section on the line 4 4, Fig. 2. Fig. 5 is a cross-section on the line 5 5, Fig. 4. Fig. 6 is a detail of the parts used for reversing the entrance of air or gas when the engine is running backward. Figs. 7 and 8 are other details of said device. Fig. 9 is a detail in perspective showing the manner of locking the exhaust-valve in one end of the cylinder in an open position, so that the engine may be run from one side only.

Like letters indicate like parts in each of the figures.

In the drawings, A represents the cylinder, which is attached to the bed-plate B by means of the plate A', to which the cylinder is bolted. C is the foundation; b, the shaft; b', the balance-wheel, and b^{12} the pulley or belt wheel.

In operating my engine by compressed air or steam, which I usually do in starting the engine, the air or steam enters through the pipe a into the steam-chest a'. A slide-valve a^2 controls the ports a^3 a^4, through which the steam or compressed air enters to the cylinder. The steam or compressed air exhausting through one of these ports enters the space a^5 in the slide-valve and passes through the port c to the annular space c', formed around the cylinder in the space between the two shells of the cylinder. My cylinder is formed of two shells, an inner shell d and an outer shell d', the space between the two shells being left for a water-space, as will be more fully hereinafter described. The ports a^3 and a^4 are also controlled by means of the taper plugs or valves e e'. These are for the purpose of closing said ports when it is desired to run the engine by means of gas or where it is desired to use steam or compressed air only at one end of the cylinder. The slide-valve a^2 is attached to the end of the rod a^6 which passes out through the stuffing-box d^2 and is connected to the link b^2, which in turn is operated by the eccentrics b^3 b^4, connected thereto by the eccentric-rods b^5 and b^6, respectively. A bell-crank lever B', when operated by means of the stem or rod B², acts to reverse the links, and consequently the engine.

When I desire to operate my engine by means of gas and air, the gas and air are admitted by the pipes f^3 and f' to the governor-valve f, the air entering through the pipe f', controlled by the cock f^2, and the gas entering through the pipe f^3, controlled by the cock f^4, the mixture of gas and air entering the mixing-chamber f^5. From the chamber f^5 the mixture of gas and air enters through either one of the cocks g or g' to one of the valve-boxes G. These valve-boxes contain the inlet-valves g^2 and the exhaust-valves g^3, the valves having seats g^4 and g^5, respectively. The stem g^6 of each inlet-valve g^2 passes through the guide h, formed in the box G, and has upon its upper end the nut g^7, a spring h' being interposed between the nut and the upper face of the guide h. A cap G' is fitted into the upper end of each of these valve-boxes over the stem g^6 and nut g^7, which may be removed for the adjusting of the tension on the spring h'. The valve g^3 is attached to the valve-stem i, which passes through a guide i' of the valve-seat g^5, thence through the packing-box G^2, and carries upon its lower end the roller i^2, which revolves in the journal i^3, fitted to the lower end of said valve-stem i. The air and gas entering through the port j from the mixing-chamber f^5 passes down through the valve into the space G^3, formed in the valve-box, and thence it enters through the ports k into the adjacent end of the cylinder.

The piston L is formed hollow and carries the packing-rings l, one at each end of the piston. A disk or wall l' extends across the center of the piston, dividing the piston into two compartments L' and L^2. A piston-rod M is secured to the piston at the center of said wall l' and is threaded therein and more permanently secured thereto by means of the jam-nut l^2. This piston is constructed as described for the purpose both of lightening the piston and also of forming a chamber in each end thereof, into which the air and gas may be compressed. An annular space or groove l^3 is cut upon the outer surface of the piston, midway between the packing-rings l, for a purpose which will be more fully hereinafter described. The exhaust-valves g^3 are raised and lowered by means of the cams n, which are mounted upon the shaft n'. These cams and their shaft are operated from the main driving-shaft b in the following manner: A bevel-gear o is mounted upon the shaft b and revolves therewith. A bevel-pinion o' is secured to one end of the shaft o^2, which is mounted to revolve in the bearings o^3, secured to the bed-plate. At the other end of said shaft o^2 is the bevel-pinion o^4, which meshes into the gear-wheel n^2, mounted to revolve with the shaft n'. Bearings n^3 are formed in the lower end of the depending arms n^4, which are attached to the lower end of the valve-boxes G. In these bearings the shaft n' revolves. Guides n^5 are formed upon these depending arms n^4, which serve to guide the movement of the stems i of the exhaust-valves g^3. The gases in exhausting pass through the port k from each end of the cylinder into the space G^3 of the valve-box and thence through the openings g^8, formed in the valve-seat g^5, to the space p, formed below said valve, whence they escape by means of the opening p' into the pipe p^2, which opens into the main exhaust-pipe P. When a fresh charge has been compressed in one end of the cylinder, a portion of said charge is forced back through the inlet-port k to the space G^3 in the valve-box G. It is then forced into the igniting-tube q through the passage q', formed in the coupling Q, which is attached to the valve-box G. A pipe q^2 surrounds this igniting-tube q, into which a small portion of gas enters through the pipe q^3. Air-inlet ports q^4 are formed around the circumference at the lower end of said pipe q^2 for the purpose of supplying air to the gases which come through the pipe q^3.

The cams n are so arranged upon the shaft n' that they operate the exhaust-valves alternately. These cams, as shown in Fig. 5, are set at an angle of ninety degrees to each other. The bevel-gear o upon the shaft b is twice the size or diameter of the pinion o', the shaft o^2 being revolved at a speed double that of the shaft b. The pinion o^4 is one-fourth the diameter of the gear-wheel n^2, thus revolving the shaft n' at one-fourth the speed of the shaft o^2. By means of these proportions between the gear o, the pinion o', the pinion o^4, and gear n^2 it will be seen that the shaft n' revolves but once while the shaft b is making two revolutions, allowing the cams n to raise the exhaust-valves alternately during one cycle of the engine and to remain closed during the succeeding cycle thereof.

To reverse my engine, I turn on the steam or compressed air by operating the rod r, which in turn operates upon the cranks r' to open the taper-valves e, allowing steam or compressed air to enter into the cylinder, and thereby operate the engine. By operating the rod B^2 the links b^7 are reversed, thus reversing the position of the slide-valve a^2, allowing steam or compressed air to enter the ports opposite to that through which they were previously entering, and thus reversing the motion of my engine. During this operation the air and gas are turned on the same as when my engine is being operated thereby. The moment the valves e and e' are opened the steam entering the cylinder closes the inlet-valves g^2, so that no mixture of air and gas may enter the cylinder, and my engine is run by steam or compressed air, as desired. When the reversing operation has been completed, I operate the rod r to close the valves e and e' in the ports a^3 and a^4, shutting off the steam or compressed air from the cylinder. As the engine continues to revolve the vacuum formed between the piston and end of cylinder acts to open the inlet-valve g^2, taking a charge into one end of the cylinder, which upon the reverse movement of the piston is compressed. At the same time that this charge is compressed a charge is drawn into the other end of said piston in the cylinder, and when the first charge is fully compressed the mixture is forced back through the port k to the space G^3 in the valve-box G and from thence through the passage q' to the tube q. This tube q is kept at a very high heat by means of the gas admitted through the pipe q^3 burning in the tube q^2, and when said gas is forced back, as previously described, into this tube q an explosion takes place in the cylinder, the fire being carried into the cylinder, and the piston is forced back, compressing the charge which has been drawn into the other end of the cylinder and when said second charge is fully compressed the explosion takes place in a similar manner to that previously described, forcing the exhaust-gases out through one of the ports g^8 into the space p and thence to the exhaust-pipe P, the valve g^3 having been opened by means of one of the cams n. When this charge is thoroughly exhausted and the piston starts to return, it forces the exhaust-gases out of the other end of the cylinder in a manner similar to that described previously. At the same time that this other charge is being exhausted a fresh charge is being taken into the first-mentioned end of the cylinder, and when the piston starts to return this charge is compressed and a charge admitted into the end just exhausted, and both ends of the cylinder are then exploded alternately, and the operation proceeds as previously described. When by means of steam or compressed air I have reversed my engine, it is necessary before the steam or compressed air is cut off that the cams n shall be in a proper position to raise the exhaust-valves g^3 at the proper time for said reversal of motion. This I accomplish by a certain novel construction, which is shown in Figs. 6, 7, and 8. The bevel-pinions o' and o^4 are mounted loosely upon the shaft o^2. Grooves o^5 o^6 are cut in the hubs of the pinions o' o^4, respectively, and pins o^7 o^8 are secured to the shaft o^2 in a position to enter said grooves o^5 o^6. As better shown in Fig. 7, when the pinion o' is being revolved in the direction of the arrow the hub is in contact with the pin o^7 and revolves the shaft therewith. Also the pin o^8, being in contact with the hub of the pinion o^4, revolves said pinion therewith. When the engine is reversed, the pinion o' will make a half-revolution before the metal of the hub of said pinion comes in contact with the pin o^7, the parts then being in the position shown in Fig. 8. After the pinion o' has made the said half-revolution it then in turn revolves the shaft o^2 a half-revolution before the pin o^8 comes into a position to revolve the pinion o^4 in a direction opposite to its previous revolution. It will thus be seen that the shaft b will make one half-revolution in a reverse direction before the pinion o^4 will operate to reverse the motion of the gear-wheel n^2, and consequently the shaft n', the pinion o' being one-half the diameter of the gear o. When the shaft b further revolves to complete the revolution of said shaft, the gear-wheel n^2, attached to the shaft n', revolves said shaft, bringing the cams into proper position for opening the exhaust-valves for the reverse motion of the engine.

In Fig. 9 I have shown a means for holding the exhaust-valve open when I desire to run the engine by exploding in but one end of the cylinder. A latch s is pivoted to the upper side of the guide n^5 at s' and is in such a position that the lip s^2 of said latch may be thrown in under the block i^3 of the valve-stem i, holding the valve g^3 in a raised position and allowing the air to circulate freely in the end of the cylinder which is not being used during the operation of said cylinder by means of one end only. I also close the cock g or g', as the case may be, during said operation.

As previously stated, I form my cylinder with two shells, an inner shell d and an outer shell d', thus allowing a space d^3 between said shells, through which water is allowed to circulate. My cylinder-heads D and D' are also formed hollow and with ports d^4, communicating with the water-space d^3 between the two shells of the cylinder. In the front end of the cylinder is the stuffing-box D^2, through which the piston-rod M reciprocates. This stuffing-box has therein the packing m' m^2 and a ring m^3 between said packing-rings. A cap m^4 is bolted to the outer end of said stuffing-box, holding the ring m^3 and the packing m' m^2 in place. The ring m^3 is formed with two grooves, the one, m^5, upon its outer circumference and the groove m^6 upon its inner circumference. Ports m^7 allow of free access from one groove m^5 to the other, m^6. The water is allowed to enter this outer groove m^5 through the ports m^8, one of which is shown in dotted lines, Fig. 4. Thence it passes through the port m^7 to the groove m^6 and surrounds the piston-rod at that point. A water-supply pipe t is attached to the lower end of the cylinder, through which pipe water is supplied to the space in said head. It then passes through the ports d^4 (shown in dotted lines, Fig. 4) to the space formed between the two cylinders, a portion of said water circulating around the piston-rod in the annular groove m^6, with which it is in communication. From the space around the cylinder it enters through the other ports d^4 to the space formed in the head D, whence it passes through the pipe t' and enters the exhaust-pipe P, as shown in Fig. 1, through the openings t^2, formed around the lower end of the pipe t', the lower end of said pipe being closed by means of the plug t^3. The manner of circulating the water and the cooling means for the piston form no part of my invention, and it is not thought necessary to describe the same in any further detail.

The operation of my engine when it is to be operated by gas is as follows: The valves f^2 and f^4 are first opened, admitting the air and gas to the mixing-chamber f^5. The valves g and g' are then opened and the mixture of air and gas held in check by means of the valves g^2. Steam or compressed air is then turned on as desired, the rod r being operated to open the valves e and e' in the steam-inlet ports a^3 and a^4. The steam or compressed air then acts to start the engine. The inlet-pipe a may be attached to an air-reservoir, into which the air may be compressed while the engine is in operation by means of a pump operated by the machinery from the engine. By the use of said air-reservoir air may be stored for the purpose of starting or reversing the engine when desired, and the laborious operation of starting the engine by hand is obviated. When the engine is in full operation and running by means of steam or compressed air, the rod r is operated to close the valves e and e', cutting off the supply of steam or compressed air, allowing the mixture of gas and air to enter through the ports k to the cylinder and the engine run thereby. Suppose, for instance, that the piston was in the position shown in Fig. 4 and traveling to the right when the supply of steam was cut off. As the piston travels in the direction described the steam in the end of the cylinder corresponding to the side L^2 of the piston is forced out through the exhaust, and a vacuum is formed in the other end of the cylinder, and consequently in the space G^3 of the valve-box G. The mixture of gas and air entering through the port j to the upper end of the valve-box from the mixing-chamber f^5 forces the valve g^2 away from its seat, and the mixture of gas and air enters through the port k to that end of the cylinder corresponding to the end L' of the piston. When the piston reverses and travels in an opposite direction, the mixture of air and gas is compressed in the space between the cylinder-head D and the piston and in the space L' of the piston. At the same time that said charge is being compressed in the space L' of the piston a charge is being drawn into the other end of the cylinder. When the charge in the space L' is compressed, it is ignited in the manner previously explained and the piston forced in the direction indicated by the arrow, compressing the charge in the other end of the cylinder in the space L^2 of the piston and between the piston and cylinder-head D'. When the piston completes its stroke in this direction, the compressed charge is ignited, forcing the piston in the opposite direction or in a direction opposite to that indicated by the arrow, and the exhaust-gases in the end of the cylinder corresponding to the end L' of the piston are discharged through the port k to the space G^3 in the valve-box G at that end of the cylinder. The cam operates to lift the valve g^3 in said valve-box G from its seat, allowing the exhaust-gases to escape into the compartment p and thence to the main exhaust-pipe P. The engine then runs a full revolution by its momentum, first exhausting the gases from the end L^2 of the piston and at the same time taking in a fresh charge of the mixture in the end L' as the piston travels to the right. When the piston reverses, traveling in a direction opposite to that indicated by the arrow, the charge in the end L' is compressed, as previously explained, and a fresh charge is admitted to the end L^2 of the piston. The engine continues to operate in a like manner, taking and compressing, exploding and compressing in the one cycle, exploding and expelling, expelling and compressing in the second cycle, and so on repeatedly. It will thus be seen that the engine explodes at each end alternately in the one cycle and then runs by its momentum through another cycle.

I have thus described the operation of my invention when it is to be operated by means of gas alone. It is apparent, however, that by simply closing one of the valves e e' the engine may be operated by the use of the explosive mixture at one end and steam or compressed air at the opposite end. Supposing that the valve e' is closed, the admission of steam by the port a^3 will drive the piston to the right and the admission of gas by the port k at the opposite end of the cylinder will drive the piston to the left. Under such circumstances the valves e e' will not be operated simultaneously by the rod r, but said rod may be disengaged from the cranks r' and said cranks operated independently of each other to close one or other of the valves e e'.

In case it is desired to operate the engine by merely using an explosion at one end of the cylinder the valves e e' are closed and one of the exhaust-valves g^3 at the opposite end of the cylinder from that at which the explosive mixture is to enter is lifted and held in its raised position by means of the latch s. The air in this end of the cylinder is permitted to circulate freely where the explosive mixture is only admitted to one end of the cylinder. This is a matter of great advantage, as it permits the repairs to be made on the valve mechanism at that end of the cylinder not in use without shutting down the engine. It often occurs in engines where the explosion only takes place at one end of the cylinder that the valve mechanism or igniting mechanism gets out of order and a shut down of the engine is the result. By my invention, however, this is avoided, as it would seldom occur that the valve mechanism at both ends of the cylinder would need repair at the same time.

As before stated, my cylinder and cylinder-heads are so constructed as to completely envelop the space in which the piston travels by a water-jacket. The water entering through the inlet-pipe t into the interior of the cylinder-head D' courses through said cylinder-head, a portion of the water entering through the port m^8 into the space formed around the piston-rod in the stuffing-box, circulating therein and returning to the cylinder-head. From the cylinder-head it passes through the openings d^4 in said cylinder-head and enters the water-jacket formed between the two shells of the cylinder. From this water-jacket it passes through the openings d^4 in the cylinder-head D and into the water-space formed in said cylinder-head, from which it passes away through the outlet-pipe t' and into the exhaust-pipe P. The water circulating around the cylinder in this manner takes up the heat which is imparted to the inner shell of the cylinder, cooling the same and preventing sudden expansion and contraction and preventing the piston from either sticking in the cylinder or becoming so loose as to allow the explosion to fly past. If, however, the piston should at any time become so loose as to allow the explosion to fly past, the gases will collect in the annular groove l^3, formed around the piston, and will exhaust through the ports l^4 into the annular space c' and will pass from thence into the main exhaust-pipe P. The water in leaving the water-jacket passes through the pipe t' and into the exhaust-pipe P. As the lower end of the pipe t' is closed by the plug t^3, the water is forced to pass through the perforations t^2 in very small streams or jets. The exhaust-gases in passing through the pipe P reduce these jets into spray and mix therewith. This mixing of the spray with the exhaust-gases cools the latter, reducing their volume, and in consequence thereof the exhaust-gases in leaving the exhaust-pipe and entering the air do not expand so suddenly.

What I claim as my invention, and desire to secure by Letters Patent, is—

1. In an engine, the combination of a cylinder having two sets of ports, one set for the admission of steam to each end of said cylinder, and the other set for the admission of an explosive mixture to each end of said cylinder, valves controlling said ports, and a valve in each steam-port, whereby said steam-ports may be completely cut off from said cylinder.

2. In an engine, the combination of a cylinder having steam-ports at each end thereof, a main valve controlling said ports whereby the steam may be admitted alternately to each end of said cylinder, an independent valve in one of the steam-ports adapted to close said port permanently, said cylinder having a port for the admission of an explosive mixture to one end thereof, and inlet and exhaust valves controlling said explosive-mixture port, substantially as set forth.

3. In an engine, the combination of a cylinder having at one end thereof a steam-port, and a port for the admission of an explosive mixture, a steam-valve controlling said steam-port connected to a moving part of the engine to operate said valve, and a stop-valve in the same port between the steam-valve and the cylinder for permanently closing said port to the admission of steam.

4. In an engine, the combination of a cylinder having at one end thereof a steam-port, and at its opposite end a port for the admission of an explosive mixture, a steam-valve controlling the steam-port connected to a moving part of the engine to operate said valve, and a stop-valve in the same port between the steam-controlling valve and the cylinder for closing said port to the admission of steam.

5. In a gas-engine, the combination of a cylinder, a piston, said cylinder having two sets of ports at each end thereof, one for the admission of steam, and one for the admission of an explosive mixture, valves for controlling said ports, said gas-valves arranged to be held closed by the steam admitted through said steam-ports.

6. In an engine, the combination of a piston, a cylinder having two sets of ports, one set for the admission of steam to each end of said cylinder, and the other set for the admission of an explosive mixture to each end of said cylinder, exhaust-valves controlling the exhaust of steam and explosive mixture from said cylinder, mechanism for rendering permanently inoperative one of said inlet-valves, and mechanism for rendering permanently inoperative one of said exhaust-valves at the same end of the cylinder.

7. In an engine, the combination of a piston, a cylinder having two sets of ports, one set for the admission of steam to each end of said cylinder, and the other set for the admission of an explosive mixture to each end of said cylinder, exhaust-valves controlling ports leading from said cylinder to the exhaust, means for shutting off the explosive mixture from one of said inlet-valves at an end of the cylinder, and means for holding one of said exhaust-valves permanently open at the same end of the cylinder.

In testimony whereof I, the said GEORGE PALM, have hereunto set my hand.

GEORGE PALM.

Witnesses:

ROBT. D. TOTTEN,
ROBERT C. TOTTEN.