W. D. EDWARDS.

INTERNAL COMBUSTION ENGINE.

APPLICATION FILED APR. 2, 1910.

996,626.

Patented July 4, 1911.

6 SHEETS—SHEET 1.

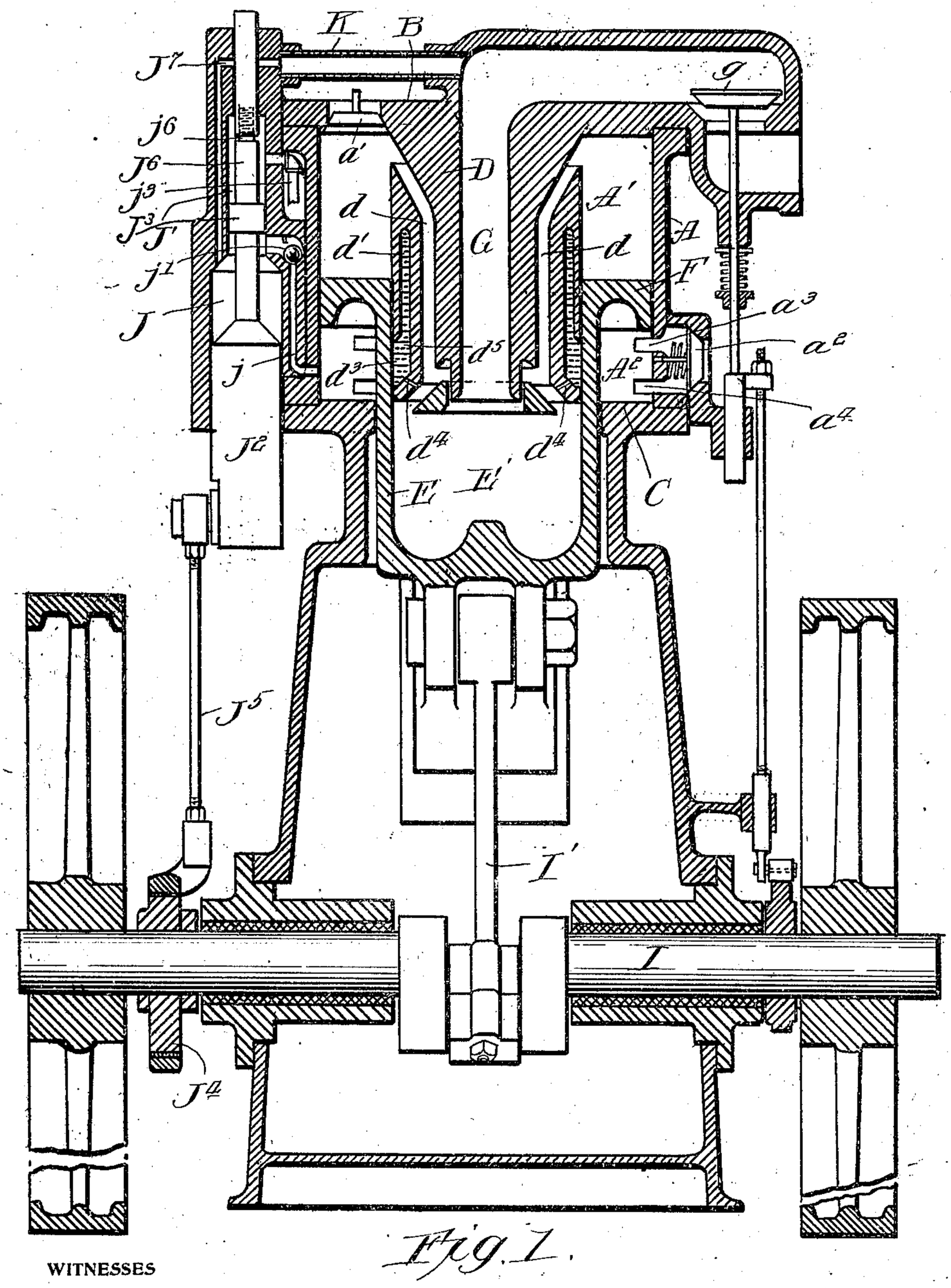

Fig. 1.

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5 SHEETS—SHEET 2.

Fig. 4.

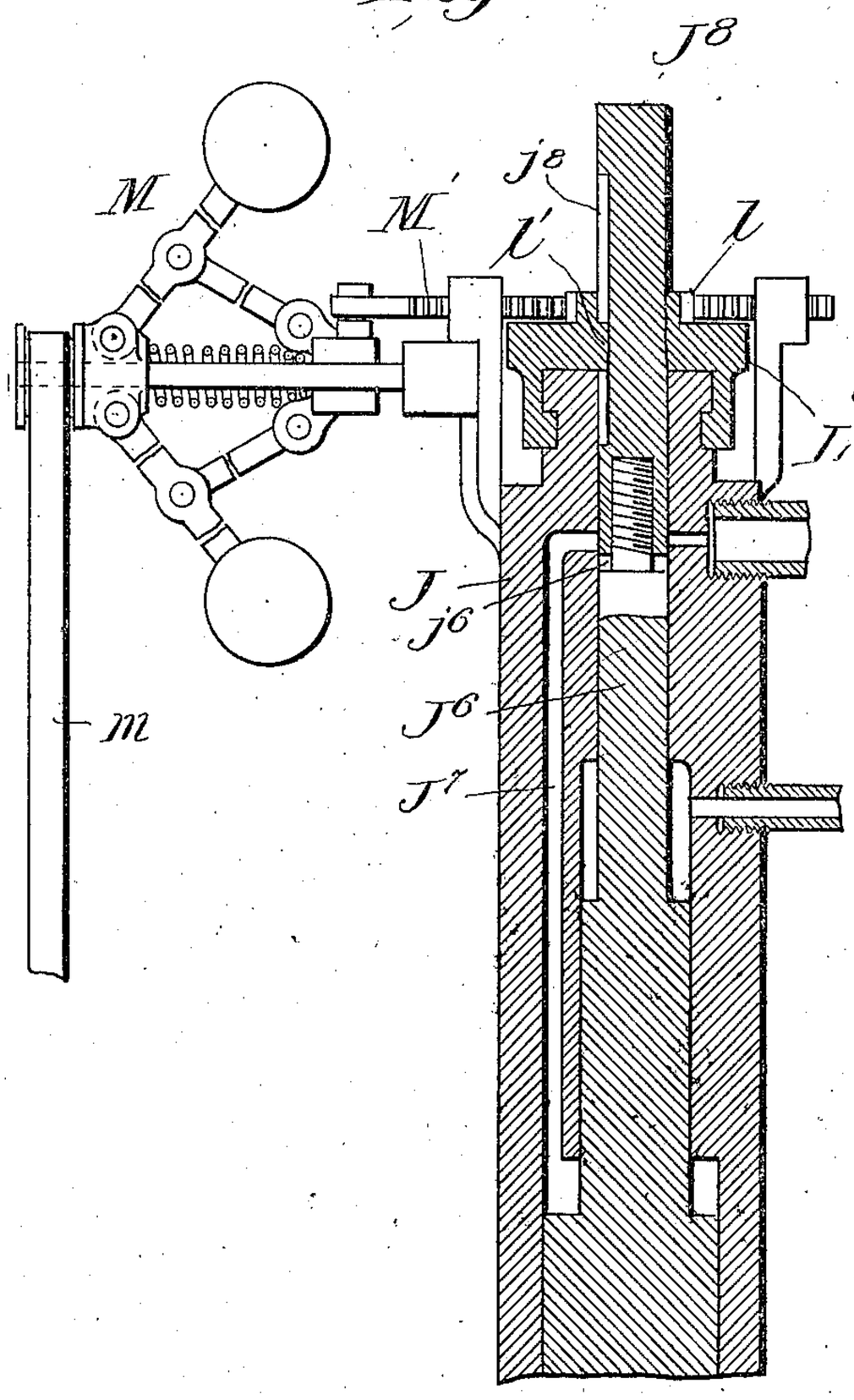


Fig. 3.

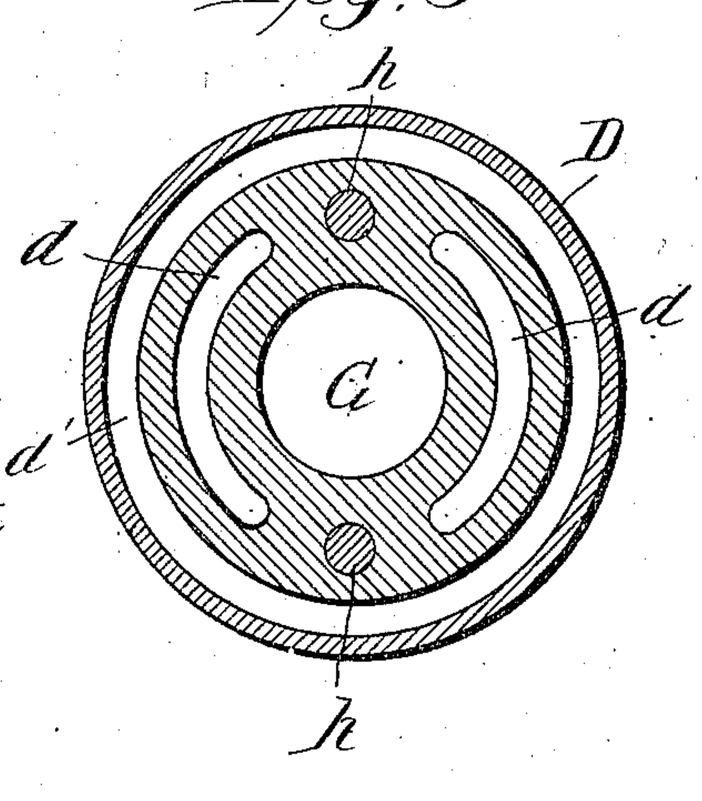
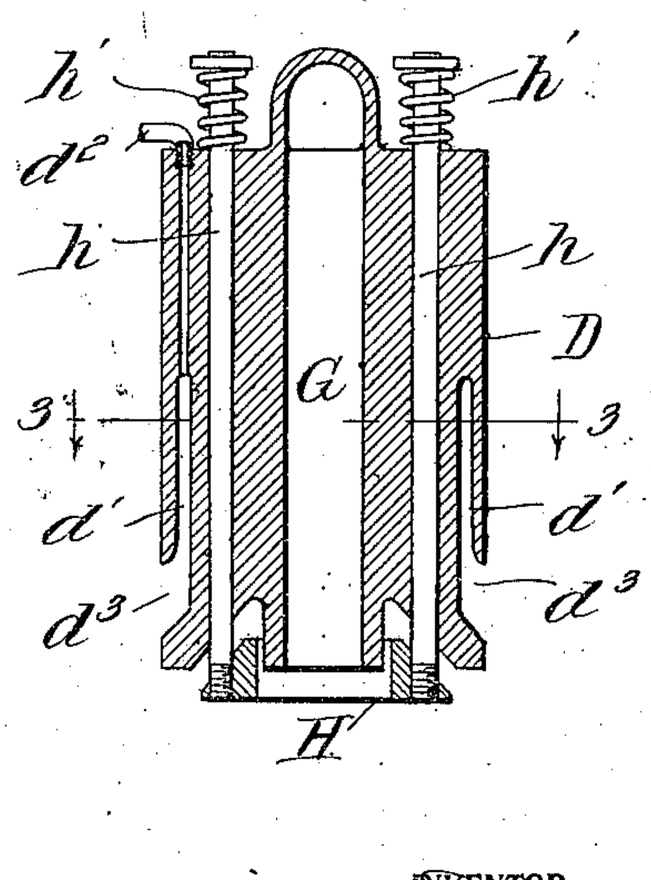


Fig. 2.



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5 SHEETS—SHEET 3.

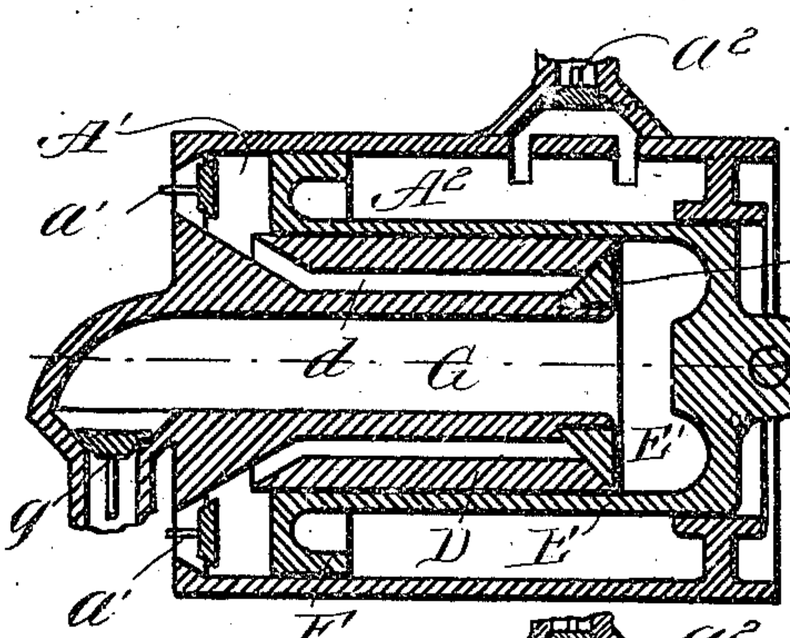

Fig. 5.

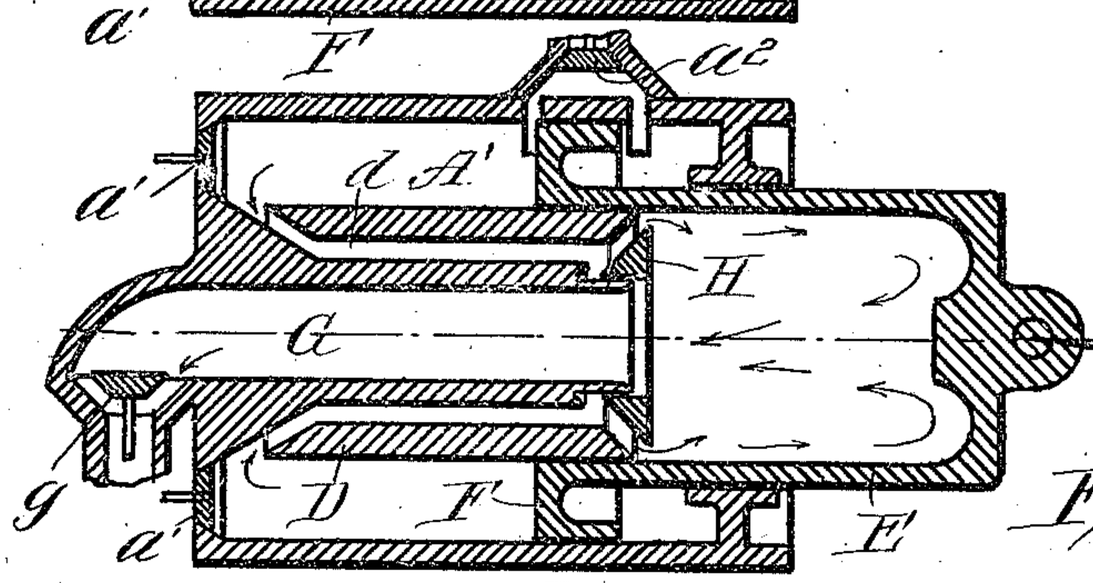

Fig. 6.

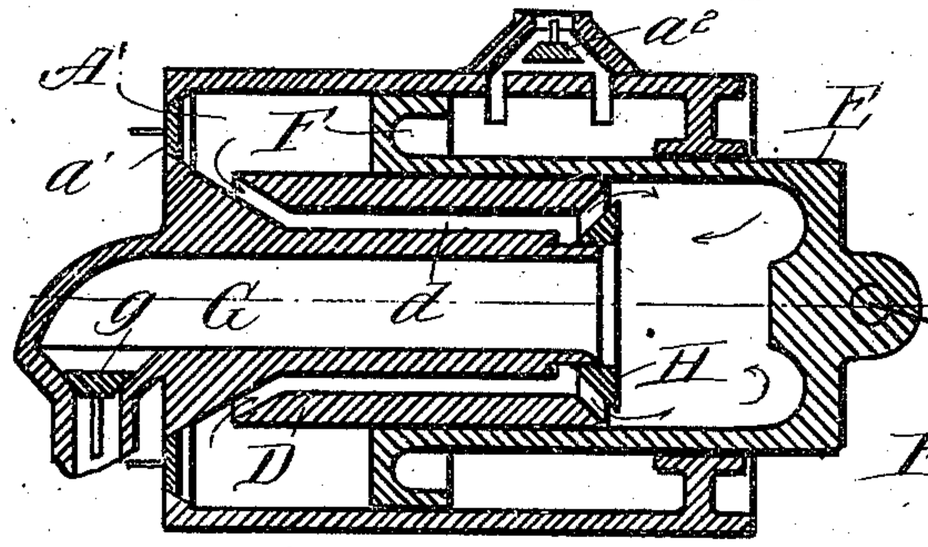

Fig. 7.

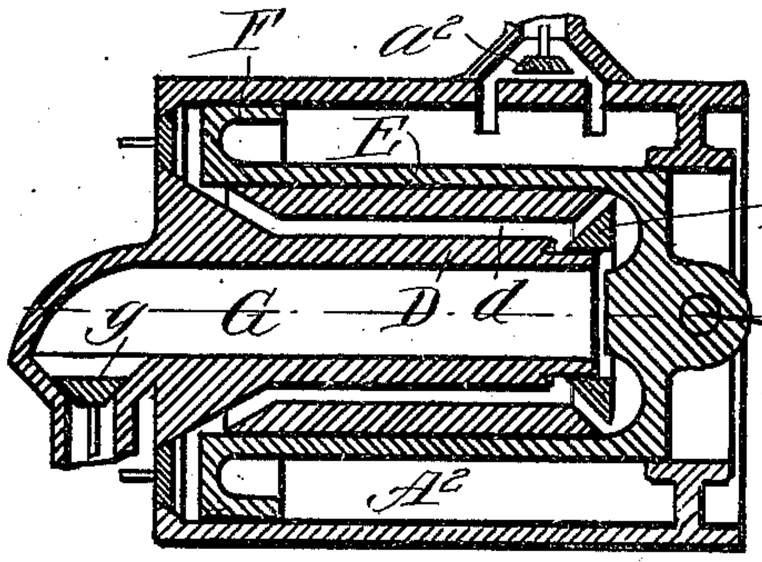

Fig. 8.

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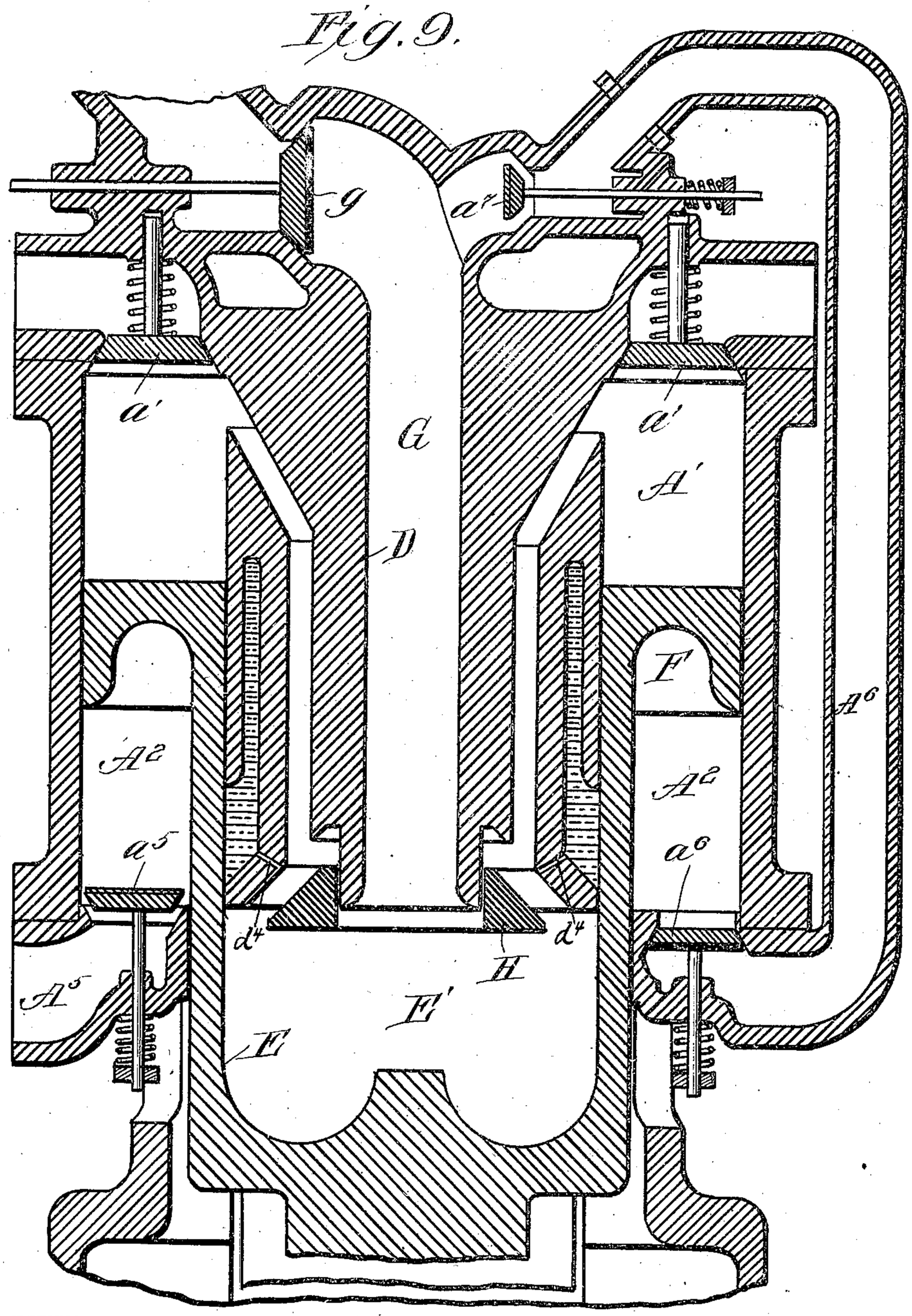
5 SHEETS—SHEET 4.

Fig. 9.



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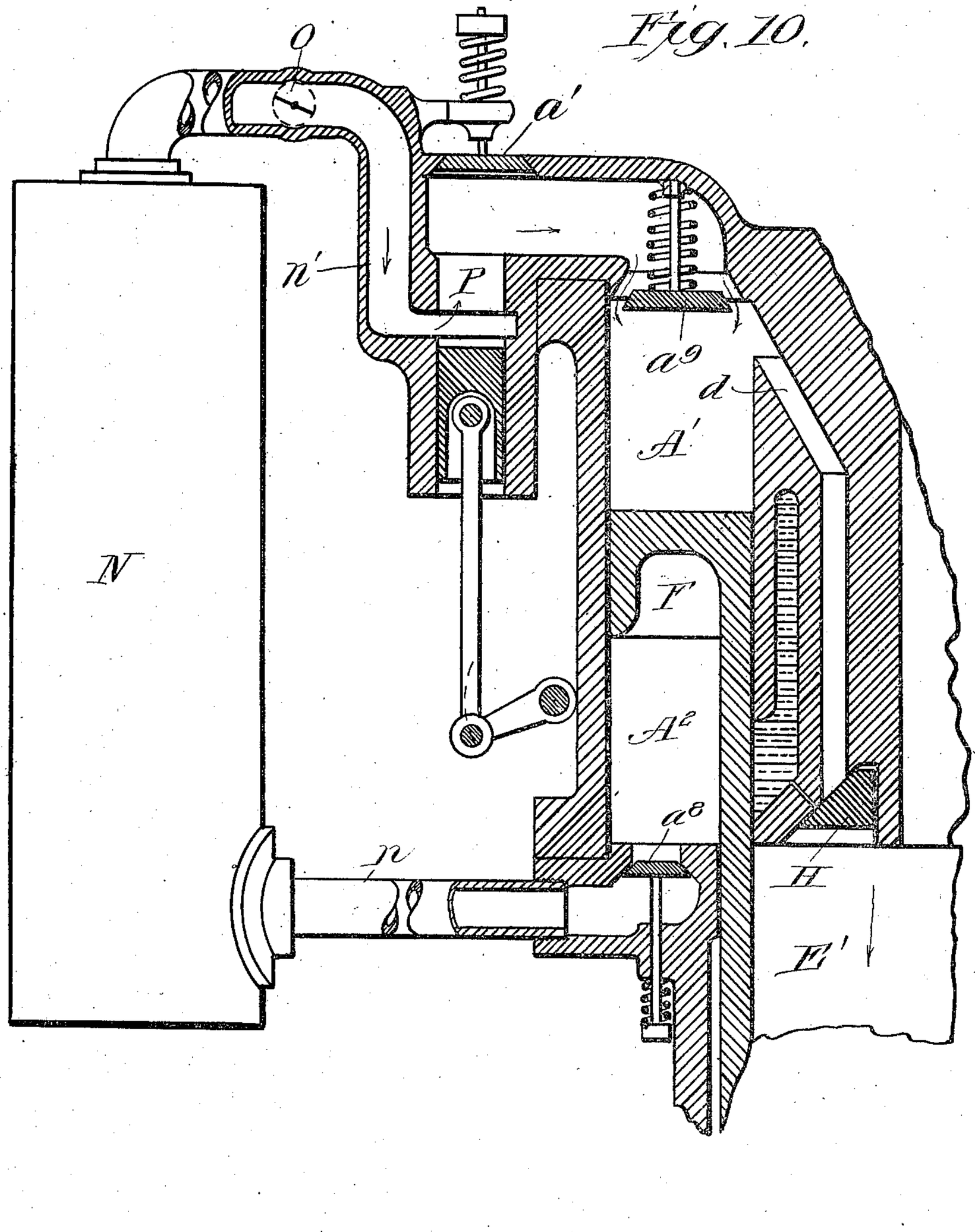
5 SHEETS—SHEET 5.

Fig. 10.



WITNESSES

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UNITED STATES PATENT OFFICE.

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INTERNAL-COMBUSTION ENGINE.

996,626. Specification of Letters Patent. Patented July 4, 1911.

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To all whom it may concern:

Be it known that I, WILLIAM D. EDWARDS, a citizen of the United States, residing at Portland, county of Multnomah, State of Oregon, have invented a certain new and useful Improvement in Internal-Combustion Engines, and declare the following to be a full, clear, and exact description of the same, such as will enable others skilled in the art to which it pertains to make and use the same, reference being had to the accompanying drawings, which form a part of this specification.

My invention has for its object to produce an engine in which there will be available for compression a supply of fresh air which is independent of the size of the engine cylinder or of the piston displacement.

A further object of my invention is to produce an engine from which the combustion gases will be completely expelled after each explosion.

A further object of my invention is to produce an engine in which a current of air will be forced through the engine cylinder and clearance space after each explosion and thus cool and cleanse the working surface.

A further object of my invention is to produce an engine in which the air will be automatically preheated prior to compression of the same.

A further object of my invention is to produce an engine in which the surfaces of the piston which are exposed to the combustion gases will be cooled by contact with water or other cooling fluid.

A further object of my invention is to provide a supply of water in the form of steam in the working charge of air.

A further object of my invention is to produce a simple and novel engine which will give a power impulse during each revolution of the crank shaft.

The various features of novelty whereby my invention is characterized will hereinafter be pointed out with particularity in the claims; but for a full understanding of my invention and of its objects and advantages, reference may be had to the following detailed description taken in connection with the accompanying drawings, wherein:

Figure 1 is a central longitudinal section through a preferred form of engine embodying my invention; Fig. 2 is a section taken at right angles to the plane of Fig. 1, showing a portion of one piston head; Fig. 3 is an enlarged section taken on line 3—3 of Fig. 2; Fig. 4 is a section on an enlarged scale showing an automatic governor for the fuel supplied to the engine; Figs. 5 to 8 inclusive are diagrammatic views showing the condition of the parts at various points during one complete revolution of the engine; Fig. 9 is a section similar to Fig. 1, showing on an enlarged scale a modified form of engine in which a gaseous fuel is used; and Fig. 10 is a view showing a fragment of the engine and a starting apparatus for starting the engine from a position of rest.

Referring to the first eight figures of the drawings; A represents a cylinder having at one end a head B and at the other end a head C. The head B is provided with a central projection D which extends to the opposite end of the cylinder.

E is a piston in the form of a hollow plunger which extends into the cylinder through the head C. The parts are so shaped and proportioned that the plunger has a working fit upon the projection D. Upon the inner end of the hollow piston is an annular laterally extending flange F which has a working fit within the cylinder and divides the same into two compartments, A′ and A². The compartment A′ communicates with atmosphere through a port controlled by a check valve *a′* which permits air to flow into the compartment but prevents a flow in the opposite direction. The compartment A² communicates with atmosphere through a port controlled by a check valve *a²* similar to the valve *a′*. It will be seen that as the piston moves back and forth one compartment is always serving as a compression chamber while the other is drawing in air from the atmosphere.

G is a passageway extending through the projection D, opening at its inner end into the space E′ within the hollow piston and at its outer end communicating with the atmosphere. Communication between the atmosphere and the passage G is controlled by a valve *g* which serves as the exhaust valve of the engine and which is operated in any suitable way from a moving part of the engine. The passage G serves not only as an exhaust passage but also, as will hereinafter appear, as the combustion chamber of the engine. The projection D is also pro-

vided with passages *d* which serve to connect the compartment A′ with the compartment or chamber E′ in the hollow piston.

The passages *d* are controlled by a check valve H which opens when the pressure in the compartment A′ is greater than that in the compartment E′ and which closes when the reverse conditions obtain. This check valve may conveniently lie beneath the lower end of the projection D and be supported by means of rods *h* passing upwardly through the projection and supported at their upper ends by means of suitable springs *h′*. The projection D is provided near its periphery with an annular chamber *d′* which is adapted to be supplied with water or lubricating oil through a pipe d^2. The chamber *d′* has an open mouth d^3 at a point which is always covered by some portion of the inner wall of the piston so that the surface of the piston which is subjected to the hot combustion gases is continually under the influence of a cooling medium which will prevent the piston from becoming too hot. There are a number of ports d^4 leading from the chamber *d′* into the chamber or compartment E′, these ports preferably being adapted to be closed by the check valve H so as to be closed when the check valve is closed and open when the check valve is open. It will be seen that when the check valve is open water or oil (indicated at d^5) can flow through these ports into the compartment E′.

Provision is made for placing the chambers or compartments A′ and A^2 in communication with each other when the piston is at the end of the stroke which brings the flange F into proximity to the piston head C; this being accomplished by providing communicating ports a^3 and a^4 in the wall of the cylinder at such a point that when the piston is in the proper position both ports are left uncovered by the flange, one port lying on one side of the flange and the other in the opposite side. The piston is connected to a suitable crank shaft I by means of a connecting rod I′.

At one side of the main cylinder is the fuel feeding device which I prefer to construct so that it will positively inject a predetermined amount of fuel into the combustion chamber in an atomized condition at the proper point in each revolution. To this end I have provided two connecting cylinders J and J′, the former being larger than the latter and communicating with the chamber or compartment A^2 by means of a small passage *j*. The passage *j* is controlled by a check valve *j′* which will permit air to flow toward the cylinder J and will prevent a flow in the opposite direction.

J^2 and J′ are connected pistons movable within the cylinders J and J′ respectively and actuated from the crank shaft by means of an eccentric J^4 and rod J^5. The piston J^3 is provided with a reduced extension J^6 having therein an annular groove j^6. The cylinder J is an air cylinder while the cylinder J′ is a fuel cylinder; the latter being connected to a source of fuel supply by means of a pipe j^3.

J^7 is a passage extending from the cylinder J across the opening within which the stem J^6 moves and communicating with a tube K which in turn communicates with the combustion chamber. The parts are so proportioned that the member J^6 closes the passage J^7 except when the main piston of the engine is at the beginning of its working stroke, the groove j^6 at this time registering with the passage J^7 and giving free communication between the combustion chamber and the cylinder J.

The operation of the parts heretofore described is as follows: Assuming the parts to be in the condition shown in Fig. 5 with the crank shaft rotating in the direction of the arrows, then it will be seen that the chamber or compartment A^2 is serving as a compression chamber while the valves *a′* are open and are permitting air to flow into the compartment or chamber A′. The piston is now upon the beginning of its working stroke so that the pressure in the chamber E′ is much greater than the pressure in the compartment or chamber A′ and the check valve H is therefore closed. As the piston continues its movement, the air in the chamber A^2 is compressed more and more and the quantity of air drawn into the chamber A′ increases. When the parts reach the positions indicated in Fig. 6, the exhaust valve is opened and the spent gases begin to flow from the chamber E′ through the passage G and out of the exhaust port. At this point the annular flange F uncovers the port a^3 so that the highly compressed air within the chamber A^2 begins to flow through the ports a^4 and a^3 into the chamber A′. The pressure in the latter chamber is now greater than that in the chamber E′, which is open to atmosphere, and therefore the check valve is forced open and there is an inrush of compressed air into the chamber E′. The incoming air flows down the interior walls of the piston and then out through the exhaust passage, driving before it and carrying with it the spent gases. The check valve is preferably made conical as shown so that the incoming air is deflected laterally against the walls of the piston, thus cooling and cleansing them. As the parts proceed from the position shown in Fig. 6 to that shown in Fig. 7, communication between the chambers A^2 and A′ is cut off; the chamber A^2 becomes a suction chamber; and the chamber A′ becomes a compression chamber, the valve *a′* being forced shut so as to prevent escape of air from the chamber A′ directly

to atmosphere. As soon as the exhaust valve is closed the chamber E′ also becomes a compression chamber so that the remaining air in the chambers A′, E′ and G is compressed preparatory to receiving a charge of combustible. It will be seen that as long as the valve H is open, water will flow from the well or chamber d' into the path of the air rushing in from the chamber A′ so that it will be carried into contact with the hot walls of the piston and it will be vaporized. This serves two functions: In the first place the vaporization of the water produces a cooling action upon the piston; and second the chamber E′ becomes filled with water-laden air which promotes combustion when the fuel is introduced. When the parts reach the position indicated in Fig. 7 the exhaust valve is completely closed and the compression begins. As the parts move to the positions indicated in Fig. 8 the air from the chambers A′ and E′ will have been compressed into the combustion chamber G and the chamber A^2 will be full of fresh air ready to be compressed upon the return stroke. The momentum of the moving parts carries them from the position indicated in Fig. 8 to that indicated in Fig. 5 at which point in the cycle the fuel is introduced and the check valve H closes. It will be seen that the pistons J^2 and J^3 move in substantial unison with the main piston so that as the latter is traveling on its working stroke, the piston J^2 is being withdrawn from its cylinder so as to provide a comparatively large chamber into which compressed air may flow from the chamber A^2; while the piston J^3 is likewise withdrawing and causing a supply of fuel to flow into the cylinder J′. When the main piston starts on its return stroke, the piston J^2 further compresses the air in the cylinder J and the groove j^6 in the stem J^6 picks up a quantity of oil and carries it upwardly toward the passage J^7. As the main piston approaches the position shown in Fig. 5, the groove j^6 registers with the passage J^7 and the highly compressed air in this passage, rushing through the groove, picks up the fuel and carries it through the tube K into the combustion chamber in a thoroughly atomized condition. The ignition of the fuel may be effected in any suitable way as, for example, by heating the tube K to a fairly high degree.

I prefer to provide means for regulating the fuel supply automatically as the speed of the engine varies and this may conveniently be accomplished by varying the width of the groove j^6 so that more or less fuel will be carried thereby as occasion may demand. In Fig. 4 I have shown a simple arrangement for accomplishing this. The stem J^6 is made in two parts the upper part J^8 being screw-threaded upon the lower part and forming at its lower end one of the sides of the groove. Upon the upper end of the cylinder J′ and surrounding the projecting stem member J^8 is a revoluble cap L having secured thereto or formed thereon a pinion l. The member J^8 is provided with an elongated key-way j^8 and the cap L is provided with a key l' which projects into this key-way. Consequently the stem is free to move axially within the cap but must rotate therewith. M is an ordinary ball governor driven in any suitable way from the engine shaft, as by means of a belt m, and attached to this governor is a rack M′ which engages with the pinion l. It will be seen that as the stem reciprocates it is not affected in any way by the governor unless the speed of the engine changes, thereby causing the rack to be reciprocated and to rotate the pinion. Whenever the pinion is rotated it produces a similar rotation of the stem member J^8 and therefore screws it farther upon or else unscrews it from the coöperating member J^6 and varies the width of the groove. Thus the charge of fuel which is introduced at each revolution may be regulated accurately by the speed of the engine.

It will thus be seen that I have produced a simple and novel engine in which the parts are effectively cooled and cleansed; from which all of the spent combustion gases are discharged after each power stroke; in which any desired volume of air may be utilized, regardless of the displacement of the main piston; in which a power impulse is obtained during each revolution; and in which the fuel is supplied positively and in predetermined quantities which may be nicely regulated.

In Fig. 9 I have shown a slightly modified form of engine in which the fuel is in the form of a gas or oil vapor instead of being a liquid. In this arrangement only the chamber A′, is an air chamber, while the chamber A^2 serves to receive the combustible. The parts are all substantially like those heretofore described except as will hereinafter be pointed out and therefore it is unnecessary to describe them again in detail. Instead of the air inlet valve a^2 there is an inlet valve a^5 in the chamber A^2 which controls communication between this chamber and a fuel supply conduit A^5. There is also an outlet valve a^6 which controls communication between the chamber A^2 and a fuel receiver A^6. The fuel receiver is connected with the combustion chamber G and communication between them is controlled by a valve a^7 actuated in any suitable way from some moving part of the engine. The operation in this form of my invention is as follows: On the working stroke of the main piston air is drawn into the chamber A′ through the valve a' and the gaseous fuel in the chamber A^2 is forced into the receiver A^6. On the return stroke the exhaust valve g has

been opened so that the spent gases escape to atmosphere and the air in the chamber A′ is compressed and flows into the chamber E′ and to atmosphere until the exhaust valve closes. Thereafter compression in the chambers A′ and E′ takes place as in the other form of my invention; until, at the end of the return stroke, the combustion chamber G is full of compressed air. As soon as the exhaust valve is closed the valve a^7 is opened so that the highly compressed fuel in the receiver A^6 flows into the combustion chamber and there mixes with the fresh air. Also, during the return stroke, the valve a^5 opens and causes gas to be drawn from the conduit A^5 into the compression chamber A^2 so that upon the next power stroke there will be a charge of combustible in the chamber A^2 ready for compression.

In Fig. 10 I have shown an arrangement for storing some of the air compressed in the compression chambers so as to utilize it in starting the engine from a position of rest. N is a storage reservoir connected to the chamber A^2 by a pipe *n;* communication between the reservoir and the chamber A^2 being controlled by a check valve a^8 which permits a flow in the direction of the reservoir but prevents it in the opposite direction. During the power stroke of the engine, some of the air compressed in the chamber A^2 flows past the valve a^8 into the storage reservoir so that after the engine has been running awhile there is a supply of compressed air in the reservoir. The reservoir is also connected with the chamber A′ by a conduit *n′* having three controlling valves, O, P, and a^9. The valve O is a hand operated valve which is opened when it is desired to start the engine and closed after the engine has begun to run. The valve P is a valve controlled by some moving part of the engine so as to determine the timing of admission of air from the reservoir into the chamber A′. The valve a^9, is a simple check valve corresponding to the valve *a′* and preventing a return flow from the chamber A′ to the reservoir. Assuming that the engine has stopped with the parts in the positions indicated in Fig. 10; then upon opening the valve O air will flow through the conduit *n′* past the check valve a^9 and into the chamber A′; the valve P being now open. Some of the air will flow from the chamber A′ through the passages *d* into the chamber E′ so that an effective pressure for producing a power stroke is obtained upon the flange F and within the main piston. As the piston approaches the end of its stroke the valve P is moved into a position wherein it cuts off communication between the chamber A′ and the supply reservoir and the exhaust valve is opened in the usual way. The piston now begins its return stroke, being carried back either through the momentum of the moving parts or through the momentum assisted by a power impulse in one or more additional cylinders if the engine be a multi-cylinder engine. Upon the return stroke the combustion chamber is filled in the manner previously described, with compressed air and combustible, so that the engine is now ready to start under its own power. As soon as this occurs the valve O is closed and it is not opened again until it is desired to start the engine anew.

While I have described in detail only a few preferred arrangements I do not desire to be limited to the structural details described and illustrated but intend to cover all forms and arrangements which fall within the terms employed in the definitions of my invention constituting the appended claims.

What I claim is:

1. In an engine, a piston, means coöperating with the piston to form a combustion and expansion chamber adjacent to said piston and two compression chambers, means associated with the piston for compressing air in the first of said compression chambers upon the working stroke of the piston and for compressing air in the other compression chamber upon the return stroke of the piston, and means for placing both of said compression chambers in communication with said expansion chamber at the end of the working stroke of the piston and for maintaining one of said compression chambers in communication with the said expansion chamber during the return stroke of the piston.

2. In an engine, a piston, means coöperating with the piston to form a combustion and expansion chamber adjacent to said piston and two compression chambers, an auxiliary piston associated with the main piston for compressing air in one of the compression chambers upon the working stroke of the main piston and for compressing air in the other compression chamber upon the return stroke of the main piston, means for opening communication between the last mentioned compression chamber and the combustion and expansion chamber when the pressure in the latter is less than the pressure in the former, and means for placing said compression chambers in communication with each other when the main piston reaches the end of its working stroke.

3. In an engine, a main cylinder, an inwardly extending projection at one end of the cylinder, a hollow piston surrounding said projection and having an annular flange fitting within the space between the sides of the cylinder and the sides of said projection, there being an exhaust passage leading through said projection from the interior of said hollow piston, inlet check valves in said cylinder on opposite sides of

said annular flange, means for placing the opposite ends of said cylinder in communication with each other when said piston is at the end of its working stroke, and means controlling communication between the space within the piston and the space within the cylinder.

4. In an engine, a cylinder, a hollow piston extending through one of the end walls of the cylinder, said piston having an annular flange upon the end thereof within the cylinder engaging at its periphery with the interior of the cylinder walls, there being at the other end of the cylinder an inwardly extending projection fitting within said piston, means controlling communication between the space within the latter end of the cylinder and the space within the piston, inlet check valves at opposite ends of the cylinder, and means for placing two ends of the cylinder in communication with each other when the flange is at the end through which the piston projects.

5. In an engine, a cylinder, a hollow piston extending through one of the end walls of the cylinder, said piston having an annular flange upon the end thereof within the cylinder engaging at its periphery with the interior of the cylinder walls, there being at the other end of the cylinder an inwardly extending projection fitting within said piston, means controlling communication between the space within the latter end of the cylinder and the space within the piston, inlet check valves at opposite ends of the cylinder, and means for placing the two ends of the cylinder in communication with each other when the flange is at the end through which the piston projects, there being an exhaust passage extending through said projection and communicating with the space within the piston, and means for introducing a charge of combustible material into the space within the piston.

6. In an engine, a cylinder, a hollow piston extending through one of the end walls of the cylinder, said piston having an annular flange upon the end thereof within the cylinder engaging at its periphery with the interior of the cylinder walls, there being at the other end of the cylinder an inwardly extending projection fitting within said piston, means controlling communication between the space within the latter end of the cylinder and the space within the piston, inlet check valves at opposite ends of the cylinder, means for placing the two ends of the cylinder in communication with each other when the flange is at the end through which the piston projects, said projection having a chamber for containing water, and means for permitting water to flow from the latter chamber into the hollow piston during the time the interior of the piston is in communication with the said space within the cylinder.

7. In an engine, a cylinder, a hollow piston extending through one head of the cylinder, said piston having an annular flange fitting within the cylinder, a projection extending from the other cylinder head and fitting within said piston, means controlling communication between the interior of the piston and the space between said flange and the head of the cylinder from which said projection extends, air inlet valves at the opposite ends of the cylinder, means for placing the opposite ends of the cylinder in communication with each other when said flange is adjacent to the head through which the piston projects, there being a combined exhaust passage and combustion chamber in said projection, an exhaust valve controlling the outlet from the same, and means for introducing a charge of combustible into said combined exhaust passage and combustion chamber when the piston reaches the limit of its movement into the cylinder.

8. In an engine, a cylinder, a hollow piston extending into said cylinder through one head thereof, a projection extending from the opposite head of said cylinder and fitting into said piston, said piston having an annular flange on its inner end shaped to fit the cylinder, there being passages through said projection for connecting the interior of the piston with the space within the cylinder beyond the inner end of the piston, a check valve controlling said passages and arranged to permit a flow therethrough toward the interior of the piston, air inlet valves in opposite ends of said cylinder, and ports controlled by said flange for placing the opposite ends of said cylinder in communication with each other when said flange is adjacent to the head through which the piston projects.

9. In an engine, a cylinder, a hollow piston extending into said cylinder through one head thereof, a projection extending from the opposite head of said cylinder and fitting into said piston, said piston having an annular flange on its inner end shaped to fit the cylinder, there being passages through said projection for connecting the interior of the piston with the space within the cylinder beyond the inner end of the piston, a check valve controlling said passages and arranged to permit a flow therethrough toward the interior of the piston, air inlet valves at opposite ends of said cylinder, and ports controlled by said flange for placing the opposite ends of said cylinder in communication with each other when said flange is adjacent to the head through which the piston projects, there being a combined exhaust passage and combustion chamber in

said projection, an exhaust valve in said combined exhaust passage and combustion chamber, and means for introducing a charge of combustible material into said combined exhaust passage and combustion chamber when the piston is at the limit of its stroke in the inward direction.

10. In an engine, a piston, means coöperating with the piston to form a combustion and expansion chamber adjacent to said piston and two compression chambers, means associated with the piston for compressing air in the first of said compression chambers upon the working stroke of the piston and for compressing air in the other compression chamber upon the return stroke of the piston, means for placing both of said compression chambers in communication with said expansion chamber at the end of the working stroke of the piston and for maintaining one of said compression chambers in communication with the said expansion chamber during the return stroke of the piston, means for storing a portion of the air compressed in one of said chambers, and means for introducing the stored air into the other of said chambers for the purpose of starting the engine.

11. In an engine, a piston, means coöperating with said piston to form a combustion and expansion chamber adjacent to said piston and two compression chambers, a device associated with said piston for compressing air in the first of said compression chambers during the working stroke of the piston and for compressing air in the second of said compression chambers during the return stroke of the piston, the aforesaid means having a passage extending between the said second compression chamber and the combustion and expansion chamber, and a check valve in said passage arranged to permit a flow in the direction of the latter chamber, means for placing said compression chambers in communication with each other at the end of the working stroke of the piston, means for storing a portion of the air compressed in the said first chamber, and means for admitting the stored air into said second chamber for the purpose of starting the engine.

12. In an engine, a main cylinder, an inwardly extending projection at one end of the cylinder, a hollow piston surrounding said projection and having an annular flange fitting within the space between the sides of the cylinder and the sides of said projection, there being an exhaust passage leading through said projection from the interior of said hollow piston, inlet check valves in said cylinder on opposite sides of said annular flange, means for placing the opposite ends of said cylinder in communication with each other when said piston is at the end of its working stroke, means controlling communication between the space within the piston and the space within the cylinder, said projection having a water chamber provided with an open mouth closed by said hollow piston.

13. In an engine, a cylinder, a hollow piston extending into said cylinder through one head thereof, a projection extending from the opposite head of said cylinder and fitting into said piston, said piston having an annular flange on its inner end shaped to fit the cylinder, there being passages through said projection for connecting the interior of the piston with the space within the cylinder beyond the inner end of the piston, a check valve controlling said passages and arranged to permit a flow therethrough toward the interior of the piston, air inlet valves at opposite ends of said cylinder, ports controlled by said flange for placing the opposite ends of said cylinder in communication with each other when said flange is adjacent to the head through which the piston projects, the parts being so proportioned that the air flowing through said passages is directed against the side walls of the piston.

14. In an engine, a cylinder, a hollow piston extending into said cylinder through one head thereof, a projection extending from the opposite head of the cylinder and fitting into said piston, said piston having an annular flange on its inner end shaped to fit the cylinder, there being passages through said projection connecting the interior of the piston with the space within the cylinder beyond the inner end of the piston, a check valve controlling said passages and arranged to permit a flow therethrough toward the interior of the piston, and an air inlet valve arranged to permit air to be drawn from the surrounding atmosphere into said space within the cylinder beyond the inner end of the piston.

15. In an engine, a cylinder, a hollow piston extending into said cylinder through one head thereof, a projection extending from the opposite head of the cylinder and fitting into said piston, said piston having an annular flange on its inner end shaped to fit the cylinder, there being passages through said projection connecting the interior of the piston with the space within the cylinder beyond the inner end of the piston, a check valve controlling said passages and arranged to permit a flow therethrough toward the interior of the piston, an air inlet valve arranged to permit air to be drawn from the surrounding atmosphere into said space within the cylinder beyond the inner end of the piston, said projection having an exhaust passage therethrough in open communication with the interior of the piston, and an exhaust valve controlling said passage.

16. In an engine, a cylinder, a hollow piston extending into said cylinder through one head thereof, a projection extending from the opposite head of the cylinder and fitting into said piston, said piston having an annular flange on its inner end shaped to fit the cylinder, an air inlet valve constructed and arranged to permit air to flow from the surrounding atmosphere into the space within the cylinder between said flange and the cylinder head through which the piston extends, and means including a passage through said projection for connecting the aforesaid space within the cylinder and the interior of the piston when the flange is nearest the head through which the piston projects.

In testimony whereof, I sign this specification in the presence of two witnesses.

WILLIAM D. EDWARDS.

Witnesses:
NORMAN W. SHAW,
J. W. SWOPE.

Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."