No. 733,350. PATENTED JULY 7, 1903.

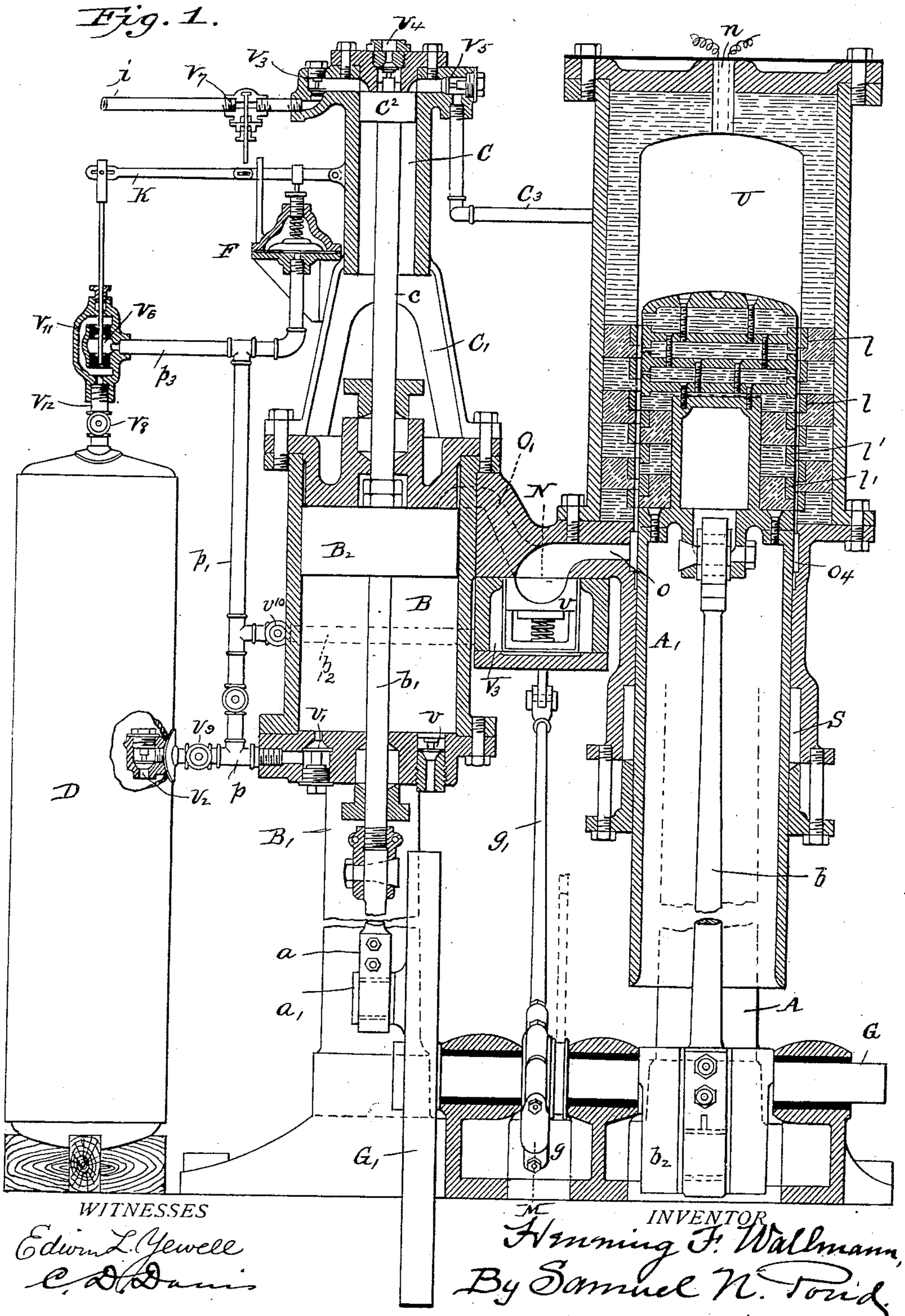
H. F. WALLMANN.

INTERNAL COMBUSTION ENGINE.

APPLICATION FILED OCT. 15, 1897.

NO MODEL. 2 SHEETS—SHEET 1.

Fig. 1.



WITNESSES

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NO MODEL. 2 SHEETS—SHEET 2.

Fig. 2.

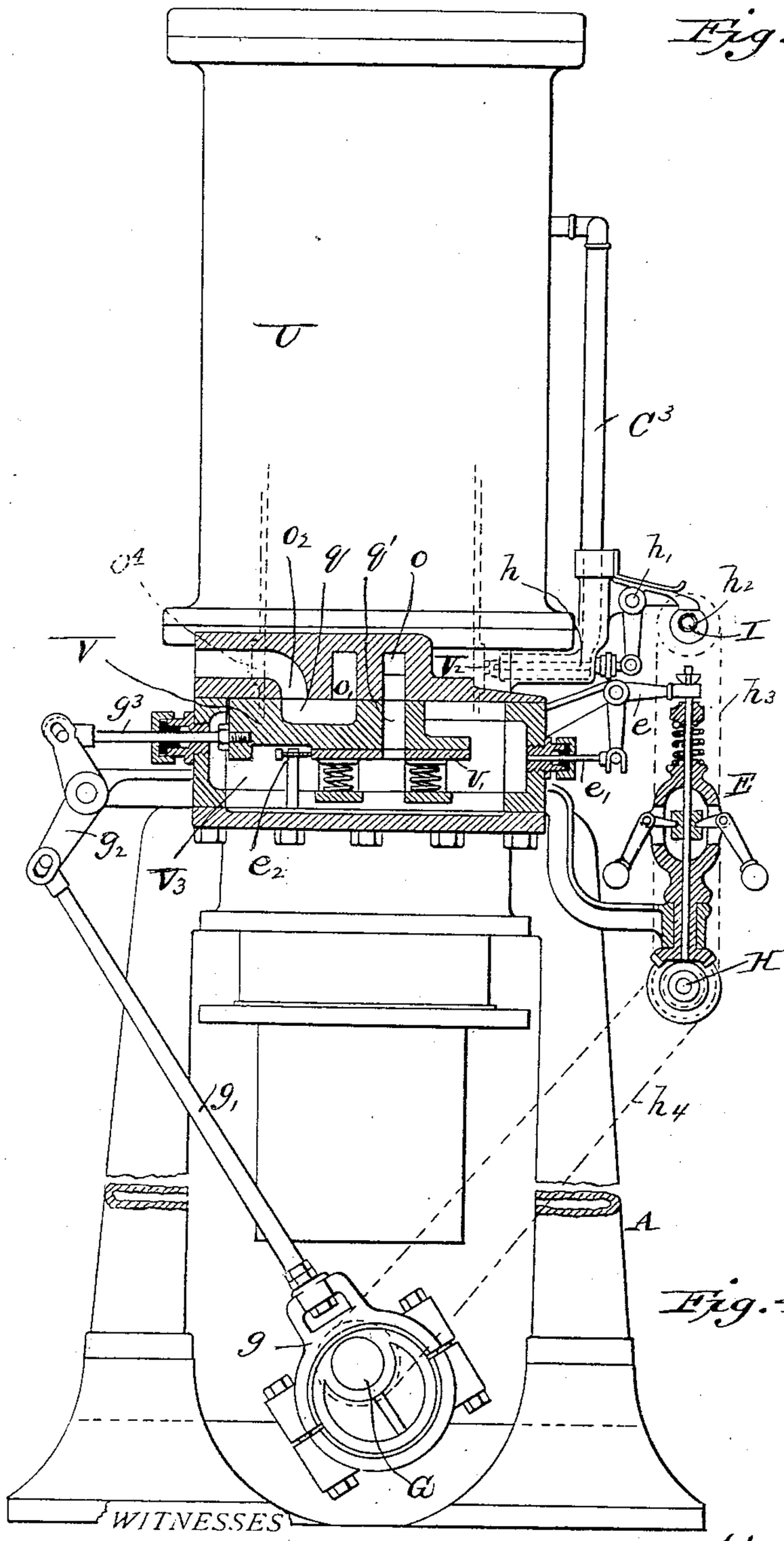

Fig. 3.

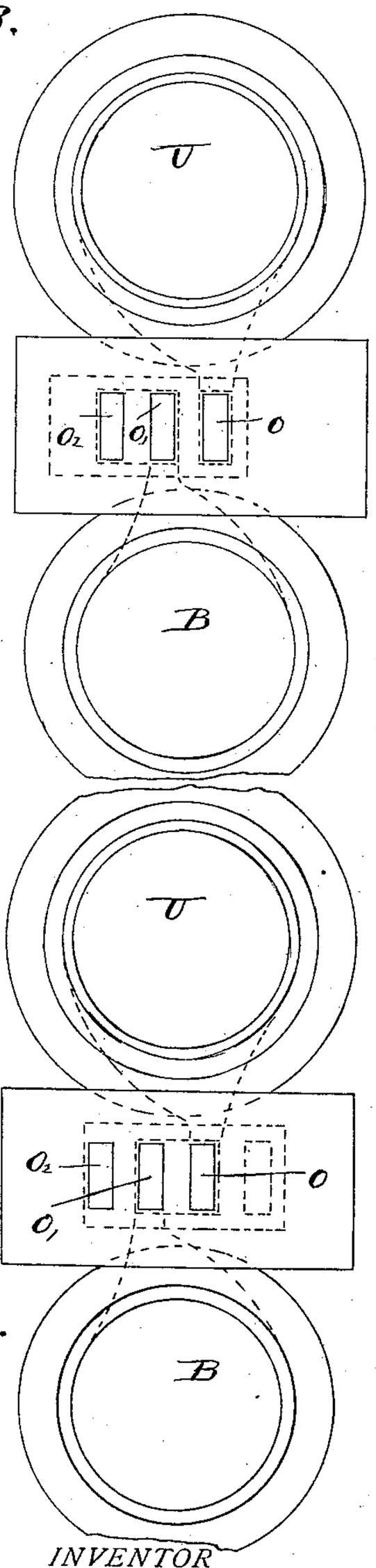

Fig. 4.

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UNITED STATES PATENT OFFICE.

HENNING F. WALLMANN, OF CHICAGO, ILLINOIS, ASSIGNOR TO THE WALLMANN ENGINE COMPANY, A CORPORATION OF ILLINOIS.

INTERNAL-COMBUSTION ENGINE.

SPECIFICATION forming part of Letters Patent No. 733,350, dated July 7, 1903.

Application filed October 15, 1897. Serial No. 655,357. (No model.)

To all whom it may concern:

Be it known that I, HENNING F. WALLMANN, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Internal-Combustion Engines, of which the following is a specification.

My invention relates to that class of engines in which a combustible fuel—as gas, petroleum, coal-dust, or any other suitable fuel—is mixed with and burned in the presence of a body of compressed air in the combustion-cylinder of an engine, whereby said body of compressed air is heated and expanded and the expanding gases are made to perform work against the piston.

An engine of the general class referred to is shown in my former patent, No. 548,824, October 29, 1895; and my present invention is in the nature of improvements upon the construction of the engine presented in my aforesaid patent, the objects of said improvements being, first, to more advantageously utilize the elasticity of the burning gases by expanding them within and through two cylinders—viz., a high-pressure combustion-cylinder and a low-pressure and low-temperature expansion-cylinder; second, to simplify the mechanism of the engine by performing the low expansion and the compression of the air in one and the same cylinder, but on opposite sides of the piston; third, to store such air compressed in excess of the amount of air consumed by the engine in a suitable reservoir in order to effect the starting of the engine without hand-power; fourth, to regulate the quantity of fuel consumed, especially of gas, by means of a separate fuel-pump, which, in connection with a pressure-regulating device, supplies to the engine just the amount of fuel required; fifth, to control the operation of the engine in a simple and efficient manner; sixth, to improve on the detail construction of engines of this character.

My invention is illustrated in the accompanying drawings, in which—

Figure 1 is an elevation, partly in central vertical section, of my improved engine. Fig. 2 is a vertical section of the engine on the line M N of Fig. 1 at right angles to the section of Fig. 1 and showing the valve mechanism controlling communication between the cylinders; and Figs. 3 and 4 are plan views in the nature of diagrams, showing the valve-ports and the main controlling-valve in two different positions.

Similar letters of reference refer to similar parts throughout the several views.

A represents a suitable cast-iron frame supporting the combustion-cylinder U. The latter is lined with some non-porous fireproof material—such as compressed mica, compressed asbestos, soapstone, porcelain, &c.—and is provided through approximately the lower half of its interior surface with a series of metal rings *l l*, separated by non-conductors of heat from each other and from the outside shell of the cylinder.

A′ represents a plunger working in the cylinder U and having its inner end made out of sections separated from each other by non-conductors of heat and provided over approximately the lower half of its exterior surface with a series of metal rings *l′ l′*, separated by non-conductors of heat from each other and from the inner metal body of the piston. The two series of metal rings *l l* and *l′ l′* form a regenerator for a purpose hereinafter described. The plunger A′ is connected to a crank b^2 on the crank-shaft G by means of a connecting-rod *b*, and its lower elongated cylindrical extension works through a stuffing-box S, formed in the lower head of cylinder U.

B represents a combined low-pressure expansion-cylinder and air-compressor supported by a cast-iron frame B′. B^2 is the piston of this cylinder, whose piston-rod *b′* passes through a suitable stuffing-box in the lower head of the cylinder and is connected to a fly-wheel G′ on shaft G by a pitman *a* and crank-pin *a′*. The upper end of this cylinder is designed to receive the exhaust from the combustion-cylinder U, and its lower end or cylinder-head is equipped with air inlet and discharge valves *v* and *v′*, respectively, for the compression of air.

Supported by a suitable cast-iron frame C′ above the cylinder B and in vertical alinement with the latter cylinder is the cylinder C of the fuel-pump, whose piston C^2 is di-

rectly connected to the piston B^2 of cylinder B by means of its vertical piston-rod c, the latter forming, preferably, an extension of the piston-rod b'.

D is a reservoir for compressed air, connected to the air-compressing side of cylinder B and adapted to receive and store the surplus of air compressed in cylinder B over and above what is necessary for the regular charges supplied to the cylinder U, as will be more fully hereinafter described.

Communication between the cylinders U and B and between the expansion side of the latter cylinder and the atmosphere and also between the air-reservoir D and the cylinder U is controlled by a single horizontally-sliding valve V, reciprocating in a closed box or chamber V^3. The downwardly and laterally extended lower head of cylinder U has a port o leading from an annular space o^4 to the valve-chamber V^3, another similar port o' leading from the valve-chamber V^3 to the upper end of cylinder B, and a third port o^2 extending at right angles to ports o and o' from valve-chamber V^3 to the atmosphere. The sliding valve V has a recess or pocket q formed in its upper face wide enough to span the faces of the ports o and o' or o' and o^2 and has also a straight vertical port q' formed directly through it at one side of the recess q. On the lower face of valve V is a spring-supported cut-off slide V', whose function is to control the amount of compressed air admitted to cylinder U through the port q' of the valve V in the manner hereinafter explained. The cut-off slide V' is carried by and reciprocates with the valve V; but the limit of its movement to the left, Fig. 2, is determined by an adjustable stop e^2, while its movement to the right is limited by a stop e', controlled by a governor E through a bell-crank lever e. The valve V and its cut-off slide V' are positively actuated in both directions from shaft G by an eccentric g, eccentric-rod g', bell-crank lever g^2, and valve-stem g^3, all as plainly shown in Fig. 2.

The fuel-inlet pipe of the fuel-pump C is designated by i and is provided with a throttle-valve v^7, automatically operated, as hereinafter described. The fuel inlet and discharge valves are shown at v^3 and v^5, respectively, and v^4 is a valve for admitting air, if desired, so that the pump may furnish fuel alone or an incombustible mixture of fuel and air (as equal parts of each) to the combustion-cylinder U. The fuel is forced from the pump C through a pipe C^3 and inlet-valve V^2 to the annular space o^4 in the lower head of cylinder U, where it meets and mingles with the compressed air admitted to said annular space through valve V.

A short pipe p, provided with a stop-cock v^9, connects the air-compressing end of cylinder B with the reservoir D, the end of said pipe entering the reservoir being provided with a check-valve v^2 to prevent air within the pipe p and its connections from entering the reservoir. The pipe p is tapped by a vertical pipe p', and this latter is in turn tapped by a horizontal pipe p^2, having a stop-cock v^{10} and leading into the valve-chamber V^3. (See dotted lines in Fig. 1.) The upper end of pipe p' taps a short pipe p^3, one end of which communicates with a diaphragm F (constituting a pressure-regulating device) and the other with a valve-chamber v^{11}, containing a sliding piston-valve v^6, located above the reservoir D and connected with the latter by a short pipe v^{12}, equipped with a stop-cock v^8. Pivoted to a lug on cylinder C is a lever K, which rests near its pivoted end on the stem of the diaphragm F and at its outer end is connected to the stem of the piston-valve v^6, it being also connected at a point intermediate its ends with the stem of the throttle-valve v^7.

H, Fig. 2, represents a way-shaft suitably journaled in brackets secured to the engine-frame and driven from a pulley on the main shaft G by a belt h^4. This way-shaft through suitable bevel-gearing, as shown, operates the governor E and through it the variable stop e'. A second way-shaft I, journaled above and operated from way-shaft H by a belt h^3, carries a cam h^2, which through bell-crank lever h' operates the inlet-valve V^2 at the proper time to admit a fresh charge of fuel to the annular space o^4.

The igniter (diagrammatically indicated at n) may be of any approved type operated from a moving part of the engine to fire the successive charges at the proper times.

The operation of the engine is as follows: The pistons A' and B^2 being connected to the driving-shaft G on cranks set one hundred and eighty degrees apart, when the piston A' is performing its downward or working stroke the piston B^2 is moving upward, expelling the expanded gas from above it through ports o' o^2 and recess q in valve V (the latter valve occupying the position shown in Fig. 2) and drawing in air beneath it through valve v. At or about the completion of this stroke of pistons A' and B^2 the valve V is shifted so as to bring cylinders U and B into communication through ports o o' and recess q in valve V. During the upward stroke of piston A' and the simultaneous downward stroke of piston B^2, therefore, the burning and expanding gases in cylinder U are passing into the cylinder B (which in practice will be made larger in diameter than cylinder U, as usual in compound engines) and exerting pressure on the upper face of piston B^2, having on their way imparted a portion of their heat to the regenerator in cylinder U. At the same time the air below the piston B^2 is compressed and discharged through valve v' into the pipes p p' p^2 p^3 and valve-chamber V^3 and fuel enters the pump C through valve v^3 and air also through the valve v^4, (where this valve is employed.) At or about the completion of the upward stroke of piston A' and the downward stroke of piston B^2 the valve V is again

shifted by eccentric g to the position shown in Fig. 2. This shuts off communication between cylinders U and B, opens cylinder B to the exhaust, and permits the air previously compressed in pipes $p\,p'\,p^2\,p^3$ and valve-chamber V^3 to rush through ports q' and o into the annular space o^4. Simultaneously (or substantially so) with the admission of the compressed air to the annular space o^4 the fuel-inlet valve V^2 is actuated by its cam h^2 to admit a charge of fuel, previously compressed into the pipe C^3 by the fuel-pump C, into said annular space o^4, where it meets and commingles with the compressed air in such proportions as to form therewith a combustible mixture, the said mixture passing thence through the regenerator (where it is preparatorily heated) into the upper end of the combustion-cylinder U, where it is fired by the igniter n just after the piston A' has begun its downward stroke. The above-described cycle of operations is thereupon repeated.

The fuel-inlet valve V^2 is open only during a short while—approximately during a quarter of a revolution—and it should close before the air-supply port o is closed in order to blow all the fuel out of the regenerator into the combustion-chamber. The closing of the port o for the compressed-air supply depends upon the action of the governor E, controlling the cut-off slide V' of the main valve V. By leading the compressed air and fuel forming the constituents of each charge into the combustion-chamber by way of the annular space o^4 the lubricated parts of the cylinder and piston are, in a large measure, protected against heat.

Whenever the pump B compresses air in excess of that required for the combustible charges supplied to the cylinder U, the air-pressure in pipes p, p', p^2, and p^3 rises and, acting on diaphragm F through lever K and the stem of piston-valve v^6, raises the latter valve and allows the compressed air to escape through stop-cock v^8, which is ordinarily open, into the reservoir D, at the same time throttling the fuel-supply by valve v^7, and thus causing the engine to slow down. This compressed air may be subsequently utilized to assist in the operation of starting the engine in the following manner: The fly-wheel will be turned by hand until the piston A' of the combustion-cylinder U has been brought to the upper end of its stroke and just past the dead-center, at which point the valve V will be brought to the position shown in Fig. 2. Then by opening stop-cock v^9 in pipe p compressed air in reservoir D will rush through pipes $p\,p'\,p^2$ and valve V into the upper end of cylinder U and expanding against the piston A' impel the latter on its downward stroke and start the operation of the engine.

It will be noticed that the valve v^6 is a balanced piston-valve, both the pressure in the reservoir D and that in the pipes p, p', p^2, and p^3 acting on the opposite ends of said valve equally, so that nothing but excess of pressure on the diaphragm F will effect the movement of said valve so as to admit compressed air to the reservoir D.

Having thus described my invention and illustrated my preferred means for carrying the same into effect, what I claim as new, and desire to secure by Letters Patent, is—

1. In an internal-combustion engine, the combination with the combustion-cylinder provided with a regenerator, and means for supplying fuel under pressure to said cylinder, of a combined low-pressure expansion-cylinder and air-compressor, and a single valve located intermediate said combustion and expansion cylinders, and controlling the admission of compressed air to said combustion-cylinder, the transfer of the products of combustion from the latter to the expansion-cylinder, and the exhaust from the latter to the atmosphere, substantially as described.

2. In an internal-combustion engine, the combination with the combustion-cylinder provided with a regenerator, and means for supplying fuel under pressure to said cylinder, of a combined low-pressure expansion-cylinder and air-compressor, a single valve located intermediate said combustion and expansion cylinders, and controlling the admission of compressed air to said combustion-cylinder, the transfer of the products of combustion from the latter to the expansion-cylinder, and the exhaust from the latter to the atmosphere, and a governor-controlled device on said valve for regulating the amount of compressed air supplied to the combustion-cylinder, substantially as described.

3. In an internal-combustion engine, the combination with the high-pressure combustion-cylinder, the low-pressure expansion-cylinder, the fuel-pump and air-compressor, all connected to a common crank-shaft and having suitable valve-controlled connections, of an air-reservoir communicating with the delivery side of the air-compressor through a suitable valve-controlled connection, a pressure-regulating device automatically governing the admission of surplus compressed air to the reservoir through said valve-controlled connection, and means for admitting compressed air from the reservoir to the combustion-cylinder to effect the starting of the engine, substantially as described.

4. In an internal-combustion engine, the combination with the high-pressure combustion-cylinder, the low-pressure expansion-cylinder, the fuel-pump and air-compressor, all connected to a common crank-shaft and having suitable valve-controlled connections, of an air-reservoir communicating with the delivery side of the air-compressor through a suitable valve-controlled connection, a pressure-regulating device automatically governing the admission of surplus compressed air to the reservoir through said valve-controlled connection, a throttle-valve in the fuel-admission pipe also operated by said pressure-

regulating device, and means for admitting compressed air from the reservoir to the combustion-cylinder to effect the starting of the engine, all substantially as described.

5. In an internal-combustion engine, the combination with a high-pressure combustion-cylinder provided with a regenerator, and having its piston connected to the crank-shaft of the engine, of a low-pressure and low-temperature expansion-cylinder, an air-compressor, and a fuel-pump, all three arranged in alinement and having their pistons connected to the crank-shaft through a common piston-rod and pitman at a point opposite the connection of the piston of the combustion-cylinder with said shaft, and suitable valve-controlled connections between the combustion-cylinder and the expansion-cylinder, the air-compressor and the fuel-pump respectively, substantially as and for the purpose described.

6. In an internal-combustion engine, the combination with a high-pressure combustion-cylinder provided with a regenerator, and having its piston connected to the crank-shaft of the engine, of a low-pressure and low-temperature expansion-cylinder, an air-compressor, and a fuel-pump, all three arranged in alinement and having their pistons connected to the crank-shaft through a common piston-rod and pitman at a point opposite the connection of the piston of the combustion-cylinder with said shaft, suitable valve-controlled connections between the combustion-cylinder and the expansion-cylinder, the air-compressor and the fuel-pump respectively, and an air-reservoir connected with the air-compressor to receive the surplus of the compressed air over that required by the combustion-cylinder, substantially as and for the purpose described.

HENNING F. WALLMANN.

Witnesses:
W. W. DONLEY,
C. C. WITT.