No. 713,366. Patented Nov. 11, 1902.

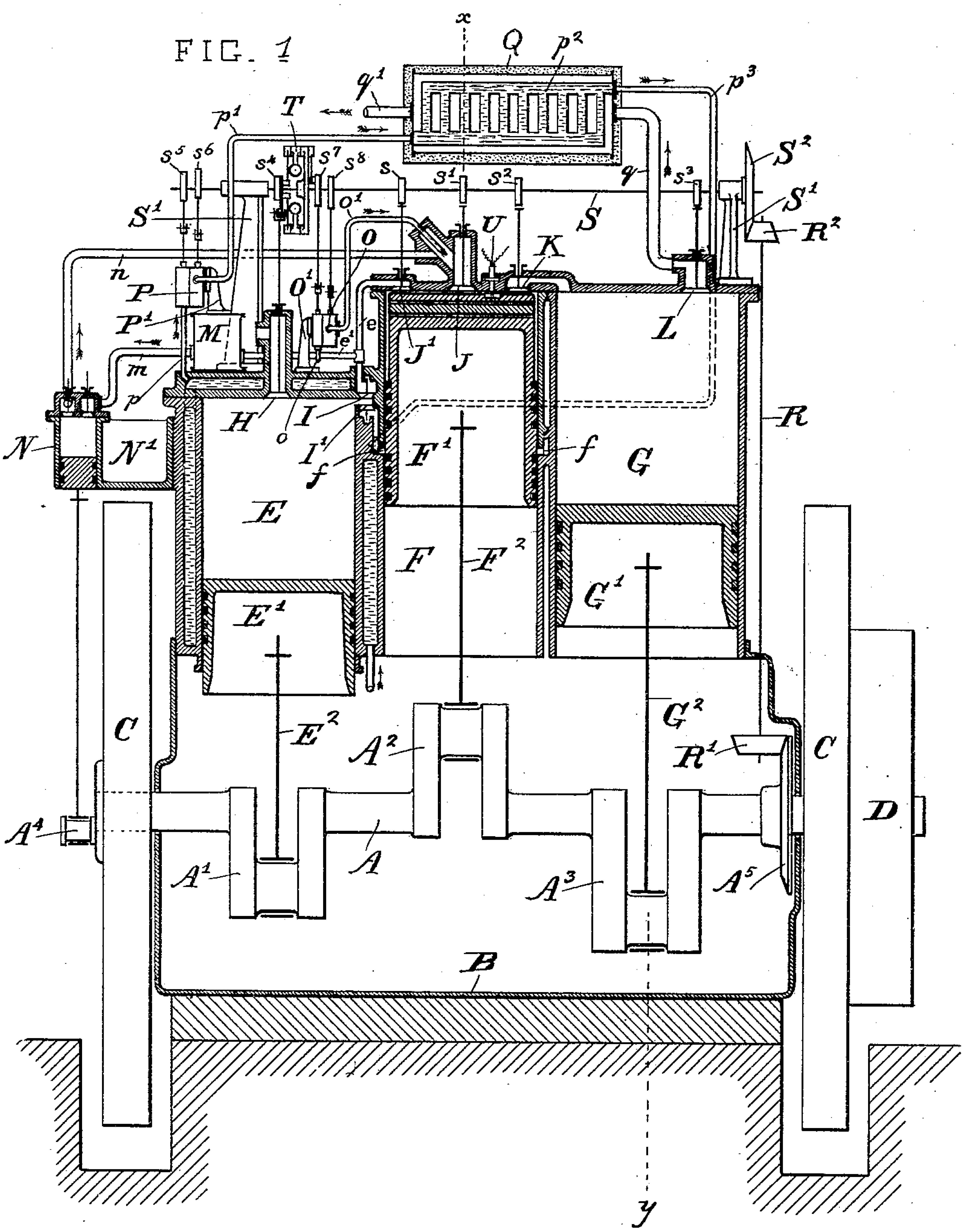
H. F. WALLMANN.

INTERNAL COMBUSTION ENGINE.

(Application filed Feb. 3, 1900.)

(No Model.) 2 Sheets—Sheet 1.

FIG. 1



WITNESSES:
Robert N. Holt
Alfred F. Tompkins

INVENTOR.
Henning F. Wallmann,
BY Samuel N. Pond,
his ATTORNEY.

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

No. 713,366. Patented Nov. 11, 1902.

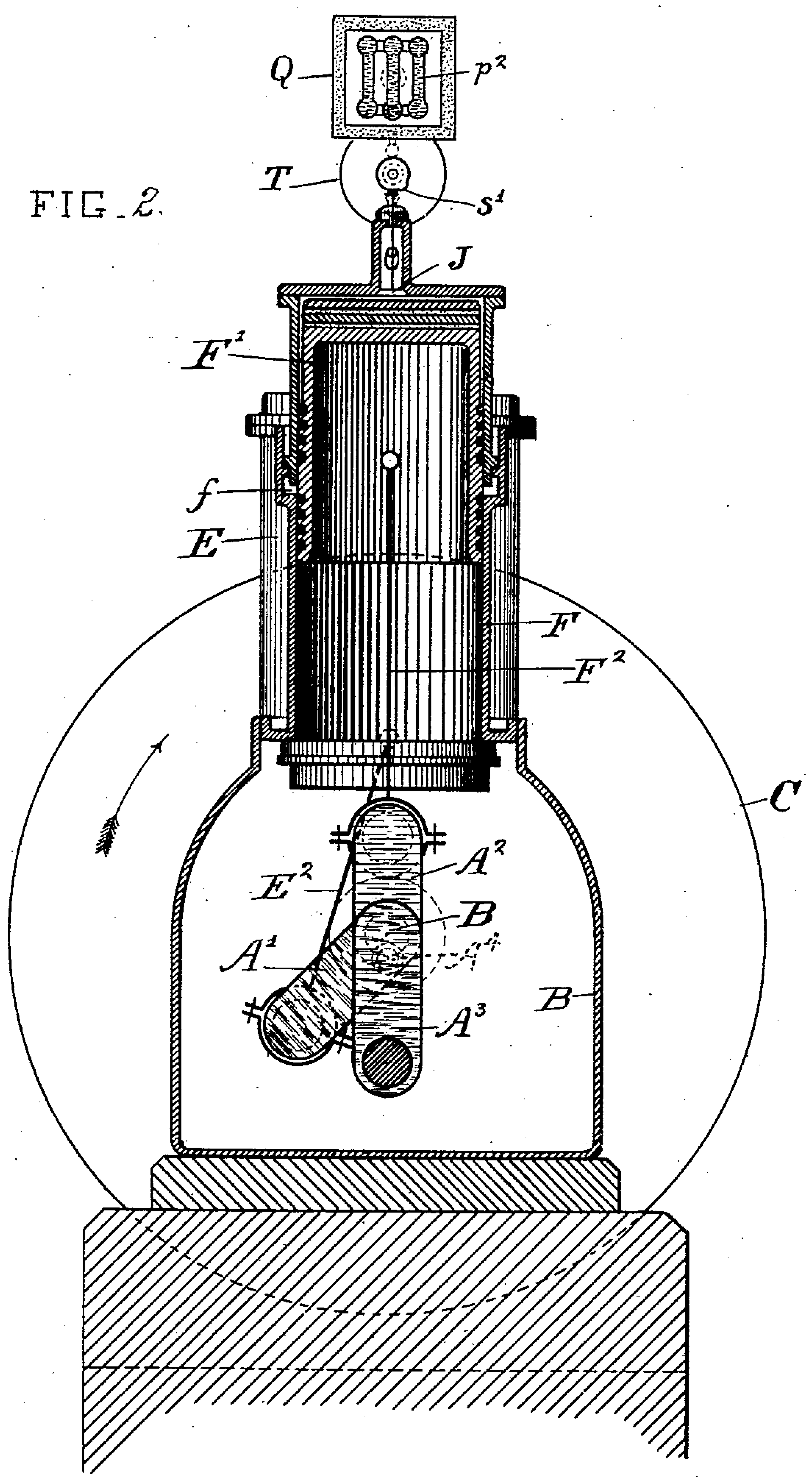
H. F. WALLMANN.

INTERNAL COMBUSTION ENGINE.

(Application filed Feb. 3, 1900.)

(No Model.) 2 Sheets—Sheet 2.

FIG. 2.



WITNESSES
Robert N. Holt.
Alfred F. Tompkins

INVENTOR
Henning F. Wallmann,
BY Samuel N. Pond,
his ATTORNEY

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

UNITED STATES PATENT OFFICE.

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

INTERNAL-COMBUSTION ENGINE.

SPECIFICATION forming part of Letters Patent No. 713,366, dated November 11, 1902.

Application filed February 3, 1900. Serial No. 3,842. (No model.)

To all whom it may concern:

Be it known that I, HENNING FRIEDRICH 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 internal-combustion engines of the two-cycle type, in which a charge of compressed air is mixed in suitable proportions with an inflammable gas or oil vapor ignited and expanded within the combustion-cylinder and made to perform work against the piston at every outstroke of the latter; and my present invention is principally in the nature of improvements upon the engines forming the subject-matter of the following applications heretofore filed by me: Serial No. 735,301, filed October 30, 1899; Serial No. 738,594, filed November 28, 1899, and Serial No. 740,719, filed December 18, 1899. In the first two of said applications I disclosed a plan for economizing power through the more effective utilization of the great heat generated in an internal-combustion engine by mixing with the hot products of combustion in the combustion-cylinder a body of compressed air and expanding the combined product through the remainder of the stroke in the combustion-cylinder and in some cases through an expansion-cylinder. In the last-named application I set forth a device for maintaining the combustion-cylinder and the working piston and other coöperating parts at a working temperature without the usual water-jacket by injecting into the combustion-cylinder along with the body of compressed air a spray of water for cooling purposes.

In my present invention I have united and combined the several improvements above alluded to in a single compound-engine structure, embodying therewith other improvements in the organization of the engine, whereby it is adapted to the use of a liquid hydrocarbon fuel and whereby also the various coöperating elements are brought into advantageous relations to secure the most beneficial results of their mutual interaction, the principal aim or object had in view being such a distribution and utilization of the heat necessarily generated in the combustion-cylinder and air-compressor as shall insure the greatest possible conversion of that heat into work performed on the crank-shaft.

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

Figure 1 is an elevation of my improved engine with the cylinders, their valve-casings, and the crank-casing shown in central vertical section; and Fig. 2 is a vertical section at right angles to Fig. 1 on the line x y of Fig. 1 and showing the relative angular dispositions of the several cranks on the crank-shaft.

Similar letters refer to similar parts throughout both views.

A designates the crank-shaft of the engine inclosed in a casing B and carrying at its opposite ends and outside the casing a pair of fly-wheels C C and a belt-pulley D, from which latter the power generated by the engine may be taken. On top of and supported by the casing B are three cylinders E, F, and G, arranged side by side, as shown. Cylinder E is a single-acting air-compressor, and its piston E′ is connected to a crank A′ on the crank-shaft A by a connecting-rod E^2. Cylinder F is a high-pressure combustion-cylinder, the piston F′ of which is connected to a crank A^2 on the crank-shaft A by a connecting-rod F^2, and cylinder G is a low-pressure expansion-cylinder having its piston G′ connected to the crank A^3 on the crank-shaft A by a connecting-rod G^2.

The air-compressor E is water-jacketed throughout, as shown, to abstract the heat of compression, and thereby lessen the power required to compress the air, and is provided with a positively-controlled inlet-valve H. It has two oppositely-located discharge-valves I and I′, the former of which controls a pipe connection leading to a reservoir M and to the top of the combustion-cylinder F, and the latter controls a cored passage-way leading to an annular port f in the walls of the combustion-cylinder, said port f being so located as to be overrun by the packing-rings of the piston at approximately the middle point of its stroke.

J represents the fuel-inlet valve of the combustion-cylinder, and K is the exhaust-valve thereof, which controls a cored passage-way leading over into the low-pressure expansion-cylinder G. L is the exhaust-valve of the latter cylinder.

M is an air-reservoir conveniently located on top of the air-compressor E, as shown, and receiving through the pipe e' a part of the air delivered by the compressor on each compression-stroke. From said reservoir M air for the combustion of the fuel is admitted to the combustion-cylinder F at the proper period in the cycle of operations through pipes e' and e and a positively-actuated air-inlet valve J'.

Secured to a bracket O' on top of air-compressor E is an oil-pump O of any suitable type or construction—as, for instance, the well-known Brayton oil-pump—the function of which is to supply a suitable hydrocarbon oil in measured quantities for the combustible charges furnished to the combustion-cylinder F. This pump draws oil from a tank or reservoir (not shown) through a pipe o and delivers the same to the casing of the inlet-valve J through a pipe o'.

In order to insure the delivery of fuel to the combustion-cylinder and to effect a thorough spraying thereof upon its introduction to the said cylinder, I have provided means for directing a fine blast of air at high pressure angularly across the mouth of the oil-delivery pipe in the casing of the fuel-inlet valve J. This means comprises a small high-pressure air-pump N, which may conveniently be secured by a bracket N' to the cylinder of the air-compressor E, as shown, its piston being operated from a crank A^4 on the end of the crank-shaft A outside the casing B. This pump N takes in air previously compressed from reservoir M through a short pipe m and delivers it at an increased pressure to the casing of the fuel-inlet valve through a discharge-pipe n.

A bracket P', supported on top of the air-reservoir M, carries a pump P, similar in construction and operation to the oil-pump O. The function of this pump is to supply to the combustion-cylinder, preferably during the working stroke and simultaneously with the introduction of the scavenging-blast, a jet or spray of water for the purpose of cooling the combustion-cylinder and piston and maintaining the same at an operative temperature without the presence of the usual water-jacket. This cooling-spray I have found to be more effective to produce a uniform cooling of the combustion-cylinder and its piston if introduced at such a temperature as will insure its instant vaporization and consequent uniform and thorough distribution over the inner walls of the cylinder in the form of superheated steam. To this end I avail myself of the heat of compression generated in the walls of the air-compressor and, further, of the heat of the final exhaust of the engine to raise the temperature of the cooling-spray prior to its introduction to the combustion-cylinder. The pump P draws water from the water-jacket of the air-compressor E through a pipe p and on each forcing stroke directs a small body of water through a pipe p' into a heating-coil p^2, incased in an asbestos-lined chamber Q. From the heating-coil p^2 the water or steam, as the case may be, is forced under the pressure exerted by the pump P through another pipe p^3, leading to the annular chamber f in the walls of the combustion-cylinder. The chamber Q is heated by the exhaust from the expansion-cylinder G, which enters said chamber at one end through a pipe q and leaves it at the opposite end through a pipe q'.

I will now describe the mechanism I prefer to employ for properly timing and controlling the movements of the valves H, J, J', K, and L and for actuating the oil and water pumps O and P, respectively. This mechanism, which for convenience of illustration is shown diagrammatically, comprises a horizontal shaft S, which is journaled in the upper ends of a pair of standards S' S', mounted on the upper heads of the cylinders E and G. This shaft S is continuously rotated in one direction on its axis from the main crank-shaft A through an intermediate vertical shaft R and bevel-gears A^5, R', R^2, and S^2, so related as to effect one rotation of shaft S during each rotation of shaft A. On shaft S are keyed four cams s, s', s^2 and s^3, so disposed and timed as to control the operations of the valves J', J, K, and L, respectively, while s^4 is a governor-controlled cam for regulating the closing of the air-inlet valve H. On the shaft S are also keyed two pairs of eccentrics s^5 s^6 and s^7 s^8, which actuate the slide-valves and plungers of the water and oil pumps P and O, respectively. Between the cam s^4 and the eccentric s^7 is mounted on the shaft S a centrifugal governor T, connected on its opposite sides to said cam and eccentric and governing the time at which the cam allows the inlet-valve H to close and also the eccentricity of the eccentric and through it the amount of oil supplied for the combustible charge.

U indicates an electric sparker of any known and approved type.

The cranks A^2 and A^3, to which are connected the pistons of the combustion and expansion cylinders, respectively, are set diametrically opposite each other on the crank-shaft, as shown by Fig. 2, while the crank A' of the air-compressor is about one hundred and thirty-five degrees behind the crank A^2. With the parts in the position shown the piston of the combustion-cylinder has just finished its inward or expelling stroke, the piston of the expansion-cylinder has just completed its outward or working stroke, the piston of the low-pressure air-compressor E is about one-sixth up on its inward or compressing stroke, and the piston of the high-pressure air-pump N has started on its inward or forcing stroke. All the valves of the several cylinders are in their closed positions. With the continued rotation of the crank-shaft the pistons of the air-pumps N and E and of the expansion-cylinder G all move inwardly, while the piston of the combustion-cylinder moves outwardly. As the latter piston begins its outward or downward stroke the cam s opens the air-inlet valve J' of the combustion-cylinder and a charge of air, compressed into the reservoir M on a previous upstroke of the piston E', is admitted through the pipes e' and e into the combustion-cylinder. A little later in the stroke, when the combustion-cylinder has thus received a certain charge of compressed air, the cam s' opens the valve J and the cam s permits the valve J' to close. The oil-pump O forces a charge of fuel through the pipe o', which is met at its point of discharge by a blast of highly-compressed air from the high-pressure air-pump N through the pipe n, and in consequence of such spraying action of the air-blast and of the heat of the combustion-cylinder the fuel enters the latter cylinder past the open valve J in a finely-divided and more or less vaporized condition, where it mingles with the air previously admitted and forms therewith a highly-combustible charge. In the meanwhile the cam s^3 has opened the exhaust-valve L of the expansion-cylinder, and as the piston G' rises the hot gases exhaust therefrom through pipe q, chamber Q, and pipe q', imparting most of their heat to the water in the pipe-coil p^2. When now the piston F' in the combustion-cylinder has moved a short distance down on its outward stroke, the valve J closes, the charge is fired either by the sparker U or by spontaneous ignition from the intense heat existing within the combustion-cylinder, and the piston F' completes its outward or working stroke under the expansive impulse of the gases thus ignited. While the piston F' is thus performing its working stroke the piston E' of the air-compressor is compressing a body of air, a part of which is forced past valve I into reservoir M and the remainder of which is forced past valve I' into the annular chamber f and the cored passage-way leading thereto. When the packing-rings of the piston F' on the outward stroke of the latter overrun the ports communicating with the annular chamber f, the compressed air, forced by the piston E', instantly rushes into the combustion-cylinder and impinging on the hot cylindrical surface of the upper end of the working piston and commingling with the hot products of combustion is heated and expanded thereby and maintains the pressure in the combustion-cylinder substantially constant to the end of the stroke at the pressure existing at the time of its introduction.

In connection with the introduction of a body of compressed air into the hot expanding products of combustion in the combustion-cylinder during the working stroke, as just described, it is also noted that the forcing stroke of the water-pump P is so timed that a jet or spray of water heated by the heat of compression in the water-jacket of cylinder E and by the low-pressure exhaust in chamber Q will be forced with the compressed air from annular chamber f into the hot products of combustion in the combustion-cylinder. This water, while possessing considerable heat and in some cases vaporized into steam, is nevertheless so cool relatively to the intense heat existing in the combustion-cylinder that it serves to maintain the temperature of the latter at an operative point in lieu of the usual water-jacket, and, furthermore, being converted into superheated steam at the instant of its introduction it augments in some measure the expansive effect of the products of combustion in the combustion-cylinder and later in the expansion-cylinder G. At the completion of the working stroke of piston F' the piston E' has completed its compressing stroke and has commenced its suction stroke. The valves J' and J are of course closed. The exhaust-valve L of the expansion-cylinder is allowed by its cam s^3 to close, and immediately thereafter the exhaust-valve K of the combustion-cylinder is opened by its cam s^2 and held open during the entire inward or expelling stroke of the working piston. The products of combustion, commingled with the heated compressed air and superheated steam, exhaust over into the cylinder G, in which they further expand down to nearly atmospheric pressure, driving the piston G' to the limit of its outward stroke, and thus performing additional work on the crank-shaft. At the same time the piston E' completes its suction and commences its compression stroke, while the high-pressure air-pump N admits a charge of air from the reservoir M for the next spraying-blast. The moving parts thus arrive once more at the positions illustrated, whereupon the hereinabove-described cycle of operations is repeated.

The governor T on the shaft S regulates the speed of the engine primarily through its control of the operating mechanism of the oil-pump O, the governor acting to shorten or stop altogether the stroke of the oil-pump plunger when the speed becomes excessive. It further regulates the speed by more or less delaying the closing of the inlet-valve H of the air-compressor E when the speed exceeds normal until after the compression stroke has begun, thus furnishing a smaller body of air to the combustion-cylinder.

Inasmuch as the fuel is introduced into the combustion-cylinder after the introduction of the compressed air for the combustion of the fuel, it is essential that the body of air forming the spraying-blast should be at a higher pressure than the body of air previously admitted. For this purpose the two air-pumps E and N form, in effect, a two-stage air-compressor, the function of the small air-pump N being to compress to a higher stage a portion of the air previously compressed in cylinder

E, so as to insure the introduction of the fuel into the combustion-cylinder against the pressure already existing therein at the instant of its introduction.

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

1. In an internal-combustion engine, the combination with a combustion-cylinder, of means for supplying a body of compressed air thereto for the combustion of the fuel, means for subsequently injecting a charge of fuel at a higher pressure into said body of compressed air and for firing the mixture, and means for introducing into the hot expanding products of combustion in the combustion-cylinder another body of compressed air commingled with a spray of water or steam, substantially as described.

2. In an internal-combustion engine, in combination a combustion-cylinder, means for supplying a combustible charge thereto, an air-compressor, an air-reservoir between the compressor and the combustion-cylinder, a valve-controlled passage-way between the compressor and an annular chamber in the walls of the combustion-cylinder, said annular chamber communicating with the interior of said cylinder through ports which are overrun by the working piston, a valve-controlled connection between the air-reservoir and the combustion-cylinder, and suitably-timed valve-actuating mechanism whereby a part of the air compressed on each forcing stroke of the air-compressor is injected into the combustion-cylinder, and the remainder is stored in the air-reservoir and subsequently utilized to form a part of the next combustible charge.

3. In a compound internal-combustion engine, in combination a combustion-cylinder, means for supplying a body of compressed air thereto for the combustion of the fuel, means for subsequently injecting a charge of fuel at a higher pressure into said body of compressed air, means for introducing into the hot expanding products of combustion another body of compressed air commingled with a spray of water or steam, and a low-pressure expansion-cylinder in which the products of combustion, commingled with the heated air and superheated steam, may be expanded down to substantially atmospheric pressure.

4. In a compound internal-combustion engine, the combination with a combustion-cylinder and an expansion-cylinder communicating with each other and having their pistons connected to diametrically opposite cranks on the crank-shaft, of an air-compressor whose piston is operated from a crank on the crank-shaft set approximately one hundred and thirty-five degrees behind the crank of the combustion-cylinder, and suitable valve-controlled connections between said cylinders whereby a part of the air compressed on each forcing stroke of the air-compressor is directly injected into the combustion-cylinder and passes thence, with the products of combustion, into the expansion-cylinder, and the remainder is subsequently utilized to form a part of the next combustible charge.

In testimony that I claim the foregoing as my invention I have hereunto signed my name in the presence of two witnesses.

HENNING FRIEDRICH WALLMANN.

Witnesses:
SAMUEL N. POND,
J. K. LAMBERT.