No. 800,996. PATENTED OCT. 3, 1905.

C. S. DRUMMOND.

INTERNAL COMBUSTION ENGINE.

APPLICATION FILED NOV. 6, 1903.

2 SHEETS—SHEET 1.

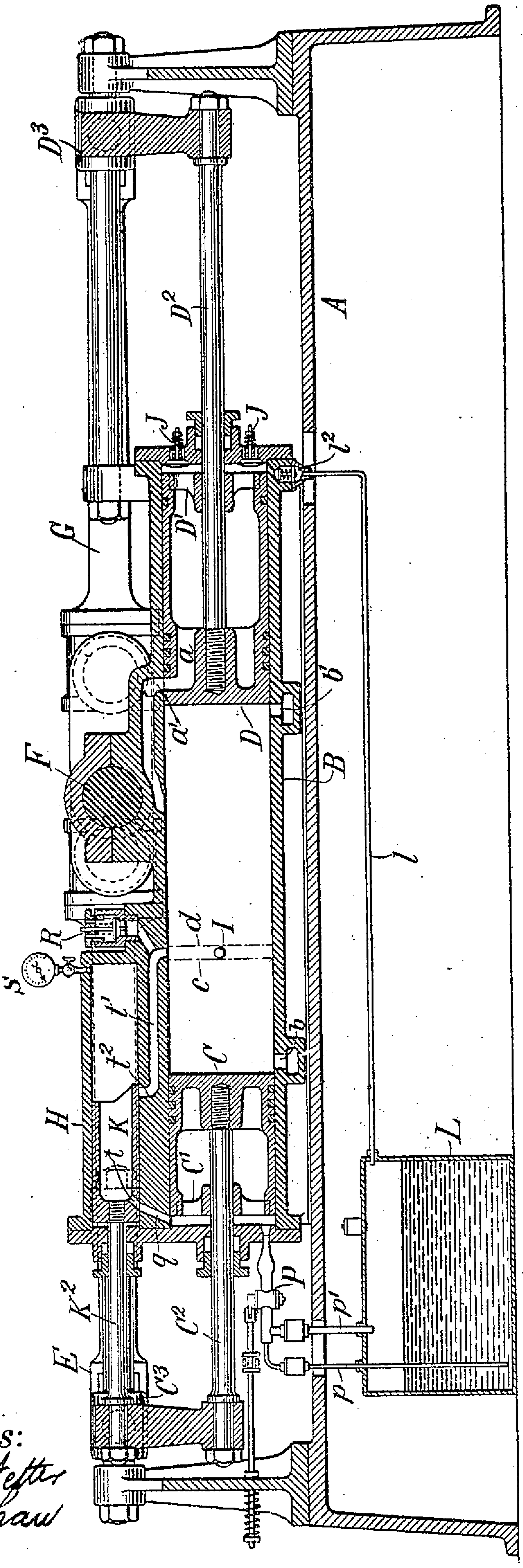


Fig.1

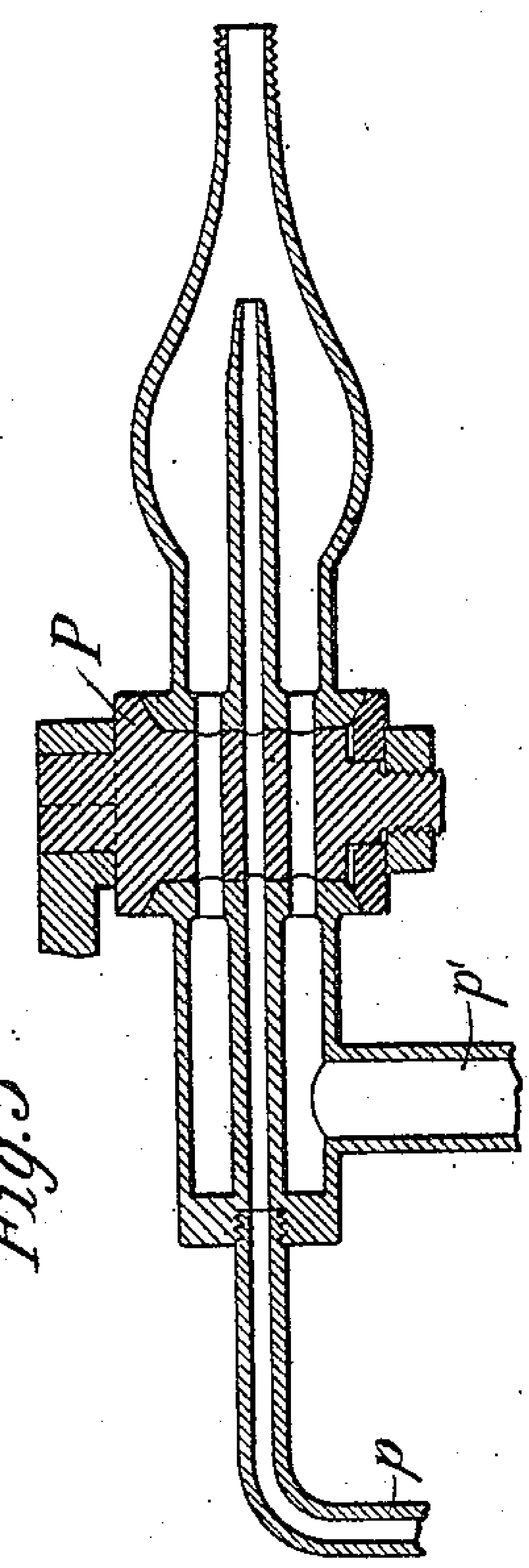


Fig.3

Witnesses:

Raphaël Netter

L. J. Shaw

Inventor

Charles S. Drummond

by E. M. Bentley

Atty.

No. 800,996. PATENTED OCT. 3, 1905.

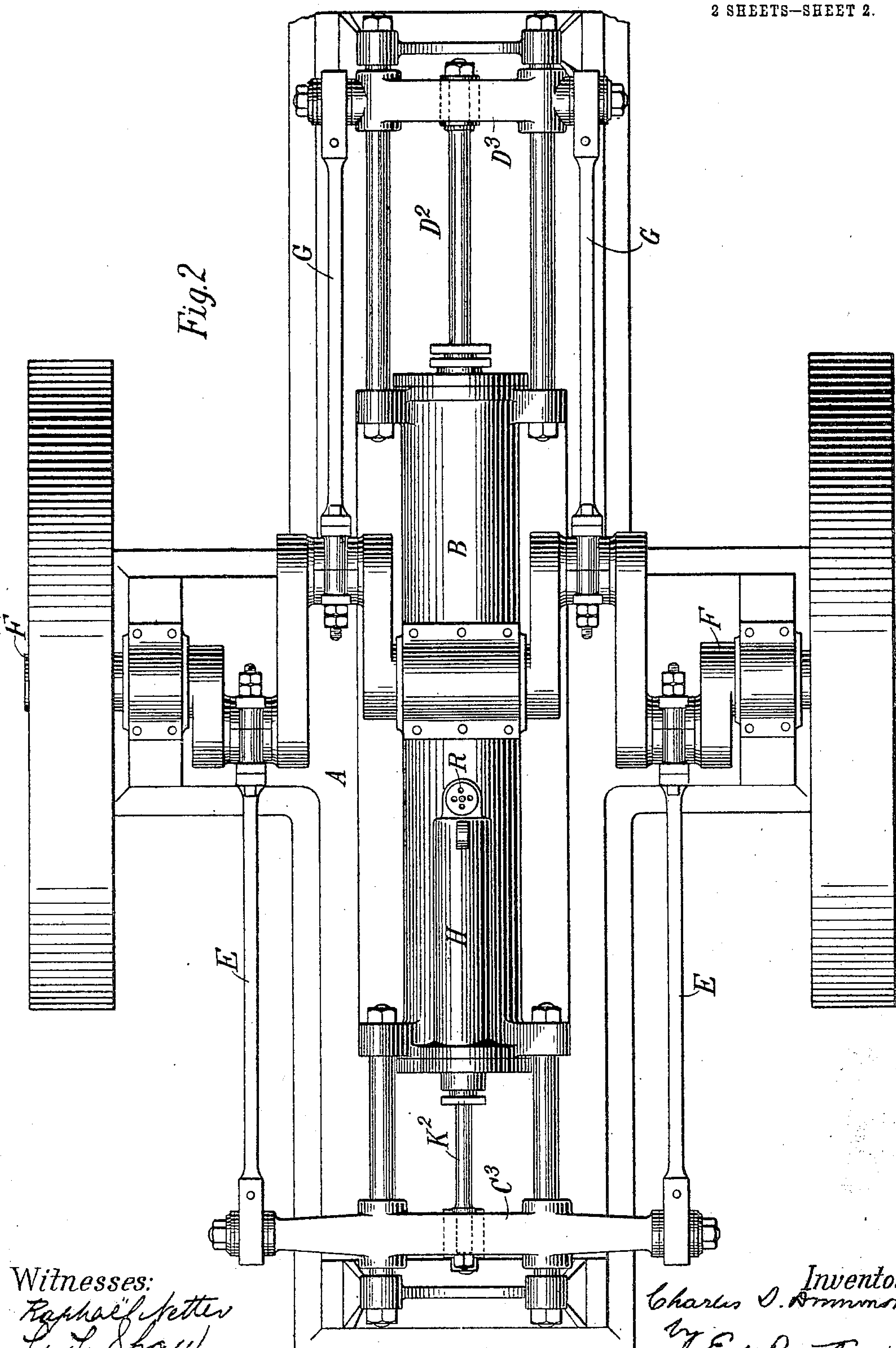
C. S. DRUMMOND.

INTERNAL COMBUSTION ENGINE.

APPLICATION FILED NOV. 6, 1903.

2 SHEETS—SHEET 2.

Fig. 2



Witnesses:
Raphael Netter
L. S. Shaw

Inventor
Charles S. Drummond
by E. M. Bentley Att'y.

UNITED STATES PATENT OFFICE.

CHARLES S. DRUMMOND, OF LONDON, ENGLAND.

INTERNAL-COMBUSTION ENGINE.

No. 800,996. Specification of Letters Patent. Patented Oct. 3, 1905.

Application filed November 6, 1903. Serial No. 180,011.

To all whom it may concern:

Be it known that I, CHARLES S. DRUMMOND, a citizen of Great Britain, residing at Westminster, London, England, have invented certain new and useful Improvements in Internal-Combustion Engines; and in pursuance of the statute I have set forth in the accompanying drawings and specification as an illustration of the invention that form thereof which I now regard as the best one of the various forms in which the principle of the invention may be embodied.

In the drawings, Figure 1 is a vertical section, Fig. 2 is a plan view, Fig. 3 a detailed view, of the atomizing device.

My invention relates to engines of the internal-combustion type in which an explosive gaseous mixture is ignited within the engine itself to give the required expansive effort which represents as nearly as possible the energy involved in the combustion of the gases.

In my invention the explosive mixture is produced from any liquid or gaseous form of material containing hydrogen, such as hydrocarbon gas, kerosene, fuel-oil, crude oil, or other form of petroleum. In particular I propose to employ a liquid hydrocarbon as a source of fuel.

One of the objects of my invention is to provide an arrangement wherein a liquid fuel may be first thoroughly atomized or subdivided into minute particles and then given a sufficient time exposure to heat and compression for thoroughly volatilizing it and converting it into a gas prior to its admixture with air or other source of oxygen to complete the explosive compound. Moreover, I purpose to accomplish this within the time interval between the engine-strokes. By this means I avoid the formation of carbon within the cylinder, which is due in some cases to imperfect combustion of the charge and in others to perfect combustion of only a part of the charge. For example, in some gas-engines the exhaust will show a considerable percentage of unconsumed carbon, showing imperfect combustion, while in other cases the exhaust will be practically free from carbon, yet within the cylinder and ports of the engine the carbon will continue to accumulate, indicating that only a portion of the charge has been thoroughly consumed. This is outside of such carbon as may come from the lubricating-oil.

My invention also includes the features hereinafter described in detail and embraced by the claims.

Turning to the drawings, A is the engine-bed, near the center of which is mounted a long cylinder B, containing two pistons C and D, which travel in the respective ends of the cylinder B. The stroke of the piston C is, however, considerably shorter than that of the piston D, for a purpose which will be hereinafter explained. The piston C is hollow, and on the side facing the end of cylinder B it is entirely open except for the presence of the spider C′, by which the piston-rod C^2 is centered in the piston. This rod is secured at one end in the bottom of the piston C and after passing through the stuffing-box in the head of the cylinder is attached to a cross-head C^3, which in turn travels in guides in the usual manner and carries connecting-rods E, which operate crank-arms on the main shaft F of the engine. The piston D is connected in like manner to a piston-rod D^2 and is also hollow except for the bracing-spider D′. The piston-rod D^2 is also connected to a cross-head D^3, which in turn operates the connecting-rods G, both coöperating with crank-arms on the main shaft F. Since the travel of the piston D is substantially twice that of the piston C, its crank-arms are correspondingly longer than those of piston C. Above the main cylinder B is a smaller compression-cylinder H, in which travels a hollow piston K, connected by piston-rod K^2 to cross-head C^3. By this means the two pistons C and K travel together and have the same length of stroke.

It is my purpose to ignite the charge within the main cylinder B at a point between the two pistons C and D when they are both at the innermost end of their stroke, preferably immediately after they have completed their stroke and have started to move outward toward the respective ends of the cylinder. This not only balances the engine, but has other important functions, which will be described hereinafter. The inward stroke of piston D draws in air through the check-valves J in the head of the cylinder, and the outward stroke compresses this air between the piston and the head of the cylinder until the port *a* comes in line with the port *a′*, and the compressed air then escapes into the central part of the main cylinder B, driving before it the spent gases through the exhaust-ports *b b′*. The next inward stroke of piston D shuts off the ports *a a′* and the exhaust-port *b′*, (the exhaust-port *b* being simultaneously cut off by the piston C,) and the air is compressed between the two pistons into the very small space between the lines d and c, which indicate the innermost points of approach of the respective pistons. In the meanwhile a charge of gas has been provided by the action of piston C, this charge being in a gaseous form and produced by mingling a spray of oil thoroughly atomized with a small amount of compressed and heated air in the hot chamber on the outer side of piston C and then further compressing the mixture in the cylinder H to a pressure higher than that of the aforesaid charge of air compressed between the two pistons C and D. The amount of air in the gas charge is not sufficient to make an explosive mixture, but when the gas is allowed to mingle with the air charge in the combustion-chamber the proportion required for the most perfect combination is obtained. This charge of gas is secured in the following manner: L is an oil-tank in the base of the engine, the tank being air-tight, but provided with a suitable safety-valve and its upper part communicating by a pipe l with the right-hand end of the main cylinder B through a suitable check-valve l^2. By this means each compression-stroke of the piston D will give an impulse of air-pressure in the tank L equal to the pressure produced by the piston D in the right-hand end of the main cylinder. This impulse of pressure will force a certain amount of oil from the tank L through the pipe p into the atomizer and also a certain amount of air into the atomizer through the pipe p'. In a manner well known the air will pass through the external pipe of the atomizer and the oil through the internal pipe, so that the latter will be drawn into the atomizer and delivered therefrom in the form of a spray into the left-hand end of the main cylinder at the back of the piston C. This will occur during the inward stroke of the piston C and will continue until the pressure behind the piston C overcomes the pressure in the tank L, when the check-valves of the respective pipes p and p' will close and shut off the flow of air and fuel through the atomizer. This means that the charge is automatically injected by means of the air-pressure produced by the piston D and continues until automatically checked by the rise of pressure back of the piston C, the differential pressures being adjusted as desired to give the particular amount of charge that is needed for any particular power of the engine. If desired, I might control the charge by a centrifugal or other governor acting in a well-known manner upon valve P in the atomizer-pipes just back of the bulb, as will be understood without specific illustration. As the atomized oil enters the left-hand end of cylinder B it passes through a small permanently-open port q into the cylinder H at the left-hand side of the piston K. Then as the pistons K and C move outward toward the left they both act to compress the charge until the port t in piston K comes into line with the port t^2, through which the cylinder B communicates with the cylinder H. At this instant the compressed charge is admitted into the cylinder H, and then by the inward stroke of the piston K it is further compressed until all the pistons approach the end of their inward strokes, when the port t comes opposite the port t^2, and the charge, which by the heat and compression has been thoroughly volatilized, is suddenly admitted to the cylinder B at a pressure considerably higher than that of the air in the said cylinder, which has in the meanwhile, as already described, been compressed between the pistons C and D into the small clearance-space between the lines c and d. This introduction of the gas charge into the air charge gives a perfect explosive mixture, which is immediately fired by an igniter I of any well-known description at a point of time after the pistons C and D start on their outward strokes. This gives the power impulse to the pistons C and D, and thereafter the cycle of operations already described is repeated indefinitely.

R is a relief-valve such as is ordinarily employed, and S is a pressure-indicator on the cylinder H.

In the above-described engine it will be noted that the explosion takes place just as the pistons C and D get under way on their outward stroke, so that the energy of the combustion is almost entirely converted into a mechanical movement of the pistons and the minimum percentage of it into the generation of needless heat by compression of the gases in an unyielding chamber—that is to say, the heat energy of the combustion should be expended as completely as possible in the mechanical movement of the piston, and whatever percentage may be expended in merely establishing a high degree of compression, and thereby producing a further amount of heat by the compression itself, is wasted. Thus in an ordinary gas-engine the piston itself will remain comparatively cool, while the cylinder, particularly the explosive end, becomes abnormally hot and needs to be cooled by a water-jacket. This I conceive to be due to the fact that since the piston is free to move that portion of the charge immediately in contact with it is expanding more freely and giving out its energy in the form of mechanical movement, while in that portion of the charge in contact with the walls of the cylinder there is, on the contrary, a tendency to merely create pressure within a confined space, the heat energy merely acting to produce more heat by compression. Of course these are but tendencies which can continue for only a brief and an almost theoretical point of time, but are sufficient to cause a large portion at least of the difference in temperature between the piston itself and the walls of the cylinder, which inclose the same space and which would otherwise be subject to exactly the same heating conditions.

By providing two pistons which form the opposite sides of the explosion-space and comprise the greater part of the surface by which the said space is bounded I secure the same economic advantage of a moving piston on both sides of the explosive space, which in an ordinary engine is obtained on one side only. Moreover, it is only the very narrow space between the two pistons at the moment of explosion which is surrounded circumferentially by the wall of the cylinder, so that only a very small portion of the exploded charge reacts against the immovable abutment formed by the cylinder-wall. It is also to be remarked that by increasing the length of stroke of the air-compressing piston D, I secure the more gradual compression of the air, such as is desirable for the air compression, and then by transferring it at the end of the stroke to the opposite side of the piston I compress it still further into the small space which it occupies at the time of explosion, thus giving a very gradual compression of about one-half of the entire contents of the cylinder B into the small explosive space. The length of this part of the cylinder and the consequent larger exposed surface also assists in dispersing the gradually-accumulated heat of compression. In the other end of the cylinder, on the contrary, the heat is purposely maintained greater in order to produce the volatilization of the atomized oil. The air which enters with the oil is already heated by its previous compression by the piston D in the opposite end of the cylinder, and the oil is likewise heated by its contact in the tank with the hot air. To this is added the heat of compression in both cylinders and that of the subsequent compression in cylinder H.

The areas and lengths of the two parts of the main cylinders, which can be regarded as two cylinders, if desired, may be varied as required, also the details of the construction; but the arrangement shown is the one that I now consider the best.

In the following claims I have as a matter of convenience referred to the central portion of the cylinder B between the two pistons C and D as the "combustion-chamber" or the "combustion-cylinder," while that part to the right is designated as the "air-compressing" cylinder and that to the left as the "charge-compressing" cylinder, the second charge-compressing cylinder being also referred to as the "supplementary" charge-compressing cylinder.

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

1. In an explosion-engine the combination of a working cylinder and piston, and three compressing-chambers with pistons operated by the engine, one of said chambers compressing air for the working cylinder, and two being in series for compressing fuel for said cylinder, said three chambers having pistons, two of which have compressing strokes on the working stroke of the working piston.

2. The combination in an internal-combustion engine, of a working cylinder and piston, a compressor to furnish air only, a main charge-compressor whose piston has a compressing stroke on the working stroke of the working piston, means to supply fuel to said main charge-compressor, and a supplementary charge-compressor to introduce the charge from the main charge-compressor to the working cylinder, all of said compressors operated by the engine.

3. In a two-cycle explosion-engine, the combination of a working cylinder and piston, an air-compressor having a suction-stroke on the non-impulse stroke of the working piston and a compression-stroke on the impulse-stroke thereof, a main charge-compressor, and a supplementary charge-compressor whose piston has a compressing stroke alternating with that of the main charge-compressor receiving the charge from the main charge-compressor and introducing it to the working cylinder.

4. In a two-cycle explosion-engine, the combination of a working cylinder and piston, an air-compressor for supplying the working cylinder, a charge-compressor having a suction-stroke on the non-impulse stroke of the working piston and a compression-stroke on the impulse-stroke thereof, and a supplementary charge-compressor to introduce the charge into the working cylinder.

5. In a two-cycle explosion-engine, the combination of a working cylinder and piston, a main charge-compressor, a supplementary charge-compressor in series therewith and provided with a piston having its compression-stroke alternating with that of the main charge-compressor and coincident with the non-impulse stroke of the working piston and acting as a valve to admit the charge to the cylinder at the completion of its compressing stroke, and means to supply charges of air and fuel to said main charge-compressor.

6. The combination, in an internal-combustion engine, of a combustion-chamber, a main charge-compressing chamber, a fuel-supply tank, an atomizing connection between said tank and the said compressing-chamber for delivering fuel into said chamber in an atomized condition, a supplementary charge-compressing chamber, an outflow-duct from the main compressing-chamber communicating with the inflow-duct into the supplementary chamber and a duct connecting the said supplementary chamber with the combustion-chamber.

7. The combination, in an internal-combustion engine, of an air-compressing cylinder and piston therein, a main charge-compressing chamber and piston therein, a combustion-chamber between the said pistons, a duct be-

tween said compressing-chamber and the combustion-chamber, a fuel-supply tank, an atomizer between said tank and the charge-compressing chamber, and a supplementary compressing-chamber having its inflow-duct communicating with an outflow-duct from the main compressing-chamber and its outflow-duct communicating with the combustion-chamber.

8. The combination, in an internal-combustion engine, of a combustion-chamber, means for igniting a charge therein, oppositely-moving pistons in the respective ends of the cylinder, a main shaft, driving connections between said shaft and both of the said pistons, and chambers for the outer ends of said pistons for compressing both air and fuel in the combustion-chamber prior to ignition.

9. The combination, in an internal-combustion engine, of oppositely and synchronously moving pistons having different lengths of stroke, a single combustion-chamber between the pistons, a main shaft, driving connections between said shaft and the said pistons respectively each adapted to the length of stroke of its operating-piston and means for igniting a charge in said combustion-chamber between the two pistons.

10. The combination, in an internal-combustion engine, of a combustion-cylinder, oppositely-moving pistons therein connected to a common shaft, means for igniting a charge in the said chamber between the two pistons, air-compressing devices operated by one piston and charge-compressing devices operated by the other piston.

11. The combination, in an internal-combustion engine, of a combustion-cylinder, oppositely-moving pistons in said cylinder having different lengths of stroke, air-compressing devices operated by the piston having the longer stroke, and charge-compressing devices operated by the piston having the shorter stroke.

12. The combination, in an internal-combustion engine, of a combustion-cylinder, oppositely-moving pistons therein having different lengths of stroke, air-compressing devices operated by the piston having the longer stroke, charge-compressing devices operated by the piston having the shorter stroke, and means for giving the fuel charge a second compression and delivering it to the combustion-chamber.

13. The combination, in an internal-combustion engine, of a combustion-cylinder, oppositely-moving pistons therein, means for igniting the charge in said cylinder between the pistons, an air-compressing chamber on the opposite side of one piston, a charge-compressing chamber on the opposite side of the other piston, and ducts between each of the said compressing-chambers and the combustion-cylinder.

14. The combination, in an internal-combustion engine, of a combustion-cylinder, oppositely-moving pistons therein having different lengths of stroke, means for igniting a charge in said combustion-cylinder between the two pistons, an air-chamber on the opposite side of one piston having its outflow-duct communicating with an inflow-duct into the combustion-cylinder, whereby air may be compressed in said chamber and cylinder successively, a fuel-supply tank, a main charge-compressing chamber on the opposite side of the other piston, communicating ducts between the supply-tank and both of the two compression-chambers aforesaid, and a second charge-compressing chamber having an inflow-duct leading from the main charge-compressing chamber and an outflow-duct leading into the combustion-cylinder.

15. The combination, in an internal-combustion engine, of a combustion-cylinder, oppositely-moving pistons therein having different lengths of stroke, an air-compressing chamber on the opposite side of the piston having the longer stroke, an outflow-duct from said compressing-chamber communicating with the inflow-duct into the combustion-cylinder, a fuel-supply tank, a pipe between said compressing-chamber and the said tank, an atomizer between said tank and a charge-compressing chamber on the opposite side of the piston having the shorter stroke, and a supplementary charge-compressing chamber having its inflow-duct leading from the outflow-duct of the main charge-compressing chamber and its outflow-duct leading into the combustion-chamber.

16. The combination, in an internal-combustion engine, of a combustion-cylinder, oppositely-moving pistons in the two ends of the cylinder having different lengths of stroke, operating connections between each of the said pistons and the main shaft suited to the respective strokes of the pistons, an air-compressing chamber on the opposite side of the piston having the longer stroke, an outflow-duct for the said compressing-chamber communicating with an inflow-duct into the combustion-cylinder, a fuel-supply tank, a connecting-pipe between said tank and the said compressing-chamber, an atomizer between the said supply-tank and a second compressing-chamber on the opposite side of the piston having the shorter stroke, and a third compressing-chamber having its inflow-duct leading from the outflow-duct of the second compressing-chamber and its outflow-duct leading into the combustion-cylinder.

17. The combination, in an internal-combustion engine, of a combustion-cylinder, an air-compressing chamber and piston, an outflow-duct from said compressing-chamber communicating with an inflow-duct into said combustion-cylinder and set to be opened by the piston at the end of its compressing stroke, an inflow-duct into said compressing-chamber

and a check-valve therefor, a fuel-supply tank containing fuel under pressure, a duct between said tank and said air-compressing chamber for maintaining the pressure, an atomizer connected with said tank having an oil-duct extending into the contained fuel and an air-duct communicating with the air-space above said fuel, a charge-compressing chamber and a piston therein, a supplementary charge-compressing chamber, and communicating ducts from the said atomizer through the charge-compressing chambers into the combustion-cylinder, whereby the atomized fuel may be compressed by successive steps and delivered into the compressed air in the combustion-chamber preparatory to ignition.

In witness whereof I have hereunto set my hand, before two subscribing witnesses, this 5th day of October, 1903.

CHARLES S. DRUMMOND.

Witnesses:
G. W. HOPKINS,
L. T. SHAW.