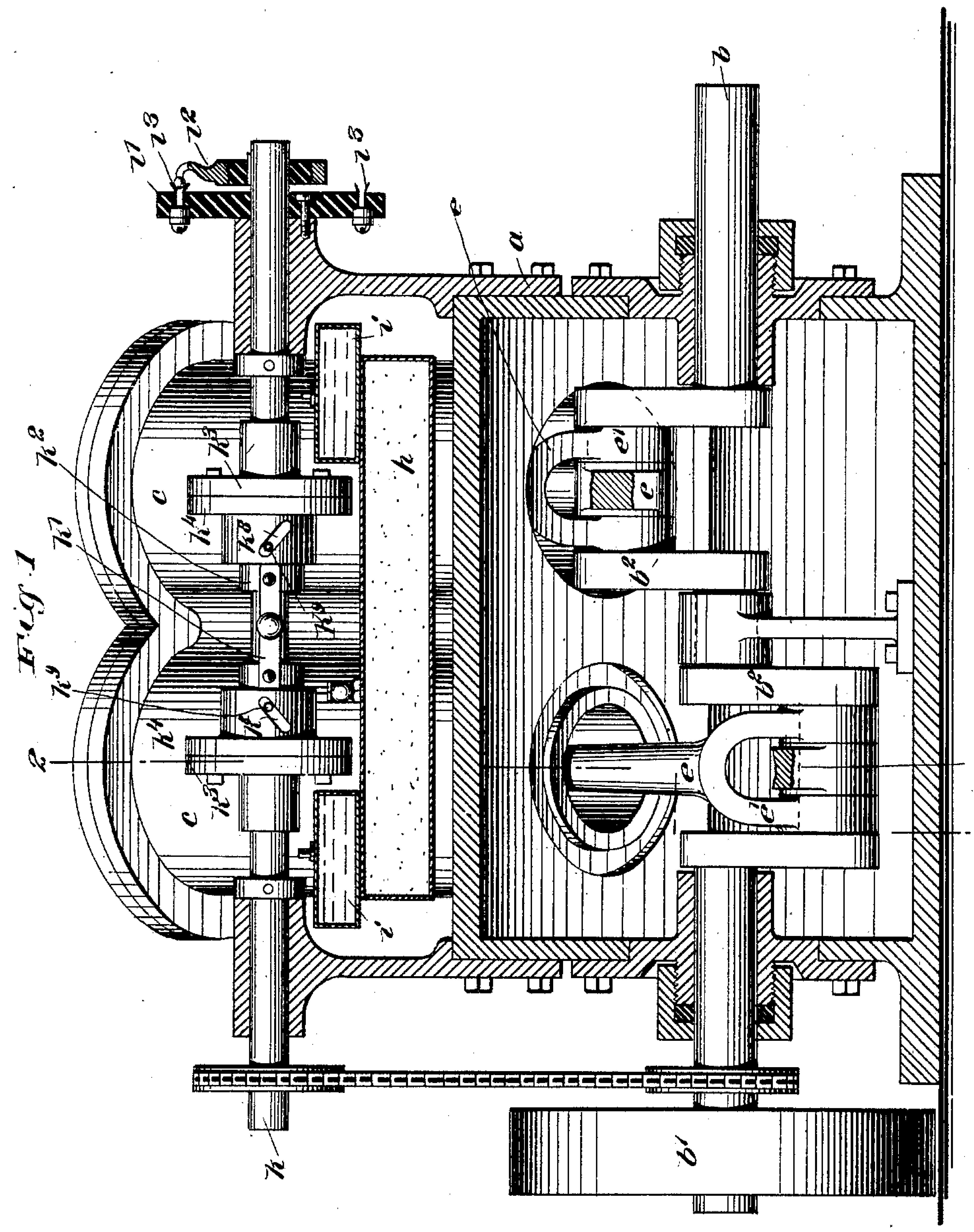
No. 719,547. PATENTED FEB. 3, 1903.

J. WILLOUGHBY.

EXPLOSIVE ENGINE.

APPLICATION FILED MAR. 26, 1901.

NO MODEL. 3 SHEETS—SHEET 1.



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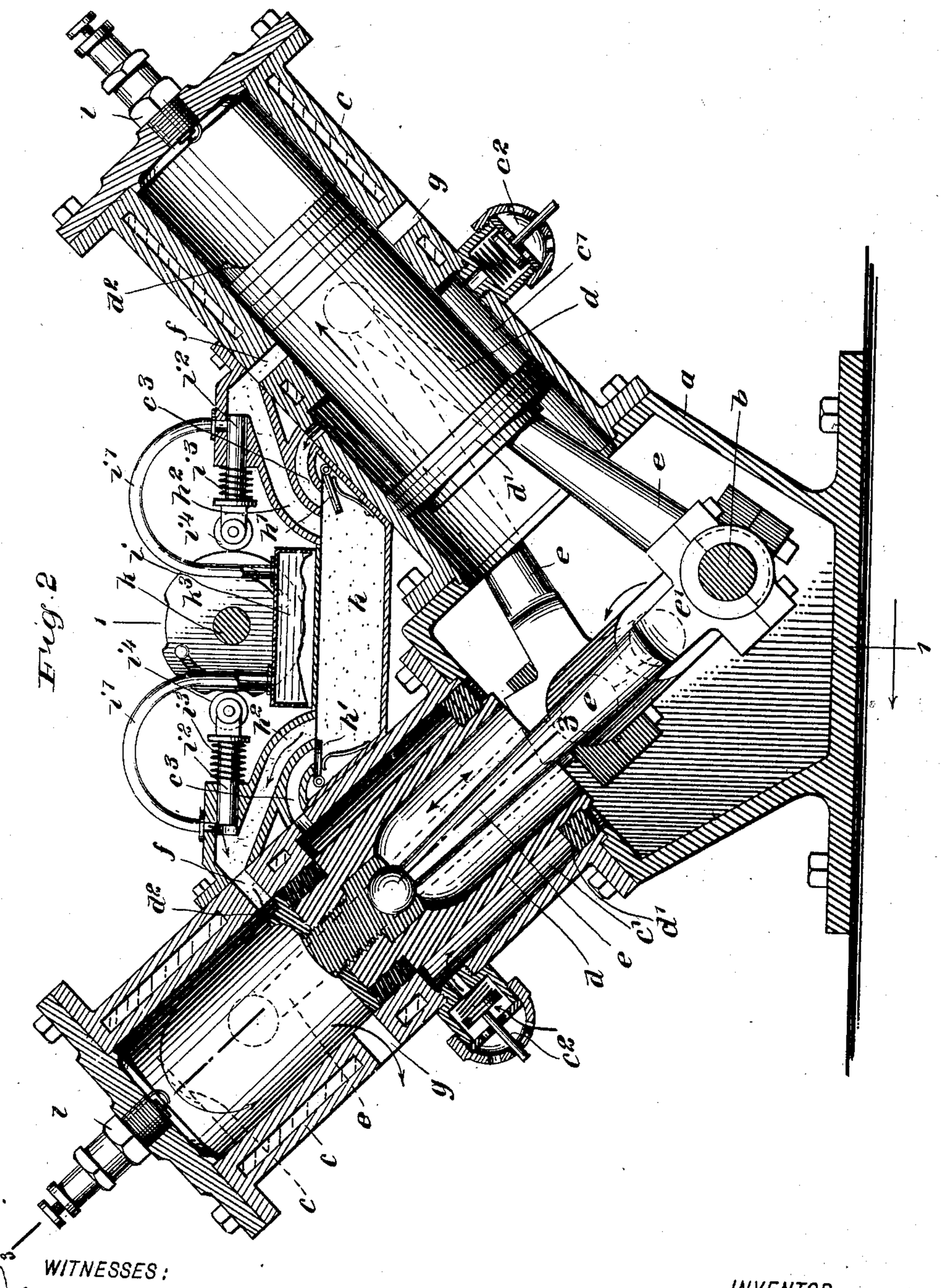
NO MODEL. 3 SHEETS—SHEET 2.



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NO MODEL. 3 SHEETS—SHEET 3.

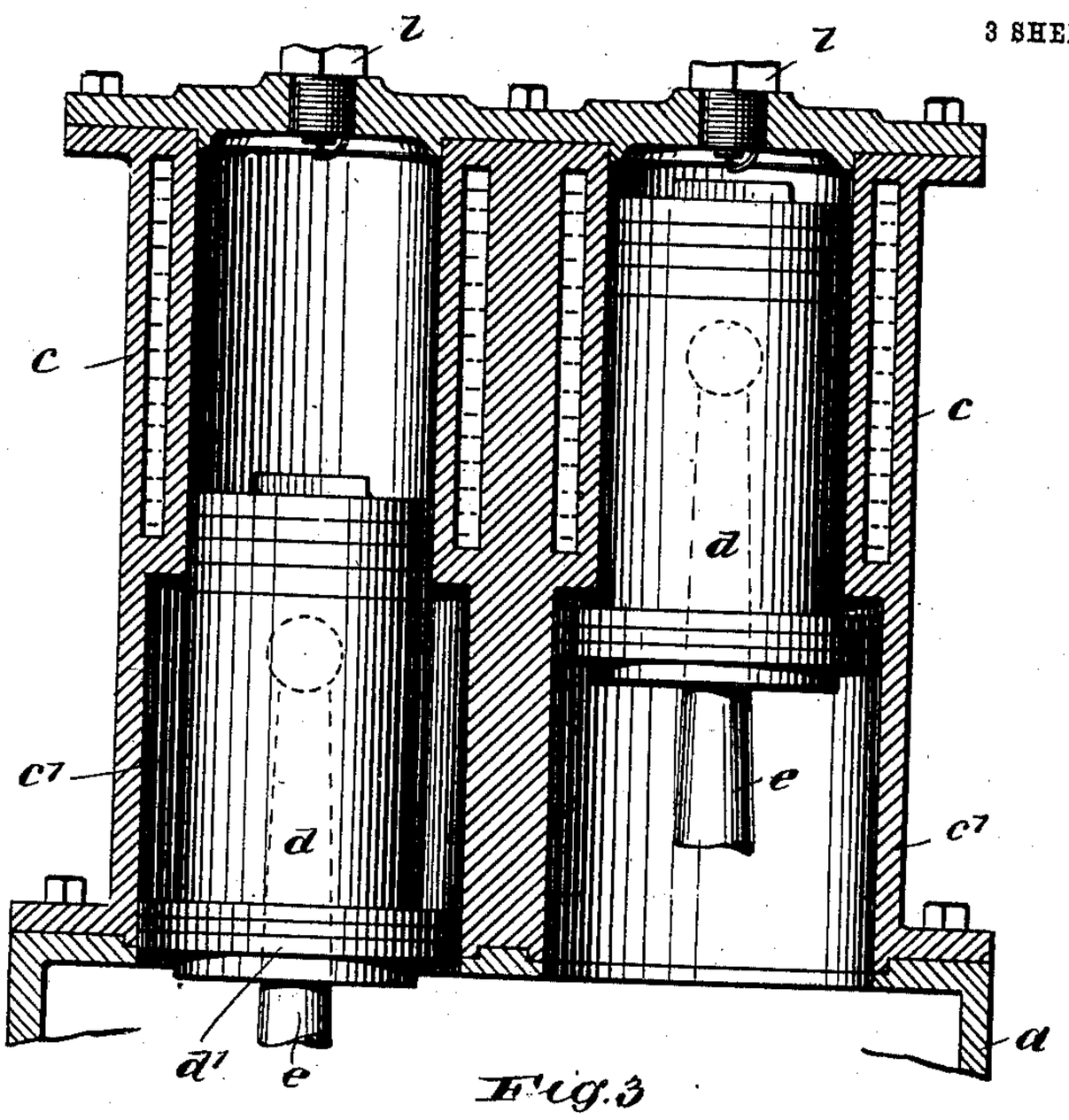

Fig. 3

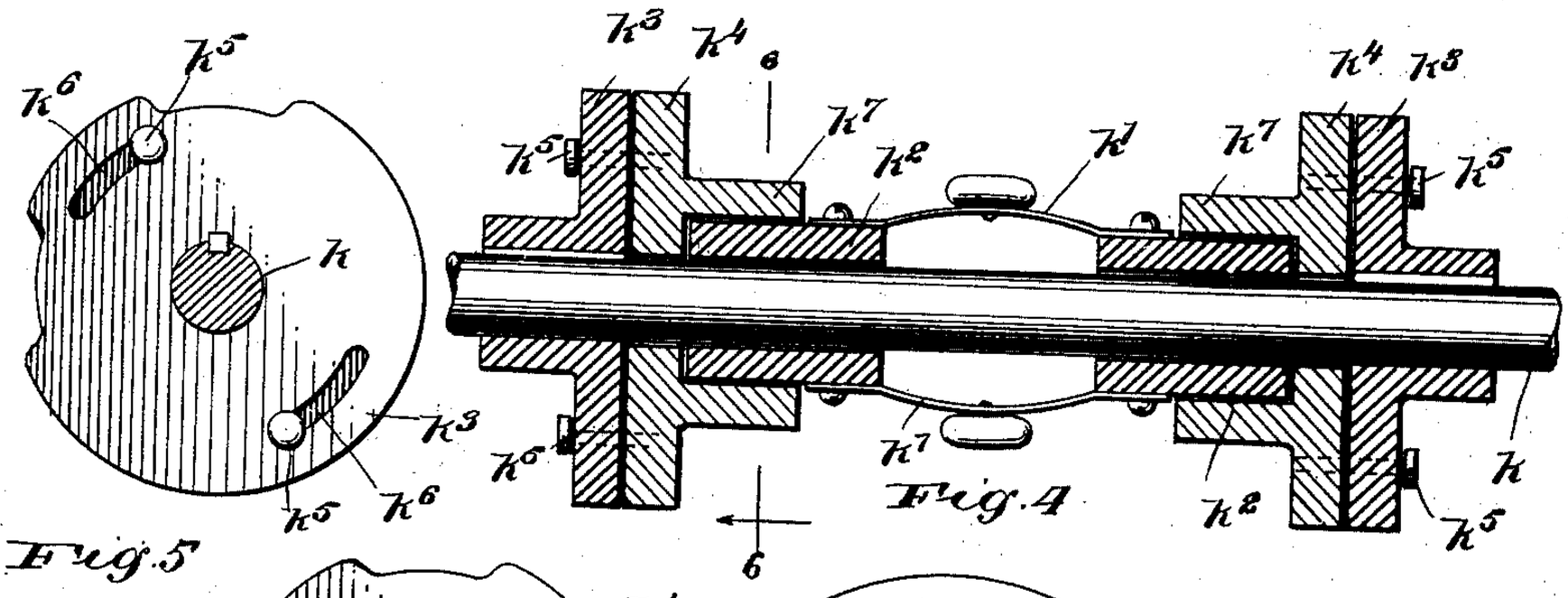

Fig. 5

Fig. 4

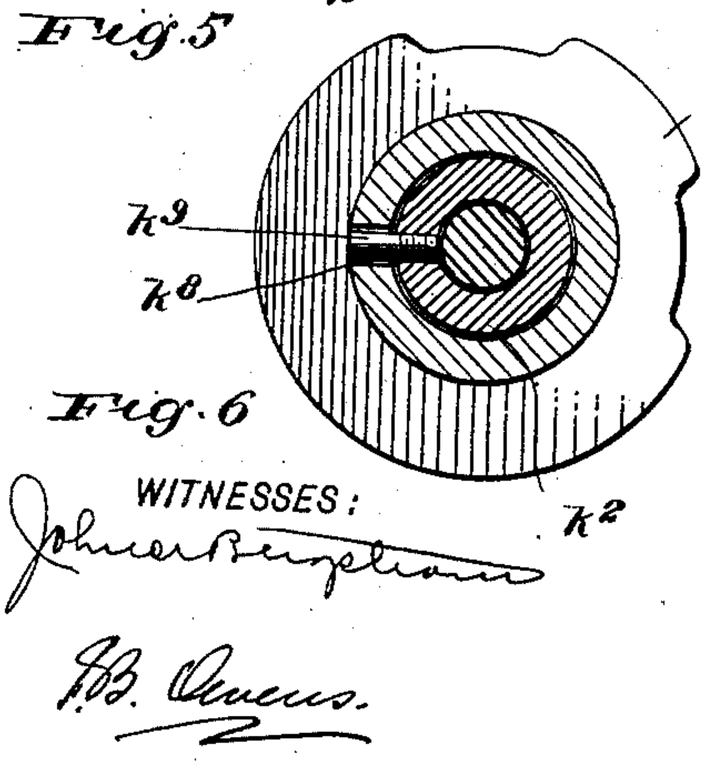

Fig. 6

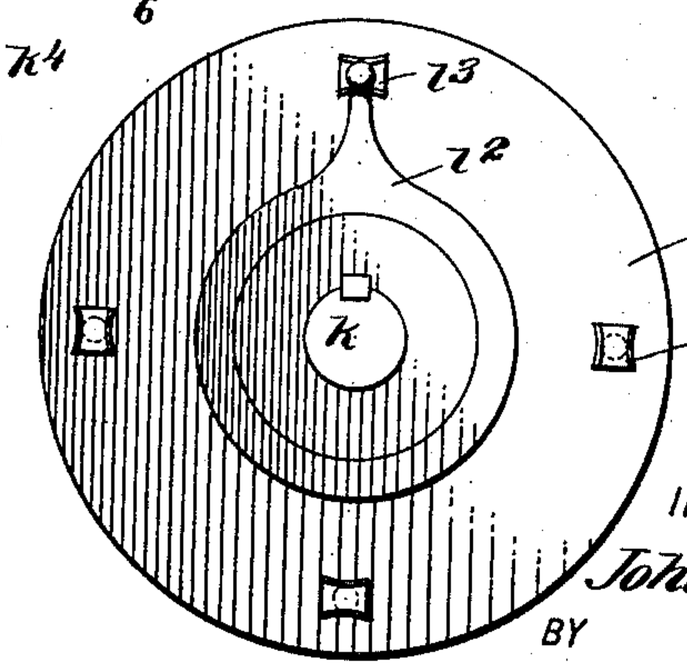

Fig. 7

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UNITED STATES PATENT OFFICE.

JOHN WILLOUGHBY, OF BROOKLYN, NEW YORK, ASSIGNOR OF ONE-HALF TO GEORGE W. BAYLEY, OF BROOKLYN, NEW YORK.

EXPLOSIVE-ENGINE.

SPECIFICATION forming part of Letters Patent No. 719,547, dated February 3, 1903.

Application filed March 26, 1901. Serial No. 52,924. (No model.)

To all whom it may concern:

Be it known that I, JOHN WILLOUGHBY, a citizen of the United States, and a resident of the city of New York, borough of Brooklyn, in the county of Kings and State of New York, have invented a new and Improved Explosive-Engine, of which the following is a full, clear, and exact description.

This invention relates to an explosive-engine which in its preferred form embodies a double crank-shaft to which are connected the rods of four pistons, these pistons working, respectively, in four cylinders, so as to give four impulses to the shaft during every revolution thereof. The engine also has a novel form of air-compressing means by which the products of combustion are swept out of the cylinders immediately prior to the introduction of the fuel, which latter operation is controlled by an automatically-governed cam working in time with the movement of the cam-shaft.

This specification is a specific description of one form of the invention, while the claims are definitions of the actual scope thereof.

Reference is to be had to the accompanying drawings, forming a part of this specification, in which similar characters of reference indicate corresponding parts in all the views.

Figure 1 is a sectional view of the invention on the line 1 1 of Fig. 2. Fig. 2 is an irregular section on the line 2 2 of Fig. 1. Fig. 3 is a section on the line 3 3 of Fig. 2. Fig. 4 is a detail section of the governor. Fig. 5 is an elevation of one of the governor-cams. Fig. 6 is a section on the line 6 6 of Fig. 4, and Fig. 7 is a detail view of the sparking device.

a indicates the crank-case or framing of the engine, and *b* indicates the crank-shaft, which is mounted therein and may, if desired, be fitted with a balance-wheel *b'*.

b^2 indicates the cranks on the shaft *b*. These cranks are two in number, and each crank has attached thereto two connecting-rods, as will be fully described hereinafter. The cylinders are four in number and are designated *c* in the drawings. These cylinders are arranged in pairs, two at each side of the crank-shaft, and said pairs of cylinders are disposed approximately at an angle of ninety degrees to each other.

d indicates the pistons, which are one for each cylinder and have the connecting-rods *e*, attached, respectively, thereto. The connecting-rods of the cylinders which are opposite each other are joined to the same crank b^2, and this is effected by forking one of the rods, as indicated at *e'*, and arranging the end of the other rod between the ends of the fork, all of such parts being connected to the wrist-pin of the crank, as best shown in Fig. 1. The cranks b^2 are set diametrically opposite each other, and by the arrangement of parts above described the pistons are caused to occupy the relative positions shown in the drawings—viz., when one position of each pair of coupled connecting-rods is in an extreme or end-of-stroke position, the other piston is at the middle of its stroke. Thus referring to Fig. 2 the left-hand piston (shown in full lines) is at the point of exhaust, or the limit of its outer stroke, and the right-hand piston (shown in full lines) is at the middle of the compression-stroke, assuming that the parts be moving in the directions of the arrows in said said view. Of the two pistons which are supposed to lie behind the pistons illustrated in Fig. 2 the left-hand piston (see the dotted lines) is at the limit of its inward stroke, or the point of ignition, and the right-hand piston (see the dotted lines) is at the middle of an impulse or expansive stroke. The result of this arrangement is that as all of the parts work in time and as the cylinders are all of the two-cycle type, as will be hereinafter set forth, four impulses are imparted to the crank-shaft for each revolution thereof.

f indicates the feed-ports of the cylinders, which are one for each, and *g* indicates the exhaust-ports, which open directly into the atmosphere. These ports are commanded by the pistons and are opened as the pistons reach the limit of their working strokes and closed at other periods. Each cylinder is formed in its lower portion with an air-chamber *c'*, and each piston has a packing-collar *d'* at its lower portion, such collars forming supplementary pistons. These collars or supplementary pistons *d'* work in the air-chambers *c* of the cylinders, and as the pistons move outward on the impulse air is drawn into the chambers *c'* through inwardly-open-

ing check-valves c^2. From the upper portions of the air-chambers c' passages c^3 lead to an air-reservoir h, these passages being commanded by check-valves h', opening into the air-reservoir and spring-pressed to their seats. As the pistons move upward on the compression-stroke the air is forced from the chamber c' through the passages c^3 into the reservoir h, and an air-pressure is here accumulated. Leading from the air-reservoir h are passages h^2, which communicate with the feed-ports f of the cylinders. As the pistons d move down to the end of their impulse-stroke the ports f are uncovered and air from the reservoir h rushes through the passages h^2 and into the cylinders, thus sweeping out therefrom the products of combustion. This sweeping course of the air is facilitated by the abutments d^2, formed on the pistons.

i represents the fuel-reservoirs, which may be one or two in number, as desired. As here shown they are two in number, each reservoir being related to two of the cylinders. These reservoirs are adapted to contain the liquid fuel under pressure. Any suitable means may be employed to communicate the necessary pressure to the fuel. I prefer to employ a main reservoir (not shown) and to lead thereto an air-pressure pipe from the reservoir h, this main fuel-reservoir having communication with the reservoirs i to feed them with fuel, by which arrangement the reservoirs i become the supplemental or local reservoirs. Leading from the reservoirs i are pipes i', which pass, respectively, into the passages h^2 at points adjacent to the feed-ports f of the cylinders and which are commanded by plug-valves i^2, pressed by springs i^3 into open position. (See the left-hand side of Fig. 2.)

k indicates the governor-shaft, which is geared with and to be suitably driven from the crank-shaft b. This shaft carries a centrifugal governor k', which may be of any construction desired. Such governor is connected with sleeves k^2, splined on the shaft k. Working with the sleeves k^2 are cams formed in two parts, (designated k^3 and k^4, respectively.) These parts of the cams are in the form of disks provided with peripheral notches, as shown best in Figs. 5 and 6. The sections k^3 of the cams are keyed fast to the shaft k, and the sections k^4 thereof are loose on the shafts, but are provided with guide-pins k^5, which fit loosely in concentric slots k^6, formed in the cam-sections k^3. Each cam-section k^4 is provided with a boss k^7, and these bosses fit loosely over the sleeves k^2. They are formed with diagonal slots k^8, in which are received loosely pins k^9, fastened to the sleeves k^2.

Normally the sections of the cam lie with their notches in transverse registry with each other. The springs i^3 of the valves i^2 tend to move the valves to open position, and this movement is normally arrested by the engagement of the rollers i^4 of the valves with the cams. As the cams turn with the shaft k and one of the notches is brought opposite a certain valve this notch will permit the spring i^3 to move the valve to open position. (See the left-hand side of Fig. 2.) Therefore as the shaft k turns the valves i^2 are periodically permitted to move back by the action of their springs i^3 and the feed-pipes i' are opened to supply the fuel to the cylinders. The cams have their notches so disposed that the valves are opened in the proper time, as will be understood by persons skilled in the art. When the speed of the engine runs too high, the action of the governor k' will slide the sleeves k^2 on the shaft k, and the action of the pins k^9 in the diagonal slots k^8 of the bosses k^7 on the cam-sections k^4 will impart to said cam-sections a rotary movement independent of that characteristic of the shaft k and cam-sections k^4, thus shifting the cam-sections with respect to each other. This shifting movement of the cam-sections will tend to throw the notches of said sections out of transverse registry, and since the rollers i^4 of the valves i^2 have sufficiently broad faces to bear on both sections of the cam when the notches are thrown out of registry the valves are permitted to stay open for a less period than when the notches are in registry. The greater the action of the governor the shorter will be the opening periods of the valves. Therefore when the speed of the engine becomes too great the governor will automatically regulate the cam to cut off the supply of fuel. The governor may of course be adjusted to suit the speed at which it is desired the engine shall run. Reference to Figs. 1, 2, and 4 will show that two cams each composed of two sections are mounted on the shaft k and that each cam operates two of the valves i^2, said valves being related, respectively, to the pistons which occupy opposite positions with respect to the crank-shaft.

Any suitable mechanism may be employed for igniting the charges. I prefer a jump sparking igniter, as indicated at l in the drawings. I have not illustrated the electrical circuits incident to this igniter, because they will be fully understood. The sparking device comprises on insulated disk l', fast to the framing of the engine adjacent to and concentric with the shaft k.

l^2 indicates an arm which is fastened on the shaft and turns therewith, this arm being insulated from the shaft. On the disk l' are four contacts l^3, arranged in quartered position and adapted to be alternately engaged by the arm l^2. The contacts l^3 are respectively related to the igniters l, and as the arm l^2 travels around with the shaft k the igniters are successively actuated to produce the spark, thus firing the charges in the proper succession. The parts l^2 and l^3 are in proper electrical connection with the parts l, as will be understood.

In the operation of the engine the blast of air is first introduced into the cylinder at the

exhaust period and the products of combustion blown out. Then the fuel is introduced in company with the blast of air and is diffused through the cylinder. The piston now returns and compresses the charge, ignition takes place, and the piston is driven forward. The cycle of operations is then repeated. No two pistons work on the same time, and consequently there is no dead-center of effort. The pistons work successively and an impulse is imparted to the shaft for every quarter-revolution thereof. This is due to the peculiar arrangement of the cranks and connecting-rods and the disposition of the cylinders with respect to each other and to the crank-shaft.

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

1. An explosive-engine having two cylinders arranged opposite and at an inclination to each other and provided with feed and exhaust ports, pistons therein, a crank-shaft and connecting-rods extending between the crank-shaft and the pistons, the said cylinders each having an air-chamber and the pistons having supplementary parts working in said air-chambers, to draw the air into said air-chambers and to force it therefrom, an air-reservoir connected with the air-chambers, and receiving compressed air therefrom, unobstructed passages leading from the air-reservoir in opposite directions and connected with the feed-ports of the respective cylinders, and a fuel-reservoir connected with the passages leading from the air-reservoir at a point adjacent to the cylinder feed-ports.

2. An explosive-engine having four cylinders arranged in pairs side by side and said pairs lying opposite and at an inclination to each other, the cylinders being provided with feed and exhaust ports, pistons in the cylinders, means for driving the same, each of said cylinders having an air-chamber, and the pistons each having a supplementary part working in the air-chamber, an air-reservoir located between the pairs of cylinders, valve-controlled passages leading from the upper part of the air-chambers to the said air-reservoir, unobstructed passages connecting the reservoir with the feed-ports of the several cylinders, a fuel-reservoir located above the air-reservoir, pipes connecting the fuel-reservoir with the passages leading from the air-reservoir to the cylinder feed-ports, valves spring-pressed to open position and commanding said pipes and a shaft extending between the pairs of cylinders and provided with means for normally holding the valves closed.

3. An explosive-engine having cylinders with feed and exhaust ports, the cylinders each having an air-chamber provided with a valve-controlled inlet, pistons working in the cylinders and each having a part working in the air-chamber to draw the air into the air-chamber and force it therefrom, an air-reservoir connected with the air-chambers and supplied with air under pressure therefrom, the said reservoir having free communication with the feed-ports of the cylinders, whereby upon the opening of the feed-port of a cylinder at the end of the working stroke a blast of air is introduced into the cylinder to clear the same of the products of combustion, a fuel-reservoir connected with the feed-ports, a valve commanding the fuel-supply, for each port, a spring adapted to open said valve, and means for normally holding said valve closed against the tension of the spring and arranged to permit the spring to act to open said valve immediately after the removal of the products of combustion to admit the fuel to the cylinder with the blast of air.

4. An explosive-engine, comprising cylinders with feed and exhaust ports, the cylinders each having an air-chamber, a piston working in each cylinder and having a supplementary part working in the air-chamber to draw the air into the air-chamber and force it therefrom, inwardly-opening valves commanding the air-inlets to said air-chambers, an air-reservoir connected by passages with the respective air-chambers and supplied with air under pressure from said chambers, valves opening into the air-reservoir and commanding said passages, open passages connecting said air-reservoir with the feed-ports of the respective cylinders, and means for supplying fuel under pressure and communicating with the passages leading from the air-reservoir at points adjacent to the feed-ports of the respective cylinders.

5. An explosive-engine having cylinders with feed and exhaust ports, the cylinders each having an air-chamber, a piston working in each cylinder and having a supplemental part working in the air-chamber, an air-reservoir connected by passages with the air-chambers and supplied with air under pressure therefrom, unobstructed passages connecting said air-reservoir with the feed-ports of the cylinders, and adapted to admit compressed air to a cylinder when the piston uncovers the feed and exhaust ports, thereby forcing out the products of combustion, a fuel-reservoir, pipes leading from the fuel-reservoir to the passages connecting the air-reservoir with the feed-ports, and communicating therewith at a point adjacent to the feed-ports, valves spring-pressed to open position and commanding the fuel-supply through said pipes, and mechanism normally holding the valves closed and arranged to permit each of said valves to open after the products of combustion are forced by the compressed air from the respective cylinders.

6. An explosive-engine, comprising cylinders with feed and exhaust ports, a compressed-air supply having unobstructed communication with the feed-ports of the cylinders, a source of fuel-supply under pressure, and also communicating with the feed-ports of the respective cylinders, plug-valves spring-pressed to open position and commanding the

fuel-supply to said feed-ports, rollers on the ends of the plug-valves, and a cam located between the rollers and engaging the same and normally holding the valves closed, the cam being arranged to permit the action of the springs to open the valves.

7. An explosive-engine having a cylinder with feed and exhaust ports in its sides, the cylinder having an air-chamber, a piston working in the cylinder and having a supplementary part working in the air-chamber, an air-reservoir located at one side of the cylinder and connected by a passage with the upper part of the air-chamber and supplied with air under pressure from said air-chamber, a valve opening into the air-reservoir and commanding said passage, an open passage connecting said reservoir with the feed-port of the cylinder and adapted to admit compressed air to the cylinder when the piston uncovers the feed and exhaust ports, a reservoir for fuel under pressure and located above the said air-reservoir, a pipe leading from the fuel-reservoir and communicating with the upper part of the passage leading from the air-reservoir at a point adjacent to the feed-port of the cylinder, and a valve commanding the fuel-supply and arranged to open after the products of combustion are forced by the compressed air from the cylinder.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

JOHN WILLOUGHBY.

Witnesses:
ROBERT W. BAYLEY,
WM. H. BEECHING.