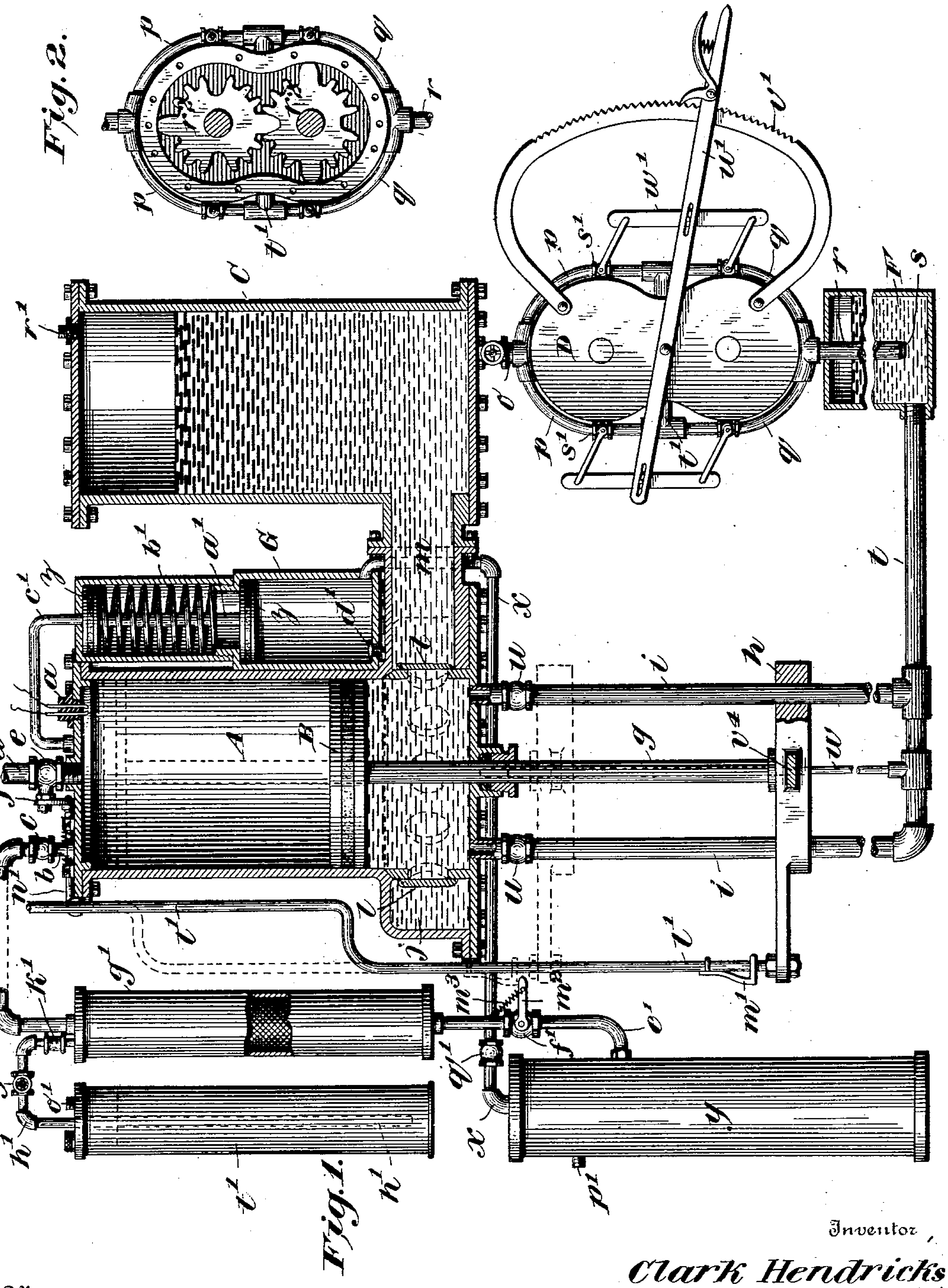
No. 714,180. Patented Nov. 25, 1902.

C. HENDRICKS.

INTERNAL COMBUSTION ENGINE.

(Application filed Dec. 11, 1901.)

(No Model.) 3 Sheets—Sheet 1.



Witnesses

Elmer Seavey

J. C. Glorius

Inventor,

Clark Hendricks,

By Davis & Davis,

Attorneys.

No. 714,180. Patented Nov. 25, 1902.

C. HENDRICKS.

INTERNAL COMBUSTION ENGINE.

(Application filed Dec. 11, 1901.)

(No Model.) 3 Sheets—Sheet 2.

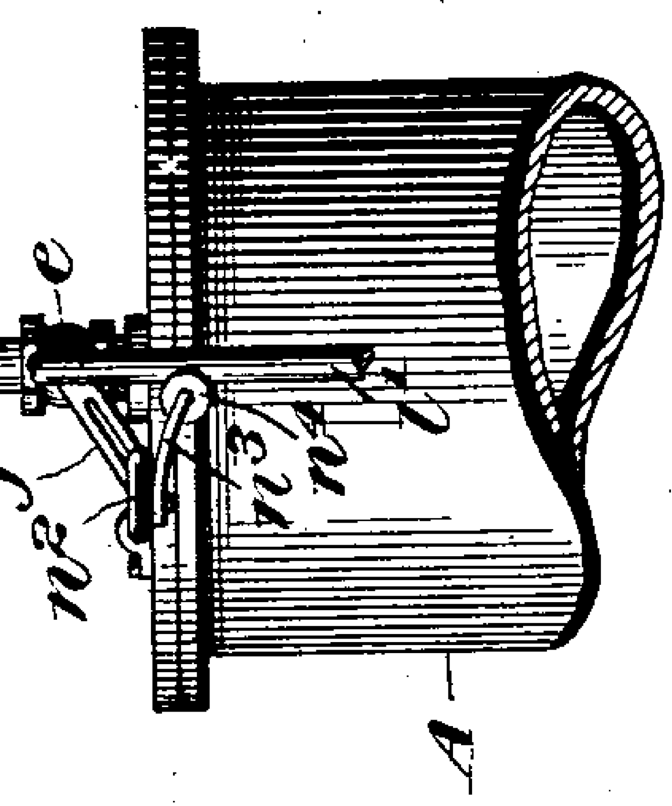


Fig. 5.

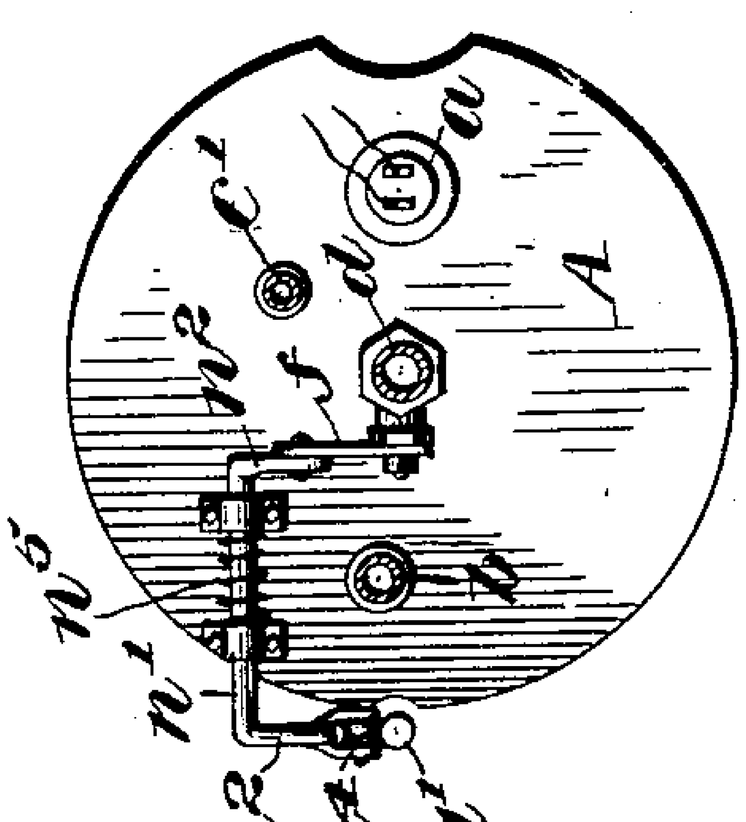


Fig. 6.

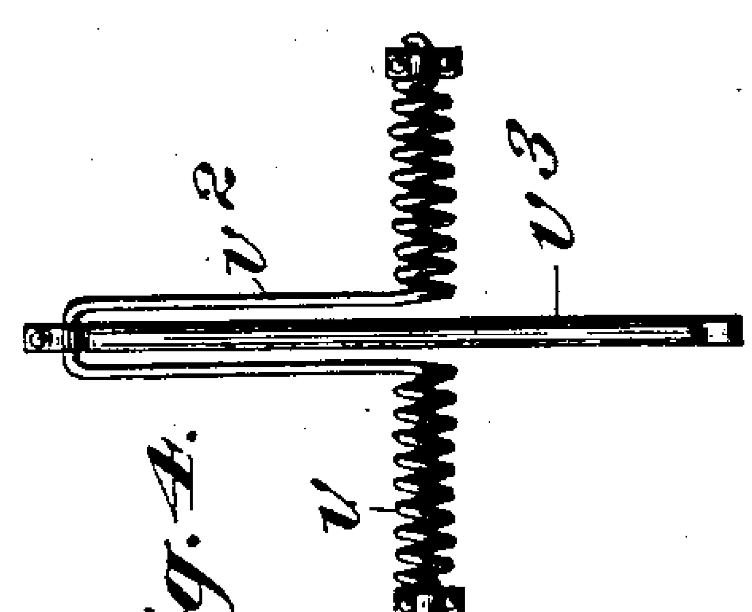


Fig. 4.

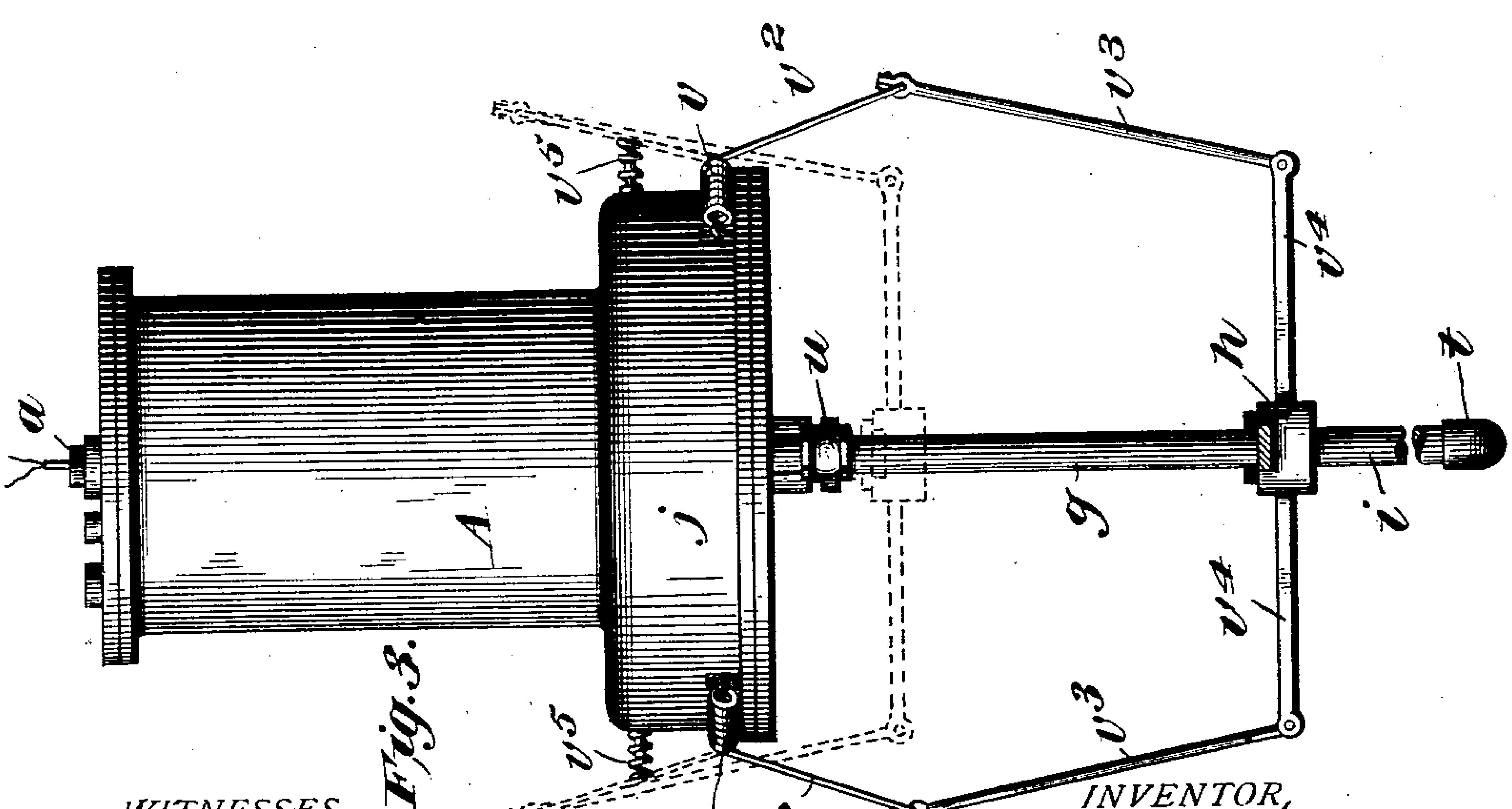


Fig. 3.

WITNESSES

Elmer Seavey

F. C. Glorius

INVENTOR,

Clark Hendricks,

Davis & Davis

Attorneys.

No. 714,180. Patented Nov. 25, 1902.

C. HENDRICKS.

INTERNAL COMBUSTION ENGINE.

(Application filed Dec. 11, 1901.)

(No Model.) 3 Sheets—Sheet 3.

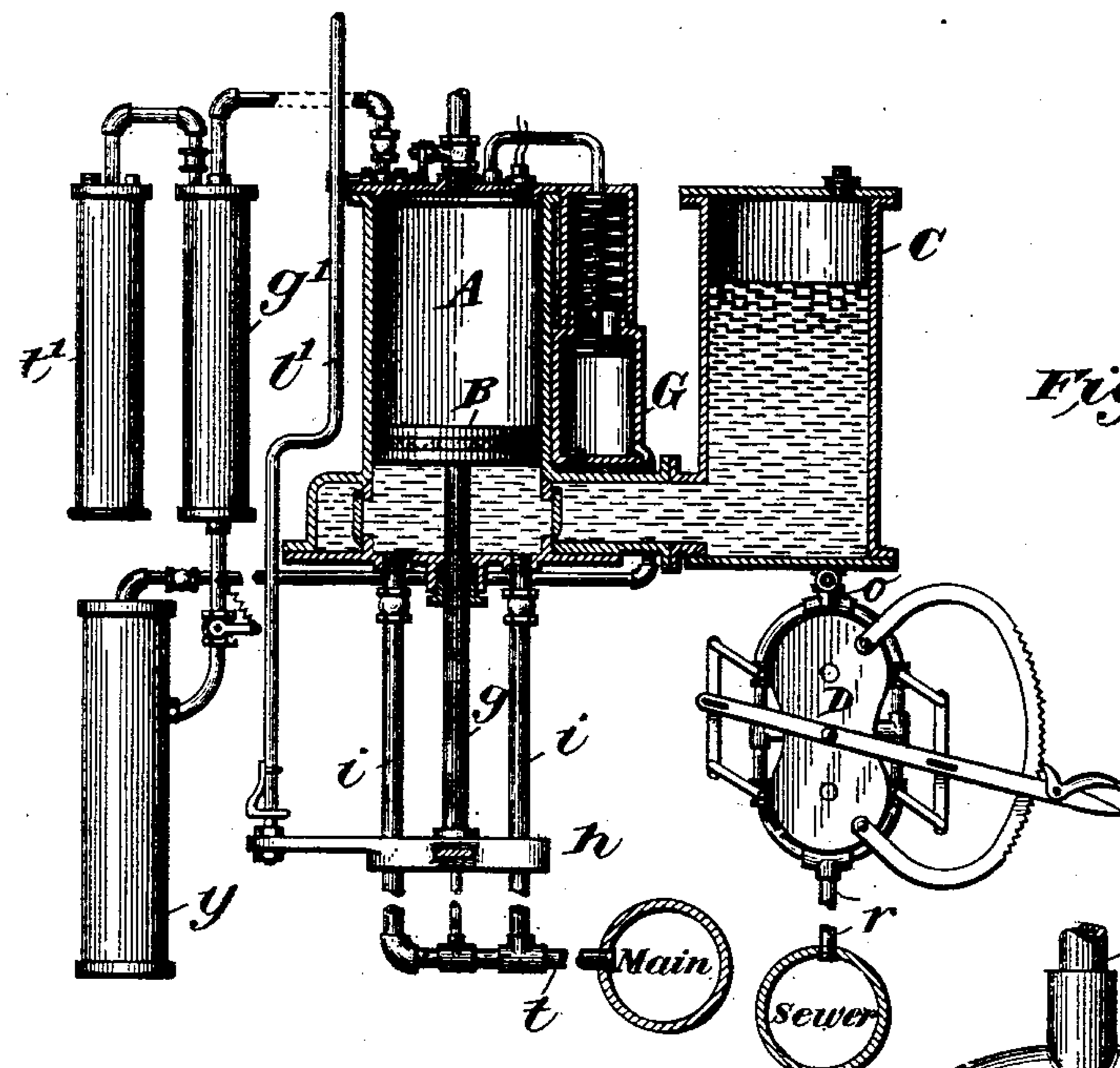


Fig. 7.

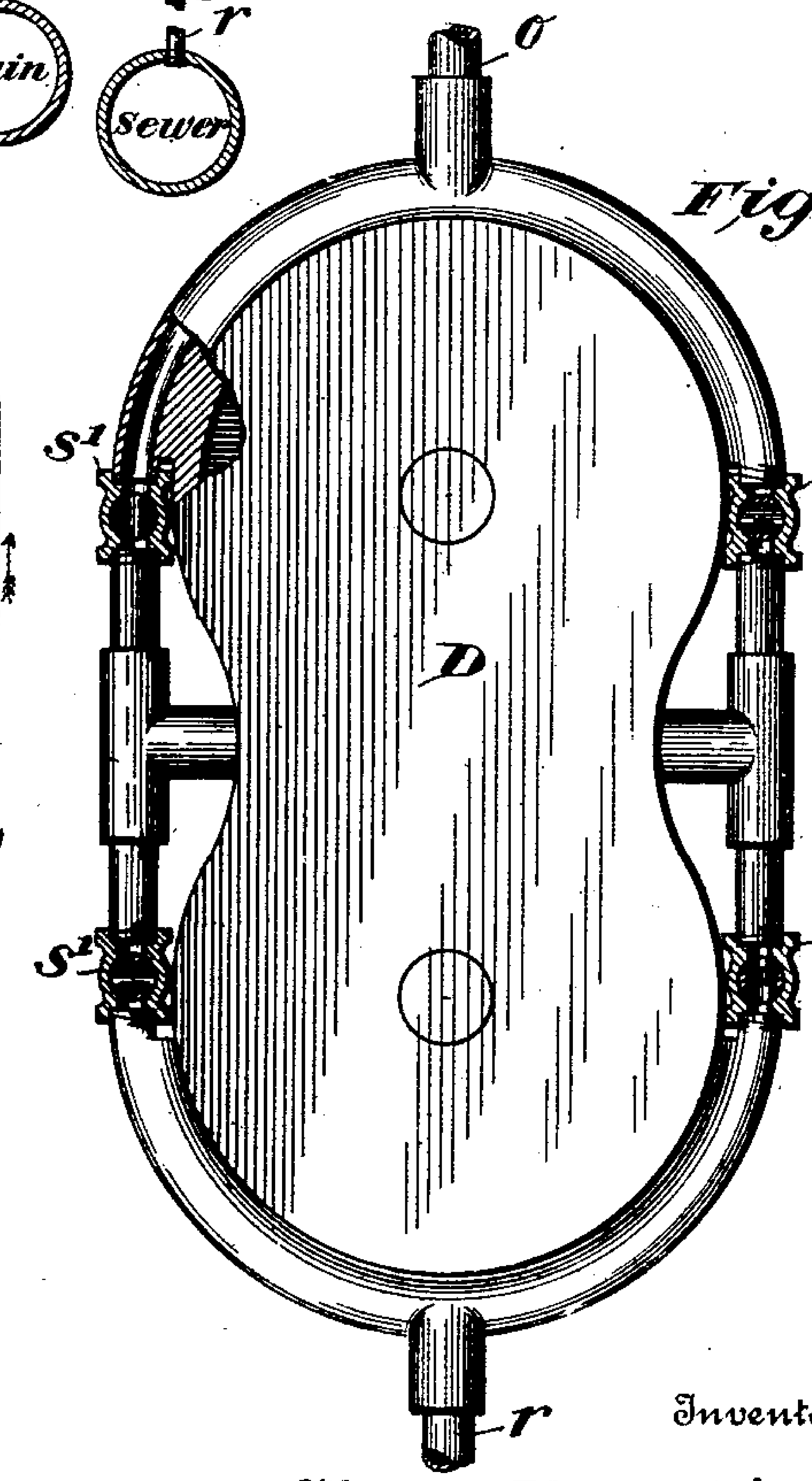


Fig. 9.

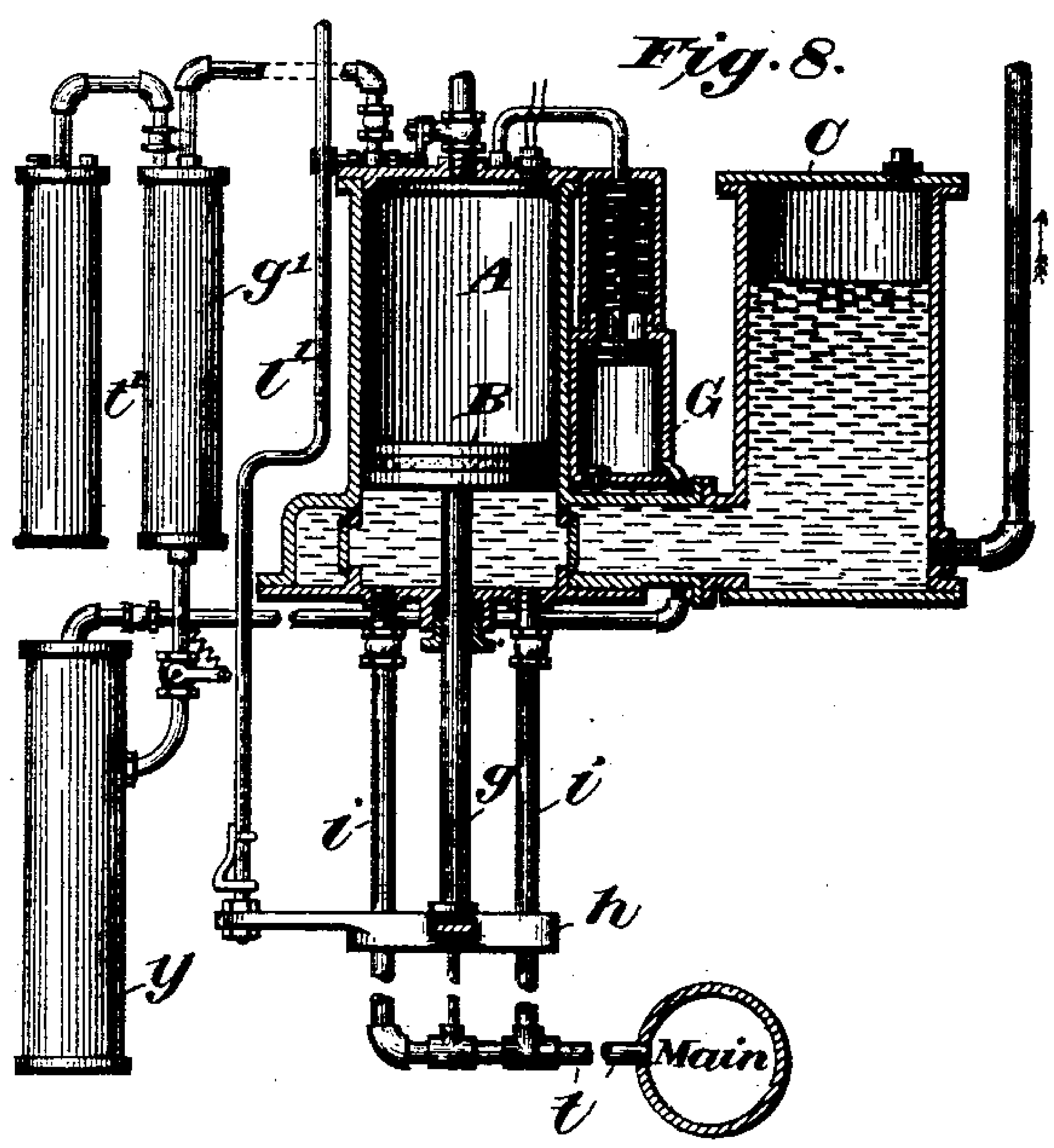


Fig. 8.

Witnesses:

Elmer Seavey

R. H. Bishop.

Inventor,

Clark Hendricks,

By Davis & Davis,

Attorneys

UNITED STATES PATENT OFFICE.

CLARK HENDRICKS, OF RIVERSIDE, CALIFORNIA.

INTERNAL-COMBUSTION ENGINE.

SPECIFICATION forming part of Letters Patent No. 714,180, dated November 25, 1902.

Application filed December 11, 1901. Serial No. 85,512. (No model.)

To all whom it may concern:

Be it known that I, CLARK HENDRICKS, a citizen of the United States of America, residing at Riverside, in the county of Riverside and State of California, have invented certain new and useful Improvements in Internal-Combustion Engines, of which the following is a specification, reference being had to the accompanying drawings, in which—

Figure 1 is a view, partly in side elevation and partly in section, of an apparatus embodying one form of my invention; Fig. 2, a detail section of the hydraulic motor I prefer employing, and Fig. 3 a side elevation showing the arrangement for automatically returning the power-piston after each working stroke. Figs. 4, 5, and 6 are views of details hereinafter described; Figs. 7 and 8, views similar to Fig. 1, showing modifications; and Fig. 9 a detail view of the motor, showing a slight modification.

This invention relates to improvements in internal-combustion engines of the explosive type, in which the power is derived from a suitable inflammable mixture of air and gas or vapor exploded in the power-cylinder; but it differs from the ordinary gas or vapor engine in that the explosive force resulting from the sudden burning or consumption of the vapor or mixture is not applied through the piston-rod directly to a crank-shaft or other mechanical power transmitting or translating devices, but is applied indirectly thereto through the medium of a body of water or other non-compressible liquid, which is set and maintained in motion by the explosion of the mixture, as more fully hereinafter set forth.

In one form my invention contemplates the employment of a closed water circuit or system having included in it a suitable hydraulic motor, preferably of the rotary type or of any well-known form of rotary pump, and a power-cylinder containing a slidable piston dividing it into two parts, one end or part constituting a compression-chamber and forming a portion of the water-circuit and the other end constituting an explosion-chamber into which the explosive mixture is admitted in suitable charges and at intervals and exploded, the arrangement being such that the explosion of the mixture in the cylinder will force the power-transmitting liquid from the compression end of the cylinder into the water-circuit and thence into an air-chamber connected to the circuit and thence in an unbroken stream through the circuit or system of piping and the motor, and thereby impart to the latter a continuous rotary motion which may be utilized as a source of mechanical power, the power liquid passing through the motor and along in the circuit and back again into the compression end of the power-cylinder, to be thence forced out again through the air-chamber and motor. Suitable check-valves are employed to maintain a uniform direction in the flow of the liquid, and suitable air-chambers are provided at different points to resist the shocks incident to the explosion and equalize the pressure throughout the system and at different points in the cycle. A double by-pass around the motor or pump provided with proper valves or cocks is also contemplated for enabling the flow of liquid through the motor to be readily reversed, so as to reverse the motor and also to stop the revolutions thereof without stopping the explosions in the cylinder.

In its preferred form my invention further contemplates the employment of one or more air-pumps to be operated by the same explosions that drive the power-piston, the object of this air-pump being to maintain the pressure in a suitable air-tank, which latter is to be utilized for charging the explosion-chamber of the main cylider with explosive mixture, suitable vessels being connected thereto for holding the gasolene or other inflammable liquid and for mixing the compressed air with the inflammable vapor on its way to the explosion-chamber, and suitable valves and cocks and automatic devices being provided to control the flow of air and vapor from their respective receptacles through the mixer and to the explosion-chamber. Suitable automatic igniting and exhausting devices are also employed.

The invention in its preferred form further contemplates the employment of suitable means for accomplishing the return stroke of the piston after the explosive force is spent, thereby not only expelling the spent gases, but also drawing into the lower or water end of the power-cylinder a quantity of the power liquid which is to be afterward expelled from the cylinder by the next succeeding explosion and forced onward to the air-chamber, as more fully hereinafter set forth.

This invention has other minor objects in view which will appear in the course of this specification.

In the drawings, the reference-letter A designates the power-cylinder, to the upper or forward end of which is connected a suitable igniter *a*, which may be of any ordinary or approved construction and which may be operated automatically from a suitable moving part of the engine. To the same end of the cylinder is connected the inlet-pipe *b*, adapted to convey the explosive mixture to the explosion-chamber of the cylinder and provided with an inwardly-opening check-valve *c*. An exhaust-pipe *d* is also connected to this end of the cylinder, and in this exhaust-pipe is placed a suitable exhaust-valve *e*, whose stem is provided with an arm *f*. Working in the cylinder is the power-piston B, which separates the explosion-chamber from the liquid end of the cylinder, said piston being provided with a piston-rod *g*, which extends out through the lower or outer head of the cylinder and is connected to a cross-head *h*, which slides upon a pair of parallel pipes *i*, connected to the water-space of the lower end of the cylinder and forming a part of the water-circuit. Formed around the lower end of the power-cylinder is a suitable conduit *j*, which has free communication with the interior of the cylinder through a series of openings normally closed by outward-opening valves *l*. At one side this conduit is connected to a lateral passage or conduit *m*, which connects with the water-space of an air-chamber C. A pipe *o*, provided with a suitable regulating-valve, connects the water-space of this air-chamber with induction-pipes *p* of a rotary hydraulic motor D, and the eduction-pipes *q* of this motor are connected to a pipe *r*, which depends into the water-space of an auxiliary air-chamber F and is provided at its lower end with an outward-opening check-valve *s*. From the water-space of the chamber F extends a pipe *t*, which is connected to the lower ends of the parallel pipes *i*. The pipes *i* are each provided with an upward-opening check-valve *u*. Suitable spring-actuated devices (shown in Fig. 3) are connected to the cross-head to automatically return the piston B and expel the burned gases, and, if desired, the piston-rod may be formed hollow, and a guide-rod *w*, suitably supported, may be arranged to work therein, and thereby serve to assist in guiding the cross-heads and connected parts.

An air-pump G is arranged adjacent to the power-cylinder and has its eduction-pipe *x* connected to an auxiliary air-tank *y*. This pump is preferably constructed of two cylinders of different sizes and connected together end to end, a piston *z* working in each cylinder and connected by a rod *a'* and a spring *b'* being arranged in the upper cylinder to return the pistons after each stroke. The upper smaller cylinder is connected by a pipe *c'* to the explosion-chamber of the power-cylinder, whereby a sufficient portion of the power generated by each explosion will be carried over and applied to the upper one of the pistons *z* to force the same and its connected piston downward and expel the air contained in the lower cylinder out into tank *y*. Upon each upward stroke of the pistons *z* the burned gases, which are carried over into the upper cylinder by the explosion, are expelled and a new charge of air is drawn into the lower cylinder through the inlet *d'*, which is controlled by a suitable inward-opening check-valve. In this way a high pressure is maintained in tank *y*, and but a small part of the power of the explosion mixture is employed for this purpose.

The eduction-pipe *e'* is provided with a valve *f'* and is connected to a mixing tank or vessel *g'*, containing wire-gauze or other material, and this mixing-chamber is connected at its opposite end to the inlet-pipe *b*. The mixing-chamber *g'* is connected at its top by means of a pipe *h'* to a tank *i'*, containing gasolene or other volatile inflammable liquid, this pipe *h'* depending to near the bottom of the tank, so as to be always submerged in the gasolene. The pipe *h'* is provided with a suitable globe-valve *j'* and a suitable sight-feed *k'*. To open and close the exhaust-valve *e* and the inlet-valve *f'*, I employ a valve-rod *l'*, connected to the cross-head, and suitable coöperating devices. An adjustable spring-actuated tappet *m'* is attached to the rod near the cross-head for the purpose of opening the air-valve *f'*. The valve *f'* is provided with a lateral arm m^2, attached to its stem, which arm projects laterally into the path of the tappet *m'*. A spring m^3 is connected to arm m^2 to normally hold the valve closed. Upon the upward stroke of rod *l'* tappet *m'* is forced toward rod *l'*, so as to pass arm m^2; but upon the downward stroke of rod *l'* the abrupt lower end of the tappet engages arm m^2 and opens the valve and holds it open during a portion of the downward stroke of the piston. To operate the exhaust-valve, I employ a short rock-shaft *n'*, journaled on top of the cylinder A and provided with a short lateral arm n^2 at each end, the inner one of which is connected to the arm *f* of the exhaust-valve and the outer one of which terminates adjacent to the rod *l'*. Attached to the under side of the outer one of the arms n^2 is a flat spring n^3, which is provided with a roller n^4 at its free end, which bears against and tracks on rod *l'*. When the rod *l'* descends, the spring n^3 and its connected arm n^2 are forced downward and the exhaust-valve is closed, and when the rod *l'* ascends the spring n^3 will be forced upward against arm n^2 and cause a sufficient binding action to rock-shaft *n'* and open the exhaust-valve, as is obvious. It will be seen that by making the tappet *m'* adjustable the air-valve may be opened at any point in the downstroke of the valve-rod and that by means of the rock-shaft n' and connected parts the exhaust-valve will be normally held closed while the rod l' is descending and will be automatically opened the instant the valve-rod begins to move upward. Thus providing means for the opening of the exhaust-valve the instant the expulsion stroke of the piston begins is peculiarly advantageous in an engine of this class, for the reason that the length of the stroke is variable, depending as it does upon the pressure in tank C and upon other minor conditions. To insure the exhaust-valve being closed at all times except while the power-piston is moving upward, I may employ a torsion-spring n^5 on rock-shaft n', as shown in Fig. 6.

To automatically return the power-piston after each working stroke, I preferably employ the devices shown in Figs. 3 and 4, which consist, essentially, of two torsional springs v, mounted upon opposite sides of the conduit j and each having an elongated loop or arm v^2 formed in it about midway its length and projecting laterally from it at substantially a right angle to the spring. Connected to the outer end of each of the arms v^2 is rod v^3, which at its lower end is pivotally connected to a lateral arm v^4, carried by the cross-head h. The torsional action of springs v normally throws arms v^2 upward and inward toward the opposite sides of cylinder A, and thereby draws up the cross-head. To form a buffer against which each arm v strikes when it is drawn upward, a coil-spring v^5 is mounted on a pin projecting laterally from the conduit j above the spring v. These springs v^5 not only serve to cushion the action of arms v^2, but also serve to throw out arms v^2 upon their recoil, and thereby assist in starting the power-piston downward, thus insuring the closing of the exhaust-valve and the opening of the air-valve.

Suitable pressure and water gages may of course be attached to the various tanks and vessels, these parts being omitted from the drawings, as they form no part of the present invention.

To prepare the apparatus for operation, gasolene or other volatile explosive liquid is poured into tank i' through a suitable filling-opening and the air in the top of said tank is compressed sufficiently to force the liquid up through pipe h' into the mixing-chamber g', the quantity being regulated by valve j' and the pressure being obtained by a suitable hand-pump, which may be connected to a nipple o'. A hand-pump is also connected to a nipple p' of tank y and operated sufficiently to obtain a starting pressure in said tank, the air being prevented from escaping from this tank by a check-valve q' and by the closed outlet-valve f'. Water or other non-compressible liquid that is to be employed to transmit the power to the pump is poured into tank C through a suitable filling-opening r'. To start the motor, it is then simply necessary to open valve j' and when sufficient gasolene has been forced over into the mixing-chamber open inlet-valve f' by hand, whereupon the air from tank y will be forced up through the mixing-chamber, where it will be carbureted, and into the explosion-chamber of the engine. Thus admitting the explosive mixture under pressure into the cylinder will be sufficient to force piston B downward against the action of its springs v, and when it has reached a predetermined point the inlet-valve is closed and the charge automatically ignited, whereupon the piston will continue to descend to near the bottom of the cylinder, and thereby force the power liquid out into the air-chamber C. When the force of the explosion is spent, the piston B will be automatically returned by springs v and the spent gases will be forced out, and with the closing of the exhaust-valve the inlet-valve will be automatically opened and the operation just described will be repeated. The return of the power-piston draws into the lower end of the cylinder a quantity of water from tank F, and this water is again forced out into the air-chamber C, and so on as long as the explosions are kept up. By the employment of the air-chamber C the shocks of the explosion are neutralized, the power is accumulated, and a continuous stream of water is caused to pass to and through the motor, thus maintaining a constant supply of power to the power mechanism connected to the motor and doing away with the necessity of a balance-wheel and the usual crank-shafts.

If the tank F be closed, as it is preferred to have it, it will form an auxiliary air-chamber and not only serve to take up the jar or shock, but will also assist in raising the power-piston through the medium of the power liquid, as is evident. As has been set forth, the pressure in tank y will be maintained by the air-pump G, which will be operated with each explosion.

Any suitable motor may be employed; but I prefer the rotary motor shown most clearly in Fig. 2, in which is employed a pair of interlocking gears or pistons r^2, inclosed in a casing closed on all sides except where the inlet and outlet pipes are connected, the shafts of said pistons being geared together, if desired, and connected to the machinery to be operated in any suitable way outside of the casing. These rotary pistons are provided upon their peripheries at regular intervals with large teeth or cogs and with notches or recesses on each side of each tooth for the reception of the teeth or cogs of the opposite piston, as is well known. It will be observed that I employ two induction-pipes p, which embrace the motor and connect, respectively, with similarly-arranged eduction-pipes q, and that each branch of the induction and the eduction pipes is provided with a valve or cock s'. At a point between each pair of valves the connected ends of the induction and eduction pipes are connected to the motor by a short inward-extending conduit or port t'. It will be observed, therefore, that by properly adjusting these valves or cocks the power liquid may be caused to pass around the pipes without entering the motor, thereby stopping the motor without necessitating the stopping of the explosions, and that the liquid may be directed into the motor from either side, whereby the motor may be run in either direction and may be readily reversed without interruption in the movement of the power liquid or the engine proper. To shift the valves, any suitable devices may be employed. In the drawings I have shown a hand-lever u', pivoted at a point between its ends to the center of the motor-casing and provided with a spring-pawl adapted to engage a stationary rack v' and hold the lever in its adjusted position, the lever being connected to the valves by a pair of links w', pivoted to it at points equidistant from its pivotal point and pivotally connected at their ends to suitable arms attached to the stems of the respective valves. With this arrangement when the lever is at center all the valves will be open and the liquid may pass freely around the motor without entering its casing, and when it is shifted to an oblique position one of the induction-valves and the diagonally opposite eduction-valve will be opened and the remaining two valves will be closed, thereby directing the power liquid into one side or the other of the casing, according to which position the lever is adjusted, and causing it to emerge from the opposite side.

It will be observed that my apparatus utilizes the combined advantages of a gas or hydrocarbon-vapor engine and a hydraulic rotary engine or motor, is readily reversible, and produces a uniform movement of the rotating shafts, since while the actuating impulses due to the explosion of the successive charges of gas are intermittent and severe the cushioning tendency of the air-chamber interposed in the water-circuit results in an approximately uniform velocity. A further important advantage is that the usual crank-shaft and fly-wheel are avoided, thereby permitting me to obtain and utilize a greater percentage of power from the fuel employed than is possible with the common form of explosive-engine.

It will of course be understood that various changes may be made in the details of the apparatus without involving any departure from the broad principles of the invention involved or sacrificing any of the advantages thereof or voiding the appended claims, and I therefore reserve to myself the right to make such changes as fairly fall within the scope of my invention. For instance, the induction and eduction pipes of the motor may be formed integral with the casing, as shown in Fig. 9.

Instead of applying my invention to the closed power-circuit shown it is possible to employ it in connection with open or broken circuit where a convenient and sufficient head of water is obtainable, in which case the pipe t will be connected with the water source and pipe r or chamber F with a waste-conduit, as shown in Fig. 7. The closed-circuit apparatus is desirable where the engine is employed for motor-vehicles, launches, &c., while the open-circuit apparatus may be employed in connection with stationary engines, as is evident.

It will be observed, further, that without departing from the spirit of this invention the motor D and chamber F may be omitted and the apparatus employed for pumping water, as shown in Fig. 8, in which capacity it will be especially valuable as a simple and economic apparatus for draining mines, &c., and for hydraulic mining.

Having thus fully described my invention, what I claim, and desire to obtain by Letters Patent, is—

1. In combination, a power-cylinder having an igniter and also inlet and outlet ports at one end, means for supplying an explosive mixture to said inlet-port, a conduit for a power liquid connected to the other end of the cylinder, a valve or valves between this conduit and the cylinder, a valved supply pipe or pipes connected to the end of the cylinder adjacent to the said conduit, an air-chamber connected to said conduit, a sliding power-piston in the cylinder provided with a piston-rod working through the cylinder-head at the liquid end of the cylinder, and means connected to this piston-rod for automatically controlling the gas supply and exhaust devices, for the purpose set forth.

2. In combination, a power-cylinder, a sliding piston therein, converting one end of the cylinder into an explosion-chamber and its other end into a liquid-chamber, means connected to the explosion-chamber for supplying and igniting and exhausting the gases, a piston-rod connected to the piston and working through the head thereof at the liquid end of the cylinder, means connected to this piston-rod for controlling the gas-supply and exhaust devices, means for supplying a power liquid to the liquid end of the cylinder, a conduit connected to the liquid end of the cylinder and separated therefrom by an outward-opening valve or valves, an air-chamber connected to the conduit, and a motor connected to the liquid-space of the air-chamber.

3. In combination, a power-cylinder, igniting and gas supplying and exhausting devices connected to the explosion end thereof, a piston working in the cylinder, a piston-rod working through the opposite head of the cylinder, a valved pipe or pipes adapted to convey liquid to the liquid end of the cylinder, a conduit connected to the liquid end of the cylinder and separated therefrom by a check valve or valves, an air-chamber connected to said conduit, a motor connected to the liquid-

space of said air-chamber, a reservoir connected to the eduction-pipe of the motor, and a return-pipe connecting this reservoir to the aforesaid valved supply-pipes, and means for automatically operating the gas supply and exhaust devices from said piston-rod.

4. In combination, a power-cylinder, a sliding piston working therein and provided with a piston-rod working through one head of the cylinder, an igniter, gas supply and exhaust devices connected to the explosion end of said cylinder, an air-tank connected to said supply-pipe, carbureting or mixing devices, an air-pump having its power end connected to the explosion-chamber of the power-cylinder and its eduction end connected to said air-tank by a valved pipe, a liquid-conduit connected to the end of the cylinder in which the piston-rod works and separated therefrom by a check valve or valves, a valved pipe or pipes adapted to convey liquid to the liquid end of the cylinder, and means connected to the piston-rod for automatically operating the supply and exhaust devices therefrom.

5. In combination, a power-cylinder, means for igniting and supplying and exhausting the gases, a sliding piston in the cylinder provided with a piston-rod working through the cylinder-head opposite the explosion-chamber, a valved supply pipe or pipes adapted to convey liquid to this latter end of the cylinder, a conduit connected to the same end of the cylinder and separated therefrom by an outward-opening valve or valves, and resilient devices for automatically returning the piston after each working stroke, for the purposes set forth.

6. In an engine of the class described, the combination, of a power-cylinder, means for admitting and igniting an explosive mixture, an igniter, a piston and piston-rod, means for supplying water to one end of the cylinder, a valved conduit leading from the same end of the cylinder, a piston-rod connected to the piston and working through the liquid end of the cylinder and means for returning the piston and piston-rod after each stroke.

7. In an internal-combustion engine, the combination of a cylinder, a piston and piston-rod having a variable stroke, a valve-rod actuated from the piston-rod, an igniter, supply and exhaust valves, means for opening the supply-valves, and means for automatically opening the exhaust-valves at the beginning of the expulsion or return stroke of the piston, said means consisting essentially of a rock-shaft, means for connecting it at one end to the exhaust-valve, and a resilient roller-carrying arm at the other end of the rock-shaft adapted to resiliently engage the valve-rod, for the purposes set forth.

In testimony whereof I hereunto affix my signature, in the presence of two witnesses, this 4th day of December, 1901.

CLARK HENDRICKS.

Witnesses:

J. HARVEY ELLIS,

WM. STUDABECKER.