No. 668,075. Patented Feb. 12, 1901.

W. O. WORTH.

# PISTON FOR EXPLOSIVE ENGINES.

(Application filed Apr. 9, 1900.)

(No Model.) 3 Sheets—Sheet 1.

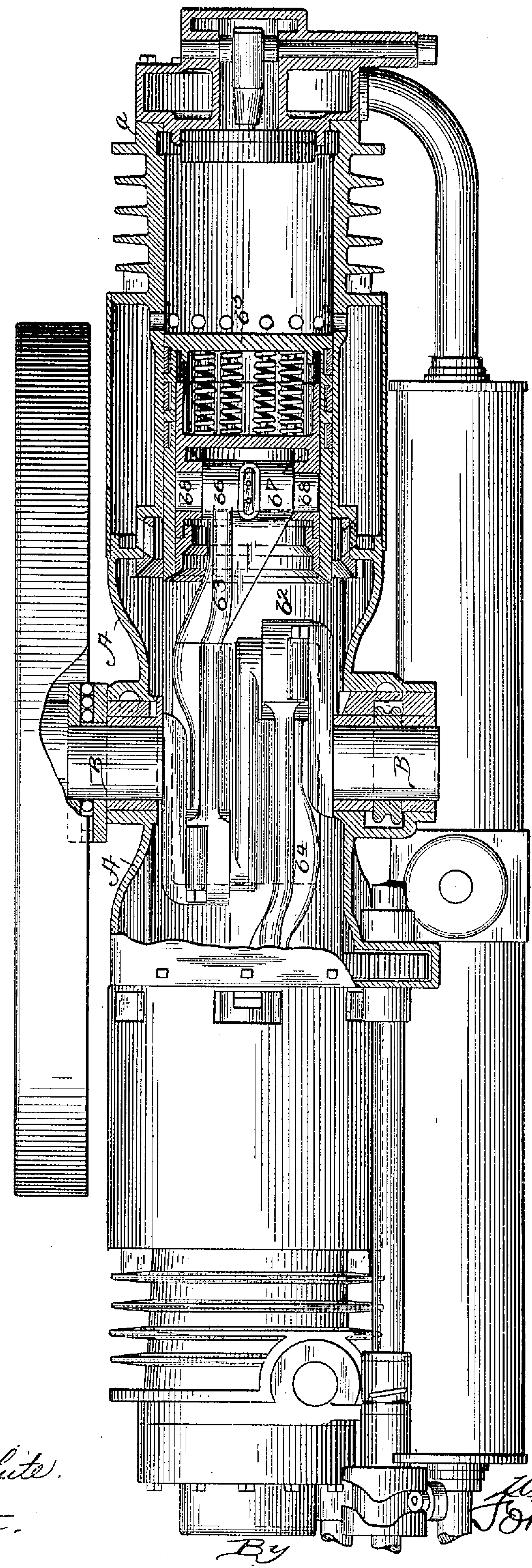

Fig. 1.

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3 Sheets—Sheet 2.

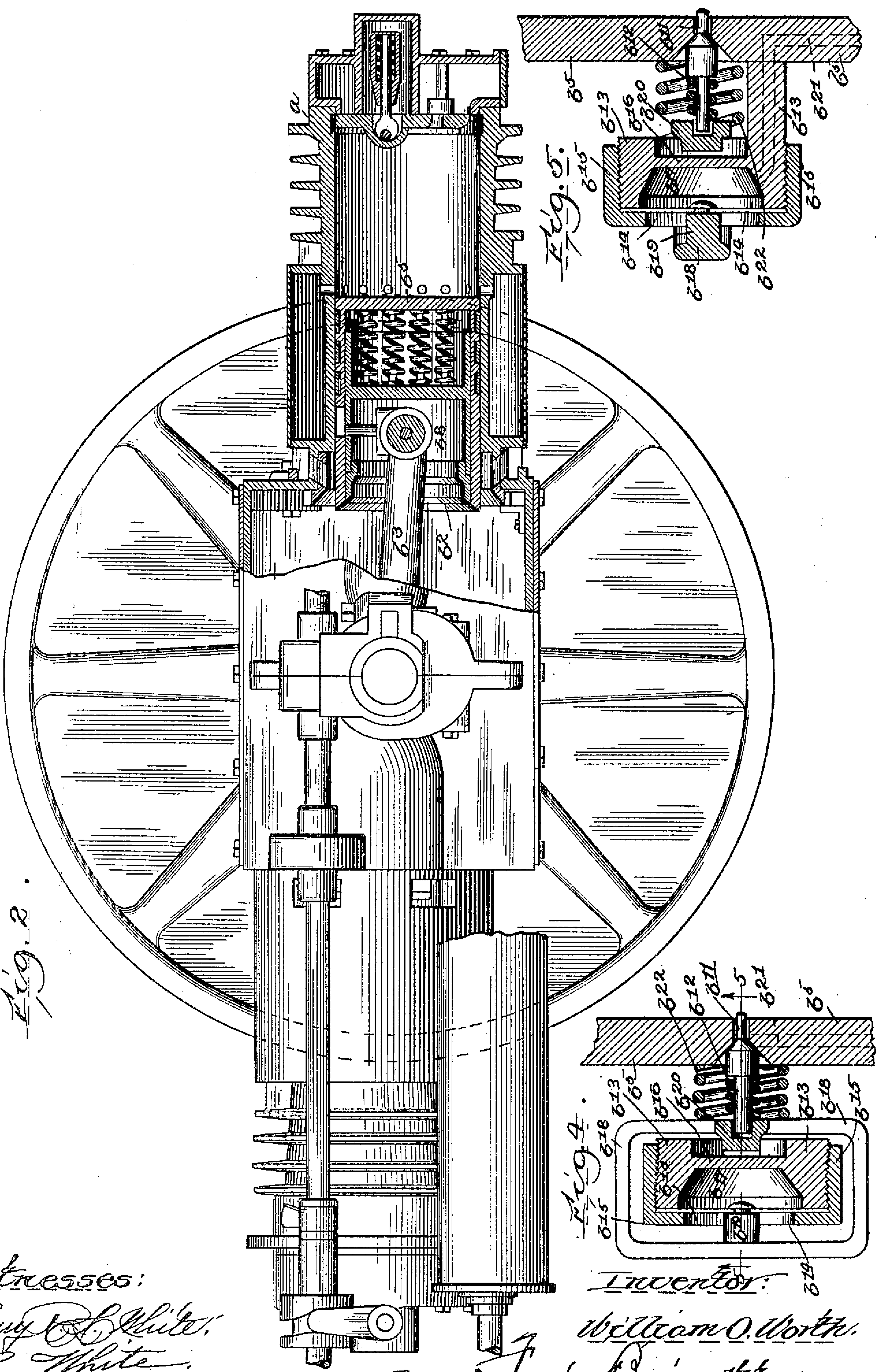

Fig. 2.

Fig. 5.

Fig. 4.

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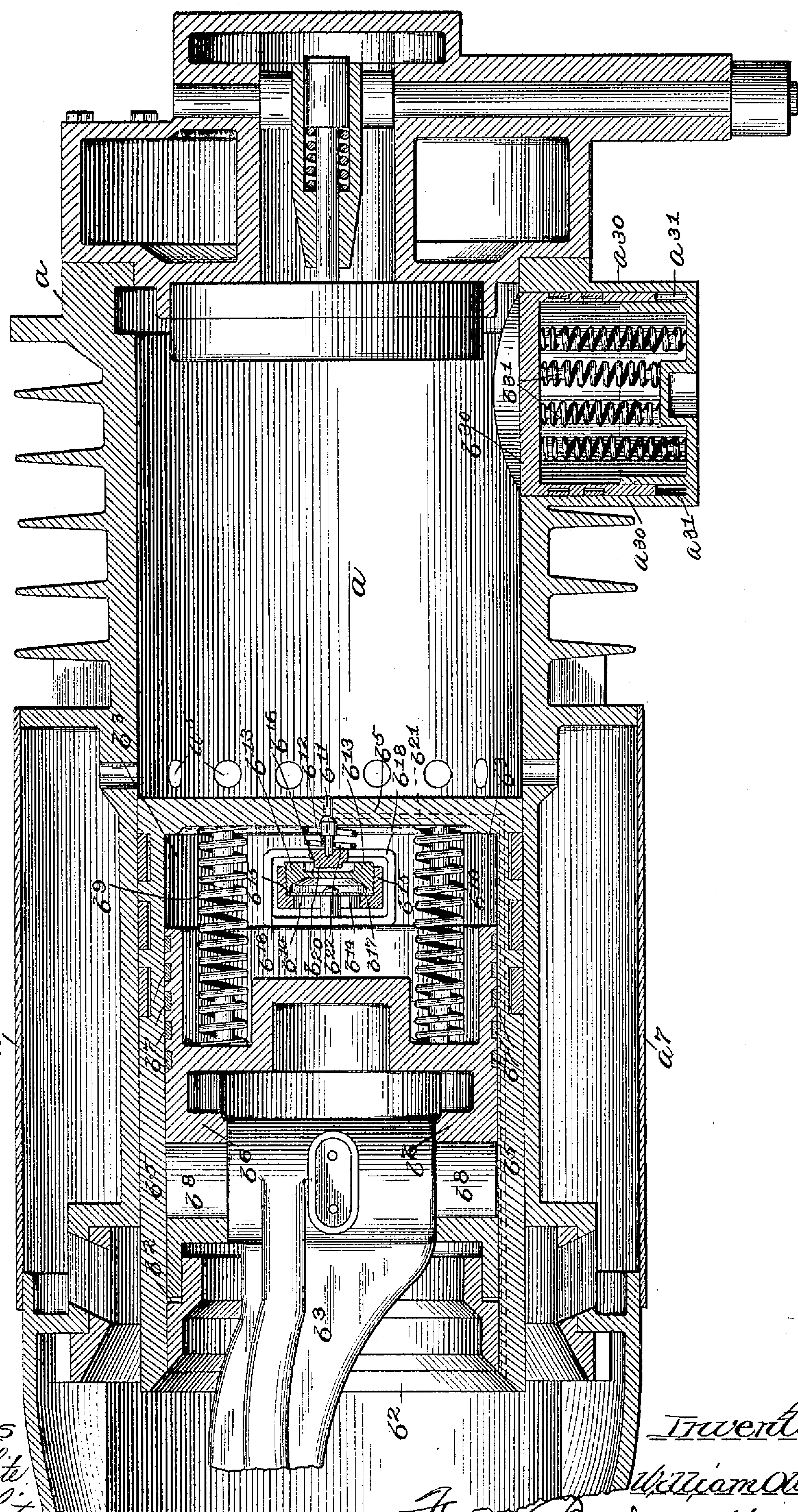
(No Model.) 3 Sheets—Sheet 3.

Fig. 3.



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# UNITED STATES PATENT OFFICE.

WILLIAM O. WORTH, OF CHICAGO, ILLINOIS, ASSIGNOR OF TWO-THIRDS TO WILLIAM R. DONALDSON, OF SAME PLACE, AND HENRY W. KELLOGG, OF BATTLE CREEK, MICHIGAN.

## PISTON FOR EXPLOSIVE-ENGINES.

SPECIFICATION forming part of Letters Patent No. 668,075, dated February 12, 1901.

Original application filed September 9, 1899, Serial No. 729,910. Divided and this application filed April 9, 1900. Serial No. 12,200. (No model.)

*To all whom it may concern:*

Be it known that I, WILLIAM O. WORTH, a citizen of the United States, residing in Chicago, county of Cook, and State of Illinois, have invented certain new and useful Improvements in Pistons for Explosive or Rapid-Combustion Engines, (being a divided application from the original filed September 9, 1899, Serial No. 729,910;) and I do hereby declare the following to be a full, clear, and exact description, such as will enable persons skilled in the art to which it appertains to make and use the same.

My invention relates to improvements in pistons for explosive or rapid-combustion engines or to engines of any class where the power is applied to the piston by sudden intermittent impulses, as when the abruptive impact is applied to a reciprocating piston by the explosion of a charge of gas, vapor, or other material that may be used the nature of which is to impart its energy in impulses of great initial force, but of short duration.

The object of my invention is to provide a piston that will absorb a portion of the energy liberated by a charge of fuel having the characteristics described and which will contribute the power or force so held in reserve by the said piston to the other moving parts of the engine at a time later in the stroke, when the direct effect of the exploding charge has been diminished.

The force of an exploding charge within the cylinder of an ordinary engine of the class described is so violent and comes with such sudden vigor that the effect upon the mechanism of the engine is similar to the results that would follow from the concussion produced by sledge-hammer blows of equal energy.

This improved piston may be made a part of the ordinary reciprocating piston, or it may be an independent auxiliary piston that may be adjusted so as to enlarge the contents of the cylinder at the time of the severest effect of the explosion and then by returning to its former condition in virtue of the compressed resilient element associated therewith reduce the contents of the cylinder to its normal capacity, and thereby impart to the moving piston the energy that will be stored in the said element, which is compressed by the said auxiliary piston at the instant of the explosion.

In the drawings, Figure 1 is a plan view of an engine containing my improved pistons attached and a part of the ordinary piston. Fig. 2 is a side elevation of the same. Fig. 3 is an enlarged broken-away portion of the view shown in Fig. 1 in section, showing the pressure-valve located in my improved piston, also the auxiliary piston located in the side of the cylinder. Fig. 4 is an enlarged detailed sectional view of the piston pressure-valve. Fig. 5 is a section of same through lines 5 5 of Fig. 4.

In all of the views like letters of reference are used to indicate similar parts.

The pistons $b'$ $b^2$ are connected to their respective cranks by the usual connecting-rods $b^3$ and $b^4$.

By referring to Fig. 3 it will be seen that the pistons are composed of two major portions—the outside shell $b^5$, which carries the usual packing-rings, and an internal piston $b^6$, which also carries a series of packing-rings $b^7$. The latter is adapted to be reciprocated within the former. $b^6$ carries a pin $b^8$, upon which the crank-arm $b^3$ has bearing. A series of open spiral springs $b^9$ $b^{10}$ are designed to hold the component parts of the piston in the position normally occupied and as shown in Fig. 3. The head of the piston $b^5$ is perforated by a small hole, preferably near its center, into which a valve $b^{11}$ is seated by spring $b^{12}$. The power of this spring is proportioned to the area of the valve and is sufficient to hold the valve closed against a predetermined pressure within the cylinder $a$.

Referring to Figs. 4 and 5, ring $b^{13}$ (shown only in Fig. 5) extends from the outer surface of the main piston-head $b^5$ and is formed into an annular exterior-threaded projection. A sheet-spring or flexible diaphragm $b^{14}$ is placed over the face of the projecting ring $b^{13}$, and the cap $b^{15}$ is then screwed on, and by this means the diaphragm $b^{14}$ is firmly secured around its edges, leaving its center free to be moved by the pressure, as will be more fully explained. The other end of the ring $b^{13}$ is closed by a rigid diaphragm $b^{16}$, leaving a space $b^{17}$ between the two diaphragms. A yoke $b^{18}$ has an internal projection $b^{19}$, which is firmly attached, as by riveting, to the center of the flexible diaphragm $b^{14}$. The yoke $b^{18}$ is then passed around the ring $b^{13}$ and cap $b^{15}$, and at a point opposite to that at which it is connected to the diaphragm a recess or guide $b^{20}$ is formed in it for the valve-stem of the valve $b^{11}$. The valve-closing spring $b^{12}$ has one of its abutting ends resting against the yoke. An air-vent or passage-way $b^{21}$, opening into chamber $b^{17}$, communicates with the outside atmosphere or with the compression-chamber A, as may be desired. The spring $b^{22}$ abuts against the surface of the cylinder $a^5$ and the yoke $b^{18}$ and holds the said yoke normally in the position shown. This spring is auxiliary to the spring $b^{12}$ and diaphragm $b^{14}$ and is not absolutely essential.

The internal space between the pistons $b^5$ and $b^6$ I will call the "pressure-space," and designate it by $b^{23}$. The object of this space is to maintain a constant quantity of air or fluid between the two pistons as an auxiliary for the springs $b^9$ $b^{10}$ or in lieu of any springs, and the object of the valve $b^{11}$ and its associated elements is to prevent this quantity from falling below a desired value, or rather the office of the valve referred to is to supply the quantity that may be lost by leakage or otherwise from time to time, so that the cushion thus produced may be relied upon to perform in a constant degree the functions for which it is intended.

In Fig. 2 only open spiral springs are shown for the purpose of holding the two portions of the piston $b^5$ and $b^6$ in a strained relation in lieu of the air-cushion just referred to. In this event the valve and appurtenant elements just described are not essential.

In Fig. 3 an auxiliary cylinder $a^{30}$ is shown, made into the side of the cylinder $a$, preferably within the combustion-space or at a place where the piston $b^5$ will not cover it at the time when the explosion takes place. A piston $b^{30}$ is adapted to be reciprocated within the cylinder $a^{30}$. Spring $b^{31}$ holds the piston in the position shown. An air-valve and air-cushion may be used instead of the springs $b^{31}$, such as are shown in connection with piston $b^5$ and in detail in Figs. 4 and 5. The piston $b^{30}$ is cushioned by the elastic medium pent up within the annular space $a^{31}$, provided within the cylinder $a^{30}$. A similar space $b^{32}$ and for the same purpose is provided in piston $b^5$.

It is of great importance for the continuous smooth operation of an engine that the various charges of mixture, regardless of quantity, should be compressed to practically the same density. Partly for the purpose of accomplishing this end I have made my operative piston in two portions and have designed them to be held distended by either springs, compressed air, or both. In Fig. 2 springs only are shown. In Fig 3 I have shown springs $b^9$ and $b^{10}$ and also a means for admitting compressed air or gas between the two parts of the piston for accomplishing the same result. When the tension between the two parts of the piston is greater than the compression within the cylinder $a$, the piston will move ahead bodily as one piece; but when the two pressures begin to approach equality the part $b^2$, of which $b^5$ is the head, will practically remain stationary and the part $b^6$ will move ahead and by this action will further compress the springs $b^9$ $b^{10}$ and the air contained within the chamber $b^{23}$, and then $b^5$ will move ahead again until another equilibrium has been established between the two pressures.

The admission of gases within chamber $b^{23}$ from cylinder $a$ in virtue of the momentarily-increased pressure of the explosion cannot pass beyond a predetermined limit at any time, and any lack in quantity is secured by operation of the valve $b^{11}$ in the cylinder-head $b^5$. The valve $b^{11}$ is seated normally by an open spiral spring $b^{12}$. The extended end of the valve is guided in yoke-piece $b^{18}$, and this yoke-piece is attached at $b^{19}$ to diaphragm $b^{14}$, which covers a chamber $b^{17}$, that is open to the atmosphere by the duct $b^{21}$. When the air-pressure within the chamber $b^{23}$ rises above a certain determined point, the diaphragm $b^{14}$ is pressed inward toward the cavity $b^{17}$ in virtue of the difference of pressure existing on the two sides of the diaphragm $b^{14}$, and the yoke $b^{18}$, which is attached to the diaphragm and which bears against and supports valve $b^{11}$, presses valve $b^{11}$ more firmly onto its seat and prevents the further admission of gas within the chamber $b^{23}$. Should the pressure within the chamber $b^{23}$ fall below the normal or predetermined point, the pressure on the diaphragm $b^{14}$ would be less from within, and the valve $b^{11}$ would therefore be less firmly held in its seat, and in consequence the deficient quantity of gas necessary to raise the pressure within the chamber $b^{23}$ would be admitted through valve $b^{11}$ from the cylinder $a$ when the pressure therein has been raised to its maximum degree. The power consumed in compressing the air or springs within the chamber $b^{23}$ of the piston is held in a stored condition and is given back to the return stroke, so that there is no lost energy as a result of this operation. When the charge is fired in the manner set forth, the violence of the abrupt explosion is absorbed to some degree by the effect of compressing air or the springs within the piston. The power thus stored is given out at a later part of the stroke, and thus the impulse occasioned by the explosion is imparted to the moving elements of my engine by a more gradual and prolonged pressure. A greater portion of the resulting energy is converted into motion instead of heat, because the yielding parts may at once respond instead of requiring the inertia to be overcome before the energy can be transformed into motion. The yielding piston also serves as a cushion and relieves the mechanical organism from suffering by the percussive violence of the explosion. The result of this construction is that the explosion is relieved of its violent initial impact, and thereby the effect of the impulse is distributed over a greater part of the stroke. The extreme pressure within the cylinder $a$ occasioned by the violence of the explosion therein will cause the piston $b^{30}$ to be driven deep into its cylinder $a^{30}$ against the resistance of the springs $b^{31}$ or compressed air or gas, should that form of piston be used, the effect of which is to enlarge the contents of the cylinder $a$ and to modify to some extent the high pressure effected by the explosion. As the piston $b^{5}$ leaves the cylinder $a$ in completing the stroke the resilience of the springs $b^{31}$ will cause the piston $b^{30}$ to return to its normal position, thereby decreasing the contents of the cylinder $a$, and as a result an even constant pressure is maintained within the cylinder $a$ during a considerable portion of the stroke, which renders the engine highly economical.

Another benefit to be derived from this construction is that which has already been referred to, to wit: The fierce and violent concussion is not imparted to the working parts of the engine; but a portion thereof is absorbed by the most sensitive expansible pistons, and thus a steady even motion is imparted to the moving portions of my engine. The working parts and the frame of the engine may be made lighter, as the strain thereon is not so great when the power is applied in steady even reciprocations of even constant pressure as when the impulses come in sharp high-pressure impacts of short duration.

I do not desire to be limited to the exact constructions shown and described, but desire to avail myself of the right to make such changes in the form and arrangement of the various parts of the apparatus as fairly fall within the spirit and scope of my invention.

Having described my invention, what I claim as new, and desire to secure by Letters Patent of the United States, is—

1. An engine of the class described, comprising a main shaft, a cylinder, a composite piston, an air-chamber between the parts of the said piston, a valve-opening, between the cylinder and the said chamber, a valve for said opening and a means responsive to the pressure within the chamber for holding said valve on its seat, substantially as set forth.

2. An engine of the class described, comprising a main shaft, a cylinder, a composite piston, an air-chamber between the parts of the said piston, an opening from said chamber, and a diaphragm covering said opening, adapted to operate a valve, substantially as set forth.

3. An engine of the class described, comprising a main shaft, a cylinder, a composite piston, an air-chamber between the parts of the said piston, a valve-opening communicating between said cylinder and chamber, a valve held in its seat by a diaphragm within said chamber, said diaphragm being made responsive to a difference of pressure between that of said chamber and that of outside atmosphere, substantially as set forth.

4. An engine of the class described, comprising a main shaft, a cylinder, a composite piston, an air-chamber between the parts of said piston, a valve-opening, communicating between said cylinder and chamber, an air-pressure responsive device within said chamber for holding said valve closed when the pressure within said chamber reaches a predetermined value, substantially as set forth.

In testimony whereof I have signed this specification, in the presence of two subscribing witnesses, this 4th day of April, 1900.

WILLIAM O. WORTH.

Witnesses:

FORÉE BAIN,

M. F. ALLEN.