(No Model.) 2 Sheets—Sheet 1.

C. WHITE & A. R. MIDDLETON.

GAS ENGINE.

No. 406,807. Patented July 9, 1889.

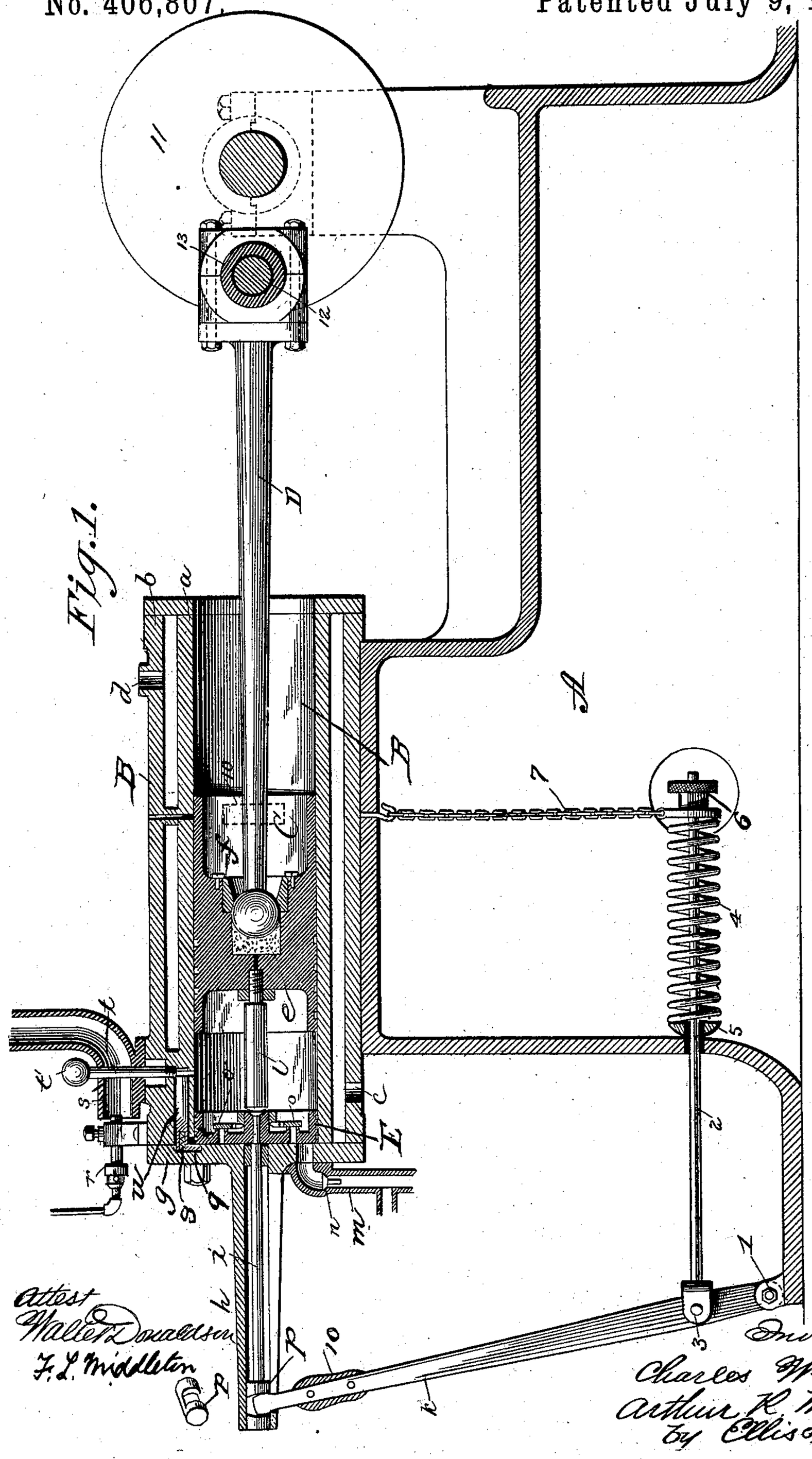

Fig. 1.

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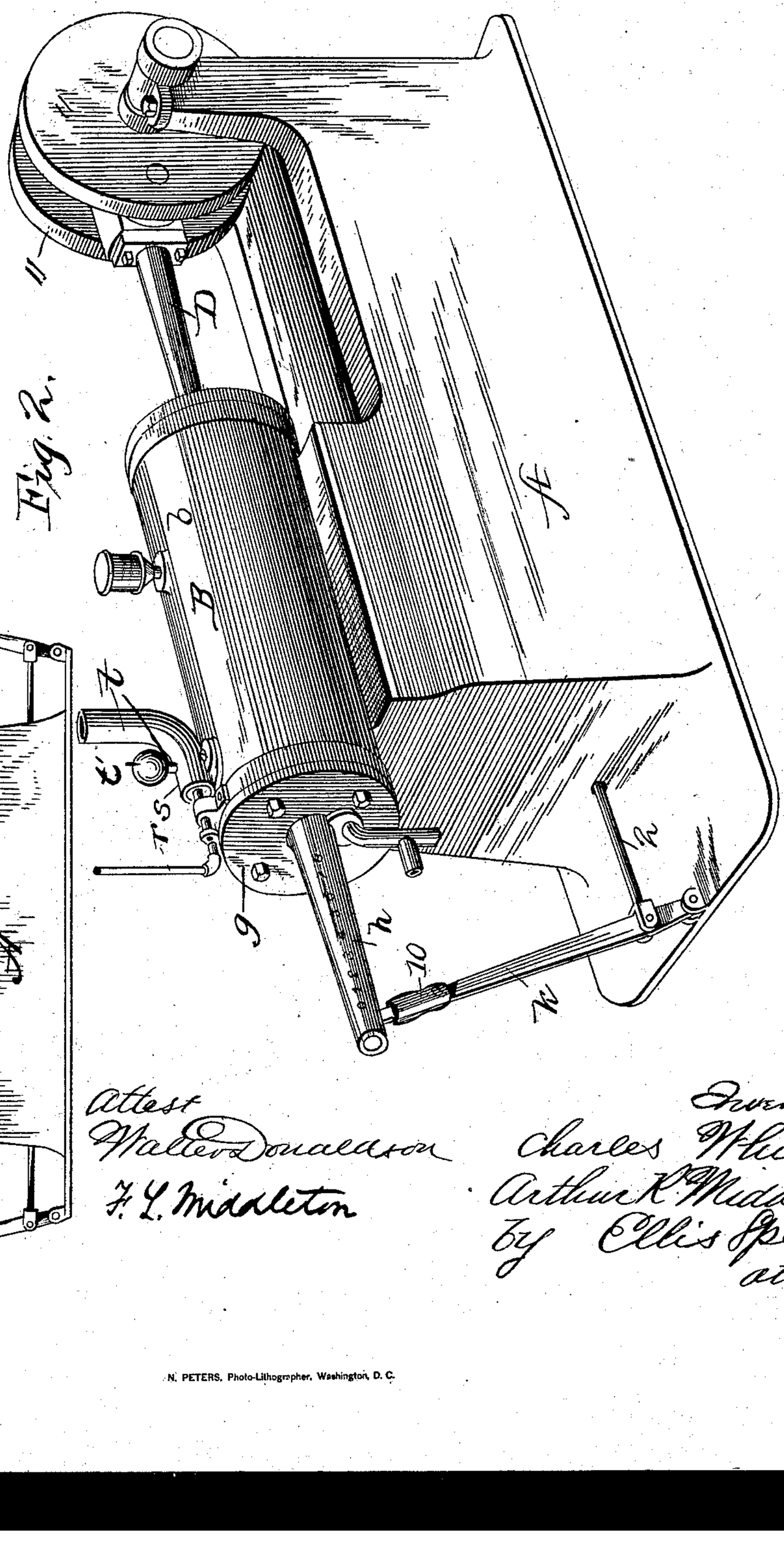

Fig. 2.

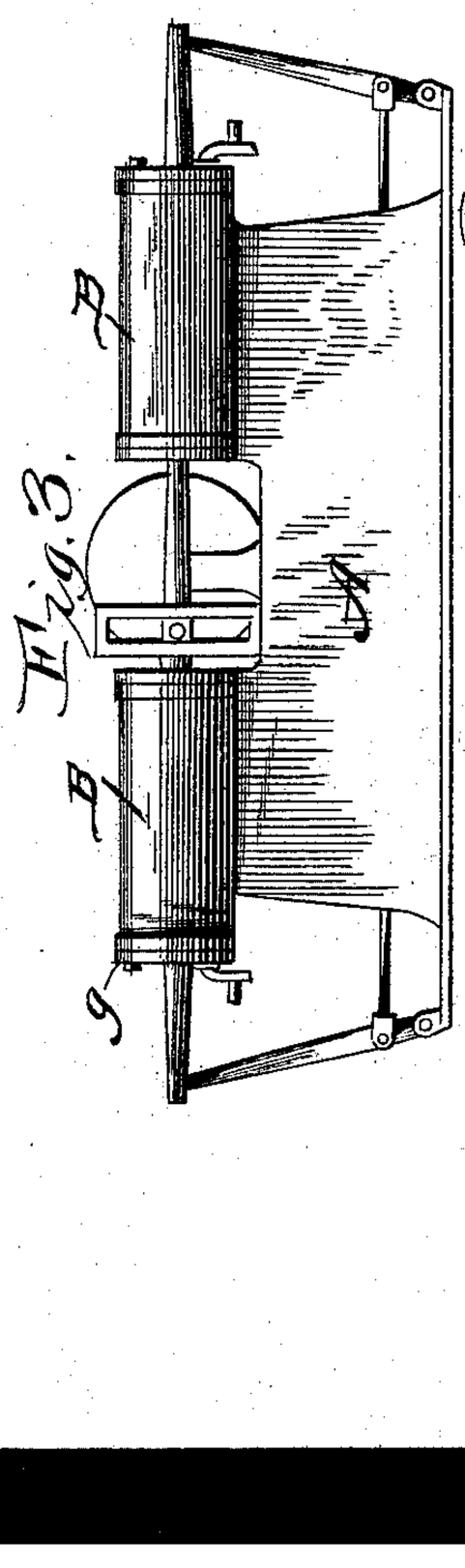

Fig. 3.

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UNITED STATES PATENT OFFICE.

CHARLES WHITE AND ARTHUR R. MIDDLETON, OF BALTIMORE, MARYLAND.

GAS-ENGINE.

SPECIFICATION forming part of Letters Patent No. 406,807, dated July 9, 1889.

Application filed January 18, 1889. Serial No. 296,728. (No model.)

To all whom it may concern:

Be it known that we, CHARLES WHITE and ARTHUR R. MIDDLETON, of Baltimore, in the State of Maryland, have invented a new and useful Improvement in Gas-Engines; and we do hereby declare that the following is a full, clear, and exact description of the same.

Our invention is an improved gas-engine, and is designed to simplify the construction of this class of engines, to economize in the amount of gas used, to lessen the number of parts and to make the engine in compact form, to provide for the automatic governing of the engine without exterior connections to operating parts, to prevent the discharge of any of the consumed products into the shop or place where the engine is situated, and to provide, generally, an effective construction of the operating parts, whereby the working efficiency of the engine is largely increased over the known forms of such engines, while the cost of construction is very materially diminished.

Our invention includes in its structure a cylinder with a piston therein connected by means of a pitman or a piston-rod to the driving-shaft, with an explosion-chamber in rear of the piston having a suitable fuel-supply leading thereto; an igniting-orifice leading to the chamber; an auxiliary piston within the explosion-chamber, acting as an automatic governor for the amount of fuel admitted to the explosion-chamber and controlling, also, the igniting of the fuel, and, finally, of means for controlling the movement of the auxiliary piston.

Our invention consists in the various devices and combination of devices hereinafter described, and particularly pointed out in the claims.

In the drawings accompanying this application, Figure 1 represents a longitudinal vertical section of the cylinder of the engine, with some of the parts in side elevation. Fig. 2 is a perspective view of the same. Fig. 3 is a side elevation of a compound engine, two cylinders being here represented.

While we have shown the invention as applied to but a single and double cylinder engine, it will be understood that any number of cylinders may be used and the connection to the driving-shaft be made in any suitable manner.

In the drawings we have represented the frame of the engine at A, and this may be either of the form shown or made in any way suited to the requirements of the engine and the place where it is to be located. The cylinder of the engine is represented at B, and is preferably jacketed, having an interior space between the inner and outer parts *a b* thereof, and while ordinarily cylinders of this kind are kept cool by the circulation of water through the space we prefer to establish the circulation of air by providing an opening *c* at one end of the cylinder in the outer jacket and an opening *d* at the opposite end and on the upper side, or on the side opposite to that in which the opening *c* occurs. The opening *d* may be in connection with a suitable flue, in which may be placed an ordinary suction-fan to induce the circulation. We may, however, use the water-circulation; but we prefer the use of air either in the manner above described or in any other suitable manner.

Within the cylinder B is located the piston C, which has sliding movement back and forth within the cylinder, being fitted thereto by suitable packing, so as to have a gas-tight connection therewith. This piston has a flanged forward part, which provides a long bearing in connection with the cylinder-walls, but at the same time does not add materially to the weight of the piston. At the rear part of the piston a similar flange is formed, though not quite to the extent of the flange on the front part. A piston-rod D, provided with a spherical end, has its bearing in the piston at about the center thereof, resting against the seat *e*, of Babbitt metal preferably, and with a collar *f*, having an interior periphery adapted to the spherical end of the piston-rod, fitting the opening made in the body of the piston to allow for the insertion of the spherical end of the said piston-rod. This collar *f* is held in place by screws and reduces the size of the opening to less than the diameter of the spherical end of the piston-rod. The outer part of the inner periphery of the collar *f* is made flaring, so as to permit the necessary movement of the piston-rod as it assumes different angles in its reciprocation in pass-

ing around the circle described by the crank-shaft. The forward end of the cylinder is open, while the rear end is closed by a head *g*, which is securely bolted in place, and this head is provided with a hollow extension *h*, which carries a stem *i*, interposed between a lever *k*, and an auxiliary piston E within the cylinder and in rear of the piston C. This piston E is also fitted snugly to the inner periphery of the cylinder, and is separated from the main piston C by means of an interposed stem *l*, which is adjustably supported on the rear side directly in the center of the piston C, being provided on its rear face with an inclined or tapering part, which rests against a corresponding seat formed in the hub of the auxiliary piston E. It will thus be seen that while the piston C does not control the movement of the piston E it regulates and limits the distance between the two, and this distance may be increased or diminished by adjusting the stem *l*. The space between the two pistons constitutes the explosion-chamber, as will be hereinafter described. The fuel is led to the cylinder through the head *g* in rear of the piston E by means of a pipe *m*, which may connect with any suitable gas-supply or other explosive mixture suitable for the purpose, this pipe being provided with a suitable check-valve, as shown at *n*. The piston E is provided with openings passing through from its rear to its front side, these openings being covered by valves *o*, which normally prevent the passage of the mixture therethrough to the explosion-chamber.

The lever *k* is pivoted upon the frame of the machine at 1, and in connection with the said lever is a rod 2, pivoted to the lever *k* at 3, and carrying upon its other end a spring 4, which is under tension between a stud 5, bearing against the frame of the engine, and a regulating-screw 6, and this end of the rod 2 is supported by means of a chain 7. The tension of the spring 4 may obviously be regulated by the screw 6. It will thus be seen that the rod *k* is under tension of the spring 4 through the connections described, and the upper end of the lever *k* passes through a slot in the extension *h* of the head, and is provided with a rounded head which fits a corresponding recess in a sliding block *p*, fitted to move within the extension *h* and to be in connection with the spindle *i*, so that through the movement of the lever *k* the spindle *i* is put under tension, and as the end of this spindle connects with the center of the rear face of the piston E the said piston is likewise placed under tension, and its tendency is to advance toward the front or open end of the cylinder, according to the amount of movement allowed in this direction by the movement of the piston C as it advances forward.

For igniting the charge within the explosion-chamber, we provide a burner *r*, which is located at the mouth of a tube *s*, which terminates in a chimney, and through the horizontal part of this pipe extends a tube *t*, which passes through the shell of the cylinder to the top of a horizontal recess in which is a sliding valve or plug. An opening is formed in line with the opening of the pipe *t* through to the interior of the cylinder, and the sliding valve or plug *u* normally closes this opening by means of a spring in its head, as shown at 8. The pipe *t* extends entirely through the pipe *s*, and has an enlarged spherical chamber *t'* on its upper end. When the tube *t* becomes heated by the flame of the burner *r*, and when the valve *u* is open, some of the mixture from the explosion-chamber, being under compression, as hereinafter to be described, rushes into the tube *t* and through the same to the chamber upon the other side of the line of the burner, and the mixture, coming in contact with the heated tube, is ignited and an explosion follows, which, being directed by reason of the location of the opening from the tube *t* into the center of the explosion-chamber, causes a uniform and regular explosion, which thus produces, by having the ignition take place in the center of the mixture, a continuously-acting expansive force, which operates until the entire charge has been exploded and the chamber has increased by the forward movement of the piston C under the action of the explosion. We have found that by extending the tube *t* entirely across the pipe S all shock is prevented and there is no reactionary effect, as the first rush of the mixture through the tube *t* is not immediately checked, but some of it allowed to pass through to the chamber formed upon the end of the tube.

Supposing the parts to be in their normal condition, with the crank-shaft on the dead-center, as shown in Fig. 1. In the condition of the parts as thus shown a charge of the mixture is within the explosion-chamber between the pistons C and E, this charge having been compressed in the movement of the piston C rearward, as will be more fully explained, and the valve *u* has been retracted by reason of the face of the piston E having come in contact with the tang 9 of the said valve as the said piston E was moved to the rear limit of its movement. The charge is thus ignited and the explosion creates an expansive force, which advances the piston C with a rapidity which is controlled entirely by the amount of work which the engine has to do. This expansive force also keeps the auxiliary piston pressed closely against the cylinder-head, as it exceeds the power exerted by the spring 4 through its connection. The piston C continues to advance under the action of the expansive force until it reaches and uncovers the exhaust-passage 10, which leads to a suitable chimney. The instant the exhaust is uncovered to the interior of the cylinder a vent is formed for the exploded mixture, the pressure is removed from the auxiliary piston, and the spring 4, through the long arm formed by the lever *k*, forces the piston forward, quickly expelling an

amount of foul mixture in its movement equal in amount to the fresh mixture admitted in rear of said piston through the check-valve *n*. It will be understood that at this time—namely, during the time when the exhaust is open—the crank of the piston is making about a quarter-turn in passing the opposite center, and the movement of the piston is very slight, so that the exhaust remains uncovered a sufficient length of time for the purpose. Of course the proportion of movement of the piston may be changed by locating the exhaust port in a different relation to the limit of movement of the piston. While the port remains open the auxiliary piston is allowed its movement, and the amount of this movement, and consequently the amount of the charge admitted, is regulated by the movement of the main piston.

In order to prevent the escape of the exploded gases into the building or shop where the engine is located, the exhaust-passage is so located relatively to the piston C that it is never uncovered toward the open end of the cylinder. As the piston E advances, its valves are kept closed by the movement of the piston against the contents of the cylinder, and into the chamber behind the piston E a fresh charge of gas or other mixture enters, lifting the check-valve *n*. As soon as the piston C begins its return and passes the exhaust-port, closing the same, the movement of the piston E is gradually checked by the compression between the two pistons of the exploded mixture which has not been displaced by the forward movement of the auxiliary piston, and this serves as a cushion between the two and prevents any shock, and this compression increases until the stem *l* comes in contact with the face of the piston E. As the backward movement of the piston C continues, it forces back the piston E, and the new charge which has entered behind it passes through the valve in said piston to the space between the piston E and the piston C, the escape of the mixture through its pipe *m* being cut off by the dropping of its check-valve *n*. The new charge is therefore compressed before the piston C reaches the limit of its rearward movement, and when it reaches this limit and is ready for another impulse the valve *u*, which closes automatically under the action of its spring as soon as the piston E begins its forward movement, is again retracted and another explosion follows.

It will be seen that the auxiliary piston E serves as a perfect governor and is automatic in its action, requiring no independent connection with operating parts of the machine, as is now the case with all governors for gas-engines of which we have knowledge. As the piston E is only moved by its spring after the exhaust-port is opened, it will be seen that all its movement must take place during the passage of the crank-pin over the opposite center, or, in other words, while the exhaust is open, for as soon as this is closed the compression between the two pistons effectually prevents further advance of the auxiliary piston. It therefore follows that as the space between the head of the cylinder and the face of the piston E measures the amount of the mixture for the next charge the rapidity of movement of the main piston in closing the exhaust-opening, which is of course governed by the work being done, will regulate the force of the next explosion by allowing the auxiliary piston to move forward a greater or less degree. If, therefore, the first charge was too great for the work being done by the engine, the main piston will have a more rapid movement and will close the exhaust in less time, and thereby limit the movement of the piston E′ and thus lessen the amount of the next charge. If, upon the other hand, the first charge was hardly sufficient for the work being done, then the movement of the piston C will be so slow as to allow the piston E to advance a greater distance, and the next charge will be larger and of greater power. In order that the governing action of this auxiliary piston may be observed, we have provided an indicator on one or both sides of the extension *h*, as shown in Fig. 2, this consisting of the numerals shown, and we regulate the tension of the spring so that the movement of the lever *k* to the zero-point gives a charge sufficient to overcome the friction of the machine, and the movement of this lever to the points 1, 2, or 3 may indicate the number of horse-powers or any fraction thereof which the machine is working to.

Gas-engines as ordinarily constructed require the combined efforts of several persons to start them; but the improved engine which is the subject of this application can be started by a single person grasping the lever *k* at the hand-piece 10 and drawing it backward, which gives movement to the piston E and ignites the charge.

In Fig. 3 we have represented the engines as duplicated, one facing the other, with their piston-rods extending in a straight line, with a yoke between having a vertical opening in which plays the crank-pin of the disks on the main shaft.

It will of course be understood that for other classes of work requiring a plurality of engines they may be arranged side by side or opposite each other and connected to the driving-shaft by any suitable means.

We dispense with the heavy balance-wheel ordinarily used and provide two small fly-wheels 11, between which a pin 12 extends, being riveted or otherwise secured on its outer ends, and around this pin we place a bushing 13, of hardened steel, and this bushing receives the wear from the piston-rod, the parts of which encircle it.

While the auxiliary piston acts as an automatic governor, in case very accurate regulation is required with the least amount of variation we may apply a governor of any suit-

able or well-known construction, in connection with the fuel-supply pipe, to limit the supply according to the requirements of the engine.

What we claim is—

1. A gas-engine consisting of a cylinder, a reciprocating piston within said cylinder, an independent auxiliary piston separated from the main piston, the space between the two forming the explosion-chamber, a fuel-supply entering the cylinder in rear of the auxiliary piston, and a device for moving the auxiliary piston in one direction independent of the main piston, substantially as described.

2. A gas-engine consisting of a cylinder having main and auxiliary pistons, the said pistons being separated from each other by a projection on one extending beyond the line of the face of said piston, the space between the two pistons constituting the explosion-chamber, means for igniting the charge, means for giving movement to the auxiliary piston in one direction independent of the main piston, a fuel-supply opening into the cylinder in rear of the auxiliary piston, and a passage therefrom to the front of said piston to the combustion-chamber, substantially as described.

3. In a gas-engine, a cylinder, a piston therein, an auxiliary piston separated from the main piston by a projection from one of said pistons, the explosion-chamber being formed between the two pistons, a fuel-supply opening into the cylinder in rear of the auxiliary piston, means for igniting the charge, and means for operating the auxiliary piston in one direction, consisting of a spring and an operating connection between said spring and said piston, substantially as described.

4. In a gas-engine, a cylinder, a main piston within the same, an auxiliary piston, means for moving said auxiliary piston in one direction, consisting of a spring and connections therefrom to the said piston, a fuel-supply in rear of said piston, passages for said supply to the explosion-chamber, means for igniting the charge, and an adjustable extension projecting from one of the cylinders and separating the same, the space between the two constituting the explosion-chamber, substantially as described.

5. In a gas-engine, a cylinder, a main piston in the same, an auxiliary piston separated from the main piston, the space between the two forming the explosion-chamber, means for moving said auxiliary piston in one direction, consisting of a spring and connection therewith to the piston, a fuel-supply in rear of said piston, passages for said supply to the explosion-chamber, and means for igniting the charge, substantially as described.

6. In a gas-engine, a cylinder, a piston therein, an auxiliary piston, said pistons being separated to form an explosion-chamber, means for automatically operating the auxiliary piston, a fuel-supply, and igniting means controlled by the said auxiliary piston, substantially as described.

7. In a gas-engine, a cylinder, a main piston within the same, an auxiliary piston, said pistons being separated to form the explosion-chamber by a projection extending from one of said pistons, means for igniting the charge, a fuel-supply, means for advancing the auxiliary piston, and valved openings in said piston, substantially as described.

8. In a gas-engine, a cylinder, a piston within the same, an auxiliary piston operated independently in one direction, said pistons being separated to form the explosion-chamber by a projection extending from one of said pistons, valved openings in said auxiliary piston, a fuel-supply in rear of said piston, and a check-valve in the fuel-supply pipe, substantially as described.

9. In a gas-engine, a cylinder, a piston within the same, an auxiliary piston, said pistons being separated by a projection from one of the pistons, means for advancing the auxiliary piston, a fuel-supply, igniting means, and an opening leading therefrom to the explosion-chamber, and a valve for said opening controlled by the auxiliary piston, substantially as described.

10. In the described gas-engine, a main piston, means for igniting the charge, consisting of a burner, a chimney therefor, a tube passing through the chimney and extending into the shell of the cylinder, a passage leading therefrom to the interior of the cylinder, a valve for controlling said opening, and an auxiliary piston for operating said valve, substantially as described.

11. In combination, a cylinder, a main piston, an auxiliary piston, a separating-stem between the two, an igniting-tube, a fuel-supply, a spindle bearing against the rear face of the auxiliary piston, a spring, and a pivoted lever under the tension of said spring and in connection with the spindle for advancing the said auxiliary piston, substantially as described.

12. In combination with the cylinder, the pistons C and E, igniting means, a valve controlling the ignition of the charge, said valves being operated by the rearward movement of the piston E, a lever *k*, and a positive connection between said lever and the piston E, whereby the said piston may be retracted by hand operation of the lever *k* and the engine thereby started by the ignition of the charge, substantially as described.

13. In a gas-engine, a cylinder, a piston within the same, an auxiliary piston, an explosion-chamber between the two pistons, a fuel-supply, igniting means with an opening therefrom leading to the cylinder, and a valve for said opening normally closed and opened positively by the backward movement of the auxiliary piston, substantially as described.

14. A gas-engine consisting of a cylinder, a main piston within the same, an auxiliary piston in rear of the main piston, an explosion-

chamber between the two, a fuel-opening in rear of the auxiliary piston, an igniting-opening, an exhaust-opening arranged relatively to the main piston, whereby it is uncovered in the outward movement of said piston, and means for advancing the auxiliary piston as soon as the exhaust is uncovered, substantially as described.

15. A gas-engine consisting of a cylinder, a main piston, an auxiliary piston, a fuel-opening, an igniting-opening, an exhaust-port arranged relatively to the outward limit of the main piston, so as to be uncovered in said movement, and means for giving said auxiliary piston a quick forward movement as the port is uncovered, consisting of the spring, the lever *k*, the rod pivoted to the lever *k* at its lower end to form a long arm, and a connection between the lever *k* and the piston, substantially as described.

16. A gas-engine consisting of a cylinder, a main piston within the same, an auxiliary piston in rear of main piston, a fuel-supply pipe, an igniting-tube, means for moving the auxiliary piston, consisting of the spring and lever *k* and connections therefrom to the said piston, an extension from the cylinder-head, and a scale thereon, the lever *k* being adapted to act as an indicator, substantially as described.

In testimony whereof we have signed our names to this specification in the presence of two subscribing witnesses.

CHARLES WHITE.
ARTHUR R. MIDDLETON.

Witnesses:
MURRAY HANSON,
WILLIAM H. BERRY.