(No Model.)

4 Sheets—Sheet 1.

H. S. MAXIM.

GAS ENGINE.

No. 279,657. Patented June 19, 1883.

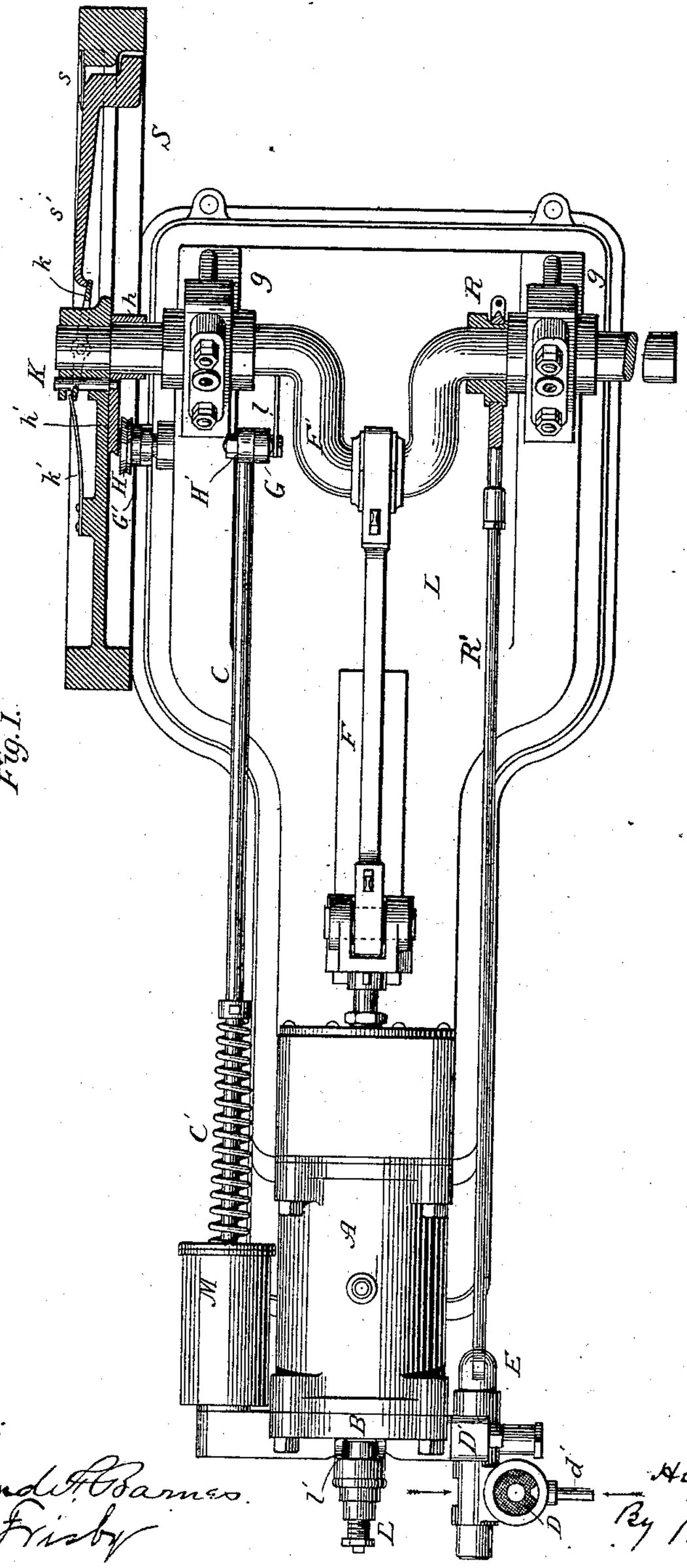

Fig. 1.

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W. Frisby

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By Parker W. Page
atty.

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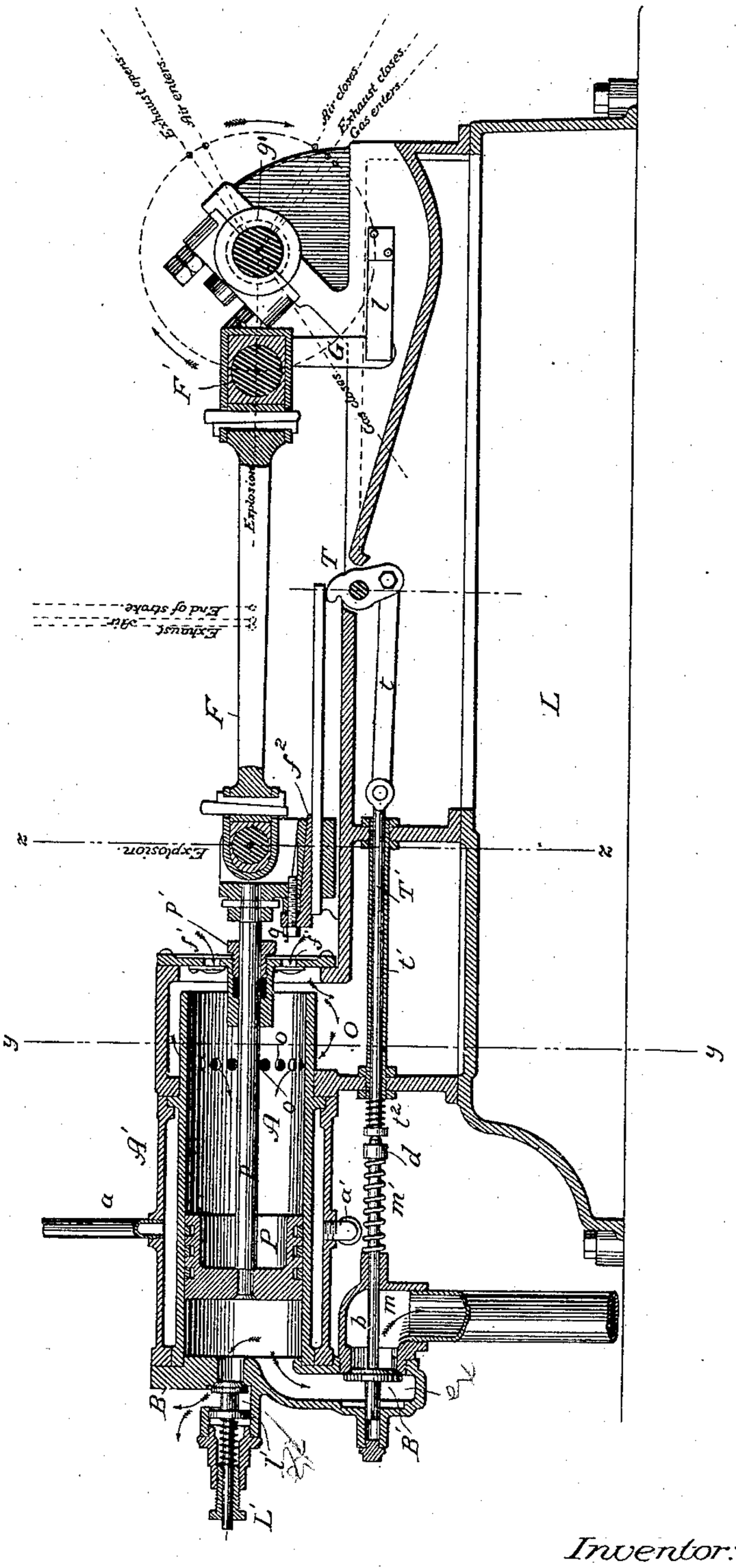
Fig. 2.



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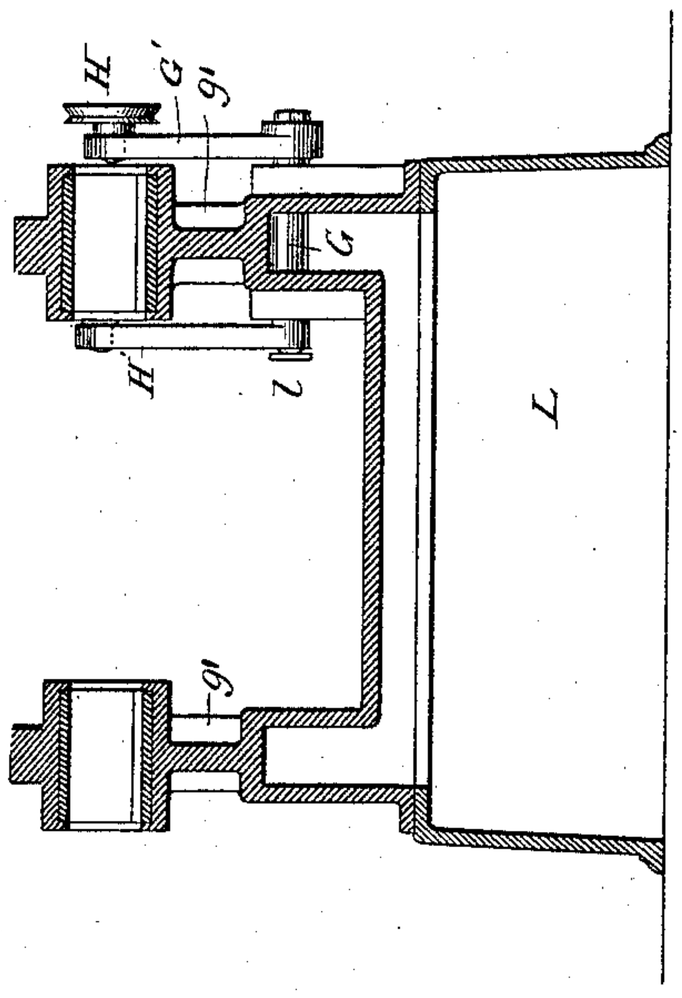

Fig. 4.

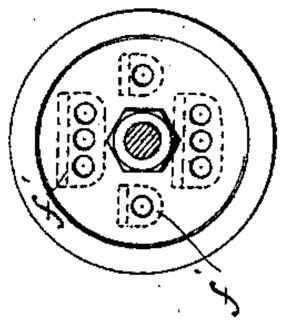

Fig. 5.

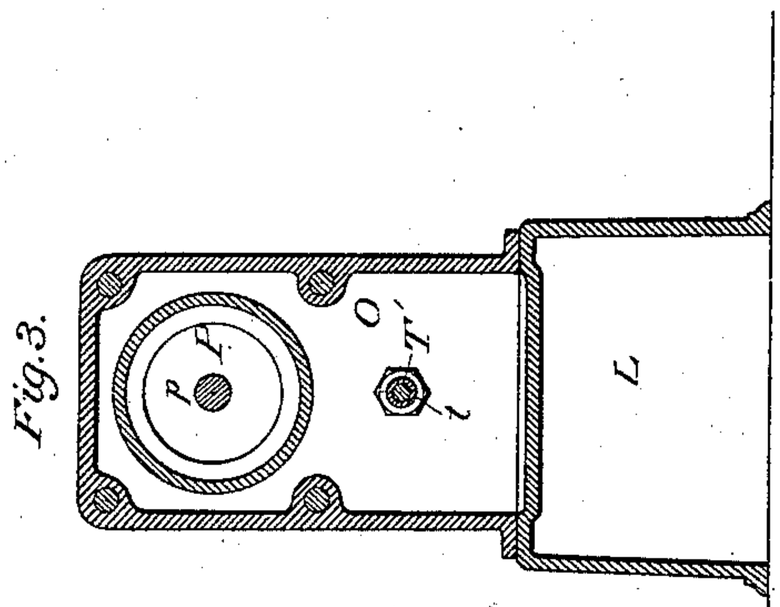

Fig. 3.

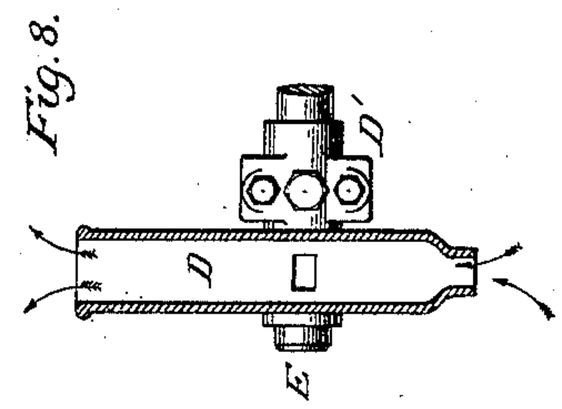

Fig. 8.

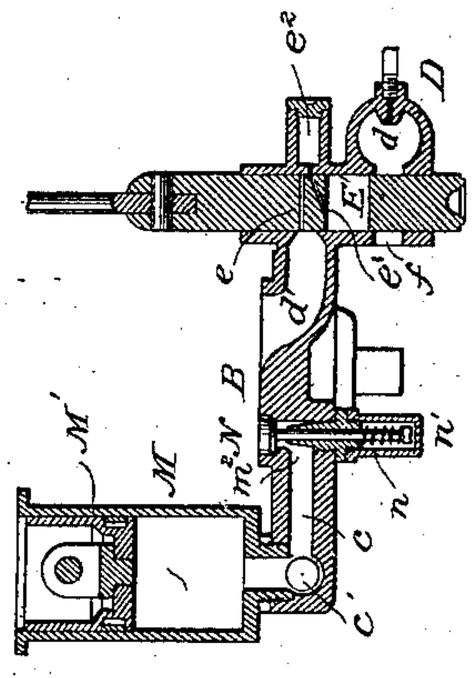

Fig. 7.

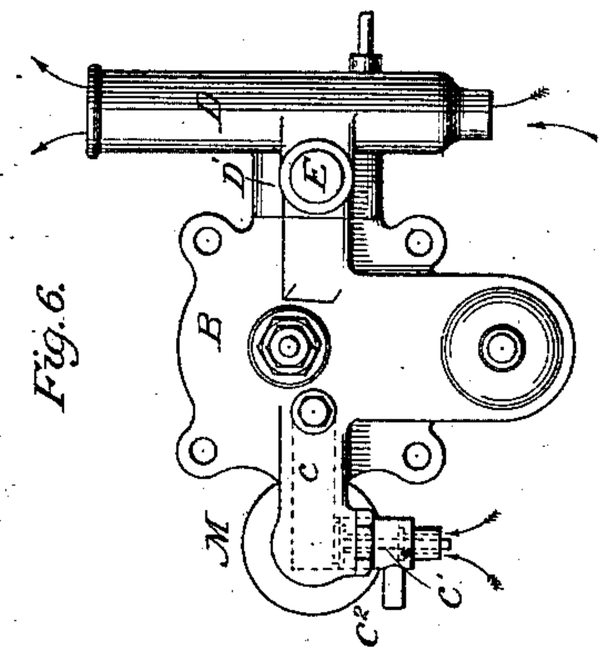

Fig. 6.

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GAS ENGINE.

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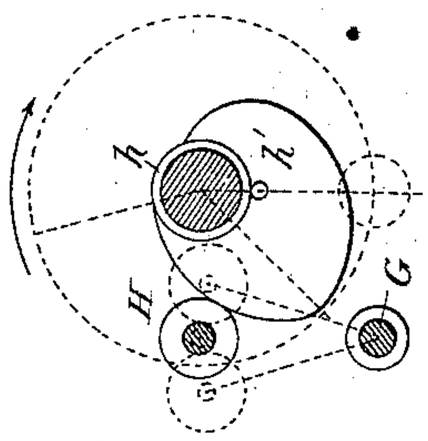
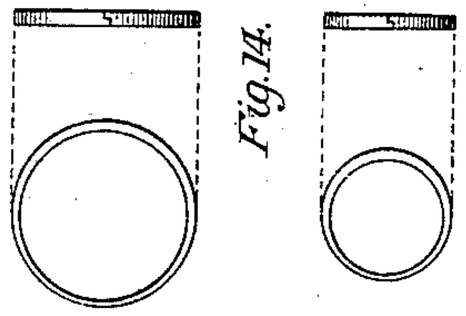


Fig. 14.



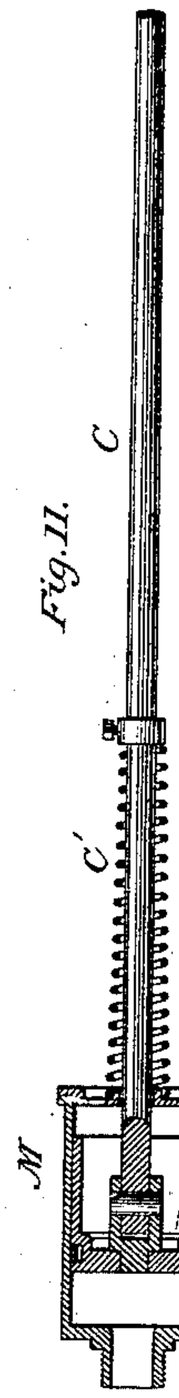


Fig. 11.

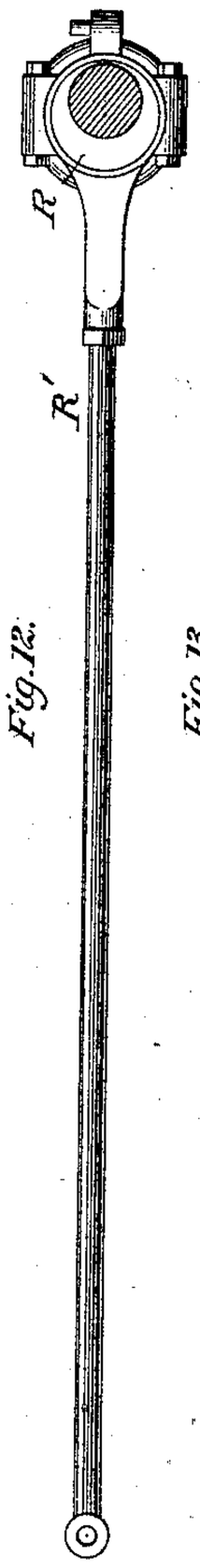


Fig. 12.

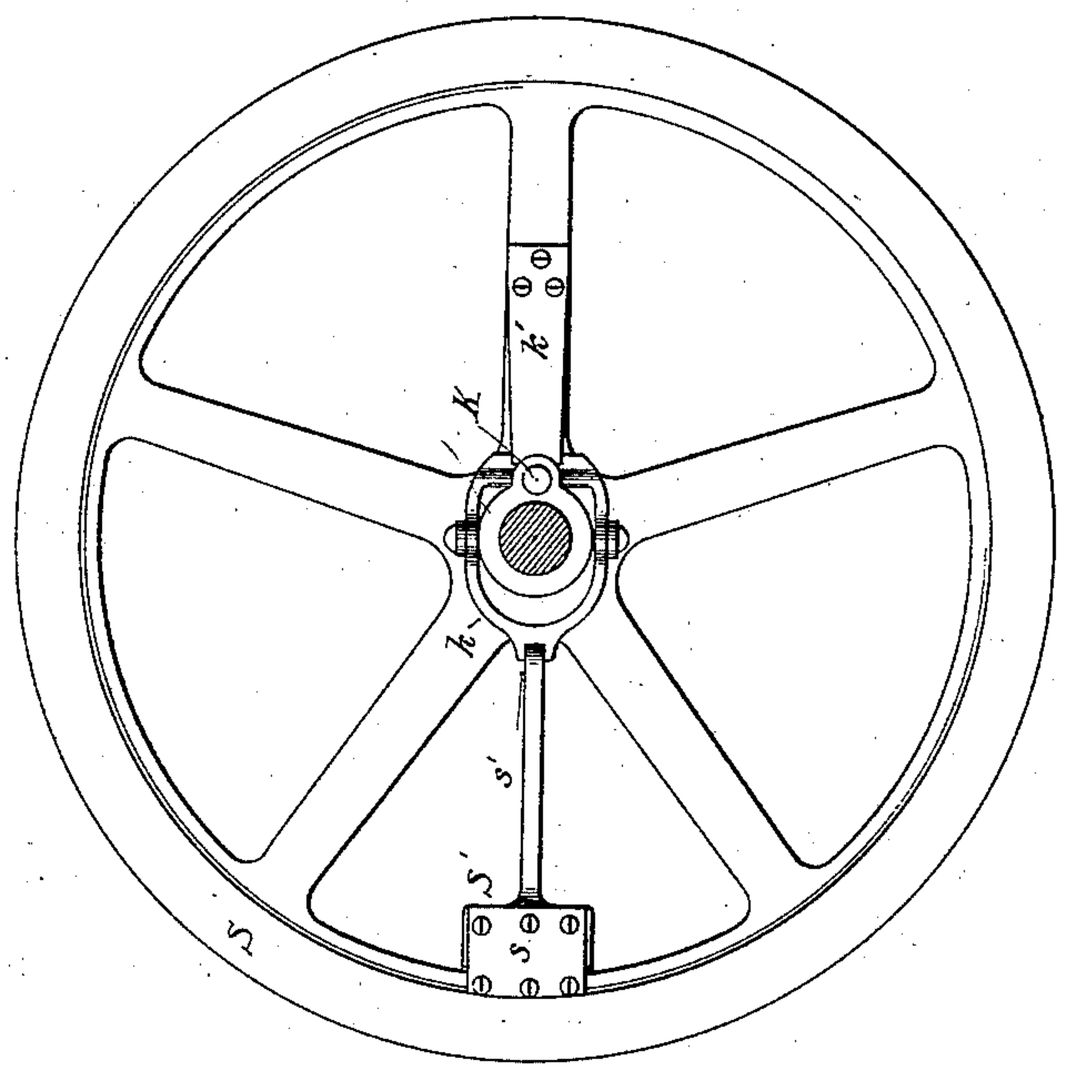


Fig. 13.

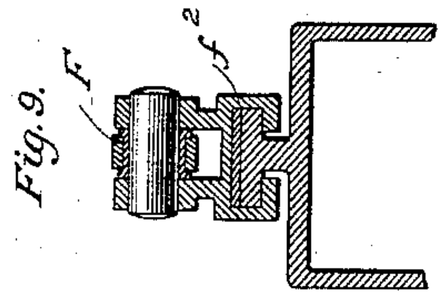


Fig. 9.

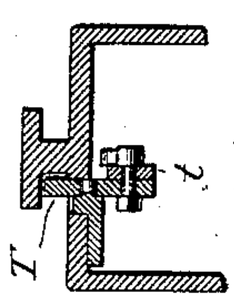


Fig. 10.

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UNITED STATES PATENT OFFICE.

HIRAM S. MAXIM, OF PARIS, FRANCE.

GAS-ENGINE.

SPECIFICATION forming part of Letters Patent No. 279,657, dated June 19, 1883.

Application filed December 1, 1882. (No model.)

To all whom it may concern:

Be it known that I, HIRAM S. MAXIM, a citizen of the United States, residing in Paris, in the Republic of France, have invented certain new and useful Improvements in Gas-Engines, of which the following is a full, clear, and exact description, reference being had to the drawings accompanying and forming a part of the same.

My invention relates to gas-engines in which a charge of gas and air mixed in definite proportions is forced into a working-cylinder and ignited at each stroke of a piston that is impelled by the combustion or explosion of said mixture; and the objects of the invention are chiefly to improve the construction of said engines, whereby their cost is reduced, and their operation rendered more efficient, steady, and economical.

In the drawings, where these improvements are illustrated in an engine constructed in accordance with my invention, Figure 1 is a plan view of an engine complete, the eccentric, fly-wheel, and devices acting as a governor being shown in section. Fig. 2 is a longitudinal central section of the same; Fig. 3, a transverse section on the line *y y* of Fig. 2; Fig. 4, a similar section through the pillow-blocks. Fig. 5 represents one of the cylinder-heads in elevation. Fig. 6 is a view in elevation of the other cylinder-head and the apparatus connected therewith for introducing and exploding the gases. Fig. 7 is a horizontal central section of the same. Fig. 8 is a view, partly in section, of a portion of the gas-igniting mechanism. Fig. 9 is a section of the cross-head on the line *z z* of Fig. 2; Fig. 10, a section of a detail of mechanism, taken on line *x x* of Fig. 2. Fig. 11 is a view, partly in section, of the portion of the apparatus constituting a gas-pump; Fig. 11ª, a diagrammatic illustration of an eccentric mechanism designed for operating the pump; Fig. 12, a view in elevation of the eccentric and rod employed in connection with the gas-exploding devices. Fig. 13 is a side view of the fly-wheel, with governing mechanism connected therewith; and Fig. 14, views of the piston-rings of the main cylinder and gas-pump.

In all the figures similar letters of reference indicate corresponding parts.

The letter A designates the main cylinder of the engine. Around it is a jacket, A′, cast independently and applied in any proper manner. Pipes *a*, for the introduction, and *a′*, for the escape, of water are connected with the jacket, as shown. The cylinder A is closed at the rear by a plate, B, through which extends a passage containing an exhaust-valve, B′. conical in shape, and provided with a stem, *b*. This stem extends through an exhaust-chamber, *m*, and is surrounded by a stout spiral spring, *m′*, that acts to keep the exhaust-valve closed. Connected also to the plate B, and communicating with the interior of the cylinder A by a passage, *m″*, is a gas-pump, illustrated in section in Fig. 11, where M designates a cylinder secured to the plate B; M′, a piston working therein; C, a piston-rod, and C′ a stout spring connected therewith and operating to draw the piston out. A pipe, *c*, containing double valve *c′*, communicates with the passage *m″*. The valve *e′* has a stem, upon which are fixed upper and lower conical valves that rest in proper seats. A pipe, *c″*, from a gas-tank enters the pipe *c* between the upper and lower valves, and the lower end of the pipe *c* is open to the air. A valve, N, with a long stem extending through a gland in the plate B, closes the opening of passage *m″* into the interior of cylinder A. A spring, *n*, is secured around the projecting end of the stem of the valve N and acts to keep it firmly on its seat, and a metal cap, *n′*, is set over the stem to prevent leakage.

For introducing a flame into the cylinder the following devices are employed: A chimney, D, constructed for maintaining a draft of air, is attached to or forms part of a suitable casing, D′, on the head B. Through the case D′ works a slide, E, through which are formed the opening E′ and the small passages *e e′*. The chimney D opens into the space containing the slide E, and an opening, *f*, is formed in the casing D′ directly opposite. A gas-jet, *d*, extends into the chimney D. A passage, *d′*, leads from the interior of the cylinder A to the space containing the slide E, and a small chamber, *e″*, with an opening that registers with the passages *e e′*, is formed on the opposite side of the slide. The operation of these parts will be hereinafter described. The op-

posite end of the cylinder A to that closed by the plate B enters an air-chamber, O. The piston-rod *p* of the piston P works through a stuffing-box, *p'*, in the end of this chamber. Two or more valves, *f'*, of the common kind known as "organ-valves," are provided in the end of the chamber O around the stuffing-box. Through the cylinder A are formed a number of perforations, *o o*, at such a distance from the end that the piston P may pass beyond them in its normal movement.

The piston-rod *p* is joined by a cross-head to the connecting-rod F. This cross-head is provided with a wedge-shaped gib, *f''*, held in place by a bolt and ring, *g*. The purpose of this is to tighten up the cross-head slide when necessary, this being effected by removing and filing down the ring *g*, so that the wedge may be brought farther into the cross-head. The connecting-rod F is connected in the usual manner to a crank-shaft, F', journaled in pillow-blocks *g' g'*.

On the shaft F' is an eccentric, R, from which extends a rod, R', to the slide E, by means of which the slide E is reciprocated in unison with the movement of the piston.

G is a rock-shaft passing through one of the pillow-blocks. On one end is fixed an arm, G', carrying a roller, H, and on the other is an arm, H', connected to the piston-rod C of the gas-pump. A flat spring, *l*, bears on the inner end of the rock-shaft and keeps the roller H always in proper position.

On the end of the crank-shaft F' is the fly-wheel S, with which are combined a collar, *h*, provided with a cam, *h'*, and regulating devices, the essential portions of which are as follows: A weight, S', is secured by a flexible plate, *s*, near the inner surface of the rim of the fly-wheel S, as shown in Fig. 1. An arm, *s'*, extends from the weight and presses on one end of a frame or lever, *k*, pivoted to the hub of the fly-wheel. A stout spring, *k'*, clamped to one of the spokes of the fly-wheel, bears on the opposite end of the frame *k*. A pin, K, screwed into the collar *h*, is so connected with the frame *k* that it will be moved by it. The action of these devices depends on centrifugal force. In case the engine runs too fast the weight tends to occupy a position nearer the rim of the fly-wheel. This depresses the end of the frame *k* with which arm *s'* is in contact, and as a result pin K is moved outward. By this means the collar *h* is shifted so that cam *h'* will pass by the roller H. This is taken advantage of in regulating the action of the engine by the frequency of the discharges of gas, as will presently appear, for as long as the engine is running too fast the explosions will not occur, owing to the inactivity at such times of the gas-pump.

Under the cross-head slide, and at a point where it will be met by the cross-head near the end of every stroke, is a pivoted lever, T, the lower end of which is connected by a rod, *t*, with a rod, T', working through a tube, *t'*, that passes through the air-chamber O. Nut-locks are employed at each end of tube *t'* to secure a tight joint, and a spring, *t''*, around the rod *t* to keep it in contact with the end of the valve-stem *d*. The spring *t''*, it will be observed, is necessarily much weaker than spring *m'*.

In the plate B, and leading from the interior of the cylinder A, is a safety-valve consisting of a conical valve, *l'*, with a very stout spring for maintaining it closed, and a screw, L', for adjusting the spring.

The parts which have now been described are preferably mounted on a stout base, the construction of which will be understood by reference to Figs. 2 and 3, where L designates the base. The superposed portions may be cast independently; or the air-chamber O and pillow-blocks may be cast together. These are, however, matters not directly affecting the invention. Having, however, described the mechanical construction of the parts composing the engine, I will now describe the operation of the same, pointing out the special functions which each of the features comprising parts of my invention are designed to perform.

The pipe *c''* and jet *d* having been connected with a suitable gas-supply and the latter ignited, the engine is then turned forward by hand one turn. By so doing, the cam *h'*, operating on the roller H, imparts motion to the rock-shaft, drives forward the piston of the gas-pump, and forces the mixture of gas and air contained in the pump through the valve N, which the pressure lifts off its seat. Meanwhile the movement of the piston P compresses the air and gas in cylinder A. As the engine turns once and the piston reaches its farthest point in the cylinder A the slide E is brought by the eccentric R into a position where the flame enters the cylinder through passage *d'* and explodes the charge. The explosion drives the piston P forward and compresses the air in the chamber O. When the piston is within perhaps an inch of the end of the outstroke, the cross-head encounters the upper end of lever T, which opens the exhaust-valve B' and allows the exploded gases to escape. The piston P, as it travels forward, then passes the perforations *o o*, through which the air compressed in chamber O at once rushes, and, expanding, drives all of the exploded gases out through the exhaust-valve B', filling the cylinder again with pure air. The expansion of the air from the heat will increase its volume sufficiently to cause it to rather more than fill the cylinder, so that it will not only drive all the exploded gases before it, but a little of the air itself will pass through the exhaust-valve B'. On the return-stroke the piston P passes the perforations *o o* and draws into chamber O a fresh supply of air through the valves *f'*. After it passes the holes *o o* the exhaust-valve B' is closed, and at this moment, the cam *h'* being brought into contact with the roller H, the pump is set in operation for supplying its second charge.

It will be observed that the passage through which gas is drawn into the cylinder of the gas-pump contains the double valve *c'*; or it may have two independent valves. In either case, if the amount of gas introduced by pipe *c''* be sufficient to fill the cylinder M, little or no air will be drawn in along with it. Inasmuch, however, as the presence of some air is desirable, the gas-supply is shut off just sufficiently to cause the requisite proportion of air to be drawn in. The introduction of gas, the compression of air, and the explosion follow one another in such quick succession that the gas has scarcely time to thoroughly mix with the air. There will therefore be a layer of gas and air at one end of the cylinder and a layer of pure air at the other at the instant of the explosion. A saving is effected by this, a smaller quantity of gas being required under the circumstances, for gas which would produce an explosion when occupying only one-third of the space in the cylinder A, when the piston is in the position shown in Fig. 2 would not explode at all if it were mixed with all the air in the cylinder.

In the devices for introducing the flame into the cylinder the action is as follows: When, after an explosion, the slide E is thrown back by the eccentric R, the passage *e'* passes by the opening in the gas-chamber *e''*, where unexploded gas under pressure is contained. A portion of this gas enters the forward part of the space E' in the slide. Instantly afterward the space E' coincides with the opening *f* and that to the chimney, and the unexploded gas is drawn out by the draft in the chimney D. As the gas flows out, too, it is ignited at the moment when the slide is drawn forward. The gas in the main cylinder is at this time under pressure, so that when the passage *e* passes before the opening into the gas-chamber *e''* gas is forced into the latter. A portion of this is immediately after forced through the passage *e'* into the space E', so that there will be no danger of the flame in the space becoming extinguished. A further advantage arising from this construction is that the pressure in the space E' is raised by this extra charge of gas, so that when it is opened into the passage *d'* the inrush of gas is not so sharp.

It will be observed that the space between the two openings *e* and *e'* is greater than the diameter of the opening into the gas-chamber *e''*, so that when the chamber is open to one it is closed to the other. A groove may be cut in the slide E, if so desired or found necessary, by means of which gas is brought from the cylinder A to the space E' at the moment when the latter coincides with the opening *f*.

A special advantage is secured by entirely surrounding the end of the cylinder A by the air-chamber O, as by this means a complete ring of perforations *o o* may be made in the cylinder. Thus it is possible to completely clear the cylinder of exploded gases during the time that the engine is making only one-twelfth part of its stroke.

In Fig 2 the dotted lines radiating from the center of the shaft and from points on the connecting-rod show the action of the engine by indicating at what points in the stroke the various operations occur, and in Fig. 11ª the action of the governing mechanism is illustrated, the figure being a diagrammatic representation of the cam *h'* and the various positions occupied by the roller H with respect to the rock-shaft, which it operates to turn.

On the piston P are the rings *w*, three in number. They are of cast-iron, and should be three-sixteenths of an inch thick on one side and one-sixteenth on the other. They should be turned one-eighth of an inch larger than the cylinder, divided at their thinnest points and lapped together, as shown in the drawings. On the piston M' are similar rings, except that they are thinner and smaller in proportion. The pistons thus made are very durable and strong. In order to maintain lubrication within the main cylinder, oil may be introduced along with the gas and air.

I have now described an engine constructed in accordance with my invention and pointed out the mode of operation of the several parts composing the same. Those parts not herein claimed, but constituting portions of my invention, will be made the subject-matter of another application.

What, however, I now claim, and desire to secure by Letters Patent, is—

1. In a gas-engine, the combination, with the working-cylinder, of an air-compression chamber, and a pump connected to an air and gas supply, the compression-chamber and force-pump communicating with the cylinder through independent passages located at the forward and rear portions of the cylinder, respectively, and constructed and arranged for operation, substantially in the manner herein set forth.

2. The combination, with the working-cylinder and piston of a gas-engine, of passages for the admission of air, located in the forward portion of said cylinder, a cylinder-head containing an exhaust-valve operated by the movement of the piston, and a pump connected with an air and gas supply and communicating with the cylinder through the head, as and for the purpose set forth.

3. The combination, in a gas-engine, with a cylinder open at one end and a reciprocating piston, of a pump for forcing gas into the cylinder behind the piston, a device for exploding the gas, and an air-chamber communicating with the cylinder through its open end, and through perforations formed through the cylinder near that end, substantially as hereinbefore described.

4. In a gas-engine, the combination, with the cylinder and piston, and means for igniting and expelling the gases within the same, of a cylinder and spring-piston constituting a force-pump, a crank-shaft connected with the main piston, and a cam carried thereby, and arranged to operate the piston of the force-

pump in substantially the manner described.

5. The combination, with the cylinder of a gas-engine, of an exhaust-valve opening inward, a spring for holding the same closed, a pivoted lever, one end of which lies in the path of the piston or cross-head of the engine, and connections, as described, by means of which the movement of the lever is caused to open the exhaust, substantially in the manner described.

6. The combination, with the cylinder-head B, of a pump constructed for mixing charges of air and gas and forcing the same into the cylinder, the communicating passage and self-closing valve N, igniting devices, and an exhaust-valve, B′, all as set forth.

7. The igniting mechanism consisting of the chambered slide E, in combination with the head B, having passage *d′* and air-vent *f*, the chimney D, and gas-jet *d*, all as set forth.

8. The combination of the slide E, containing the space or chamber E′ and passages *e e′*, with the head B, having passage *d′*, air-vent *f*, the gas-chamber *e″*, the chimney D, and the gas-jet *d*.

9. The combination, with the cylinder A, having the perforations *o o*, of the air-chamber O, of relatively large size and surrounding the end of the cylinder, substantially as and for the purpose set forth.

10. The combination, with the cross-head in a gas-engine of the kind described, of the pivoted lever T, the connecting-rod *t*, the sliding rod T′, spring *t″*, and the exhaust-valve B′, closed by a spring, substantially as and for the purpose set forth.

11. The combination, with the crank-shaft, of the shifting-cam *h′*, the roller H, and rock-shaft G, the piston-rod C, spring C′, and pump-cylinder M, these parts being constructed and arranged for operation substantially in the manner set forth.

12. The combination, with the shaft and fly-wheel, the shifting-cam *h′*, the pivoted frame *k*, the spring *k′*, and hinged and weighted arm S′, of the rock-shaft G and force-pump connected therewith, as described.

In testimony whereof I have hereunto set my hand this 21st day of September, 1882.

HIRAM S. MAXIM.

Witnesses:
ROBT. M. HOOPER,
JOSEPH S. J. EATON.