(No Model.) 4 Sheets—Sheet 1.

J. D. SMITH.

GAS ENGINE.

No. 418,821. Patented Jan. 7, 1890.

FIG. 1.

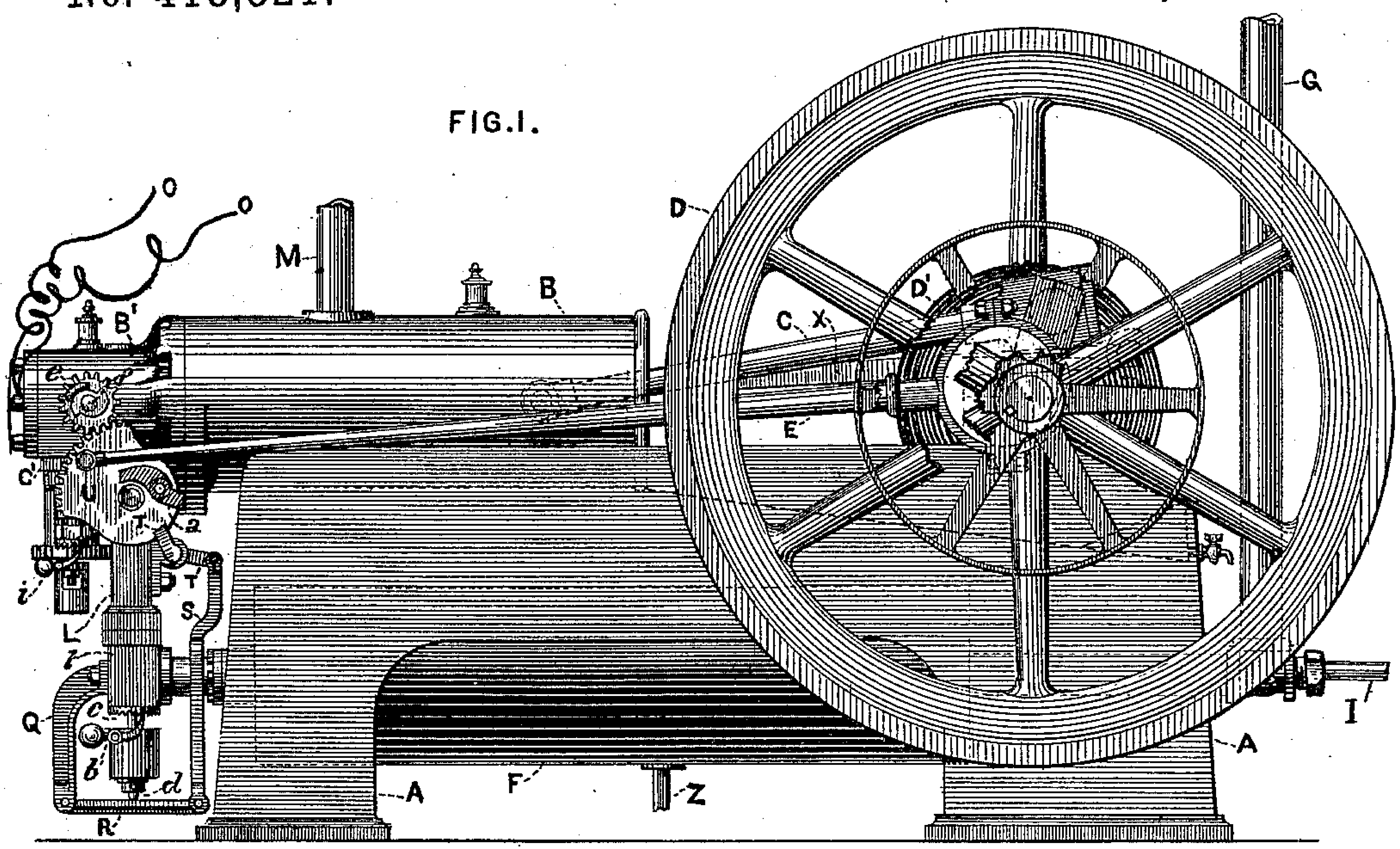
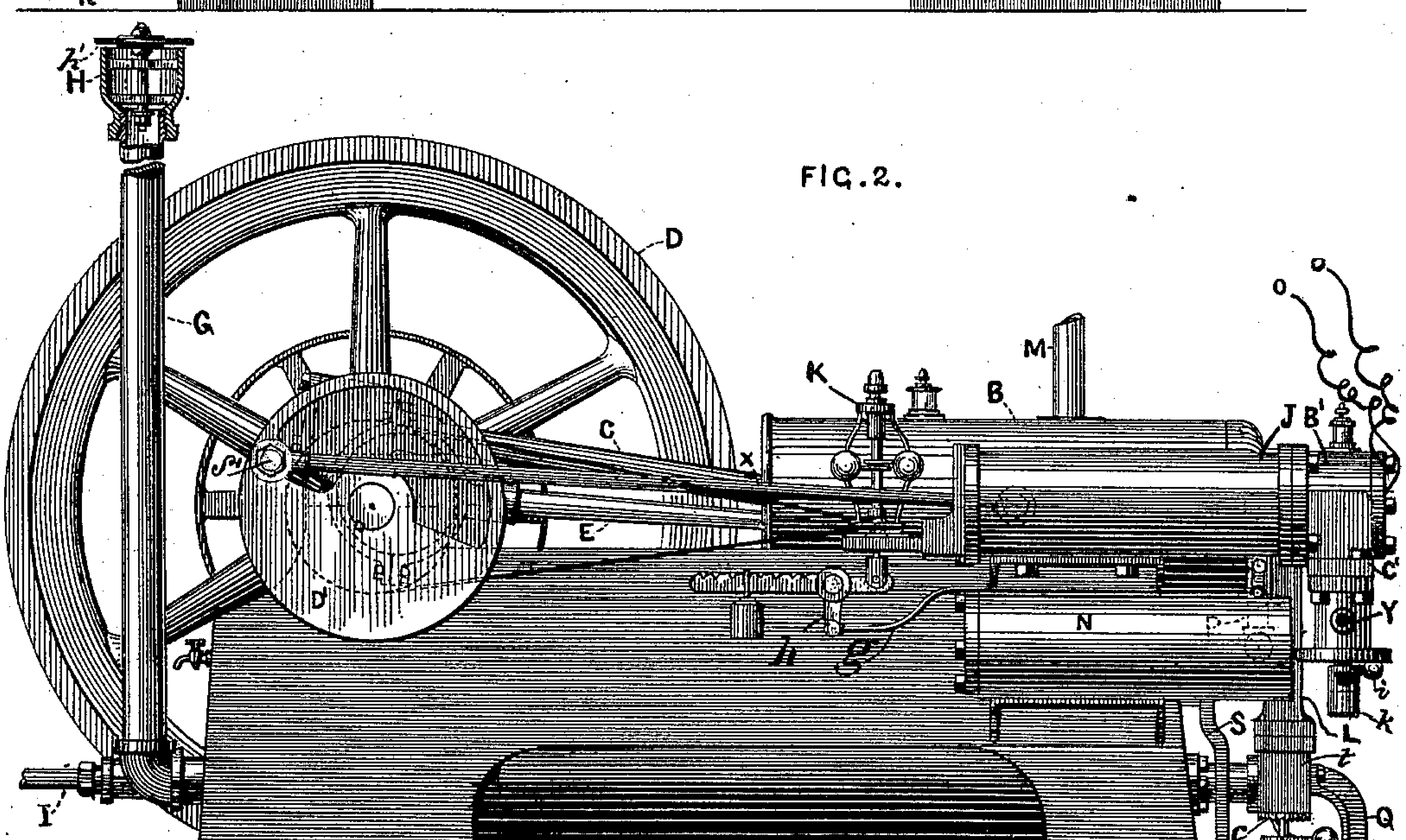


FIG. 2.



WITNESSES:

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C. H. Marple.

INVENTOR:

Jay Downer Smith

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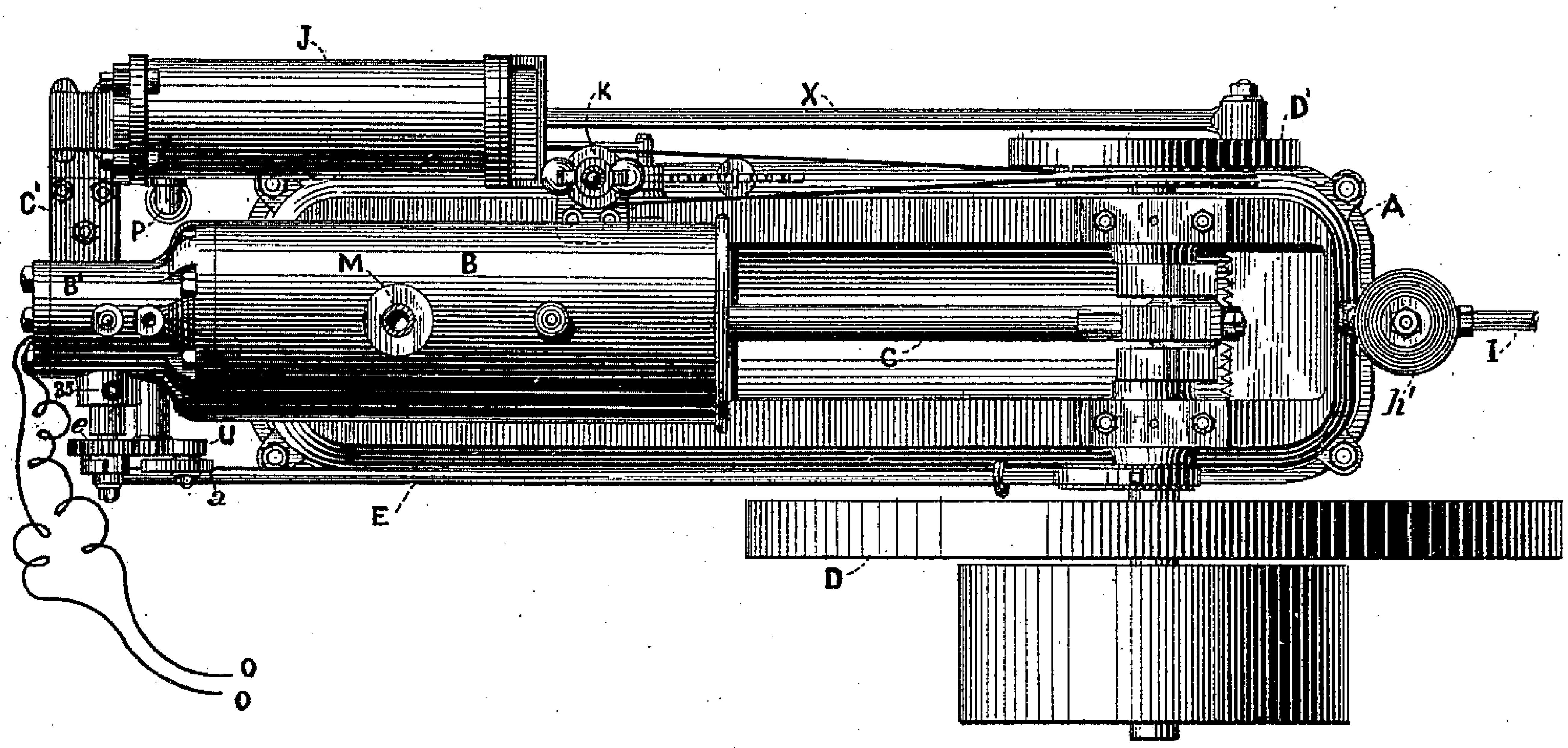
FIG.3.



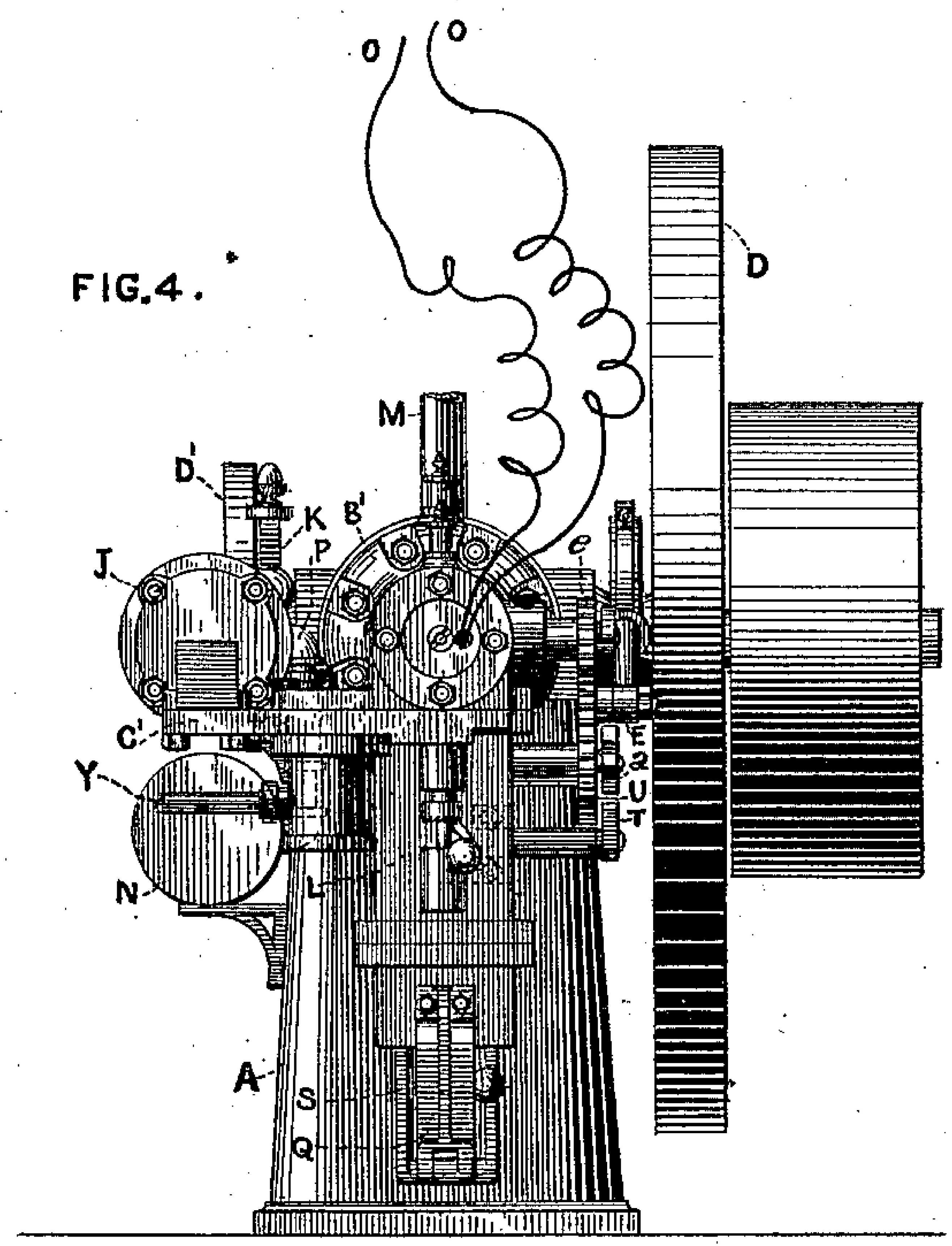


FIG.4.

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(No Model.)

4 Sheets—Sheet 3.

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No. 418,821.

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FIG. 5.

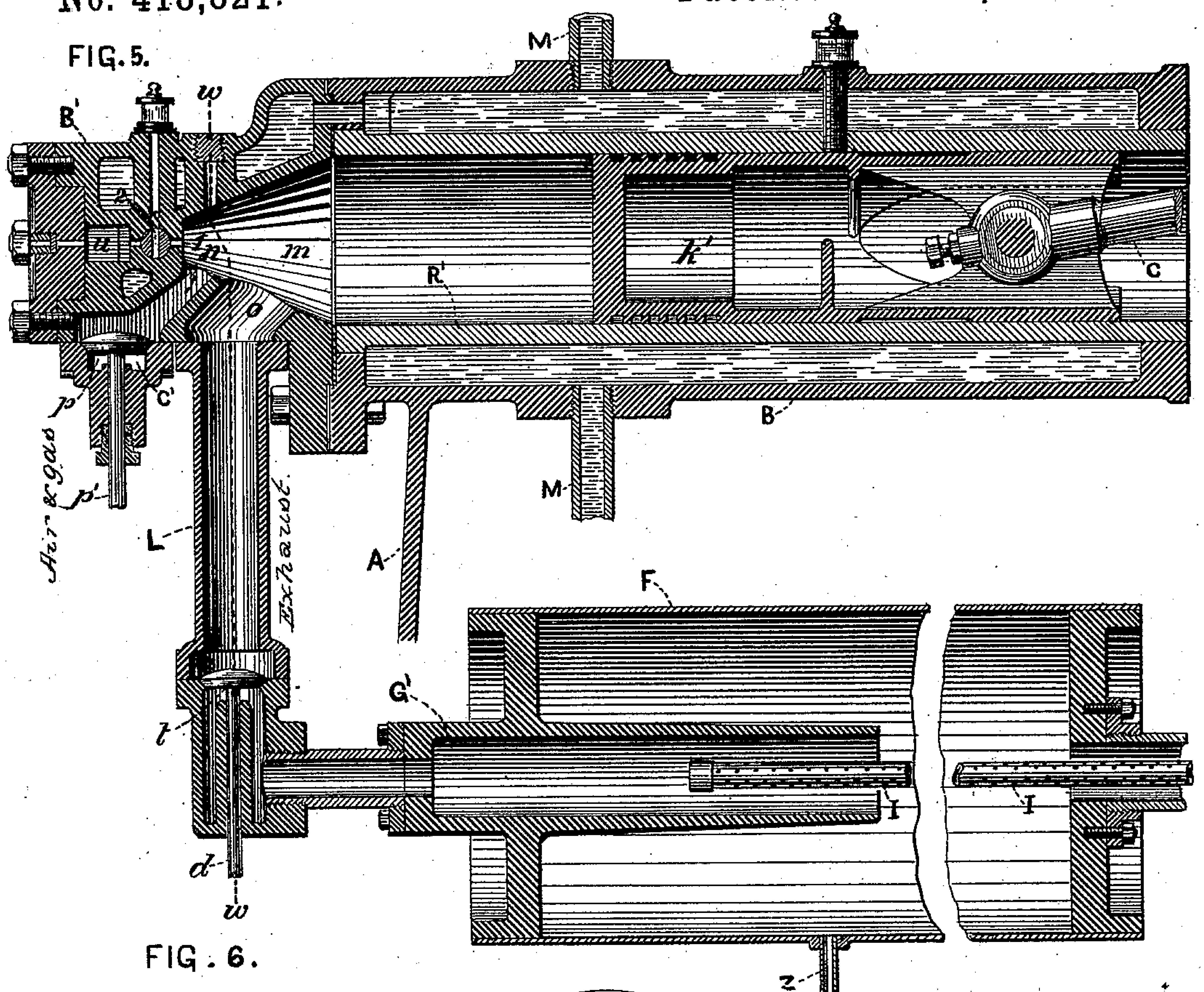


FIG. 6.

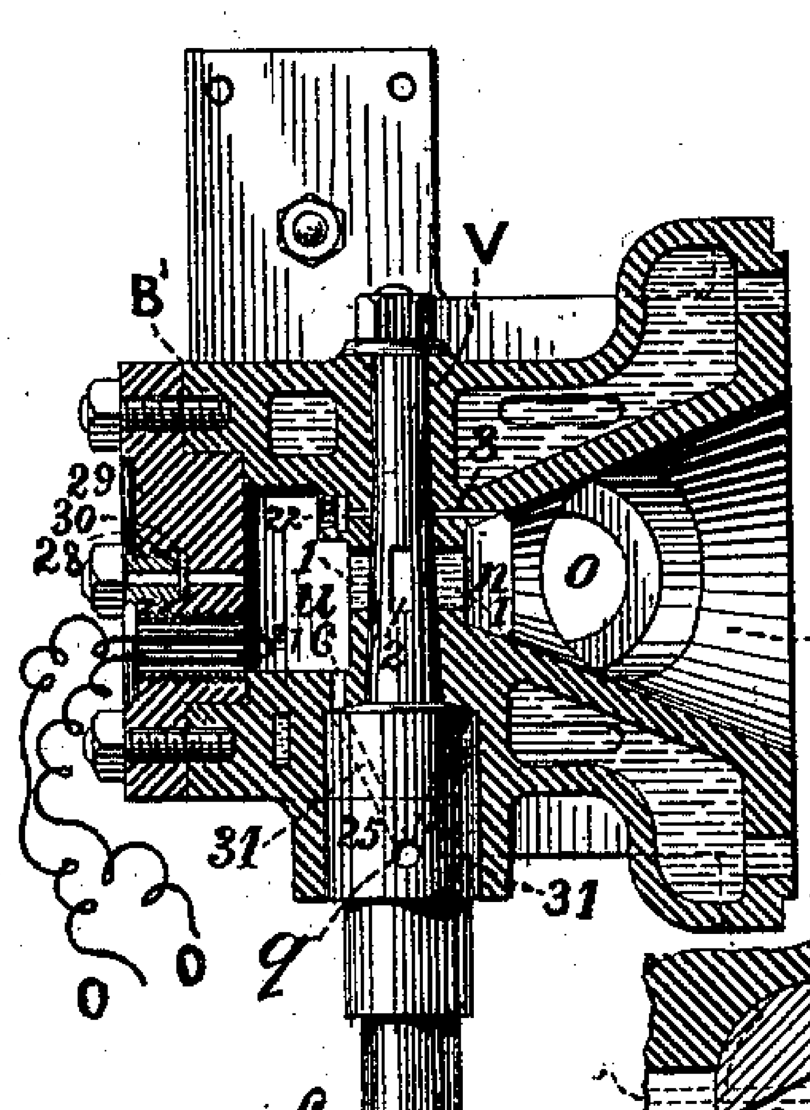


FIG. 7.

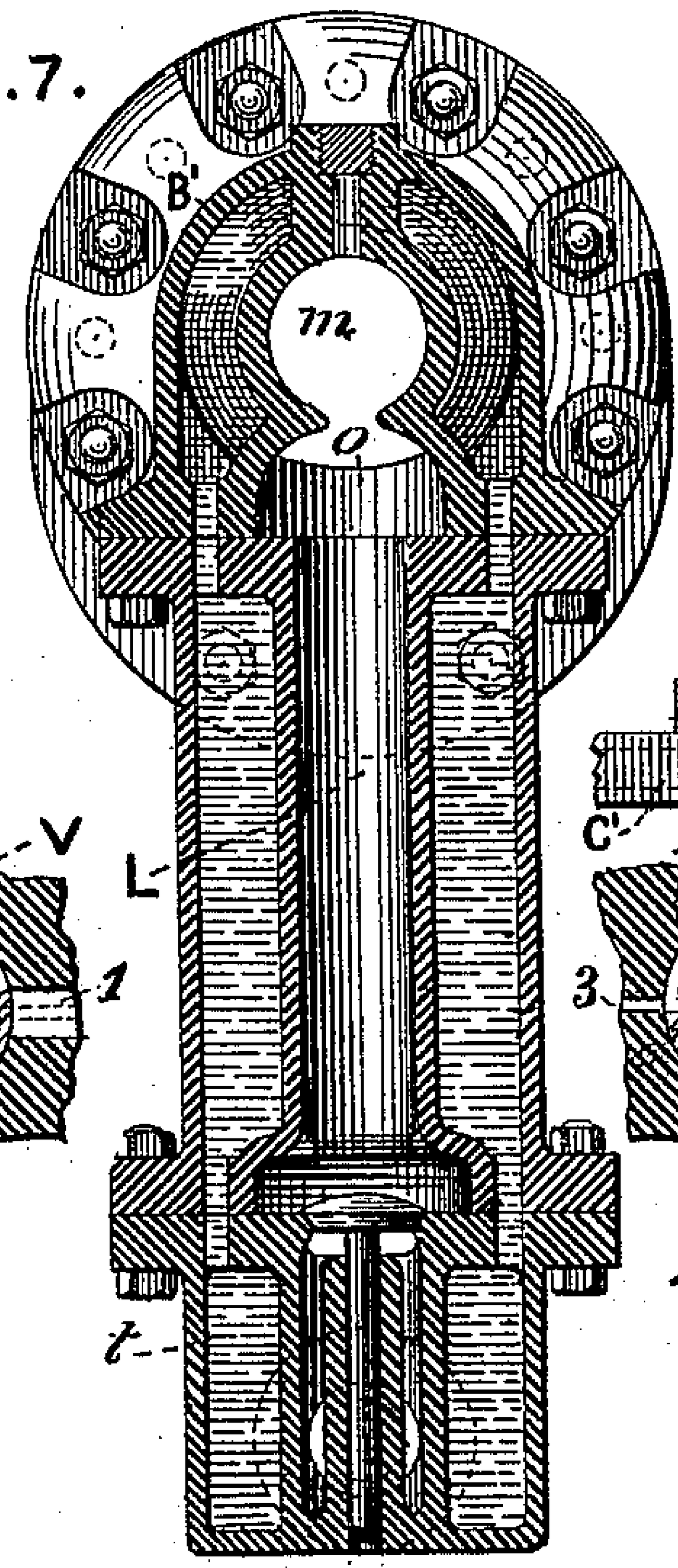
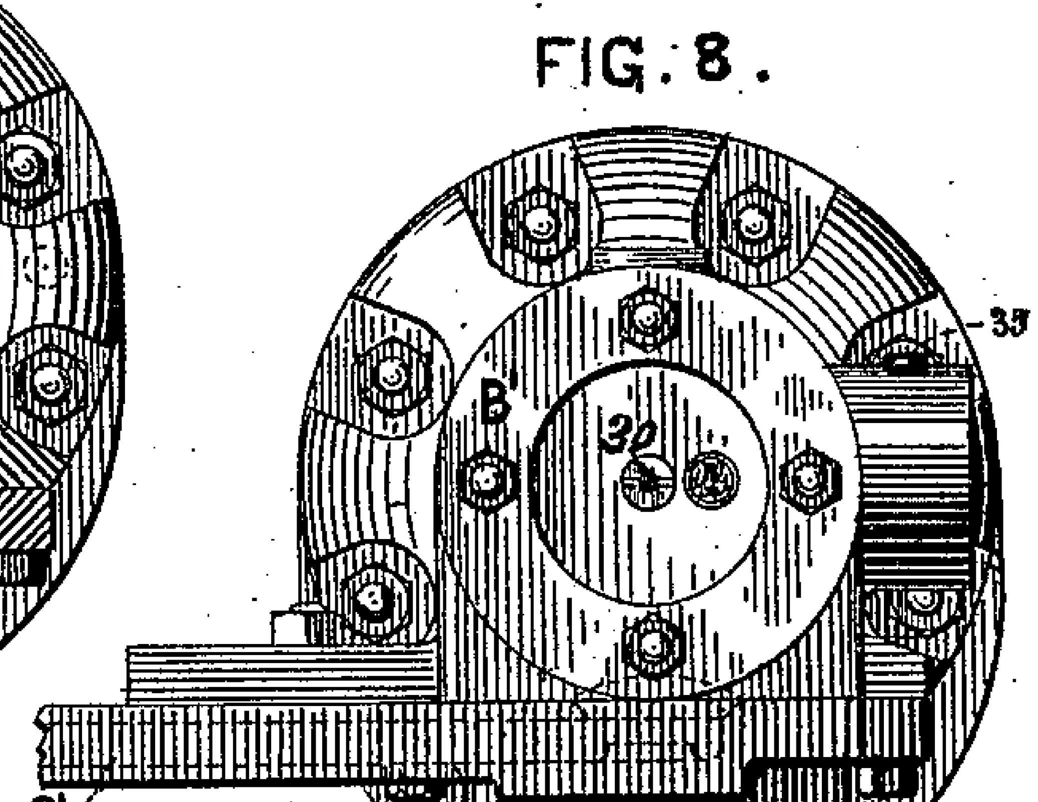


FIG. 8.



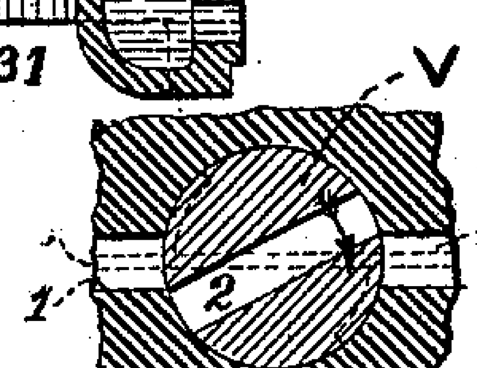


FIG. 9.

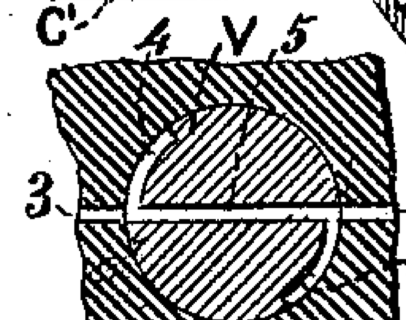


FIG. 10.

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(No Model.) 4 Sheets—Sheet 4.

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GAS ENGINE.

No. 418,821. Patented Jan. 7, 1890.

FIG. 11.

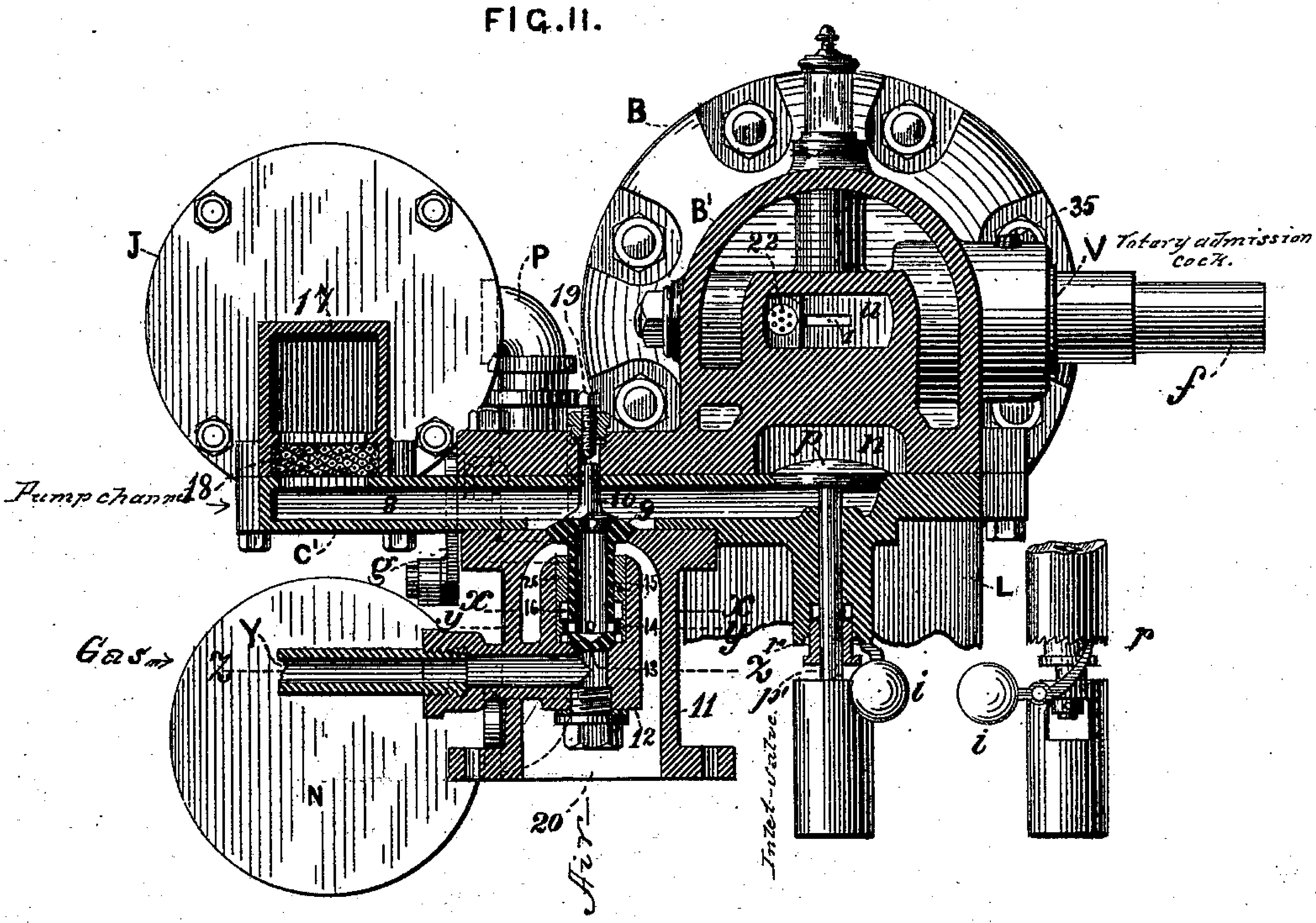


FIG. 12. FIG. 13. FIG. 14.

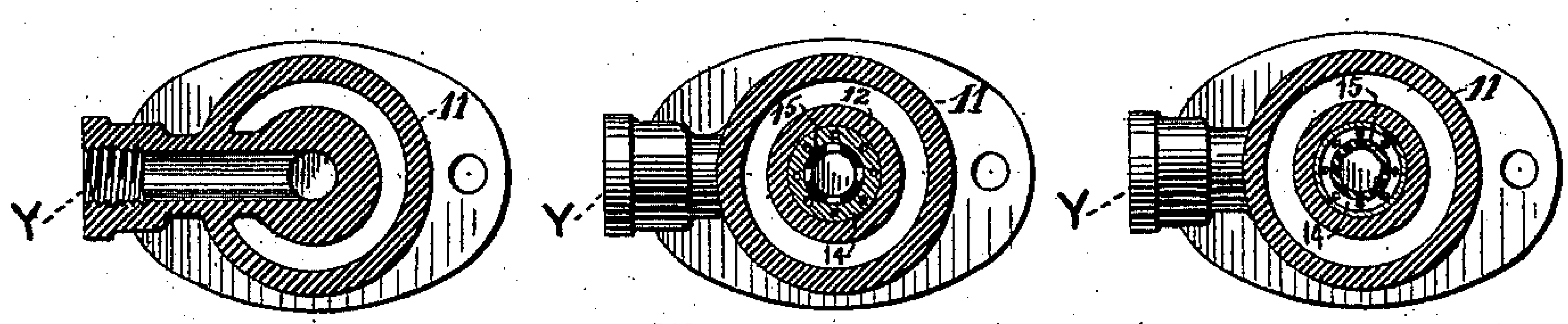
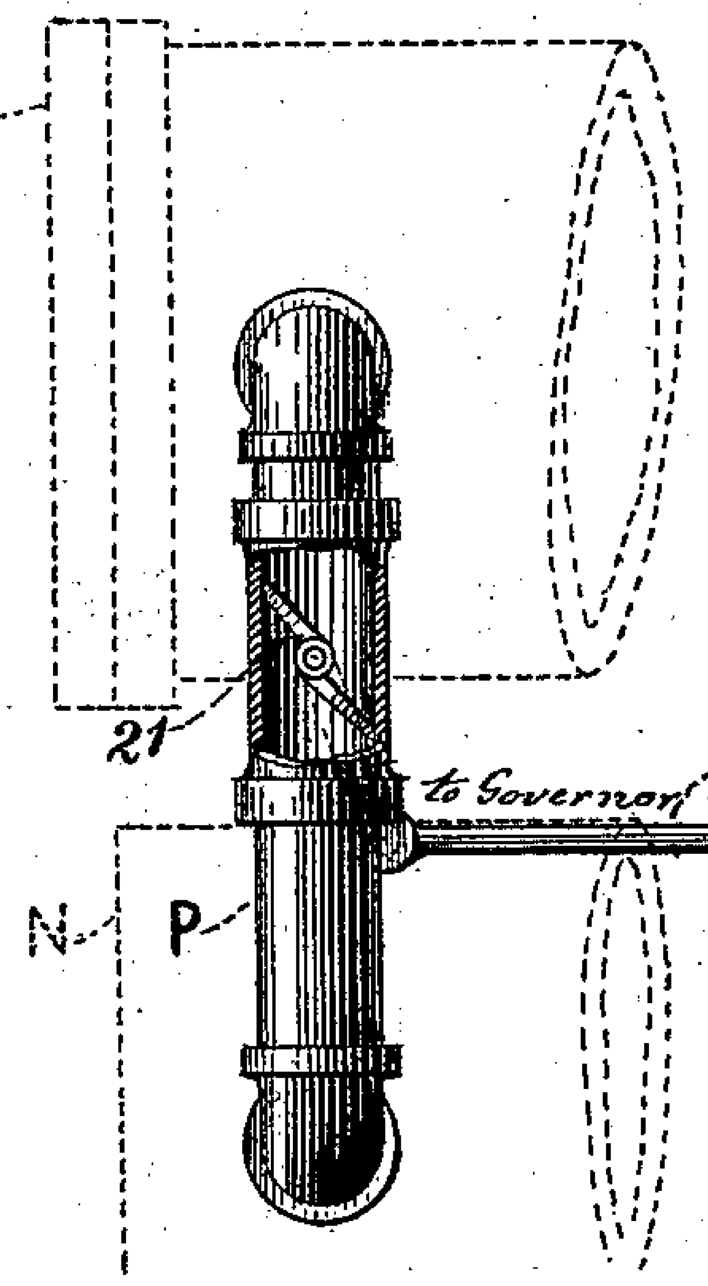


FIG. 15.



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INVENTOR:

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UNITED STATES PATENT OFFICE.

JAMES DOWNER SMITH, OF PHILADELPHIA, PENNSYLVANIA, ASSIGNOR OF ONE-HALF TO JOSEPH L. FERRELL, OF SAME PLACE.

GAS-ENGINE.

SPECIFICATION forming part of Letters Patent No. 418,821, dated January 7, 1890.

Application filed April 18, 1885. Serial No. 162,624. (No model.)

To all whom it may concern:

Be it known that I, JAMES DOWNER SMITH, of Philadelphia, in the State of Pennsylvania, have invented certain new and useful Improvements in Gas-Engines.

The following is a specification of my said improvements, reference being had to the accompanying drawings, wherein—

Figures 1 and 2 are views in elevation of the complete engine as seen from the opposite sides. Fig. 3 is a top or plan view thereof, and Fig. 4 an end view thereof. Fig. 5 is a central vertical section through the axis of the motor-cylinder and adjacent parts on an enlarged scale. Fig. 6 is a horizontal section through the ignition-chamber and the valve by which it communicates with the motor-cylinder. Fig. 7 is a vertical section on the irregular line *w w* of Fig. 5. Fig. 8 is an exterior end view of the motor-cylinder. Figs. 9 and 10 are sectional views (on a much enlarged scale) of the ignition-valve at different points. Fig. 11 is a vertical section through the center of the passages by which air and gas are admitted to the motor-cylinder, the scale of this and the succeeding figures being still further enlarged. Figs. 12, 13, and 14 are horizontal sections on the lines *z z*, *y y*, *x x*, respectively, of Fig. 11. Fig. 15 is a view, partly in section, of the valve which is controlled by the governor of the engine.

My improvements are especially adapted for use in connection with that class of gas-engines in which the charge is compressed before ignition, although some of them are applicable to engines of different types.

Their nature and objects can be best explained in describing the construction and operation of the several parts.

Referring to the general exterior view of the engine, A represents the bed supporting the motor-cylinder B, which is surrounded with the usual water-jacket, the water-circulation being maintained by means of pipe M M′.

C is the connecting-rod of the motor-piston; D, the fly-wheel; E, the rod for operating the valve mechanism, which rod is actuated by an eccentric mounted upon the main driving-shaft in the usual manner.

The charge is supplied to the motor-cylinder by a pump, whose cylinder is shown at J, and which is worked by means of a connecting-rod X, attached to a wrist-pin radially adjustable in a disk D′, mounted upon the driving-shaft.

K is a governor which controls in a manner to be hereinafter explained the extent of the charge introduced into the motor-cylinder.

N is a strong receptacle, into which under certain conditions the surplus charge is forced by the action of the pump, and which for that purpose connects with the pump-cylinder J by a pipe P.

The igniting system is contained in an end extension B′ of the motor-cylinder B, by which the charge is conveyed from the pump-cylinder J to the motor-cylinder B and igniting-chamber.

Y, Figs. 2 and 4, indicates the main inlet-pipe, which is connected with the gas-supply, and G is the discharge-pipe leading from a large chamber F, into which the direct exhaust from the motor-cylinder takes place.

The general operation of the apparatus is as follows: A charge of mingled air and gas is pumped into the motor-cylinder at a time when the motor-piston is at or near the outer end of its stroke. When the piston has been brought to its innermost position, said charge is ignited, driving the piston forward and actuating the driving-shaft. This movement opens the exhaust-valves and permits the discharge of the products of combustion into the exhaust-chamber F, and thence into the open air. In the meanwhile the return-stroke of the engine actuates the pumping mechanism, so that a fresh charge is delivered into the cylinder and the operation is repeated.

Having thus given a most general description of the operation of the machine, I will now proceed to a detailed description of those portions wherein the present improvements consist. The motor-cylinder and adjacent parts are shown in vertical section in Fig. 5. The interior shell R′ of the cylinder surrounded by the water-jacket terminates in a conical compression-chamber *m*, into which the inlet-passage *n* for the charge of air and gas leads. As will be seen in the drawings, this inlet directs the current of entering gas and air upward, so as to impinge upon the upper surface of the shell R′, the passage being preferably inclined, as shown. Beneath the inlet *n* is a downwardly-depending chamber L, partly surrounded by a water-jacket and communicating at *o* with the interior of the motor-cylinder. At the bottom of this chamber L is the exhaust-valve *t*, the actuating mechanism of which will be seen on referring to Fig. 1, but which will be hereinafter described in connection with the description of the other valve movements. When open, the exhaust-valve communicates with the large exhaust-chamber F, whose construction and functions will also hereinafter be described.

The operation of the parts now under consideration is as follows: The charge of gas and air is introduced into the cylinder through the orifice *n* and fills both the cylinder proper and the chamber L. The piston *k*′ being brought to its extreme innermost position, the charge is compressed into the chamber *m*, and is then ignited in a manner which will be hereinafter described. The ignition commences at the point *l* in Fig. 5, and primarily takes place in the conical chamber *m* of the cylinder proper. By reason, however, of the extended chamber L the combustion of the whole charge is not instantaneous, but takes place first in the compression-chamber *m* and subsequently throughout the chamber L. This method of protracting the combustion has the advantage of relieving the piston from a too sudden shock and is found to economize the actual force of the charge in the best manner. Assuming that combustion has taken place (the inlet-valve *p* being of course closed) and that the piston *k*′ has been driven to its extreme outward position, the exhaust-valve *t* is opened and the products of combustion rush out into the exhaust-chamber F. The piston *k*′ then commences its return-stroke and the exhaust-valve *t* remains open for a minute fraction of said return-stroke. At the same time the inlet-valve *p* is opened, and, owing to the direction given to the entering current at *n*, it flows into the cylinder above the products of combustion, which are still passing out through the orifice *o*. The cylinder proper is first filled, and finally the chamber L. Thus the admission of the new charge, following the exit of the products of combustion closely, aids in expelling more completely the residuum of the previous charge. The features of improvement in this connection are, therefore, the inlet-passage with an upward projection in the cylinder, the subjacent discharge-passage, and the chamber L, which forms both a supplemental combustion-chamber and a portion of the discharge-passage.

The next group of features to which my invention relates, and which may properly be described at this point, are the exhaust devices. I provide a horizontal pipe G′, leading from the exhaust-valve *t* into a large exhaust-chamber F. This chamber F has a pipe G, which communicates with the open air. The outer end of said pipe is provided with a case H, in which is seated a puppet-valve *h*′, opening outward. This valve *h*′ is intended to permit the discharge from the exhaust-chamber and to close it against admission of the outside air. The interior of the exhaust-chamber, as well as a portion of the pipe G′, is provided with a water-spraying device I, by which water is constantly injected upon the issuing products of combustion, the surplus water being discharged at the bottom through the drip-pipe Z. I have found that this method of constructing the exhaust-connection reduces the volume to be expelled, and by producing a partial vacuum within the chamber F gives a softer exhaust. It also prevents the ignition of accumulations of unburned mixture, which sometimes occur in the exhaust-passages, owing to missed ignitions in the cylinder or to defective adjustments of the valves. The features of improvement therein are the combination, with the exhaust-valve, of an enlarged exhaust-chamber and discharge-pipe leading from said chamber to the air; also the valve controlling the orifice of said exhaust-pipe against back-flow of air and the arrangement of a spraying device within said exhaust-chamber.

The next group of devices to be considered comprises the igniting devices and parts adjacent thereto. In Fig. 6 is shown a horizontal section through this portion of the apparatus. It will be seen that the chamber *m* of the motor-cylinder connects at its extreme end by means of a horizontal passage 1 with a small chamber *u*, situated within the extension B′ of the motor-cylinder. Communication between this chamber *u* (which I term the "ignition-chamber") and the compression-chamber *m* is controlled by means of the valve V. This valve is in the form of a spindle, preferably tapering, having a transverse opening or port 2, arranged to register with the passage 1, and which I term the "igniting-port." When the valve-spindle V is in the position shown in Fig. 6, communication between the ignition-chamber *u* and the compression-chamber *m* is cut off. When, however, the valve-spindle V is turned at right angles to the position there shown, the two chambers *u* and *m* communicate through the igniting-port 2. The valve movement is preferably such as to rotate the valve-spindle always in the same direction, and thus for each complete rotation of said spindle the port is opened twice. The movement of the spindle may, however, be oscillatory upon its axis instead of rotatory.

In addition to the ignition-port 2, the valve-spindle has a supplemental port 5 (see Fig. 10) for the following purpose: Referring to Fig. 6, it will be seen that a very small passage-way 3 extends from the rear portion of the chamber *m* to the spindle V and continues on the other side of said spindle until it reaches the ignition-chamber u, its orifice at this point being covered by a perforated plate 22. (Shown more clearly in Fig. 11.) The function of this passage-way 3 is to permit a small quantity of mixture to pass through for the purpose of blowing the ignition-chamber clear of the products of combustion left from the preceding charge. It is necessary that this should be accomplished in advance of the opening of the igniting-port 2, and it is also necessary that the admission of the mixture through said ports should be so conducted that the ignition cannot take place except through the igniting-port. The arrangement of the perforated plate 22 over the orifice of this supplementary port 3 prevents the backing of the flame through it, and in this manner the second of these purposes is effected.

In order to clear the ignition-chamber at the proper time with relation to the opening of the igniting-port 2, I construct the supplemental port (see Fig. 10) in the following manner: Said Fig. 10 represents a transverse section of the spindle V on a line through the adjacent passage 3. It will be seen that a small transverse passage is formed through the spindle V at 5, and that a portion of the periphery of the spindle adjacent to each end of said passage 5 is cut away, as shown at 4. The opening thus formed constitutes the supplemental port, and its relation to the main port 2 is shown in Fig. 9 by the dotted lines, where it will there be seen that as the spindle V rotates the supplemental port is opened a short time in advance of the main port 2. Thus in Fig. 9 the main port 2 is about to be opened; but for a short time prior to this the passages 4 and 5 of the supplemental port have established communication through the passage 3. During the time that the port 5 has thus been opened a small stream of gas and air has been discharged into the ignition-chamber u through the perforated plate 22, driving before it the products of combustion from the previous charge of the ignition-chamber in the following manner: At the end of the ignition-chamber u farthest from the inlet 22, I provide a small passage-way 6. In the enlarged portion 25 of the valve-spindle V are arranged two ducts 31, leading to a diametrical passage q. (Indicated by dotted lines in Fig. 6.) At each half-rotation of said spindle these ducts communicate with an outlet-passage 6, leading from the end of the ignition-chamber u, and thus immediately after the ignition of the gases has taken place and the main port 2 has closed the rotation of the valve-spindle V opens an exhaust at that end of the ignition-chamber which is farthest from the inlet 22. An opening 35 is formed in the casing of the enlarged portion 25 opposite to the points at which the passage q comes to rest on each half-rotation. The result of this arrangement is, that the entering gases at 22 drive before them the products of combustion of the old charge.

At the end of the ignition-chamber u nearest to the exhaust-passage 6 are the igniting devices. These preferably consist of a loop of platinum wire or material capable of being rendered incandescent by an electric current having conductors O, which are suitably insulated in their passage through the wall of the chamber u, and are connected with a dynamo or other convenient source of electricity, so as to maintain the loop 27 in a constant state of incandescence. When the ignition-chamber u is sufficiently charged with the combustible mixture, ignition takes place, and the flame communicates through the port n and the passage-way 1 into the cylinder, where it ignites the main charge, as has been before described. Besides affording a protection against the backing of flame, as before stated, the perforated plate 22 breaks up the entering current and obviates the risk of cooling down the incandescent loop, which might take place if the current were directed upon it with full force.

In Figs. 6 and 8 a sight-glass is shown in the cap 29, that covers the ignition-chamber. A hole 30 is pierced through the cap and the outer end of the hole is enlarged. The bottom of this enlarged portion forms a seat for a glass disk 28, the remaining portion of the enlargement being threaded to receive a hollow cylinder, also threaded on its exterior, by which the glass disk is secured in place. The object of this sight-glass is to provide means of viewing the flame as ignition takes place, since the color of the flame affords the best indication of correct proportions of air and gas mixture for perfect combustion.

The features of improvement most prominent in this group of devices are as follows: the construction of the valve which controls the ignition-port in the form of a rotating spindle. Great difficulty has been heretofore experienced in operating the slide-valves ordinarily used for this purpose, since they are exposed to the full shock of the explosion and rapidly deteriorate. I have found that the use of a rotating spindle exposes a minimum of valve-surface to the action of the flame, and that such wear as does take place from said exposure is regular and self-compensating. By combining in the same spindle with the igniting-port proper the secondary port for allowing what may be termed the "leakage of the charge" into the ignition-chamber and the exhaust-port therefrom I drive out the products of combustion in the precise relation which is necessary to the opening of the igniting-port, and, furthermore, I obtain all of these three valve movements by a simple rotary movement of the spindle. The angular relation of these various ports in the valve-spindle V is indicated in the drawings, and can be of course varied to suit the conditions desired upon any particular engine without changing the principle of operation.

The next group of devices comprises the

valve movements of this portion of the apparatus.

Referring to Fig. 1, it will there be seen that the eccentric-rod E oscillates a toothed sector U, the teeth of which engage with a gear *e*, mounted upon the projecting stem *f* of the spindle V. This gear is provided with a pawl, which engages with a double ratchet-tooth secured to the projecting end of the stem *f*. Thus as the sector U oscillates it moves the gear *e* and its pawl alternately in opposite directions, and at each complete reciprocation turns the stem *f* (by means of the ratchet-tooth) a half-rotation. Upon the sector U is pivoted a tripping-pawl *a*. At each descent of this pawl *a* it strikes a lever-arm T and raises the link S by means of said lever T. This link S is connected with a horizontal link R, which is pivoted to the rigid bracket Q. As the pawl *a* in its descent trips the lever T, the link S raises the end of the horizontal link R and falls again after the passage of the pawl *a* beyond the lever T. On the return movement of the sector the pawl turns upon its pivot, so as to pass the lever-arm T, and then drops again, by reason of its weighted rear end, into the position shown in Fig. 1. The downwardly-projecting stem *d* of the exhaust-valve *t* rests upon the horizontal link R, and each time that said link R is raised the exhaust-valve *t* is opened and kept open until the pawl *a* passes the lever T. The lower end of this stem *d* is weighted, as shown, and is provided with a pawl *b*, which engages with a circular or crown ratchet *c*, rigidly attached to the bottom of the chamber L, through which the stem *d* of the exhaust-valve projects. It will be seen that each time that the link R raises the valve-stem *d* the pressure of the pawl *b* against the ratchet *c* will tend to rotate said stem, and on the descent of the stem the pawl will slip past some of the ratchet-teeth and take a fresh hold. I have found that this constant rotation of the valve-stem and valve prevents uneven wear of the valve upon its seat and thus prolongs its efficiency. Any suitable rotating device will of course accomplish the desired results.

The next group of devices are those which relate to the operation of the air-pump and the admission of the charge into the cylinder. The interior construction of the air-pump is of any ordinary character, and its piston is operated, as before stated, by the rod X. By referring to Fig. 2 it will be seen that the wrist-pin S′, carrying the piston-rod of the air-pump, is placed in a radial slot in the disk D′ to permit adjustment of the stroke of the air-pump piston. It sometimes happens that an engine has but small duty to perform for weeks or months, and if the stroke of the pump is shortened to suit the requirements in such cases it will result in a lighter-running engine and a saving of gas. I am aware that this is a common device for many classes of machinery and a variety of pumps in general use; but I believe no gas-engine has ever been provided with a means of adjusting the charge constantly delivered by its pump, the usual method being to allow one or more reciprocations of the motor-piston without fresh charges. This last-mentioned system of regulation should only be applied to temporary or momentary charges of burden, as described farther on.

In Fig. 11, J is the end of the pump-cylinder, and 17 is the opening by which it draws in and expels its charge. This charge is composed of mingled gas and air, the gas coming through the supply-pipe Y and the air coming in at the opening 20. (Shown at the bottom of Fig. 11.)

The valve system which controls the entrance of the two components will now be described. The opening 20 is at the bottom of a vertical chamber 11, which is perfectly cylindrical in form. The upper end of this chamber communicates with a horizontal passage-way 8, the opening between them being so formed as to constitute a valve-seat for the valve 9. This valve 9 is hollow or tubular, as shown, and has at its upper end a vertical guiding-stem 10, by which its upward movement is limited, the limitation being regulated by a set-screw 19, arranged above the end of the stem 10. I prefer to construct the stem 10 in a separate piece from the valve 9, and let it seat itself in the central opening of the valve 9; but I also provide notches in that portion of the stem which is in contact with the valve 9, so that a free passage-way is left from the tubular interior. Each time that the pump draws in a charge the valve 9 is raised and air flows in by the passage 20 into the passage 8. I accomplish the admission of gas at the same time, but without direct communication with the air-inlet, in the following manner: Within the cylinder 11, I mount so as to leave an annular space between them a second hollow cylinder 12. The gas-inlet pipe Y communicates with the interior of said cylinder 12, near whose bottom is a peripheral seat 13. Upon the valve-seat 13 the lower end or stem 15 of the valve 9 rests, so that when said valve 9 is in its lowest position the opening 13 is closed. The hollow stem 15 of the valve 9 has near its lower end a series of radial or lateral openings, which are shown clearly in the sectional view of Fig. 13. A bushing 26 is arranged within the cylinder 12 for the stem 15 to slide in, and the bushing has in its lower portion an open annular space 16, surrounding the stem 15. About the middle of this annular space 16 is arranged a collar 14, having a series of vertical openings through it, as shown in Figs. 13 and 14. This collar is of such vertical height and so arranged that when the valve 9, and consequently the stem 15, are in their lowest position the collar 14 is opposite to and covers the whole or the greater portion of each lateral opening in the stem 15; but when the valve 9 and stem 15 are raised said openings in the stem 15 come opposite to the annular space 16 above the collar 14. Thus communication is established from the pipe Y, (when the stem 15 is raised from the seat 13,) through the perforations of the collar 14, into the annular space 16 above the collar, thence through the radial openings of the valve-stem 15 into the interior of said stem, and from the interior of the stem 15, through the notches of the second stem 10, into the passage-way 8. In this manner each time that the valve 9 is raised air is admitted around it and gas through its interior; but no communication is ever established between the gas-passage and the air-passage, so that the gas cannot leak into the open air. Moreover, both inlets are opened and closed by the movement of a single piece, and therefore in uniformity both as to time and relative extent of opening. Where the valves are separate or not coupled, it is found that they sometimes act irregularly, especially when the full charge is not being pumped. This is entirely avoided by my arrangement. The moment that the pump commences its back-stroke all these valves close instantly, and communication both with the gas and air supply is cut off.

To insure a thorough commingling of the air and gas, I apply across the opening which leads from the passage 8 to the inlet 17 of the air-pump a quantity of wire-gauze 18. The passage of the currents of air and gas through the meshes of the wire-gauze breaks up the stream and causes an intimate mixture, and the operation is of course repeated upon the return-stroke of the pump, which forces the mixture into the motor-cylinder. Supposing the pump to have drawn in its charge of air and gas through the combined valve system which has just been described, the return-stroke of the pump closes said system of valves and forces the mixture of air and gas along the passage-way 8 to the valve p, which controls the opening n, into the motor-cylinder. This valve is lifted by the pressure beneath it and falls as soon as the pump has completed its stroke, thus cutting off the egress of the mixture from the motor-cylinder. Said valve p is provided with a pawl-and-ratchet device $i\ r$, attached to its stem p and case, respectively, and similar to that previously described in connection with the exhaust-valve t, the object being, as before stated, to cause the continuous slow rotation of the valve.

The most prominent feature of improvement in the group of devices just described is the peculiar construction of the double valve by which gas and air are admitted through the same general inlet, but without coming in contact until actually within the main passage-way of the machine.

The next feature of improvement relates to the governing devices. Beneath the pump-cylinder J, I arrange a second cylinder or receptacle N, of about the same cubic capacity as the pump-cylinder, and establish communication between the pump-cylinder J and said cylinder N (which I term the "overflow-cylinder") by means of a pipe P. In this pipe P, which is shown in the detail view of Fig. 15, is a balanced valve 21, turned by means of the connecting-rod g, which is attached to the lever h, operated by the governor K. When the balls of the governor move outward, the lever h pulls the connecting-rod g, so as to open the valve 21. When, on the other hand, the balls move inward, the lever h pushes the connecting-rod g and closes the valve. Supposing the pump at this time to be in operation, if the speed of the apparatus is too great, the action of the governor K upon the valve 21 permits the discharge of the whole or a portion of the pump's contents into the overflow-cylinder N, since the mixture from the pump finds a more ready exit through the pipe P than it does through the inlet p of the motor-cylinder. The motor-cylinder is thus left without any new charge of air and gas, and no ignition takes place therein, so that the momentum of the fly-wheel alone continues the action of the engine. Should the omission of a single charge in the motor-cylinder thus brought about be insufficient, however, to reduce the speed of the engine, the balls of the governor still remain in their outward position and the valve 21 in the pipe P still remains open, so that on the return-stroke of the pump no new charge of air and gas is drawn in through the main inlet of valves therefor; but the contents of the overflow-cylinder are merely drawn back again, and so long as the condition of too great speed exists in the engine the pump would merely continue to draw its charge from and redeliver it into the overflow-cylinder. In practice, however, the operation cannot continue, since the speed of the engine is immediately reduced by the failure to supply fresh charges to the motor-cylinder, so that the action of the governing devices soon closes the valve so far as is necessary to maintain a uniform speed, and the normal action of the pump is resumed, supplying a fresh charge at each reciprocation to the motor-cylinder. This governing system perfectly compensates all temporary or accidental variations of burden upon the engine, while the more permanent adjustment of the charges is preferably effected by means of the radially-adjustable wrist-pin t in the disk D', as before stated.

I claim—

1. In combination with the compression-chamber of a gas-engine cylinder, an inlet-duct leading thereto near its rear end and an outlet arranged upon the same side of the chamber and between the inlet and the piston, the line of projection of the inlet-duct being such as to strike the opposite side of the chamber or cylinder, whereby when the charge is admitted before the completion of the exhaust the identity of the entering and outgoing currents is maintained, substantially in the manner set forth.

2. The combination, with the compression-chamber and the supplemental combustion-chamber, arranged relatively to one another substantially as set forth, of an inlet-duct leading into the compression-chamber at a point adjacent to the supplemental combustion-chamber and an exhaust-valve communicating with said supplemental chamber.

3. The valve-spindle having a main igniting-port and supplemental inlet and outlet ports arranged at an angle to said main port, whereby as said spindle moves the said supplemental ports are opened in advance of the opening of the main port, substantially as set forth.

4. The combination, with the supplemental inlet-port leading into the ignition-chamber, of the perforated plate arranged over the opening of said inlet-port, whereby backing of flame is prevented and the entering current is broken up to avoid direct impingement upon the igniting device.

5. The combined gas and air inlet consisting of a hollow valve the exterior periphery of whose head rests upon a seat formed in the air-channel and the bottom of whose stem rests upon a seat in the gas-channel, said stem being provided with lateral openings, and which lead into a chamber of the gas-channel above said last-mentioned seat, and said chamber being provided with a perforated ring fitting closely around the valve-stem and of such vertical height as to control the lateral openings of the stem, the whole combined and operating substantially as set forth.

JAS. DOWNER SMITH.

Witnesses:
THOS. M. SMITH,
GEO. A. VAILLANT.