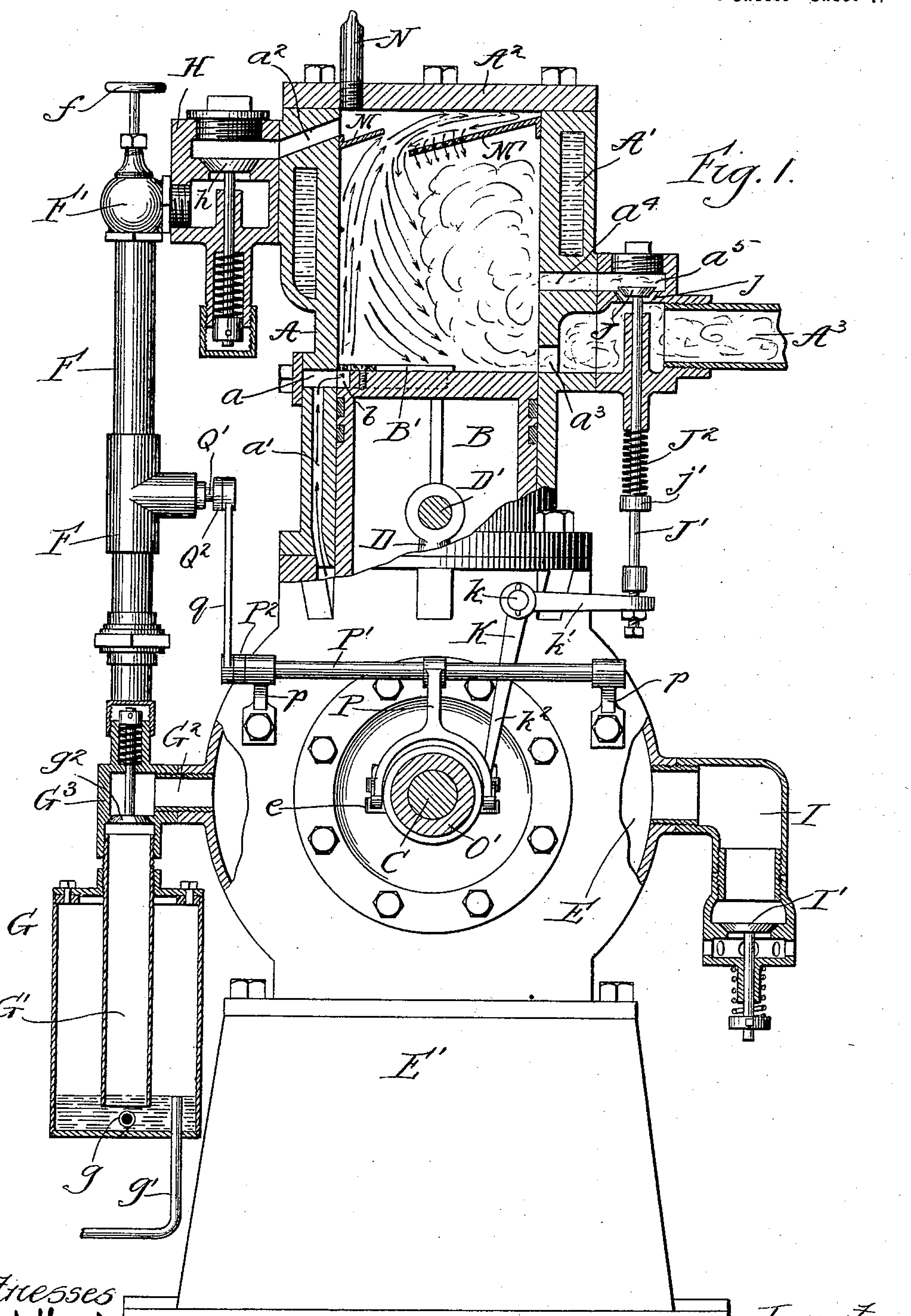
No. 640,675. Patented Jan. 2, 1900.

G. W. LEWIS.

EXPLOSIVE ENGINE.

(Application filed Apr. 9, 1896. Renewed Sept. 22, 1898.)

(No Model.) 4 Sheets—Sheet 1.



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(No Model.) 4 Sheets—Sheet 2.

Fig. 2.

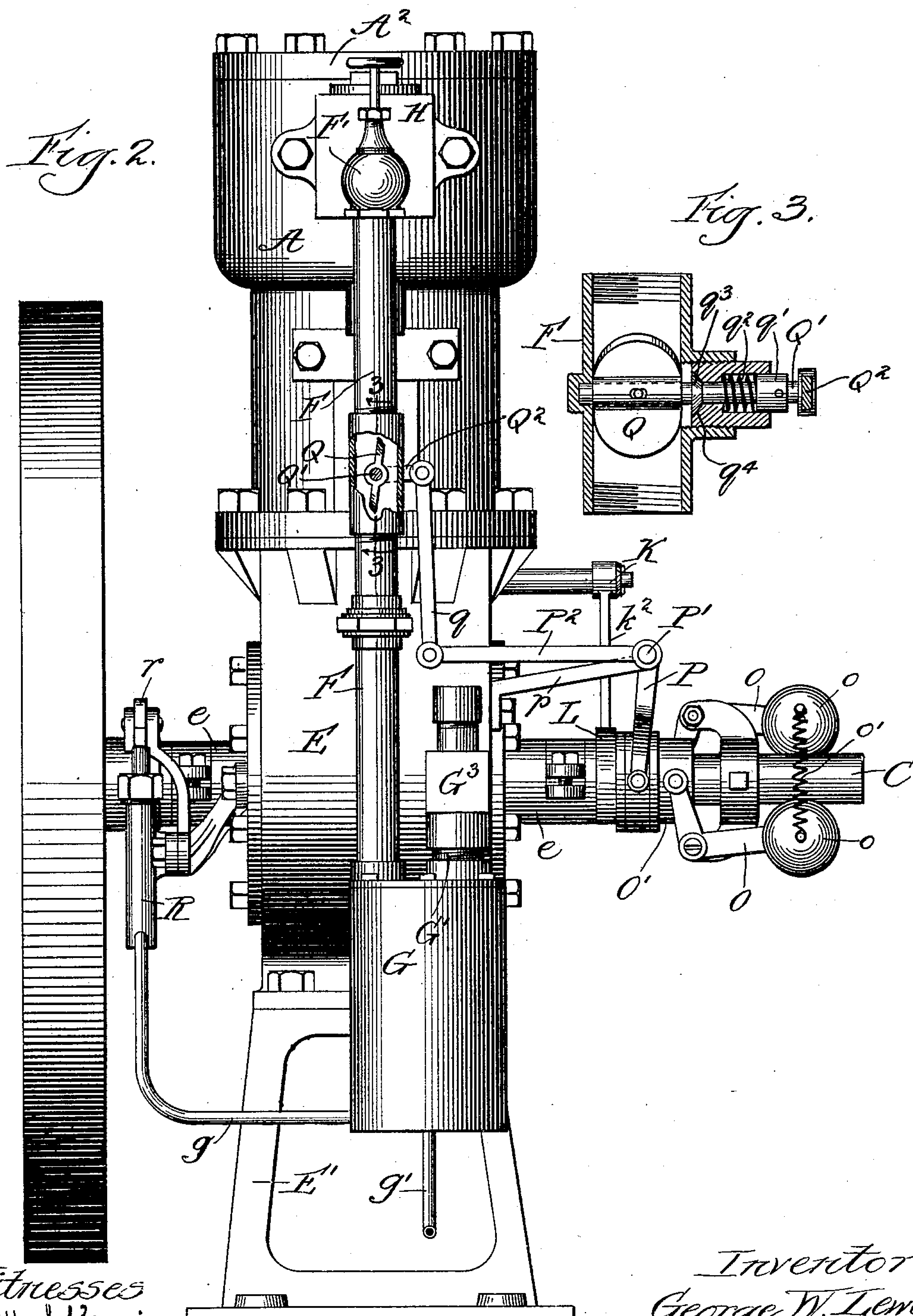

Fig. 3.

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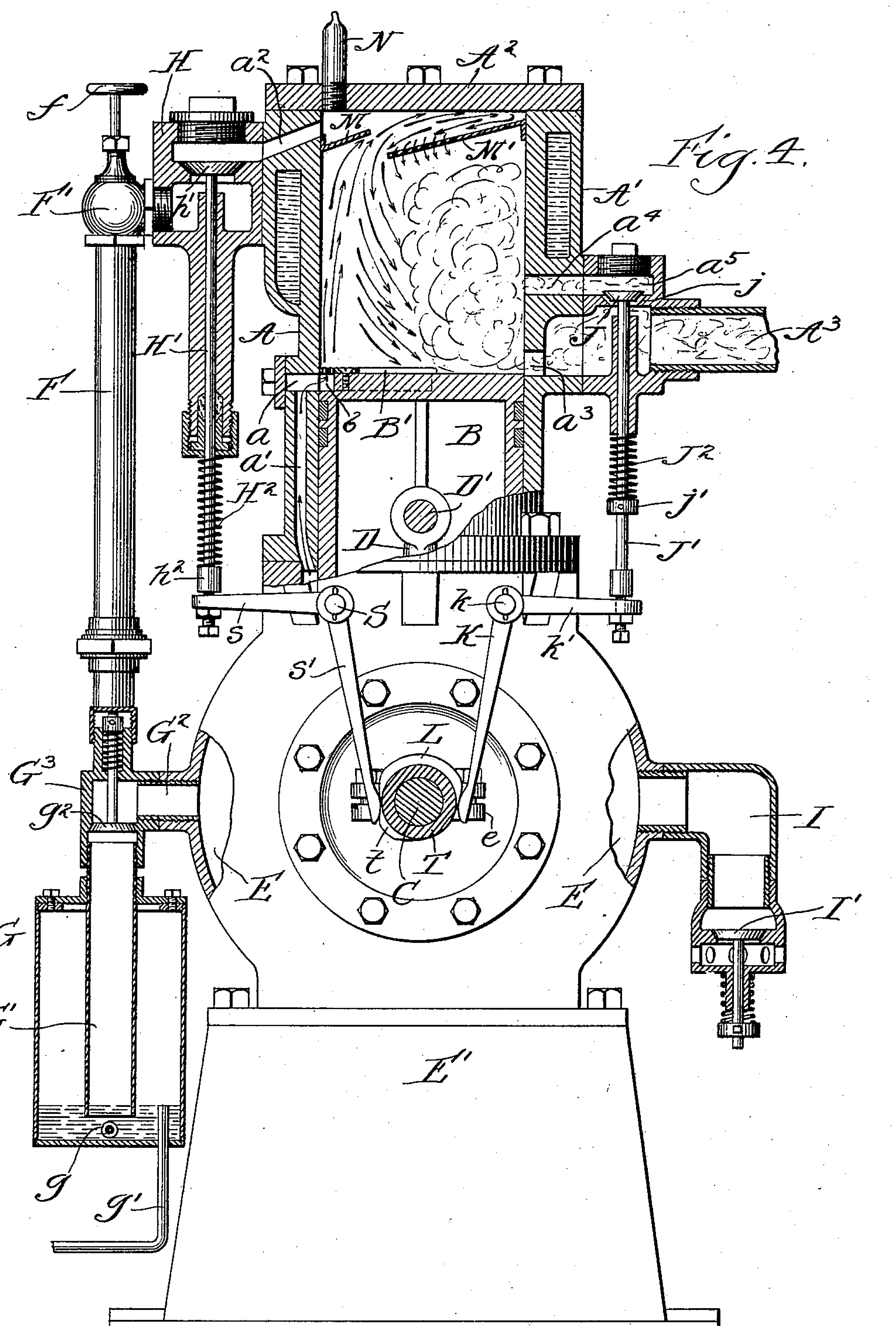
(No Model.) 4 Sheets—Sheet 3.



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(No Model.) 4 Sheets—Sheet 4.

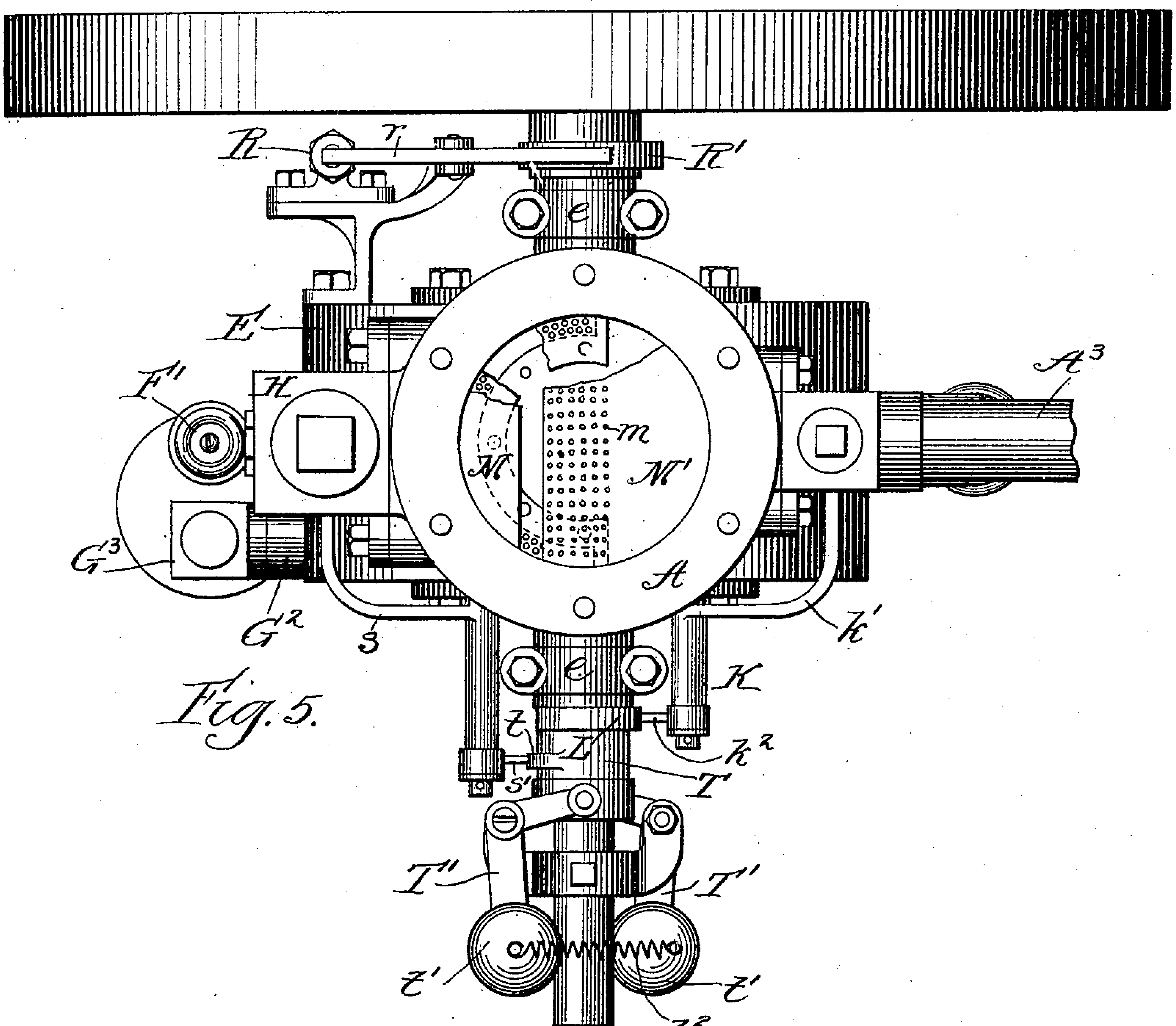

Fig. 5.

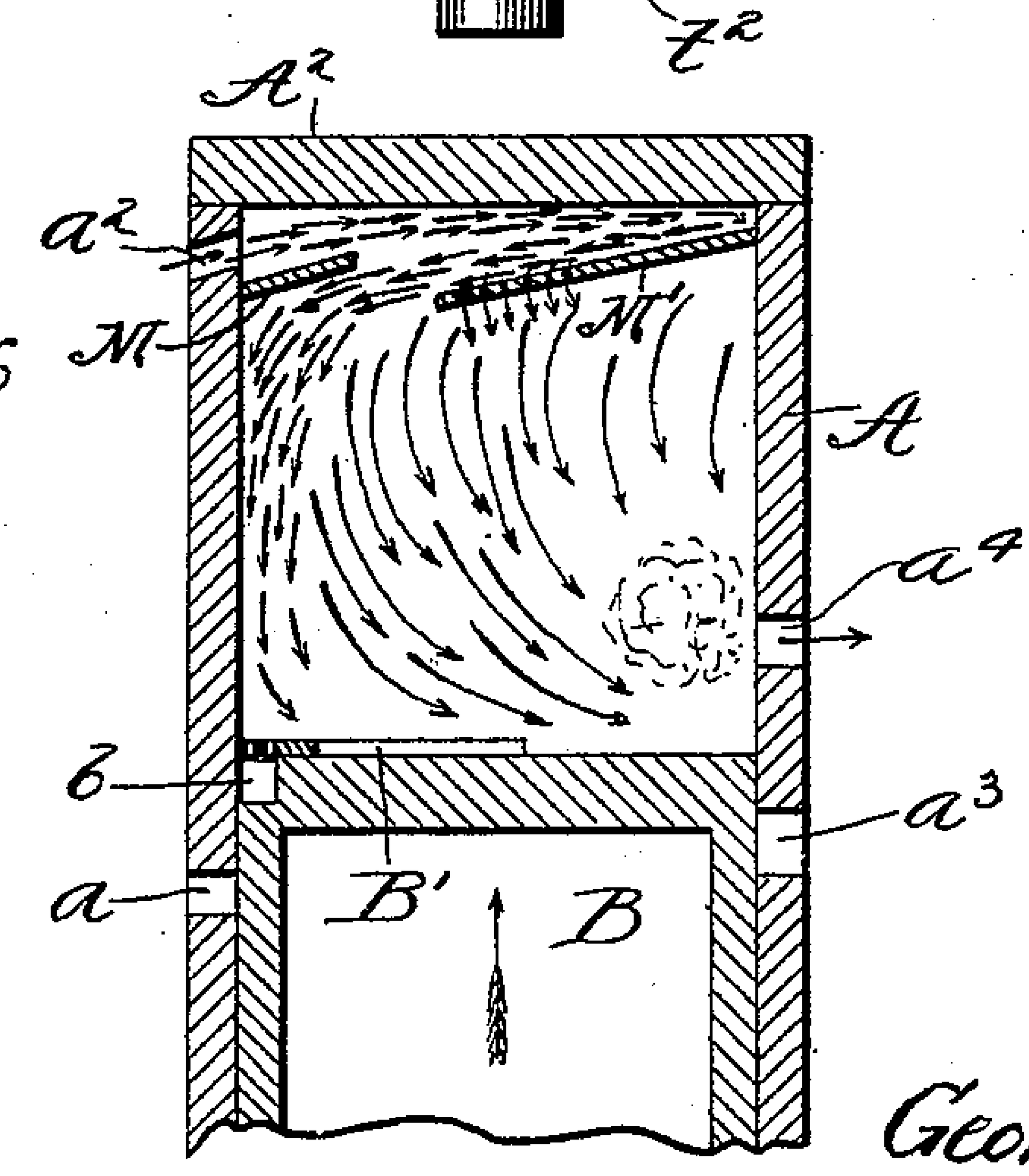

Fig. 6

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UNITED STATES PATENT OFFICE.

GEORGE W. LEWIS, OF CHICAGO, ILLINOIS, ASSIGNOR TO THE J. THOMPSON & SONS MANUFACTURING COMPANY, OF BELOIT, WISCONSIN.

EXPLOSIVE-ENGINE.

SPECIFICATION forming part of Letters Patent No. 640,675, dated January 2, 1900.

Application filed April 9, 1896. Renewed September 22, 1898. Serial No. 691,631. (No model.)

To all whom it may concern:

Be it known that I, GEORGE W. LEWIS, of Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Explosive-Engines; and I do hereby declare that the following is a full, clear, and exact description thereof, reference being had to the accompanying drawings, and to the letters of reference marked thereon, which form a part of this specification.

This invention relates to improvements in explosive gas or vapor engines of that class in which explosion or power impulse takes place with every forward stroke of the piston and which embrace an air-compression chamber in which air is compressed continuously in the action of the engine and from which a supply of air under compression is admitted to the cylinder with gas or vapor to form the explosive charge.

The invention consists in the matters hereinafter described, and pointed out in the appended claims. As one important feature of my invention I propose to employ, in addition to the exhaust-port, which is uncovered by the piston at the termination of its outward or power stroke, a second or auxiliary exhaust-port located nearer the closed end of the cylinder than the main exhaust-port and controlled by a positively-actuated valve, which valve is closed during the outer or power stroke, but is opened in the inward or back stroke, by which the waste gases are forced from the cylinder through the exhaust-ports. By the use of such auxiliary exhaust-port the waste gases are discharged from the cylinder much more effectively than in engines as ordinarily made, for the reason that the exit of said gases continues during a considerable part of the inward stroke of the piston instead of being cut off after a very short movement thereof, as is the case when a single exhaust-port is employed. In the novel construction described compression of the charge does not begin until after the piston has completed a portion of its backward stroke and has moved far enough to cover the auxiliary port. This, however, I have found to be no detriment in the action of the engine, but, on the contrary, to be an advantage, for the reason that the compressive action of the piston occurs only in the latter part of its upward stroke and when the crank and connecting-rod are in position for most effective action, it being obvious that in this construction compression is taking place to only a slight extent, if at all, at the middle of the stroke, when the crank stands at right angles to the axis of the cylinder, while in engines as ordinarily constructed a considerable amount of compression is taking place at the middle of the stroke of the piston.

As a further improvement in engines of the character described I propose to admit a charge of pure air to the cylinder at the side of the same opposite the exhaust-port and after such charge has been admitted to then admit an admixture of air and gas or vapor and to provide means by which such admixture shall be directed behind the body of fresh air previously admitted, so that the fresh air shall serve as a separating body or layer between the gas or vapor and the waste gases which are passing from the cylinder at the time the fresh charge enters the same, the body of fresh air thus constituting a barrier to prevent the gas or vapor from becoming in any degree mixed with the waste gases or from passing from the exhaust-port with the same.

The invention also embraces improvements in the mechanical devices by which the incoming charge is deflected or directed in entering the cylinder and with other details of construction, as will hereinafter fully appear.

In the accompanying drawings, illustrating my invention, Figure 1 is a view, partially in side elevation and partially in central vertical section, of an engine constructed in accordance with my invention. Fig. 2 is a view in elevation of the engine shown in Fig. 1, showing the side of the engine which is at the left hand in Fig. 1. Fig. 3 is a detail section through the throttle-governing valve of the engine, taken on line 3 3 of Fig. 2. Fig. 4 is a view similar to Fig. 1, showing a similar engine provided with a "hit-or-miss" governor. Fig. 5 is a plan view of the engine shown in Fig. 4, with the cylinder-head removed to show the interior of the cylinder. Fig. 6 is a diagrammatical section of the cylinder, illustrating the course of the entering charges when introduced into the same.

As illustrated in said drawings, A indicates the power-cylinder of the engine, which is provided with the usual water-jacket A′ and has within it a piston B, which is connected with the crank-shaft C through the medium of a pitman D, which has immediate pivotal connection with the piston by means of a transverse pivot-pin D′. The cylinder is open at its end nearest the crank-shaft and is closed at its opposite or explosive end by a head A^2, the open end of the cylinder being connected with an air-compression chamber E, which in this instance forms a casing for the crank-shaft and connecting-rod and the side walls of which form supports for the tubular bearings *e e* of the crank-shaft C. Said chamber E in the instance illustrated forms part of the engine-frame, the same being attached to a base-casting E′.

The cylinder A is provided at one side with an admission-port *a*, so located that it will be covered by the piston except when the same is at the outward limit of its stroke. Said port is connected by a passage *a′* with the interior of the compression-chamber E, said passage *a′* being in the instance shown formed in the side wall of the cylinder and opening through the end of the cylinder nearest the compression-chamber into the latter.

The inlet-port *a* is for the admission of air only to the cylinder, and a second inlet-port a^2 for an explosive mixture is located at the upper or explosion end of the cylinder, preferably entering the same through the side wall at the same side of the cylinder as the inlet-port *a*. Air is supplied from the compression-chamber E to the passage a^2 by means of a pipe F, and a carbureting device G is arranged in connection with said pipe in such manner that air passing from the compression-chamber to the cylinder takes up or is charged with the necessary quantity of vapor. The carbureter shown is in itself novel, and consists of a cylindric vessel provided with a supply-pipe *g* and an overflow-pipe *g′*, which maintains the hydrocarbon within the vessel at a constant level, and an air-inlet pipe G′, which passes through the top of the chamber downwardly to a point below the level of the liquid, so that air entering through the said inlet-pipe is brought into contact with the liquid in passing through from the pipe to the upper part of the chamber. Said inlet-pipe G′ is shown as connected at its upper end with the compression-chamber E by means of a horizontal pipe G^2, between which and the pipe G′ is located a valve-casing G^3, containing a spring-actuated check-valve g^2, which opens toward the carbureting-chamber. The pipe F, as clearly seen in Fig. 2, is connected with the top of the carbureting-chamber G and extends to and is connected with a valve-casing H, which is interposed between the said pipe and the inlet-port a^2 of the cylinder. Said valve-casing H contains a spring-actuated check-valve *h*, which opens toward the cylinder. At the end of the pipe F adjacent to the valve-casing H is located another valve-casing F′, containing an ordinary hand-actuated globe-valve, the hand-wheel *f* of which is shown in the drawings.

For the purpose of admitting air to the compression-chamber E in the inward or upward stroke of the piston an admission-pipe I is provided, the same having a spring-actuated check-valve I′, which opens inwardly to admit the air to the chamber, but closes automatically on the outstroke of the piston to prevent the escape of air at such time. It follows from the construction described that air is drawn into the compression-chamber in the inward stroke of the piston and is compressed therein in the outstroke of the piston until such time as it is allowed to escape to the cylinder through the passage *a′* and pipe F.

At the side of the power-cylinder opposite the inlet-ports *a* a^2 is located an exhaust-port a^3, which communicates with an exhaust-pipe A^3, said exhaust-port being located in position to be uncovered by the piston when the latter reaches the outer limit of its stroke. At the same side of the cylinder with the exhaust-port a^3 and at a point considerably distant from said port and preferably about the middle of the stroke of the piston is located a second or auxiliary exhaust-port a^4, which communicates with the exhaust-pipe A^3 by means of a passage a^5, provided with a valve J, the seat *j* of which is formed in a partition separating the passage a^5 from the exhaust-pipe A^3. Said valve J is attached to a valve-stem J′, on which is secured a collar *j′*, and a spring J^2 is located between said collar and the valve-casing, so as to hold the valve normally in contact with the seat. An actuating device for operating the valve is provided, the same as herein shown, consisting of a bell-crank lever K, which is pivoted on a stud *k* and is provided with an arm *k′*, which bears against the stem J′, and another arm k^2, which engages a cam L on the shaft C, which cam is more clearly shown in Figs. 2, 4, and 5. Said cam L is arranged to hold the valve J open during the inward or back stroke of the piston and to allow the closing of the valve under the action of the spring J^2 in the outward or forward stroke of the piston.

The spent or dead gases resulting from the expulsion are forced from the exhaust-ports at the time the same are uncovered by the piston and at the same time that the charge is being admitted to the cylinder through the ports *a* and a^2, the valve J remaining closed as the piston is forced outwardly after the expulsion, so that no escape of the waste gases occurs until the main exhaust-port has been uncovered by the piston. Said valve J is opened as soon as the piston begins its return movement or back stroke, so that a part of the spent gases still remaining in the cylinder at the beginning of the return stroke pass from the main exhaust-port and the remainder thereof are ejected from the auxiliary exhaust-port by the time the piston reaches and covers the same. It will of course be seen that in the operation of the engine thus made compression of the charge does not begin to take place until after the piston has passed and closed the auxiliary exhaust-port.

A segmental recess or rabbet *b* is formed in the piston opposite the air-exhaust port *a*, said rabbet or recess preferably extending about one-half way around the circumference of the piston, as seen in the plan view, Fig. 5, and said recess is covered by means of a plate B′, which is secured to the piston and perforated in its part which overlaps or extends over the said recess. As a result of the employment of said plate air entering the rabbet is partially confined therein and rises uniformly through the holes in the plate B′ in a layer or body extending along or around the side wall of the cylinder, but at its side opposite the exhaust-port. The cylinder is, moreover, provided in its inner part or adjacent to its head with two deflecting-plates M M′, one of which, M, extends across the side of the cylinder adjacent to the port a^2, the other of which, preferably considerably wider than the plate M, extends from the side of the cylinder at which the exhaust-ports are located toward the plate M, but terminates some distance from the same, as clearly seen in Fig. 5, so as to leave a space or opening for the passage of the incoming charges between them. The plate M′ is preferably provided with a plurality of holes or perforations *m* near its outer edge or margin. Said plates M and M′ are arranged with their edges at unequal distances from the head A^2 of the cylinder, the edge of the plate M being much nearer the head than the edge of the plate M′, thereby leaving a space through which air-currents may pass in a direction transverse of the cylinder. Preferably the plates M and M′ are arranged in an inclined or oblique position, as shown; but this is not essential. As a result of this arrangement of the plates M and M′ the charge of pure air entering through the port *a* and passing along the side of the cylinder before described is deflected laterally by the plate M, which extends across its path, and carried into the space between the head and the plate M′, whereby it is directed backwardly and passes partially over the free edge of said plate and partially through the perforations therein, so that its direction of movement is reversed and it is thrown toward the piston. The course of the entering air is well shown by the arrows in Fig. 1, from which it will be seen that the entering air tends to remain in a body at the side of the cylinder opposite the exhaust-ports and to press or force the waste gases toward the exhaust-ports without becoming admixed therewith.

The compressed air from the compression-chamber enters the cylinder through the port *a* as soon as the exhaust-port is uncovered, when by the escape of the waste gases the pressure in the cylinder becomes less than that in the chamber E. A charge of vapor-laden air also enters the admission-port a^2 when the pressure in the cylinder is relieved by the uncovering of the exhaust-port, such charge of air coming from the pipe F and chamber G, in which it is confined or held by the action of the check-valve g^2, the air entering the said pipe and chamber from the compression-chamber when the air in the latter is under its greatest compression and being retained therein by the check-valve in readiness to be discharged into the cylinder as soon as the pressure therein is relieved sufficiently for the purpose in the same manner as set forth in a prior application for a patent, Serial No. 572,123, filed December 14, 1895. The said passage F and the carbureting-chamber together perform generally the function of the charge-measuring chamber described in said application. The explosive charge supplied to the cylinder from the passage F will enter the same slightly later than the entrance of the pure air through the port *a*, the difference in time arising from the fact that an appreciable period of time is occupied in the opening of the check-valve *h* against the action of its spring and in the passage of the air through the port leading from said check-valve to the cylinder. As the vapor-laden air enters the closed end of the cylinder it will be thrown or directed transversely across the cylinder-head into the space between the same and the deflecting-plate M and will be by said plate deflected backwardly and thrown against the side of the cylinder at which it enters, thereby displacing or crowding outwardly the current or body of pure air moving along said surface. The body of pure air which has entered or is entering the cylinder will thus be displaced and be crowded toward the side of the cylinder adjacent to the exhaust-port, or, in other words, will be carried into the part of the cylinder beneath or opposite the deflecting-plate. This movement of the entering current of explosive mixture is clearly shown by the small arrows in Fig. 6, from which it will be clear that the general result secured is that the charge of pure air forms a barrier within the cylinder between the entering explosive charge and the waste gases which are in the neighborhood of the exhaust-port. Such barrier of pure air prevents the escape through the exhaust-port of any of the explosive charge, it being obvious that a considerable quantity of pure air may escape with the waste gases without the loss of any of the explosive charge. The important result is thus secured of avoiding not only the loss of fuel which occurs when any of the explosive charge escapes, but the tainting of the atmosphere resulting from the presence of gas or vapor therein. The plate M not only aids in guiding or deflecting the incoming explosive charge toward the opposite side of the cylinder, but also avoids liability of the incoming current of pure air from mixing with the explosive charge. The presence of the perforations in the deflecting-plate M′ is of advantage, because it allows some of the entering air to pass into the inner end of the cylinder, thereby tending to crowd the waste gases toward the exhaust-ports, as clearly indicated by the arrows in Fig. 1.

An ignition-tube N is shown as located in the cylinder-head adjacent to the plate M, this being considered the point most favorable for the location of the ignition device, because the explosive mixture is confined at this part of the cylinder by the said plate M.

I have shown in Figs. 1, 2, and 3 a throttling-governor for controlling the quantity of explosive charge delivered to the cylinder, the same being constructed as follows: O O are bell-crank levers pivoted to the arms on the crank-shaft C and provided with governor-weights *o o*, which are held at the inward limit of their movement by a spring *o′*. A sliding sleeve O′ is mounted on the shaft C, and said sleeve is connected with a rigid arm P, attached to a rock-shaft P′, which is mounted in bearings *p p* on the engine-frame. Within the pipe F is located an oscillatory butterfly-valve Q, which is attached to an oscillating valve-stem Q′, which extends outwardly through the side of the pipe and is provided with a rocking arm Q^2. The free end of said arm Q^2 is connected with an arm P^2 on the rock-shaft P′ by means of a link *q*. In the operation of this governing device an increase of the speed of the engine results in the pipe F being partially closed, with the result of lessening the quantity of explosive mixture which passes from the carbureting-chamber G to the cylinder, it being of course understood that if the size of the passage through which the explosive mixture passes be reduced the same will enter the cylinder more slowly and a less quantity will be discharged into the cylinder during the time afforded for the entrance of the charge.

In Fig. 3 is shown an improved packing for the shaft Q′ of the throttling-valve, the same being intended to take the place of the gland or packing heretofore commonly used in similar situations. In this instance the said shaft is provided with a collar *q′*, between which and an opposing shoulder of the valve-casing is located a coiled spring q^2, which serves to thrust the shaft endwise in its bearings. Said shaft is also provided with a collar q^3, which is adapted to bear against a seat q^4, formed at the inner surface of the valve-casing around the shaft-bearing. The contact-surface of the said collar q^3 and its seat is preferably made conical, as shown. The spring q^2, arranged as described, serves to hold the collar q^3 constantly in contact with the seat q^4, thereby making a tight joint more effective for retaining air and gas than the packing commonly employed.

I have shown in the drawings a pump R as arranged to supply the liquid-fuel to the carbureting-chamber G, said pump being operated by a cam R′ on the shaft C and a lever *r*, which transmits motion from the cam to the pump-rod, as more clearly seen in Fig. 5. While I have shown a carbureting device for supplying explosive mixtures to the cylinder, yet the same result may be secured by the introduction of gas into the passage F, which may be accomplished by means of a gas-supply pipe leading into a chamber like the carbureting-chamber G, the gas being supplied under pressure on entering the passage F at the time the same is relieved from pressure in the same manner as set forth in the said prior application hereinbefore referred to. It will be understood, therefore, that the term "carbureting-chamber" herein used will be understood to include also a chamber to which gas may be delivered for producing explosive mixtures, as well as one in which liquid is introduced for charging the air with vapor.

In Figs. 4 and 5 I have shown an engine in all respects like that hereinbefore described, with the exception that it is provided with a governing device applied to actuate positively a valve through which the explosive mixture is allowed to escape from the passage F into the cylinder. In this instance in place of the check-valve *h* the valve-casing H is provided with a valve *h′*, having attached to it a stem H′, which extends outside of the valve-casing and which is moved endwise by suitable operative connections for opening the said valve *h′*. I prefer to employ a spring H^2, interposed between the collar h^2 at the lower end of the stem and the valve-casing, which spring serves to hold the valve normally closed. For actuating the valve a rock-shaft S is mounted on the machine-frame and is provided with an arm *s*, which reaches to and engages the ends of the valve-stem, and a second arm *s′*, which terminates adjacent to the crank-shaft and is adapted for engagement with a revolving cam projection *t*, which is attached to a longitudinal sliding sleeve T on said shaft. Said sleeve is given endwise movement by means of a centrifugal governing device consisting of arms T′, which are connected with the sleeve and carry governor-weights *t′*, which are held adjacent to the shaft by a spring t^2. The sleeve T is shifted on the shaft by the action of the governor, so as to bring the cam projection *t* opposite the arm *s′* when the speed of the engine is reduced below the normal, said cam projection remaining free from the said arm when a certain rate of speed is exceeded. The device therefore constitutes what is known as a "hit-or-miss" governor, the explosive mixture being admitted to the cylinder whenever an explosion is required to keep up the normal speed of the engine. In an engine thus constructed the time of entrance of the explosive charge may be exactly controlled by the location of the cam projection *t* on the sleeve T, so that it may occur enough later than the entrance of the pure air to insure that the entering explosive charge shall pass behind the entering body of pure air, as hereinbefore fully set forth.

The operation of the engine as a whole will be readily understood from the foregoing, it being obvious that after each explosion in the power-cylinder, which occurs at each upward stroke of the piston, the spent gases follow the piston until the latter reaches the outward limit of its stroke, when it first uncovers the exhaust-port and a little later uncovers the air-inlet port *a*. As soon as the exhaust-port is uncovered the escape of the waste gases relieves the cylinder from pressure, so that the air in the compression-chamber rushes into the cylinder through the port *a*, being directed toward the head of the cylinder by the wall of the rabbet or recess in the piston, which serves as a deflecting-surface to throw it lengthwise of the cylinder. Immediately after the fresh air has entered or while it is still entering the explosive mixture confined in the passage F is discharged into the closed end of the cylinder, and by the action of the deflecting-plate H' is thrown against the side wall of the cylinder behind the body of fresh air which has entered the cylinder. The entering charges of fresh air and explosive mixture serve to crowd the waste gases toward the exhaust-port, the body of fresh air being between the explosive mixture and said port. As the piston begins its backward stroke it first covers the main exhaust-port and then forces the waste gases out through the auxiliary exhaust-port, which is open at the time, until the piston reaches and covers said auxiliary exhaust-port. Compression therefore takes place in the latter part or half only of the inward stroke of the piston, thus giving the advantage of compression during a comparatively small part of the stroke and when the crank is in the position most favorable to exert its power on the piston, thereby effecting a considerable saving of the energy used in compressing the charge. The charge is therefore compressed during a part only of the return stroke of the piston; but by reason of the closing of the auxiliary exhaust-port at the time of the explosion the explosive charge operates during the full outward stroke of the piston, so that the gases are given full opportunity of exhausting their expansive energy, thereby securing a more economical operation of the engine.

The arrangement of the feeding devices for the explosive mixture is especially effective, and the employment of a governing-valve arranged between the passage F and the cylinder has the advantage of securing an economical regulation, because limiting the quantity of fuel used to that needed for the work the engine is doing.

I claim as my invention—

1. A power-cylinder provided with a main exhaust-port and with a valved, auxiliary exhaust-port located in the side of the cylinder and nearer the closed end of the cylinder than the main exhaust-port; said main and auxiliary exhaust-ports being closed by the piston when the latter is at the inward limit of its stroke and being uncovered by the piston in its outward movement.

2. A power-cylinder provided with a main exhaust-port and with an auxiliary exhaust-port located in the side of the cylinder nearer the closed end of the cylinder than the main exhaust-port; said main and auxiliary exhaust-ports being closed by the piston when the latter is at the inward limit of its stroke and being uncovered by the piston in its outward movement, a valve for controlling said auxiliary exhaust-port, and operative connections with the crank-shaft of the engine for actuating said valve.

3. A power-cylinder provided with a main exhaust-port and with an auxiliary exhaust-port located in the side of the cylinder nearer the closed end of the cylinder than the main exhaust-port; said main and auxiliary exhaust-ports being closed by the piston when the latter is at the inward limit of its stroke and being uncovered by the piston in its outward movement, an inwardly-opening valve controlling said auxiliary exhaust-port, a spring applied to close said valve, a valve-actuating cam and operative connections between the cam and valve acting to open the same against the action of the spring.

4. An explosive-engine comprising a power-cylinder, an air-compression chamber and a piston in the cylinder; said cylinder being provided with an air-inlet and main exhaust port which are uncovered by the piston when at the outer limit of its stroke, and with a valved, auxiliary exhaust-port located in the side of the cylinder nearer the closed end of the cylinder than the said main exhaust-port, and which is closed by the piston when at the inward limit of its stroke and is uncovered in the outward movement of said piston.

5. A power-cylinder having an exhaust-port and two inlet-ports, one for air and the other for an explosive mixture, a piston in the cylinder having a deflecting-surface located opposite the air-inlet port and acting to direct the air toward the closed end of the cylinder and a deflecting-plate at the closed end of the cylinder, acting to deflect the incoming mixture toward and into contact with the side wall of the cylinder at the side of the latter at which the air enters, substantially as described.

6. A power-cylinder provided with an exhaust-port and two inlet-ports at opposite ends of the cylinder one for air and the other for an explosive mixture, in combination with an air-compression chamber in communication with both inlet-ports, and a piston in the cylinder which uncovers the air-inlet port at the outer limit of its stroke: said piston being provided with a deflecting-surface acting to throw the entering air toward the closed end of the piston, and a deflecting-plate ad-

jacent to the closed end of the cylinder, acting to deflect the incoming mixture against the wall of the cylinder at the side thereof at which the air enters the said cylinder, substantially as described.

7. A power-cylinder having an inlet-port for an explosive mixture entering the side of the cylinder at its closed end and having a transversely - arranged deflecting - plate located adjacent to the head and extending into contact with the side of the cylinder opposite the said inlet-port.

8. A power-cylinder having an inlet-port for an explosive mixture entering the side of the cylinder at its closed end; said cylinder being provided with a transversely-arranged, perforated deflecting-plate located adjacent to the head and extending into contact with the side of the cylinder opposite to the said inlet-port.

9. A power-cylinder having an inlet-port for an explosive mixture which enters the side of the cylinder at its closed end; said cylinder being provided with a deflecting-plate at the side of the cylinder at which the inlet-port is located, and with a second deflecting-plate at its side opposite the said port, the edge of which is located in advance of the plate first mentioned, substantially as described.

10. A power-cylinder provided with inlet-ports for air, and an explosive mixture and a piston within the cylinder which uncovers the air-inlet port at the outer limit of its stroke; said piston being provided with a deflecting-surface directing the incoming air toward the closed end of the cylinder and the cylinder having at its closed end two deflecting-plates, one located adjacent to the inlet-port for explosive mixture and the other at the side of the cylinder opposite thereto, the margin of the second plate being located in advance of the first one, substantially as described.

11. A power-cylinder provided with a main exhaust-port, a valved auxiliary exhaust-port in the side of the cylinder nearer the closed end of the cylinder than the main exhaust-port; said main and auxiliary ports being closed by the piston when the latter is at the inward limit of its stroke and being uncovered by the piston in its outward movement, and two inlet-ports one of which is in communication with a source supplying air under pressure and the other in communication with a source supplying an explosive mixture.

12. A power-cylinder provided with a main exhaust-port, a valved auxiliary exhaust-port in its side wall; said main and auxiliary exhaust-ports being closed by the piston when the latter is at the inward limit of its stroke and being uncovered by the piston in its outward movement, two inlet-ports one of which is in communication with a source supplying air under pressure and the other with a source supplying an explosive mixture under pressure, with a deflecting-surface for directing the entering air along the side of the cylinder opposite that at which the exhaust-ports are located, and with a deflecting-surface acting to direct the incoming mixture against the side wall of the cylinder at the same side thereof.

13. A power-cylinder provided with a main exhaust - port, a valved, auxiliary exhaust-port and with two inlet-ports, one of which is in communication with a source supplying air under pressure and is located in position to be uncovered by the piston at the outer limit of its stroke, and the other of which is in communication with a source supplying explosive mixture under pressure and enters the closed end of the cylinder; said cylinder having also at its closed end a deflecting-plate acting to direct the incoming mixture into contact with the side wall of the cylinder at the side of the same opposite the exhaust-ports, substantially as described.

14. The combination with a cylinder, of a piston therein and an air-compression chamber, said cylinder having a main exhaust-port and an air-inlet port, both of which are located in position to be uncovered by the piston at the outer limit of its stroke, and having also an auxiliary valved exhaust-port located nearer the closed end of the cylinder than the main exhaust-port and an inlet-port for an explosive mixture located at the closed end of the cylinder, a deflecting-surface on the piston throwing the air toward the closed end of the cylinder and a deflecting-plate at the closed end of the cylinder directing the mixture toward and against the wall of the cylinder at the side thereof opposite the exhaust-ports.

15. The combination with a cylinder, of a piston therein and a compression-chamber; said cylinder having an air-inlet port in communication with the compression-chamber located in position to be uncovered by the piston at the outer limit of its stroke, and having also an inlet-port for an explosive mixture in communication with said compression-chamber through the medium of a passage provided with a governing-valve operated by the engine, substantially as described.

16. An explosive-engine comprising a cylinder having two inlet-ports, a piston therein, an air-compression chamber, a passage leading from the compression-chamber to one of the inlet-ports, a passage which connects the said chamber with the other of said inlet-ports and is provided with a carbureting-chamber, and a check-valve in said last-mentioned passage, between the compression-chamber and the carbureting-chamber, substantially as described.

17. An explosive-engine comprising a cylinder having two inlet-ports, a piston therein, an air-compression chamber, a passage leading from the compression-chamber to one of the inlet-ports, a passage which connects the air-chamber with the other of said inlet-ports

and is provided with a carbureting-chamber, a check-valve in said passage between the carbureting-chamber and the compression-chamber, and a governor-valve in the said passage between the carbureting-chamber and the cylinder, substantially as described.

In testimony that I claim the foregoing as my invention I affix my signature, in presence of two witnesses, this 4th day of April, A. D. 1896.

GEORGE W. LEWIS.

Witnesses:
C. CLARENCE POOLE,
WILLIAM L. HULL.