(No Model.)

5 Sheets—Sheet 1.

W. E. GOOD.

BLOWING ENGINE.

No. 464,964. Patented Dec. 15, 1891.

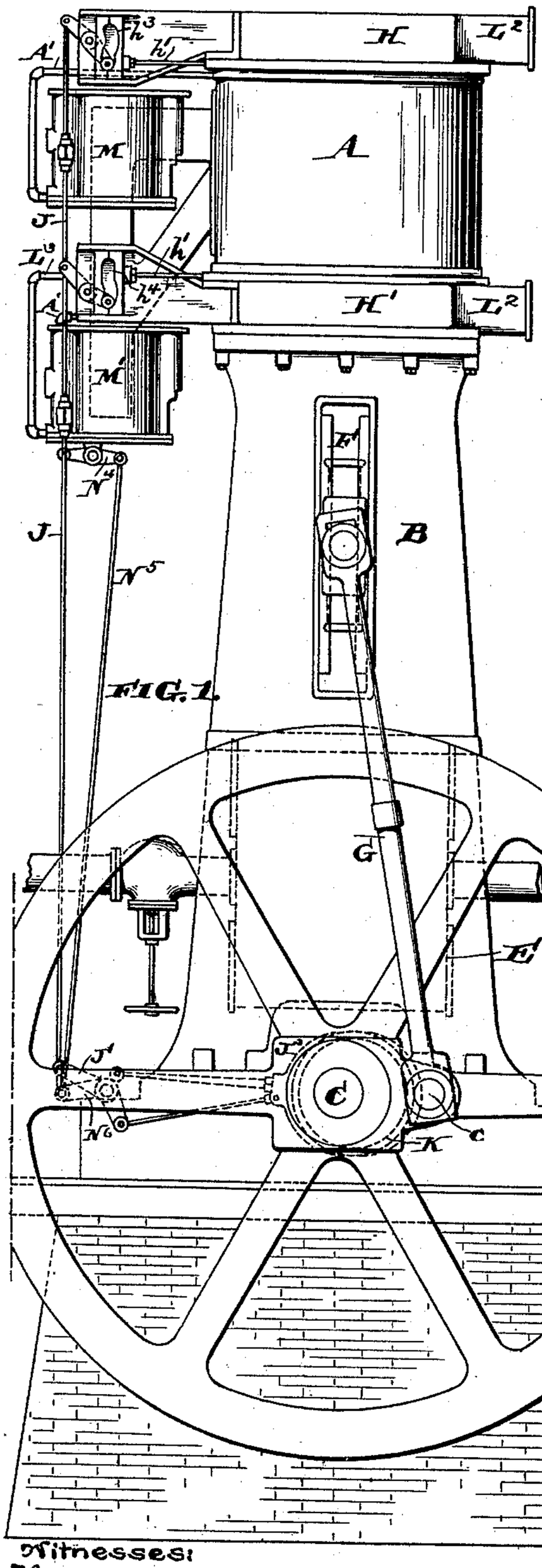

FIG. 1.

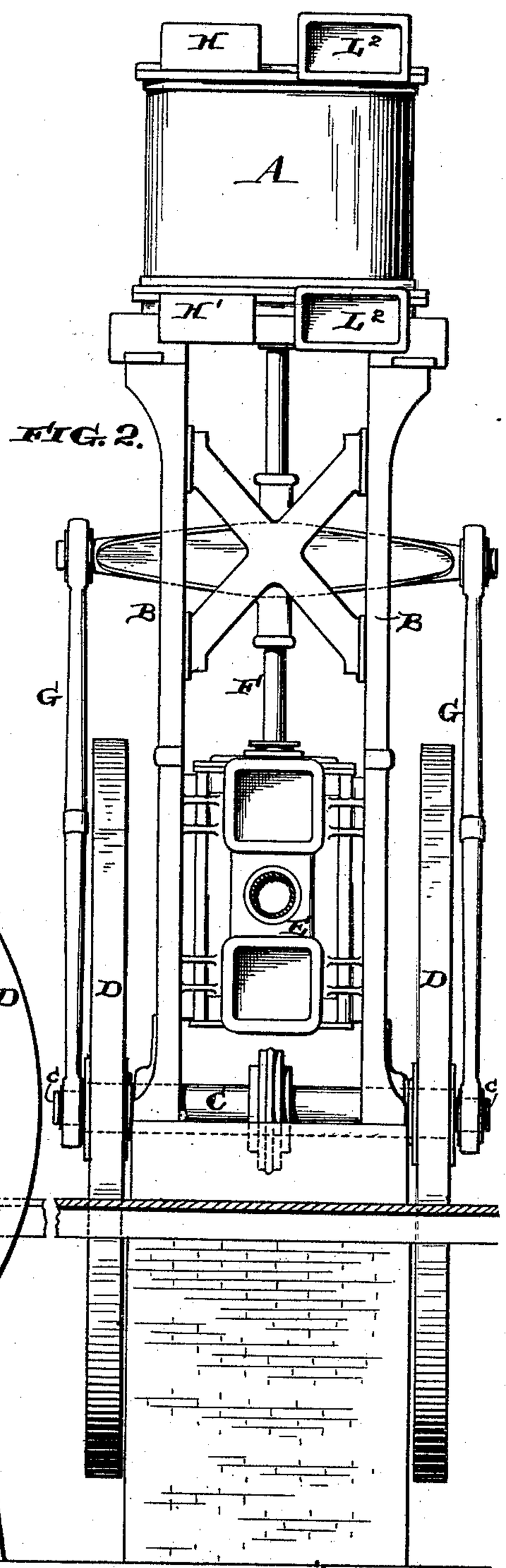

FIG. 2.

Witnesses:
Henry Bauer
Jesse Heller

Inventor:
William E. Good
by his atty.
Francis T. Chambers

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(No Model.) 5 Sheets—Sheet 2.

W. E. GOOD.

BLOWING ENGINE.

No. 464,964. Patented Dec. 15, 1891.

FIG. 3.

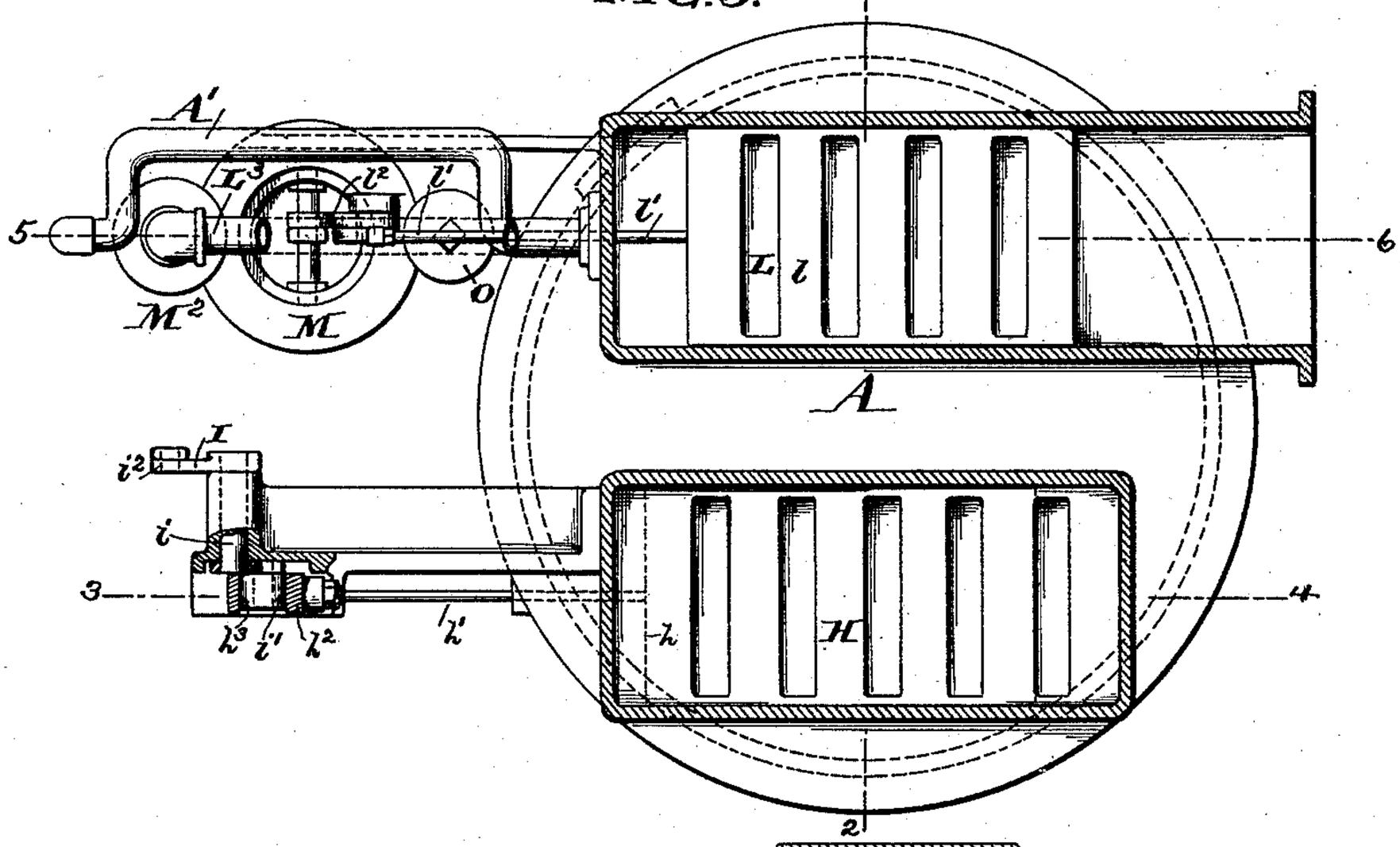
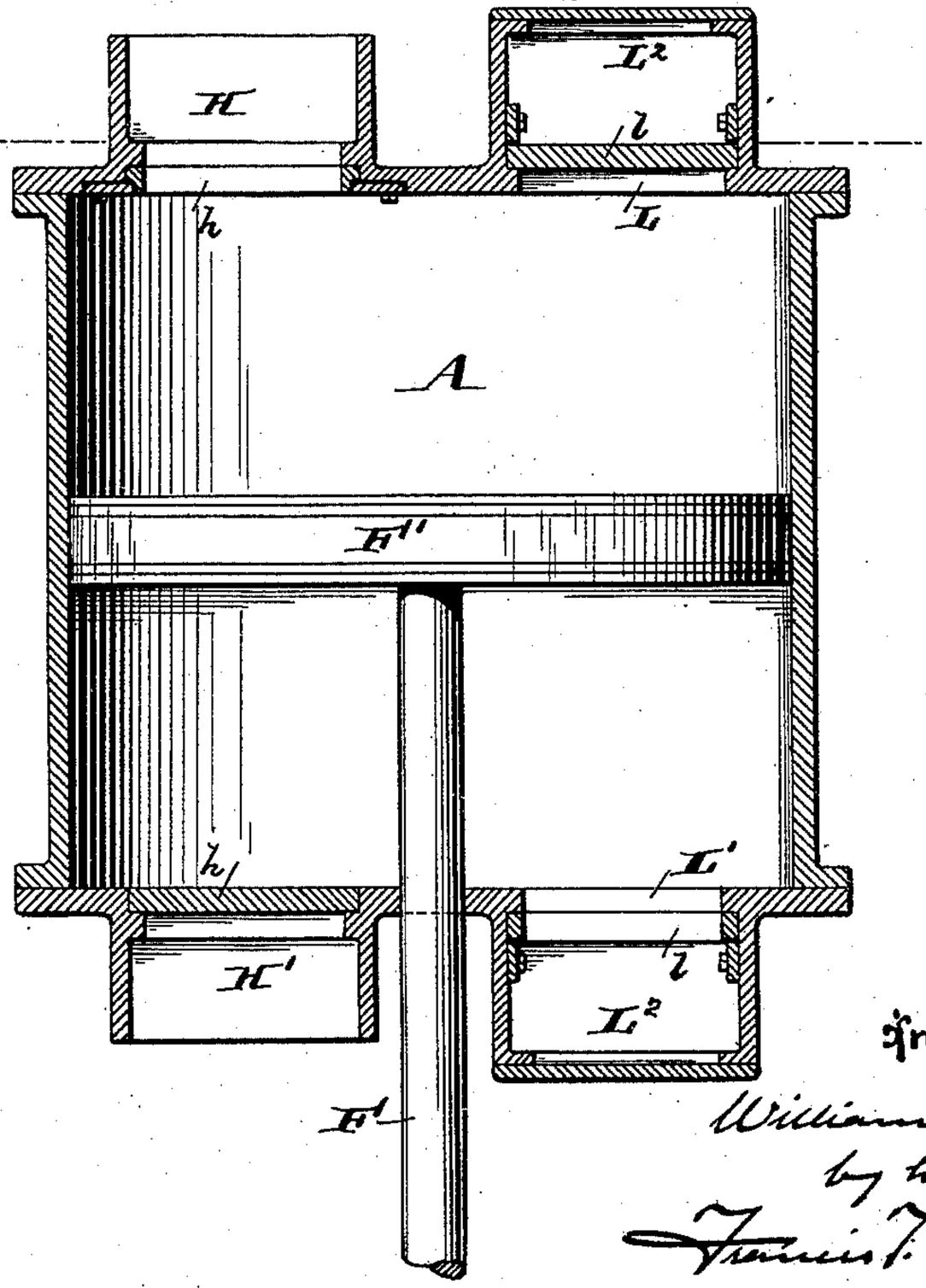


FIG. 4.



Witnesses:
Henry Bruce
Jesse Heller

Inventor:
William E. Good
by his atty.
Francis T. Chambers

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

(No Model.) 5 Sheets—Sheet 3.

W. E. GOOD.

BLOWING ENGINE.

No. 464,964. Patented Dec. 15, 1891.

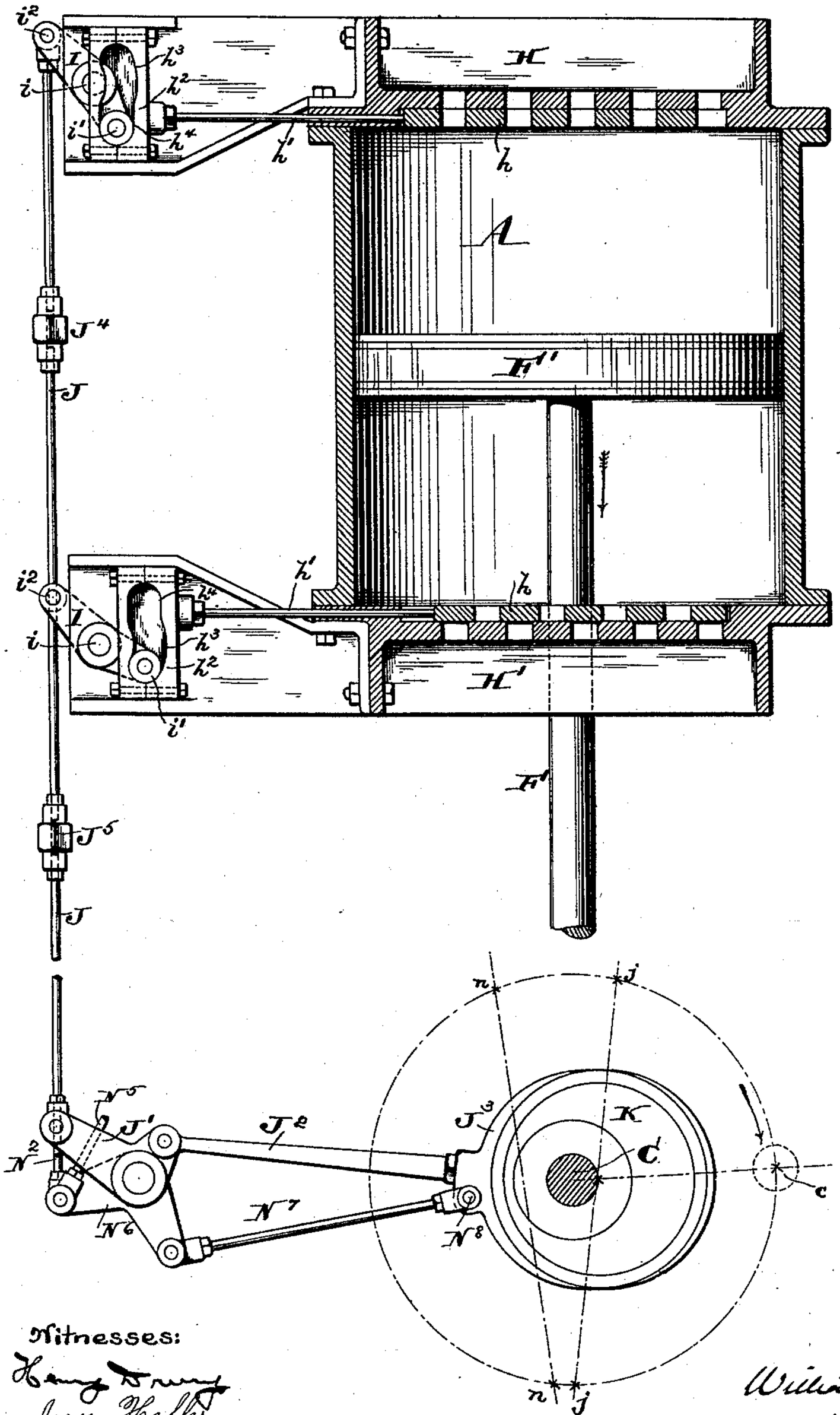


FIG. 5.

Witnesses:
Harry Drury
Jesse Heller

Inventor:
William E. Good
by his atty.
Francis T. Chambers

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

(No Model.) 5 Sheets—Sheet 4.

W. E. GOOD.

BLOWING ENGINE.

No. 464,964. Patented Dec. 15, 1891.

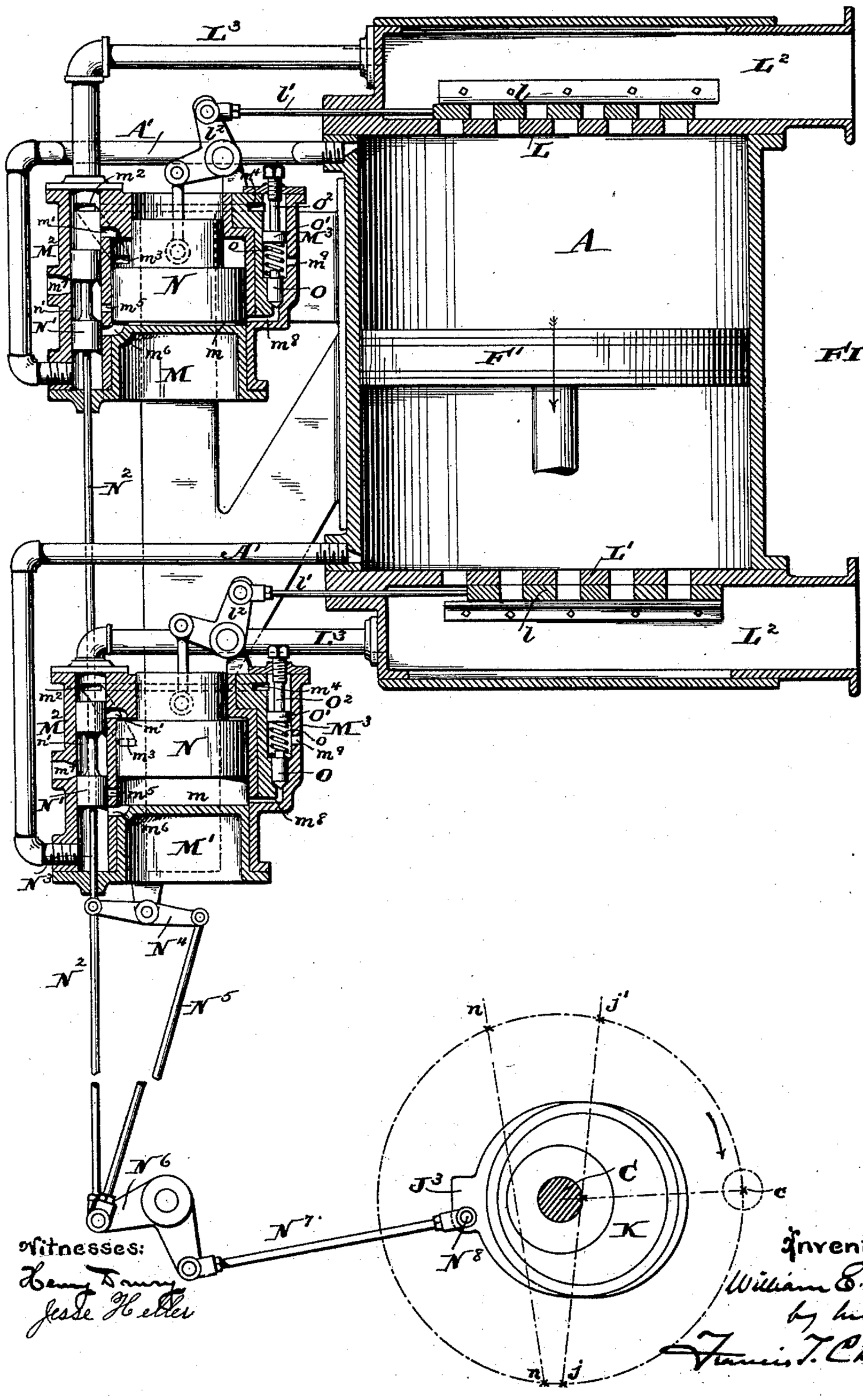


FIG. 6.

Witnesses:
Henry Towry
Jesse Heller

Inventor:
William E. Good
by his atty.
Francis T. Chambers

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

(No Model.) 5 Sheets—Sheet 5.

W. E. GOOD.

BLOWING ENGINE.

No. 464,964. Patented Dec. 15, 1891.

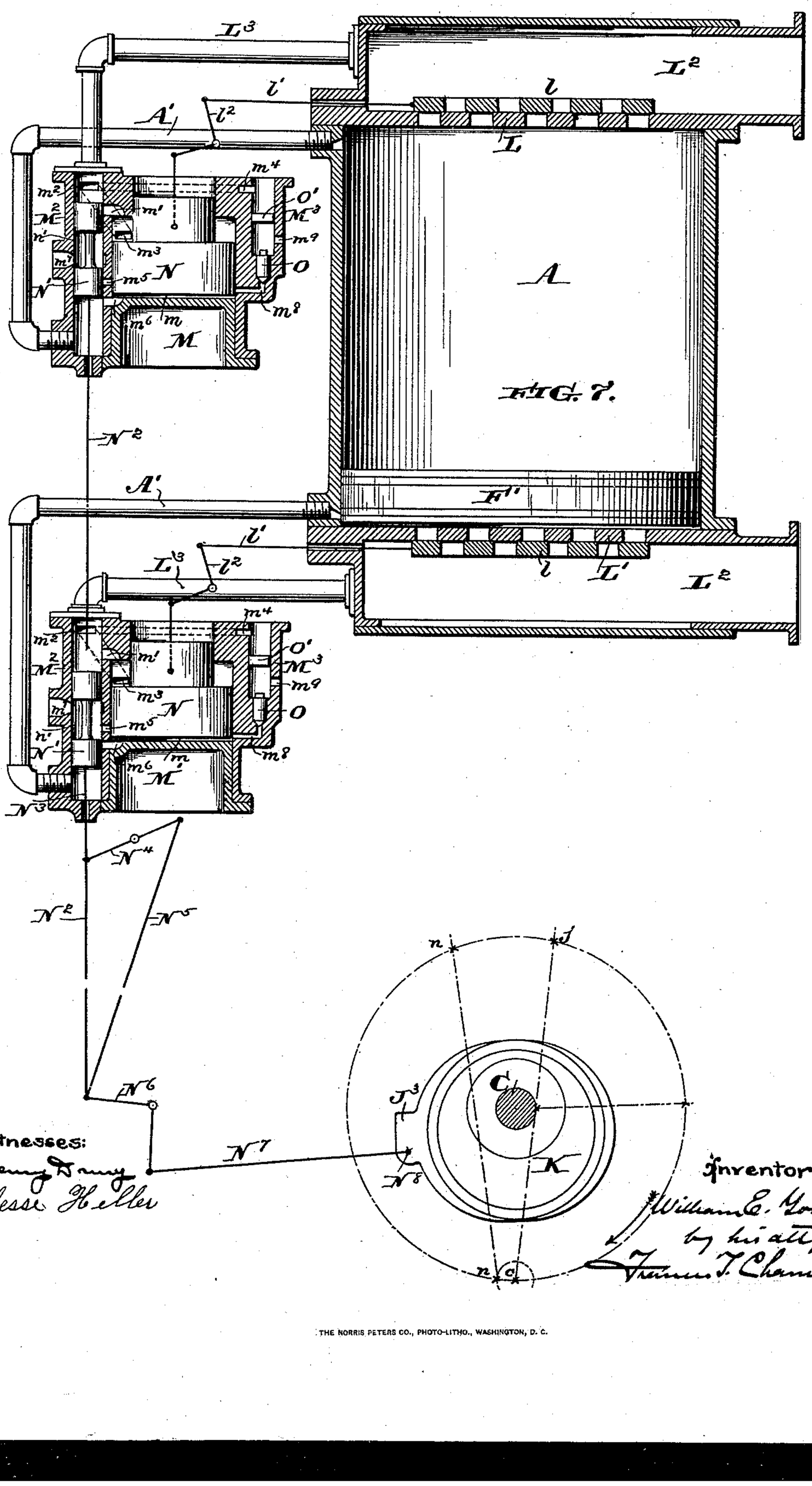


FIG. 7.

Witnesses:
Henry Drury
Jesse Heller

Inventor:
William E. Good
by his atty.
Francis T. Chambers

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

UNITED STATES PATENT OFFICE.

WILLIAM E. GOOD, OF PHILADELPHIA, PENNSYLVANIA, ASSIGNOR TO THE SOUTHWARK FOUNDRY AND MACHINE COMPANY, OF SAME PLACE.

BLOWING-ENGINE.

SPECIFICATION forming part of Letters Patent No. 464,964, dated December 15, 1891.

Application filed January 2, 1891. Serial No. 376,514. (No model.)

To all whom it may concern:

Be it known that I, WILLIAM E. GOOD, of the city and county of Philadelphia, State of Pennsylvania, have invented a certain new and useful Improvement in Blowing-Engines, of which the following is a true and exact description, reference being had to the accompanying drawings, which form a part of this specification.

My invention relates to the construction of air-compressing or blowing engines, and has for its object to provide improved valve-actuating mechanism for controlling the opening and shutting of the admission and delivery valves of such engines.

As illustrated in the drawings, I have shown my improvements applied to a double-acting blowing-engine of the vertical type in the way which I deem best adapted for practical use, and which way embodies several features of novelty; but my invention is also applicable to other types of blowing-engines, and, except where specifically limited thereto, I do not wish the claims to be understood as having special or peculiar reference to a double-acting engine. I may also here state that the feature of my former patent, No. 381,876, of April 24, 1888, which consists in giving sliding valves a motion to and from their seats, so as to combine the actions of a clack and slide valve, is applicable to my present construction and should preferably be used in connection with it.

The novel features of my present invention will be best understood as described in connection with the drawings, in which—

Figure 1 is a side, and Fig. 2 a front, elevation of a double-acting vertical blowing-engine of the type to which my valve-actuating appliances, as illustrated in the other sheets of drawings, are specially intended to be applied. Fig. 3 is a plan view of the main cylinder of the blowing-engine, showing the important connection of the valves upon the upper head, with the mechanism for actuating them. The receptacle for compressed air above the discharge-valve is shown in section, taken on the line 7 8 of Fig. 4. Fig. 4 is a vertical sectional elevation of the main compressing-cylinder, taken on the line 1 2 of Fig. 3. Fig. 5 is a cross-sectional view taken through the admission-valves on the line 3 4 of Fig. 3, and showing also the mode of actuating said valves from the main shaft of the engine. Fig. 6 is a cross-sectional view through the discharge-valves and the differential cylinders connected with them on the line 5 6 of Fig. 3, showing also the connections with the main shaft of the engine and what I may call the "pilot-valves" of the differential cylinders; and Fig. 7 is a view taken on the same plan as Fig. 6, but showing the main piston in a different position, with corresponding differences in the positions of the differential pistons and of the pilot-valves.

A is the main or air compressing cylinder of the blowing-engine; B B, parts of the frame; C, the main shaft of the engine; D D, fly-wheels; *c c*, cranks on shaft C; E, the steam-cylinder; F, the piston-rod connecting the piston within the steam-cylinder with the air-compressing piston F′ in cylinder A.

G G are pitmen connected, as shown, with the piston-rod F and the cranks *c c*.

H and H′ indicate, respectively, the upper and lower air-admission ports in the heads of cylinder A, *h h* indicating a slide-valve arranged to open and close said ports.

One feature of my invention consists in actuating the air-admission valves *h* through a connection with a continuously-acting eccentric, and by means of a cam arranged to actuate the valve and deriving the necessary intermittent reciprocating motion by devices for transmitting motion to it from the eccentric.

As illustrated in the drawings, a valve-rod *h′* connects at one end with the valve *h* and at the other with a cam-head h^2, having formed in it a slot h^3 h^4. In this slot a pin or roller *i′*, attached to the end of a lever I, moves, the said lever being pivoted at *i*, and the portion of the cam-slot h^3 being concentric with said pivot *i*, while the remaining portion h^4 of the slot is given such form as will cause the cam-roller *i′* to move the cam-head to the desired degree when it is thrown into that part of the slot. The end i^2 of lever I is connected by means of a rod J with a bell-crank lever J′, to the other end of which lever is connected an arm J^2, which extends rigidly out from an eccentric-strap J^3, secured

upon an eccentric K, which in turn is fast to the main shaft C of the engine. Preferably a single rod J is used to actuate both of the admission-valves, as shown in Fig. 5, the cam-blocks h^2 appertaining to the upper and lower valves being inverted, so that as the levers I move simultaneously the valves h h are given the desired inverse reciprocatory and intermittent motions which they should have, the cam-grooves and connections being such that each valve opens at substantially the point in the movement of the piston F′ away from it when the pressure within the cylinder-head is equal to the atmospheric pressure and closes immediately before the piston F begins to move again in its direction. The difficulty arising from the fact that the pressure is not always constant is overcome in the way described in my former patent—to wit, by giving the valves freedom to move slightly away from their seats. Adjusting-nuts, such as are shown at J^4 and J^5, will be found exceedingly useful in regulating the length of the two parts of the connecting-rod J.

As shown in the drawings, the eccentric K is set in line with the crank c, and the adjustment of the rod J^2 is made at right angles to a line j j drawn between those two points in the circle described by the crank-pin c. The upper point j will thus indicate the position of the crank when the upper valve h begins to open, and the lower point j the position of the crank when the upper valve h is closed. The length of the active part h^4 of the cam-slot is such that the roller i' will remain in engagement with it during the travel of the crank from j to j in the direction of the arrow and on the right of the drawings, and the curved portion h^3 of the cam-slot during the travel of the cam-roller, in which the valve remains stationary and closed, is of a length corresponding in the same way with the travel of the crank between the points j and j on the left hand of the circle.

Referring next to the delivery-valves, L and L′ indicate, respectively, the ports left in the upper and lower heads of the cylinder A for the escape of air, said ports opening into receptacles L^2, which communicate with a reservoir or point of use. l l are the valves which open and close the ports L L′. l' are the valve-rods; l^2, bell-crank levers, to which the valve-rods connect; M and M′, differential cylinders connecting, respectively, with the upper and lower discharge-valves, and in which work the differential pistons N N, said pistons being connected with the bell-crank levers L^2, as indicated. The smaller head of the differential cylinder is connected with the air-receptacle, into which the compressed air is forced, and the larger head with the adjacent end of the compressing-cylinder. Generally speaking, this mode of connection is known in the art, as is also the connection of the differential piston with the delivery-valve; but apart from the special devices by which the various connections are made, I wish to call attention first to the fact that my differential pistons and cylinders are placed in a vertical position, and that by reason of this arrangement the weight of the differential piston, which may be loaded to any desired degree, tends of itself to close the delivery-valve to which it is connected, this feature of construction being, I believe, novel with me and greatly facilitating the rapid closing of the valve as soon as the pressure on the lower face of the differential piston is removed or becomes less in aggregate amount than the pressure upon its upper face.

Another important and novel feature of construction consists in providing the differential cylinder with an exhaust-port at or near the end which connects with the head of the compression-cylinder, and in providing valves positively actuated in relation to the movement of the compression-piston which will alternately open and close the exhaust-port and the conduit leading from the main cylinder to the differential cylinder. Preferably the exhaust-port is situated a little above the adjacent head of the differential cylinder, so that it will be closed not only by its positively-actuated valve, but by the differential piston as it moves over it, and thus the motion of the differential piston is checked after it passes the exhaust-port by having to compress the body of air lying between the exhaust-port and the cylinder-head. Preferably, also, I provide a second exhaust-port situated at or closer to the head of the cylinder than the one above mentioned and closed by a check-valve which will yield when the air compressed exceeds a certain pressure. I will also note that I consider it important to provide means for checking the opposite movement of the differential piston and preventing it from hammering upon the end of the differential cylinder, and that a valuable point of my invention consists in actuating the valves which regulate the admission and discharge of air to the differential cylinder by means of an eccentric positively driven and preferably the same eccentric which drives the admission-valves.

The above explanation of the general objects I have in view will enable the special construction illustrated in the drawings to be followed with more intelligence.

Referring now again to the construction illustrated in Figs. 6 and 7, L^3 is the conduit leading from the compressed-air receptacle, and A′ the conduit leading from the adjacent head of the compressing-cylinder. These conduits open, respectively, at the top and bottom of a valve-box M^2, secured to the side of the cylinders M M′, and from which ports m' and m^6 lead, respectively, to the upper and lower heads of the cylinders. An exhaust-port m^5, adjacent to and preferably as shown above the port m^6, is also formed between the valve-box and the cylinder, and an exhaust-port m^7, situated between ports m^5 and m^6, leads out of the valve-box. N′ is a

piston-valve formed, as shown, so as to alternately close port m^6, opening ports m' and m^5, and close the last-mentioned ports, opening port m^6. I may here mention parenthetically that the action of the valve in opening and closing port m' is only of importance as providing a convenient plan for preventing the escape through said port of air driven from the differential cylinder by the upward motion of the piston, causing the air thus inclosed to rapidly increase in pressure as the piston moves upward, thus checking the violence of its movement. During the downward movement of the piston F′ the valves N′ occupy substantially the position indicated in Fig. 6. The upper one attached to the cylinder M closes the port m^6 and opens the port m^5, thus cutting off the pressure through conduit A′, which tends to raise the differential piston and at the same time permitting the air accumulated beneath the piston to escape, while the pressure of the receiver is transmitted through conduit L^3 and port m^5 to the upper face of the piston, the piston being thus driven down and the valve l, to which it is attached, closed and held closed. The lower valve N′, on the contrary, is in a position in which it opens the port m^6, closes the exhaust m^5, and closes the port m'. The pressure from the downwardly-moving piston F′ is thus transmitted to the lower side of the differential piston N, which is driven up and held up, opening and keeping open the lower valve l. When the piston F′ reaches the end of its stroke, as shown in Fig. 7, the valves N′ N′ are shifted to the position shown in said figure, the port m^6 in the lower cylinder M′ being covered and the exhaust-port m^5 opened, and the port m' being also open the pressure from the lower receiver L^2 instantly forces the valve N down, closing the lower valve l. At the same time the valve M′ of the upper cylinder M opens the port m^6, closes the exhaust m^5, and closes the port m'. As now the piston F′ moves upward, both valves l l remain closed until the pressure in cylinder A exceeds the pressure holding the differential piston N down, together with the weight of the said differential piston, at which time the said piston is forced upward, opening the upper valve l and holding it open until the piston F′ has completed its upward stroke and the valve N′ has opened the exhaust-port m^5. The respective areas of the upper and lower sides of the differential piston are of course nicely calculated, so that the opening of the discharge-valve governed by it will take place at the instant when the pressure within the cylinder and in the discharge-conduit leading from it are equal, or substantially so.

If in the construction shown the port m' was the only port leading into the upper end of the differential cylinder, it would be necessary, with the valve working as shown, that the piston N in its upward movement should compress the whole volume of air above it. I have found it desirable in order to quicken its initial movement in an upward direction to provide an additional port m^3, situated below the port m' and also connecting with the compressed-air receiver. As shown, it connects with a port m^2 in the valve-box M^2, situated, however, above the travel of the valve M′. Through this additional port air is forced back into the receiver during the upward movement of the differential piston and until the piston itself closes the port m^3, after which time the continued upward movement of the piston is accomplished against the resistance of the fixed body of air situated between it and the head of the cylinder.

As already mentioned, I prefer to use, in addition to the exhaust-port m^5 near the lower end of the cylinder, an additional port m^8, situated closer to the cylinder-head and closed by a check-valve. The object of this is to permit of the escape of a portion of the air compressed by the downward motion of the piston N after it passes the exhaust-port m^5. It is difficult, however, to have any ordinary automatic check-valve which will work efficiently under the varying conditions under which the engine runs. Thus when there is little or no accumulation of compressed air in the receivers it is obviously desirable that the piston N should move downward very freely and practically with no resistance from a body of compressed air beneath it, while when the pressure in the receiver is large it becomes very necessary to take up the shock of the rapidly-moving piston, which in itself is heavy, and which, besides, has the impetus of the heavy valve to which it is attached. Under these two conditions of use we require for the port m^8 a check-valve held very lightly to its seat and a check-valve held to its seat with great force, and I have secured both of these desirable qualities in the same valve by the device which I am about to describe. About the opening of the port m^8 I secure a cylinder M^3, at one end of which is the valve O, which closes the port m^8, and at the other end of which is a port m^4, which connects the said cylinder with the compressed-air receptacle. As shown, the head of the cylinder M is channeled and the port m^4 connected with the box M^2 at m^2; but the way in which the connection is made is entirely immaterial. A piston O′ is fitted in the upper part of the cylinder M^3 and connection made between the said piston and the valve O, so that whatever pressure is exerted upon the upper side of the piston O′ is transmitted to the valve O and tends to hold it to its seat. An exhaust-port m^9 is formed in the cylinder M^3 above the valve O and beneath any point reached in the downward motion of the piston O′. Preferably the connection between the piston and valve is made by means of a spring, as indicated at o, Fig. 6, this being desirable as permitting the valve O to rise from its seat without moving the piston.

O^2, Fig. 6, indicates an adjustable stop,

which assists the upward movement of the piston O′.

The operation of this device is as follows: The piston N being in its upper position, the port m^6 is closed and the exhaust m^5 open. The pressure from the receiver, acting upon the top of the piston, then drives it down with a degree of violence and rapidity proportioned to the compression of the air. After passing the exhaust-port m^5 the further motion of the piston is against the constantly-increasing resistance of the body of air in the bottom of the cylinder, the degree of compression to which this air is exposed being not only that transmitted through the piston from the compressed air driving it down, but also that due to the momentum of the rapidly-moving and weighty piston and its valve connections. As soon as the air is compressed to a degree higher than the pressure which holds the valve O to its seat it lifts the said valve and escapes through the port m^8 into cylinder M^3, and thence through the port m^9. The pressure holding the valve O closed is that of the air-receptacle acting upon the piston O′, and the size of this piston and the cylinder in which it works of course determines the point or points at which the valve O shall open.

The valve N′, as shown in the drawings, is what I may call a "divisional" piston-valve. It may be considered either as a valve or as two valves, and of course any equivalent valve or combination of valves may be substituted for it. It is actuated by means of positive connections with the engine, so that its movements will always bear a fixed relation to the movement of the compressing-piston in the cylinder A. When two differential cylinders are used in combination with a double-acting blowing-engine, the motion of the valves N′ in the two cylinders should be inversely reciprocatory, the one moving up when the other moves down, and vice versa. My preferred device for driving the pilot-valves N′ is that shown in the drawings, the valves being actuated by the continuously-rotating eccentric K, the valve-stem N^2 leading from the upper valve N′ to a bell-crank N^6 and a pivoted connecting-rod N^7, connecting the said bell-crank with the eccentric-strap J^3. The points $n\,n$ on the circle described by the crank-pin c indicate the points in the motion of the crank and of the compressing-piston, at which the upper valve N′ opens and closes the ports m^6, the connecting-rod N^7 extending at right angles to the line between the points $n\,n$ when the said valve is in its lowest position. The lower valve N′ has its valve-stem N^3 connected to a pivoted lever N^4, to the other end of which is pivoted a connecting-rod N^5, also leading to the bell-crank lever N^6, the result of this arrangement being to move the two valves N′ always in opposite directions to each other.

The one eccentric K in the arrangement shown and above described gives motion both to the valves N′ and to the cams actuating the admission-valves, and the same eccentric can be used to actuate the steam admission and exhaust valves of the steam-cylinder, as shown in the patent to Petsche granted December 9, 1890, and numbered 442,136.

Having now described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. In a blowing-engine, an air-admission slide-valve, in combination with a continuously-acting eccentric, a cam positively connected with the valve, and means for transmitting motion from the eccentric to the cam, said cam being arranged, as described, so as to intermittently actuate the valve in both directions, as and for the purpose specified.

2. In a blowing-engine, an air-admission valve, in combination with a cam-head h^2, attached to the valve-stem and having a slot h^3 h^4 formed as specified, a pivoted lever i, having a pin or roller i' working in the cam-slot, a continuously-acting eccentric, and means, as described, for transmitting motion from said eccentric to lever I and through cam-head h^3 an intermittent motion to the valve.

3. In a double-acting blowing-engine, air-admission slide-valves arranged at each head of the cylinder, in combination with inversely-arranged cams positively connected with the valves and arranged to open the valves during the movement of the piston away from them and at about the time when the pressure in the cylinder is the same as the atmospheric pressure and to close them just before the motion of the piston is reversed, a continuously-acting eccentric, and means for transmitting motion from the eccentric to the two cams, substantially as described, and so as to give the valves the intermittent reciprocal motion described.

4. In a double-acting blowing-engine, air-admission valves arranged at each head of the cylinder, in combination with inversely-arranged cams h^2 h^2, arranged to open the valves during the movement of the piston away from them and at about the time when the pressure in the cylinder is the same as the atmospheric pressure and to close them just before the motion of the piston is reversed, a continuously-acting eccentric, a rock-lever, as J′, actuated by the eccentric, pivoted levers I I, having pins or rollers i' working in grooves of cams h^2 h^2, rods J, connecting levers I I with lever J′, and adjusting-nuts J^4 J^5, connecting said rods, all substantially as and for the purpose specified.

5. In a blowing-engine, a discharge-valve, in combination with a differential cylinder and piston, said piston connecting with and actuating said valve, conduits leading from the air-reservoir to the smaller head of the differential cylinder and from the adjacent head of the compressing-cylinder to the larger head of the differential cylinder, an exhaust-port at or near the larger head of the differential cylinder, and positively-actuated valves, arranged as described, to alternately open and close the connection between the conduit

leading from the main cylinder and the differential cylinder and the exhaust-port of said differential cylinder.

6. In a blowing-engine, a discharge-valve, in combination with a vertically-arranged differential cylinder and piston, said piston connecting with and actuating said valve and arranged to close it in falling to its lower position in the cylinder, conduits leading from the air-reservoir to the smaller head of the differential cylinder and from the adjacent head of the compressing-cylinder to the larger head of the differential cylinder, all substantially as and for the purpose specified.

7. In a blowing-engine, a discharge-valve, in combination with a differential cylinder and piston, said piston connecting with and actuating said valve, conduits leading from the head of the main cylinder and the adjacent air-receptacle to the ends of the differential cylinder, as described, an exhaust-port leading from near the larger head of the differential cylinder, and positively-actuated valves arranged to open and close the conduits and the exhaust-port, substantially in the order and for the purpose specified.

8. In a blowing-engine, a discharge-valve, in combination with a differential cylinder and piston, said piston connecting with and actuating said valve, conduits leading from the head of the main cylinder and the adjacent air-receptacle to the ends of the differential cylinder, as described, an exhaust-port leading from near the larger head of the differential cylinder, positively-actuated valves arranged to open and close the conduits and the exhaust-port, substantially in the order and for the purpose specified, a second exhaust-port situated closer to the larger head of the cylinder than the first, and a check-valve closing said exhaust-port.

9. In a blowing-engine, a discharge-valve, in combination with a differential cylinder and piston, as M N, said piston being connected with the valve to actuate the same, a valve-chamber, as M^2, having ports leading into the top and bottom of cylinder M and a discharge-port, pipes, as L^3 and A′, connecting the valve-chamber, as described, with the compressed-air reservoir and the cylinder, respectively, a valve, as N′, moving in the valve-chamber and acting to open and close the ports, substantially as specified, and means for actuating said valve in a fixed relation to the motion of the main piston of the engine, all substantially as and for the purpose specified.

10. In a blowing-engine, a discharge-valve, in combination with a differential cylinder and piston, as M N, said piston being connected with the valve to actuate the same, a valve-chamber, as M^2, having ports leading into the top and bottom of cylinder M and a discharge-port, pipes, as L^3 and A′, connecting the valve-chamber, as described, with the compressed-air reservoir and the cylinder, respectively, a valve, as N′, moving in the valve-chamber and acting to open and close the ports, substantially as specified, a positively-driven eccentric, as K, and means, substantially as indicated, for transmitting the motion of said eccentric to the valve, all substantially as and for the purpose specified.

11. In a double-acting blowing-engine, discharge-valves situated on each head thereof, in combination with differential cylinders and pistons, as M M′ N N, said pistons each connecting with and actuating one of the valves, valve-chambers M^2, having ports connecting with the top and bottom of the cylinders and an exhaust-port, pipes L^3 L^3 and A′ A′, connecting the valve-chambers with the compressed-air receptacles at each end of the cylinders and with the cylinders, as described, valves N′ N′, moving in the respective valve-chambers, a positively-driven eccentric, as K, and means, substantially as described, for transmitting the motion of said eccentric to the two valves, so as to simultaneously actuate them in reciprocal direction, all substantially as and for the purpose specified.

12. In a blowing-engine, a discharge-valve, in combination with a differential cylinder and piston, as M N, said piston connecting with and actuating the valve, as described, a valve-box, as M^2, a pipe L^3, leading from the air-receptacle to the end of the valve-box near the smaller cylinder-head, a pipe A′, leading from the end of the main cylinder to the opposite end of the valve-box, admission-ports, as m' m^6, leading from the valve-box to the small and large heads, respectively, of the cylinder M, an exhaust-port, as m^7, situated in valve-box M^2 between the ports m' m^6, an exhaust-port m^5, situated near but above the larger head of cylinder M and leading into the valve-box, an exhaust-port m^3, situated near but below the smaller cylinder-head and leading into the valve-box or a connection thereof above the travel of the valve, a valve, as N′, moving in valve-box M^2, as described, and so as to close and open ports m^6, m^5, and m', as specified, and positively-acting means driven by the engine for moving said valve in a fixed relation to the motion of the main piston, all substantially as and for the purpose specified.

13. In a blowing-engine, a discharge-valve, in combination with a differential cylinder and piston, as M N, said piston connecting with and actuating the valve, as described, a valve-box, as M^2, a pipe L^3, leading from the air-receptacle to the end of the valve-box near the smaller cylinder-head, a pipe A′, leading from the end of the main cylinder to the opposite end of the valve-box, admission-ports, as m' m^6, leading from the valve-box to the small and large heads, respectively, of the cylinder M, an exhaust-port, as m^7, situated in a valve-box M^2 between the ports m' m^6, an exhaust-port m^5, situated near but above the larger head of cylinder M and leading into the valve-box, an exhaust-port m^3, situated near but below the smaller cylinder-head and

leading into the valve-box or a connection thereof above the travel of the valve, an exhaust-port, as m^8, at the larger head of the cylinder M, a check-valve, as O, closing said port, a valve, as N′, moving in valve-box M^2, as described, and so as to close and open ports m^6, m^5, and m', as specified, and positively-acting means driven by the engine for moving said valve in a fixed relation to the motion of the main piston, all substantially as and for the purpose specified.

14. In a blowing-engine, the combination, with a differential cylinder and piston arranged to operate the discharge-valve and having connections, ports, and a pilot-valve, substantially as described, of a cylinder, as M^3, surrounding the exhaust-port m^8 and having an exhaust-orifice m^9, a conduit connecting the head of said cylinder with the air-receiver of the engine, a piston O′, working in the cylinder above the orifice m^9, and a check-valve O, seated on exhaust m^8 and held to its seat by piston O′, all substantially as and for the purpose specified.

15. In a blowing-engine, the combination, with a differential cylinder and piston arranged to operate the discharge-valve and having connections, ports, and a pilot-valve, substantially as described, of a cylinder, as M^3, surrounding the exhaust-port m^8 and having an exhaust-orifice m^9, a conduit connecting the head of said cylinder with the air-receiver of the engine, a piston O′, working in the cylinder above the orifice m^9, a check-valve O, seated on exhaust m^8, and a spring o, arranged between piston O′ and valve O, all substantially as and for the purpose specified.

16. In a double-acting blowing-engine having admission and discharge valves at each end of its cylinder, cams arranged to inversely and intermittently actuate the admission-valves, as described, differential cylinders and pistons, as M M′ N N, said pistons connected with and actuating the discharge-valves of the engine, valve-boxes, as M^2, connected and arranged with the differential cylinders, substantially as described, valves, as N′, moving in said boxes, an eccentric, as K, and means, substantially as described, for transmitting motion from said eccentric to the cams actuating the admission-valves and to the valves N′, all substantially as and for the purpose specified.

W. E. GOOD.

Witnesses:
JAS. C. BROOKS,
LEWIS R. DICK.