No. 652,909. Patented July 3, 1900.

C. L. MAYHEW.

GAS MOTOR.

(Application filed June 16, 1899.)

(No Model.) 5 Sheets—Sheet 1.

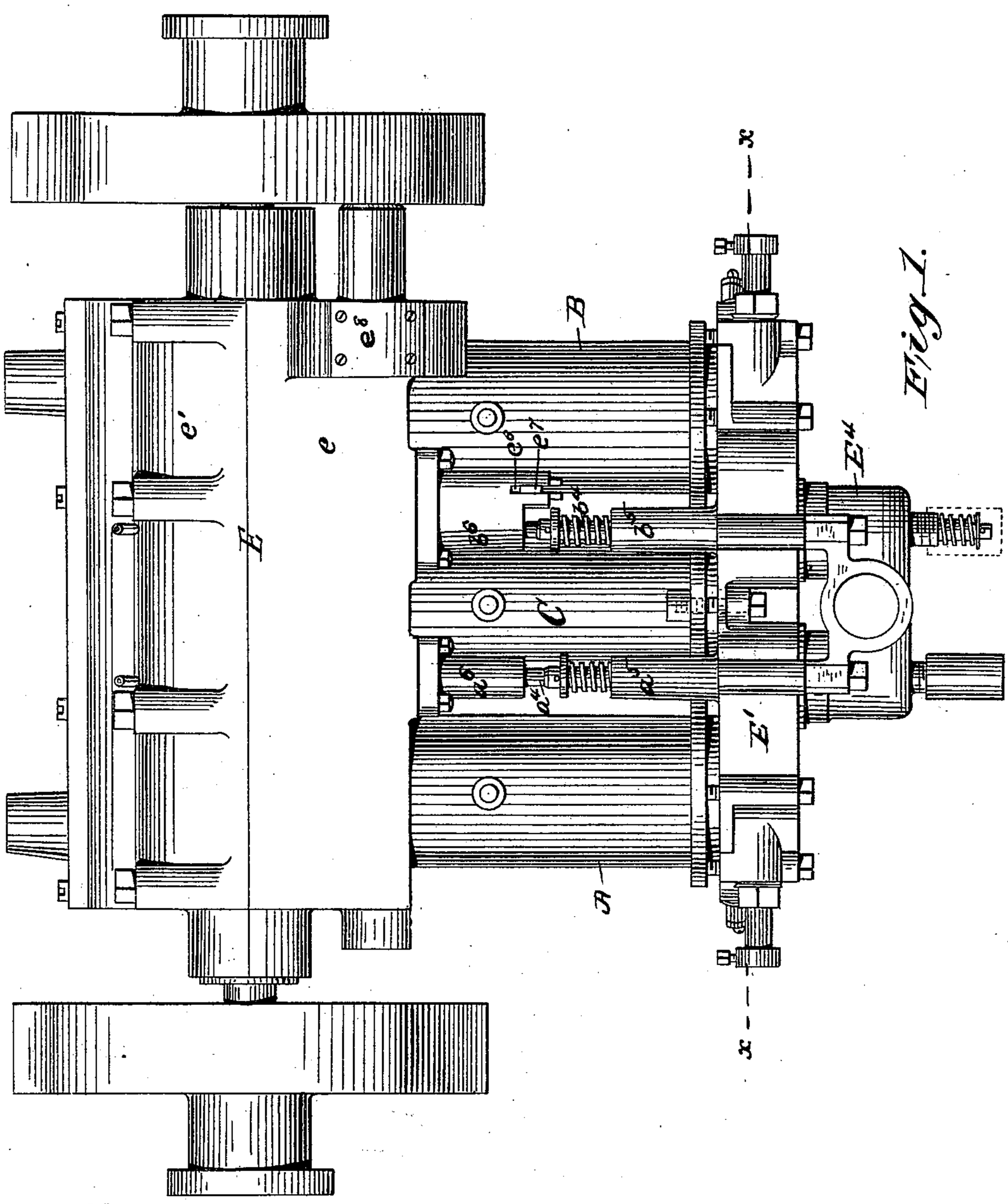

Fig. 1.

Witnesses,
C. W. Benjamin
S. Johnson.

Inventor,
Charles L. Mayhew
by Arden S. Fitch,
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5 Sheets—Sheet 2.

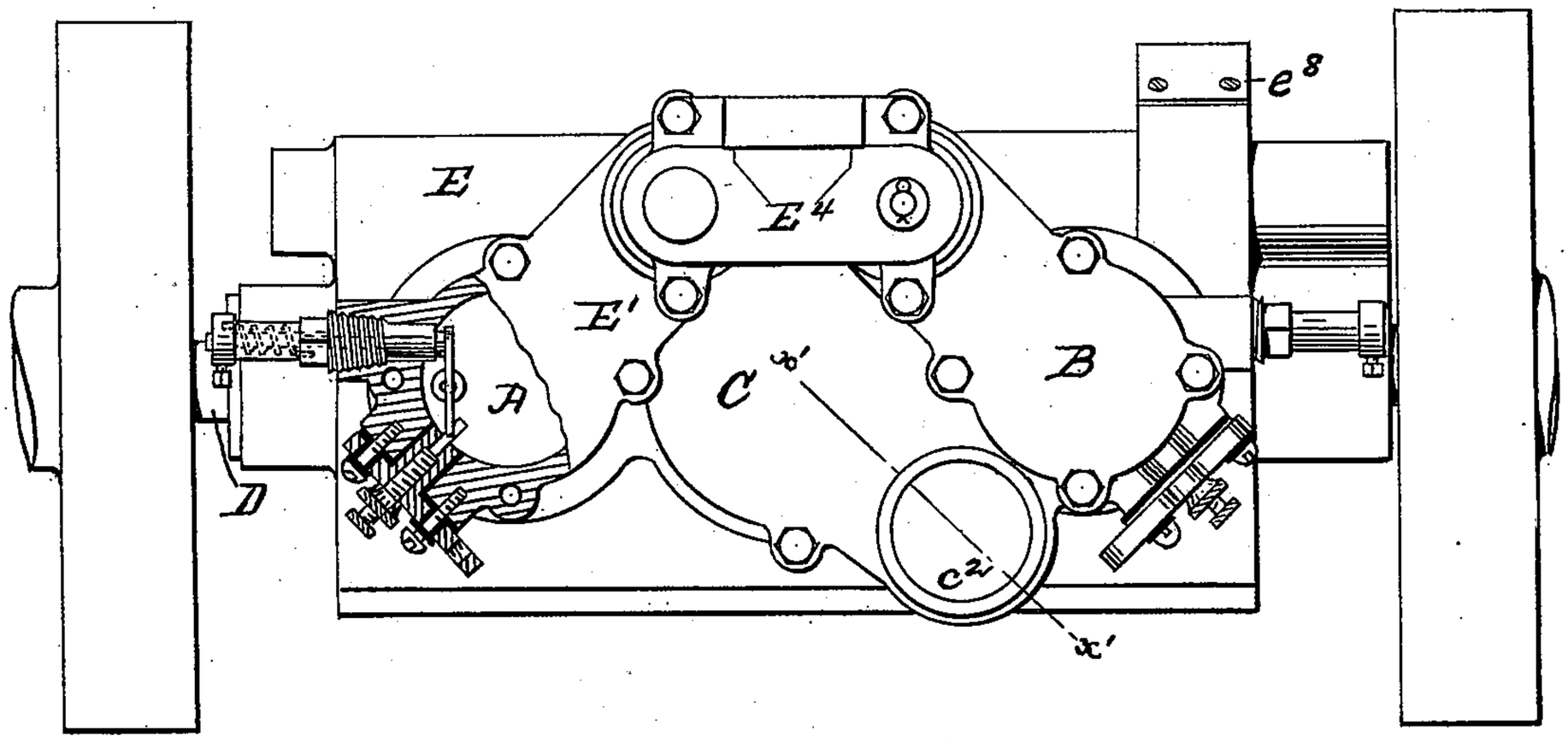

Fig. 2.

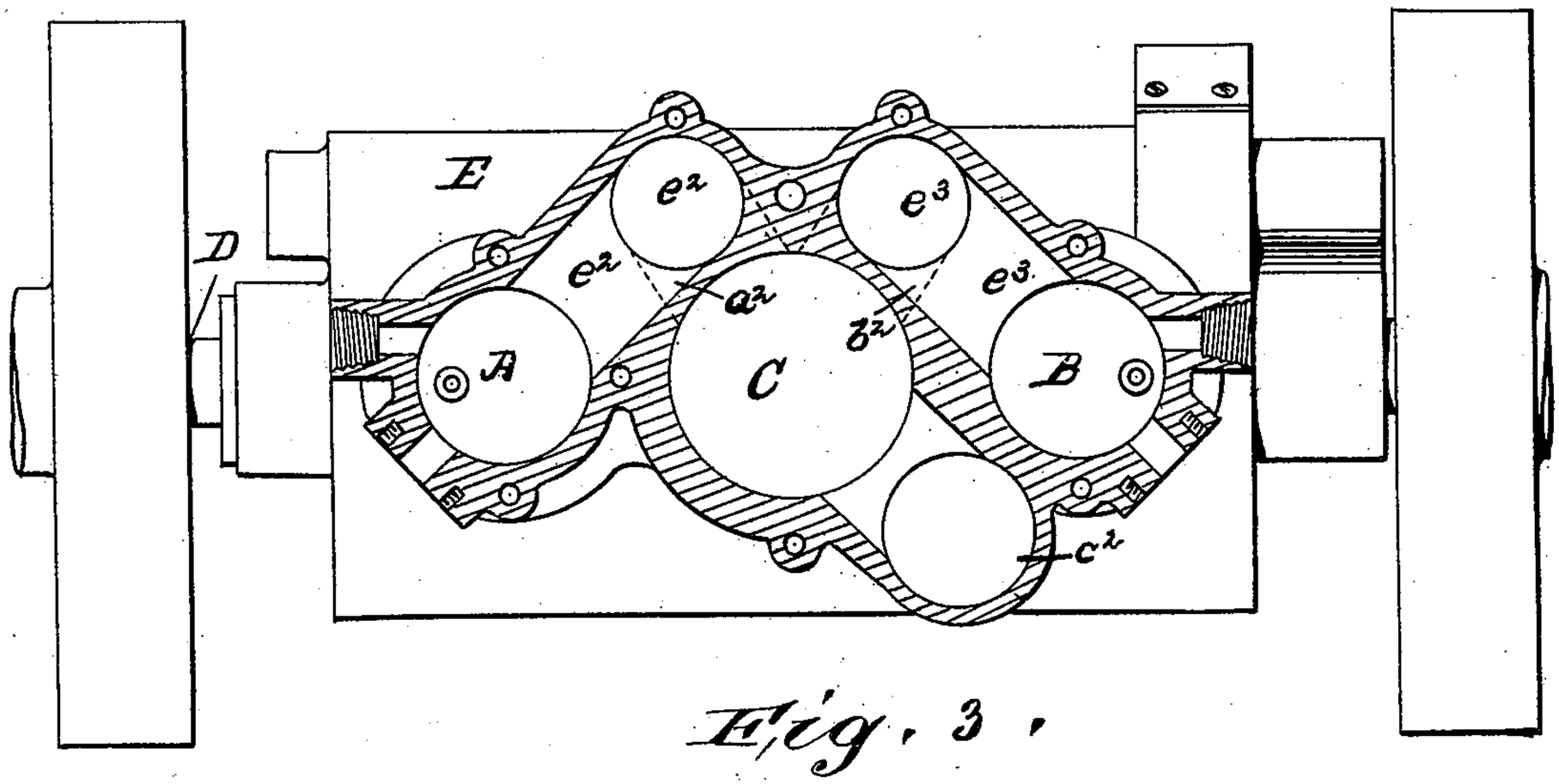

Fig. 3.

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(No Model.) 5 Sheets—Sheet 3.

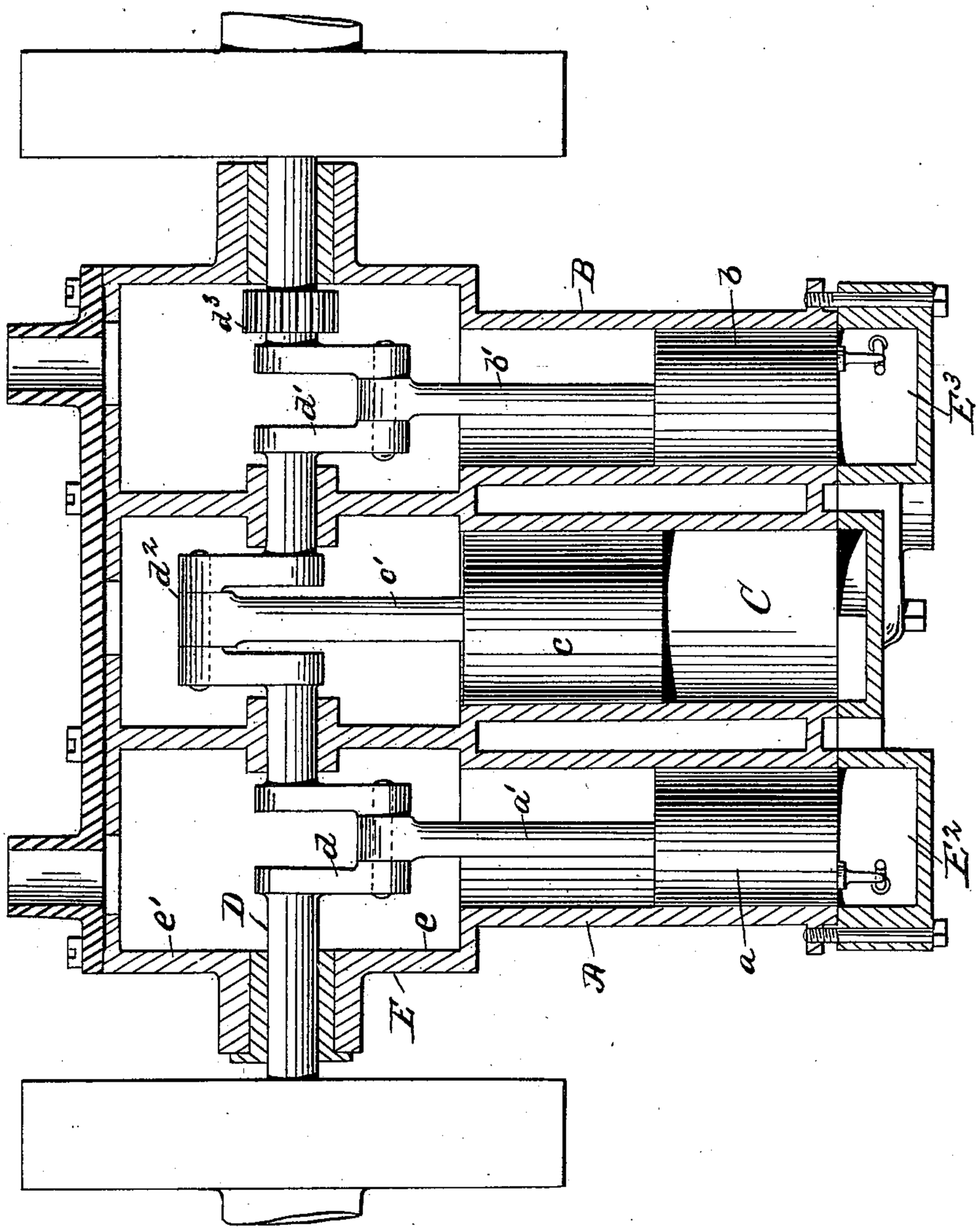

Fig. 4.

Witnesses;
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(Application filed June 16, 1899.)

(No Model.) 5 Sheets—Sheet 4.

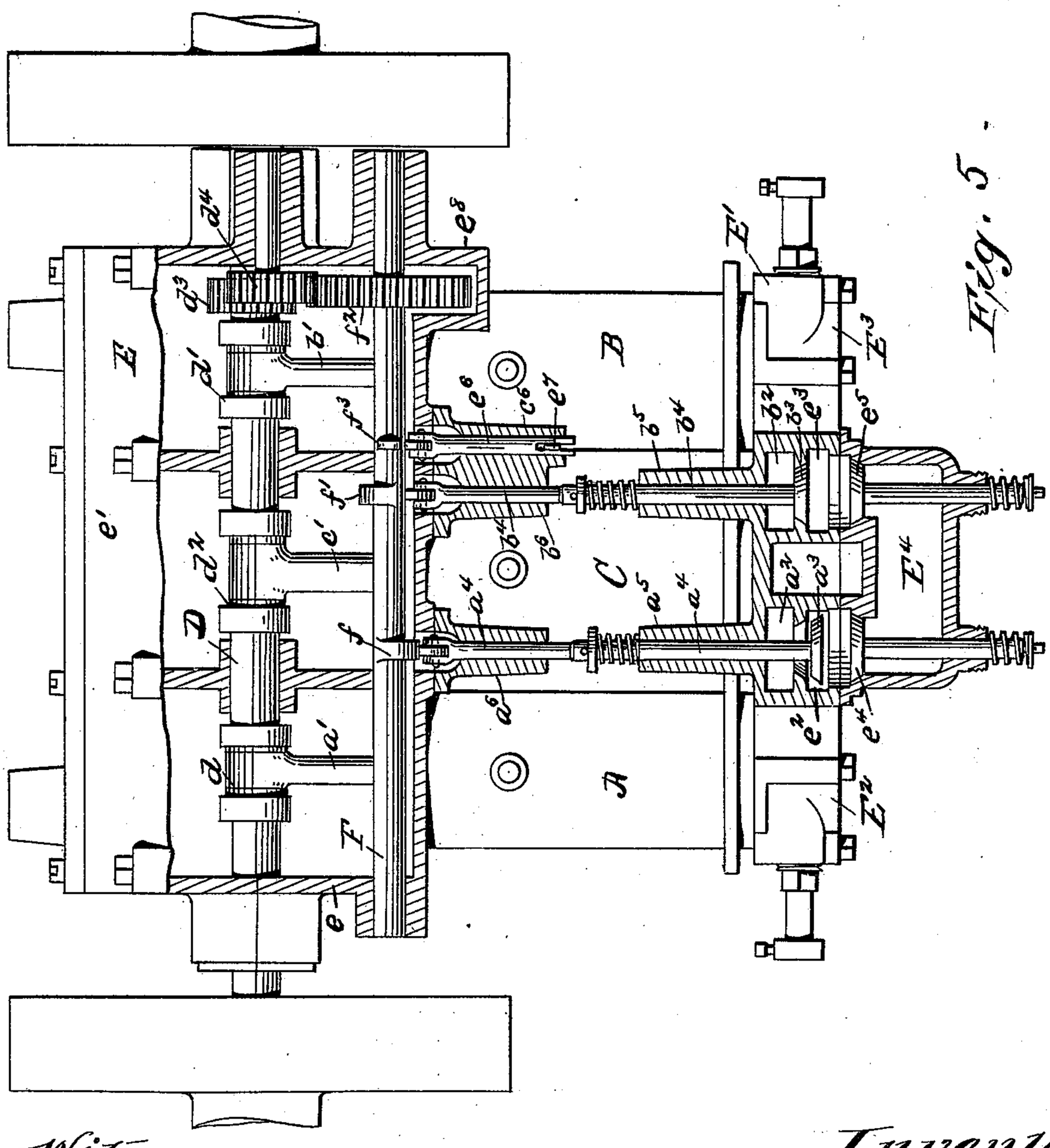

Fig. 5.

Witnesses;
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No. 652,909. Patented July 3, 1900.

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GAS MOTOR.

(Application filed June 16, 1899.)

(No Model.) 5 Sheets—Sheet 5.

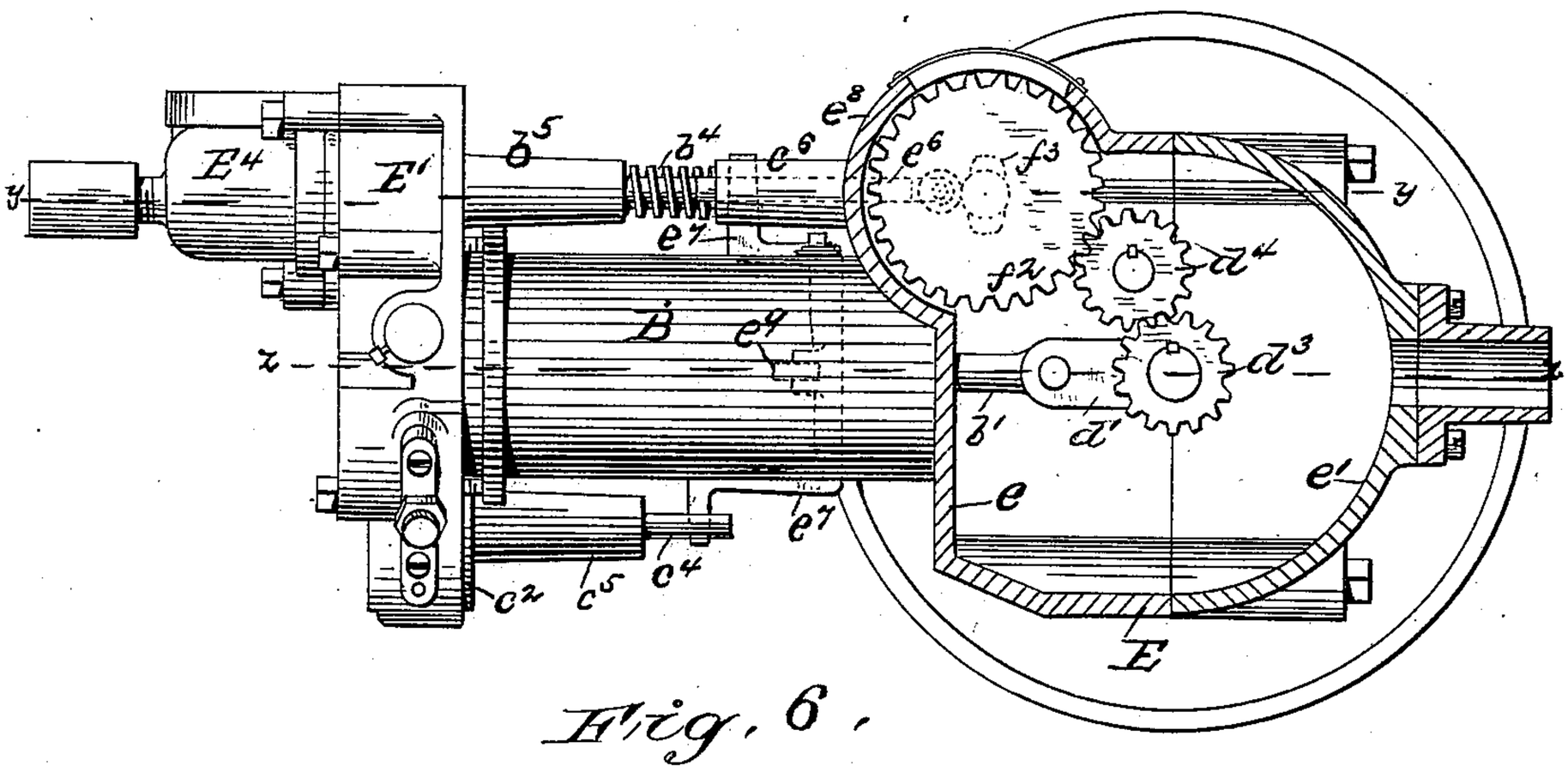

Fig. 6.

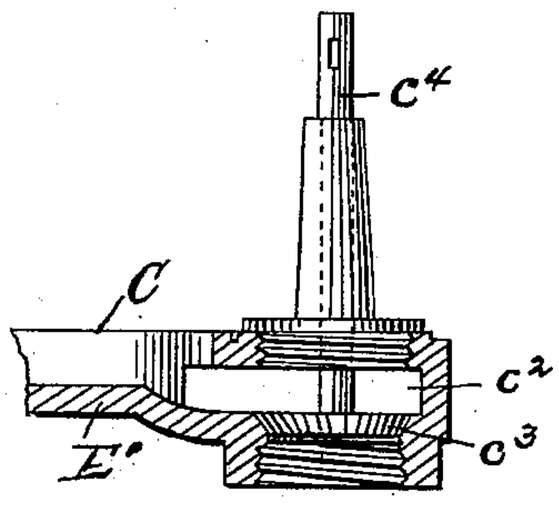

Fig. 7.

Witnesses;
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I. Johnson.

Inventor
Charles L. Mayhew
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atty

UNITED STATES PATENT OFFICE.

CHARLES L. MAYHEW, OF NEWARK, NEW JERSEY, ASSIGNOR OF TWO-THIRDS TO JAMES A. FICKETT AND WILLIAM E. BURROUGHS, OF NEW YORK, N. Y.

GAS-MOTOR.

SPECIFICATION forming part of Letters Patent No. 652,909, dated July 3, 1900.

Application filed June 16, 1899. Serial No. 720,769. (No model.)

To all whom it may concern:

Be it known that I, CHARLES L. MAYHEW, a citizen of the United States, and a resident of Newark, in the county of Essex and State of New Jersey, have invented certain new and useful Improvements in Gas-Motors, of which the following is a specification, reference being had to the accompanying drawings, forming part hereof.

My invention relates to a compound gas-motor which comprises two similar high-pressure cylinders and a low-pressure cylinder, the said high-pressure cylinders alternately exhausting into said low-pressure cylinder, and in which the pistons of the said high-pressure cylinders work to cranks set at the same angle on a shaft common to all the cylinders and the piston of the low-pressure cylinder works to a crank set on said shaft diametrically opposite to said other cranks, the pistons of said high-pressure cylinders respectively making a working outstroke during one half of every alternate revolution of said crank-shaft and the piston of said low-pressure cylinder making a working outstroke during the other half of each successive revolution of said shaft, so that the shaft is driven by power exerted upon it throughout every revolution thereof. In a gas-motor of this class while the piston of one high-pressure cylinder is making a working outstroke during one half of a revolution of the crank-shaft the piston of the other high-pressure cylinder is drawing thereinto a gas charge and the piston of the low-pressure cylinder is expelling the exhaust therefrom, and while the piston of said one high-pressure cylinder is making an instroke and expelling the exhaust therefrom into the low-pressure cylinder during the other half of said revolution of the crank-shaft the piston of said other high-pressure cylinder is compressing the combustible charge therein and the piston of the low-pressure cylinder is making a working outstroke impelled by the expansion of the exhaust it is receiving from said first-named high-pressure cylinder, and, furthermore, while the piston of said one high-pressure cylinder is making an outstroke and drawing thereinto a gas charge during the first half of the next revolution of the crank-shaft the piston of the said other high-pressure cylinder is making a working outstroke impelled by the exploded charge therein and the piston of the low-pressure cylinder is making an instroke and expelling the exhaust therefrom, and, finally, while the piston of said one high-pressure cylinder is making an instroke and compressing its gas charge therein during the second half of said next revolution of the crank-shaft the piston of said other high-pressure cylinder is making an instroke and expelling the exhaust therefrom into the low-pressure cylinder and the piston of the low-pressure cylinder is making a working outstroke impelled by the expansion of the exhaust it is receiving from said second-named high-pressure cylinder. To enable this operation of the described motor to be carried on, chambers into which the gas charges are admitted and in which said charges are ignited and exploded and which communicate with the inward ends of the high-pressure cylinders, respectively, are provided, as well as gas-inlet ports to said respective explosion-chambers, ports or communications between the respective high-pressure cylinders and the low-pressure cylinder, and an exhaust-port from said low-pressure cylinder, together with valves severally governing these ports and valve-gear to positively operate the valves governing said ports between the respective high-pressure cylinders and the low-pressure cylinder and the exhaust-port of said low-pressure cylinder, to open said ports at proper intervals.

The object of my invention is to provied a motor of the class described, comprising the said cylinders, chambers, ports, valves, and valve-gear and a common crank-shaft, in which the several parts and devices are so constructed and combined as to form a compact structure of comparatively-small weight, so that the motor will be specially adapted for use as a motor for the propulsion of vehicles.

My invention consists in the devices hereinafter described, constructed and combined as hereinafter particularly set forth and as more at length recited in the claims.

In the drawings, Figure 1 is a plan of a gas-motor containing my invention. Fig. 2 is a

front end elevation of the same with one of the explosion-chambers partly in section to show a form of igniter employed. Fig. 3 is a vertical section through the front cylinder-head on line $x\,x$, Fig. 1. Fig. 4 is a horizontal section through the cylinder on the line $z\,z$, Fig. 6. Fig. 5 is a similar section through the valves and their gear on line $y\,y$, Fig. 6. Fig. 6 is a side elevation of the motor, partly in section, at the rearward end; and Fig. 7 is a sectional view in detail on the line $x'\,x'$, Fig. 2, through the final exhaust-port and its valve.

A and B are the two similar high-pressure cylinders, and C is the low-pressure cylinder, and said cylinders are arranged side by side, parallel to one another, in close proximity, with the cylinder C between the others. The pistons a and b of the respective cylinders A and B are respectively connected by pitmen a' and b' to cranks d and d', which are set at the same angle on the shaft D, and the piston c of cylinder C is connected by pitman c' to a crank d^2, which is diametrically opposite to the cranks $d\ d'$ on said shaft. The area of the piston c is desirably approximately equal to the aggregate of the areas of pistons a and b, and the weight of said piston c and its pitman is preferably approximately equal to the aggregate of the weights of the said pistons a and b and their pitmen to effect a balance of the motor. The shaft D has bearings in a casing E at the outward ends of the several cylinders, the said casing being common to all said cylinders and preferably consisting of a section e, which is rigid upon the said outward cylinder ends and is desirably cast or otherwise formed integral with said cylinders and a removable section e', which is detachably secured, as by bolts, to said rigid section. The said casing constitutes a chamber, within which the shaft D is contained and operates, and access to the shaft or outward ends of the cylinders may readily be had by removing the case-section e'.

E^2 and E^3 are explosion-chambers respectively communicating with the cylinders A and B and provided with igniting devices, preferably electric, in any well-known form, such as illustrated in Fig. 2, and operated by the pistons a and b in the usual manner. At $e^2\ e^3$ are gas-inlet ports respectively governed by spring-controlled suction-valves e^4 e^5 and respectively communicating with the chambers E^2 E^3. Ports $a^2\ b^2$, in connection with ports $e^2\ e^3$, respectively, establish communication between the respective cylinders A and B and the cylinder C, the said ports being respectively governed by valves $a^3\ b^3$, and an exhaust-port c^2 from cylinder C is governed by a valve c^3. The valves $a^3\ b^3$ are carried by stems $a^4\ b^4$, respectively, which are severally provided with controlling-springs which act to close the valves to their seats, and said valves are positively operated to establish communication between the cylinders A and B, respectively, and the cylinder C alternately at each second revolution of the shaft D, so that during the instrokes of the respective pistons $a\ b$ thereof immediately succeeding the working outstrokes thereof said cylinders A B will alternately exhaust into the cylinder C, and said alternate operation of said valves is desirably effected by cams $f\ f'$, which are respectively set on opposite sides of a shaft F and which respectively engage the ends of the stems a^4 b^4 of said valves, the said shaft being driven from the crank-shaft D and timed to make a half-revolution to every single revolution of said crank-shaft, as by pinions $f^2\ d^3$ and intermediate gear d^4. The valve c^3 of exhaust-port c^2 is positively operated to open said port during each instroke of the piston c by a cam f^3 on said shaft F, having an engagement-face on each of diametrically-opposite sides thereof and at right angles to the cams $f\ f'$, the said faces successively engaging a reciprocating rod e^6 at each revolution of said cam-shaft, and which rod is operatively connected to the stem c^4 of said valve by a lever e^7. The cams $f\ f'$ are of such length or duration that their action upon said valves $e^3\ b^3$, respectively, will operate to maintain open communication between the cylinders A or B, as the case may be, and the cylinder C during the instrokes of the pistons a or b immediately after the working outstrokes thereof, and the respective faces of the cam f^3 are of such length or duration that the action of either upon the valve c^3 will operate to open the port c^2 during every instroke of the piston c in cylinder C.

A feature of my invention in a gas-motor comprising the described devices operating as set forth consists in the combination, with the said several cylinders A, B, and C, of a head E', which is common thereto and closes the front or inward ends thereof and is formed, as by casting, in a single piece and contains the explosion-chambers E^2 and E^3, located therein opposite to the cylinders A and B, respectively, and also the two inlet-ports e^2 and e^3, respectively leading divergently in the head from inlet-apertures therein at their outward ends on the front side of the head above the central cylinder C to the chambers E^2 and E^3, and, furthermore, the two ports a^2 and b^2, respectively leading convergently in the head from said outward ends of said inlet-ports to the low-pressure cylinder C and respectively communicating with said ports $e^2\ e^3$ by apertures which are respectively located oppositely to and registering with said inlet-apertures, seats for the valves $a^3\ b^3$ being respectively provided in the head in said communication-apertures between said ports $e^2\ a^2$ and $e^3\ b^2$, respectively, and finally the exhaust-port c^2, which extends from the cylinder C downwardly in the head to a part thereof below and between said cylinder C and an adjoining high-pressure cylinder, as B, where a seat is formed in the head for the valve c^3. By means of

this described head E′, common to the several cylinders and formed in one piece to contain the chambers E^2 E^3, the ports e^2 e^3 and a^2 b^2, and valve-seats for valves a^3 b^3, and the port c^2 and seat for its valve, located therein as set forth, an economy in space and weight is secured and compactness in the structure of the motor is attained.

Another feature of my invention consists in the combination, with the several cylinders A, B, and C and the head E′, constructed and arranged as described, of a gas-inlet piece E^4, which is attached to the front of said head E′ and is common to the inlet-apertures of the ports e^2 e^3 and has two apertures which are respectively opposed to and register with said inlet-apertures and carries the suction-valves e^4 e^5, which respectively work to seats in said apertures in said piece to govern said ports for the inlet of gas to the explosion-chambers of the high-pressure cylinders. This said inlet E^4 not only also conduces to compactness in structure and economy in weight of the motor, but, in connection with the head E′, constructed and combined as described, promotes simplicity and convenience in the assembling of the parts.

A still further feature of my invention consists in the combination, with the several cylinders A, B, and C, provided at their inward or front ends with the described common head E′, containing the ports e^2 a^2 and e^3 b^2, governed by the valves a^3 b^3, respectively, and provided at their outward or rear ends with the connected casing E and having the common crank-shaft D, having bearings in and working within said casing, of the cam-shaft F, having bearings in and located within said casing above said crank-shaft, with the pinion f^2 on said cam-shaft playing in a bay or cylindrical recess e^8 in said casing, and the gear d^4, between said pinion and the pinion d^3 on said crank-shaft, carried by a stud-shaft having bearing in said casing, together with guides a^5 b^5, extending rearwardly from the rearward side of said head E′ over the central cylinder C, and guides a^6 b^6, extending forwardly from the forward side of the casing E and opposedly, respectively, to the guides a^5 b^5 over said central cylinder, and the respective stems a^4 b^4 of said valves a^3 b^3 respectively playing in said guides a^5 a^6 and b^5 b^6 and reaching through and into said casing E, with their rearward ends respectively engageable by the cams f f' and with their respective controlling-springs severally located between the opposed ends of said guides.

A further feature of my invention consists in the combination, with the several cylinders A, B, and C, provided with the common head E′, in which is the exhaust-port c^2 of cylinder C, as described, and with the casing E, in which the common crank-shaft D and cam-shaft F have bearings and work, of a guide c^5, extending rearwardly from the rearward side of said head below said cylinders, and a guide c^6, extending forwardly from the forward side of said casing above said cylinders, with the rod e^6, engageable by cam f^3 on said cam-shaft, working in said guide c^6, and the stem c^4 of valve c^3 of said port c^2, working in said guide c^5, together with the lever e^7, which operatively connects the free ends of said rod and valve-stem, fulcrumed on a stud e^9 on the side of one of said cylinders, with its arms respectively reaching above and below said cylinders to engagement, respectively, with said rod and valve-stem.

By means of the described construction and arrangement of the valve-stems and their guides in combination with the cam-shaft F, located as set forth, the compactness and economy in weight of the motor structure are promoted, so that the completed motor of the class specified is specially adapted for use in the propulsion of vehicles.

What I claim as my invention, and desire to secure by Letters Patent, is—

1. In a compound gas-motor comprising two high-pressure cylinders and a low-pressure cylinder, located side by side, parallel to each other, with the low-pressure cylinder between the others, and in which the said high-pressure cylinders alternately exhaust into said low-pressure cylinder during the instrokes of the alternate full strokes of the respective pistons of said high-pressure cylinders, the combination with said several cylinders, of a single head common thereto to close the front or inward ends thereof and containing two explosion-chambers located therein respectively opposite to and in open communication with said high-pressure cylinders, two ports respectively leading divergently therein from inlet-apertures at their outward ends on the front side of said head above the central cylinder to said explosion-chambers, two ports respectively leading convergently therein from said outward ends of said inlet-ports to said low-pressure cylinder and respectively communicating with said inlet-ports by apertures which are respectively located oppositely to and registering with said inlet-apertures, and two valve-seats respectively located in said communication-apertures between said ports, together with two valves respectively working to said valve-seats to control communication between the respective high-pressure cylinders and the low-pressure cylinder; substantially as and for the purpose specified.

2. In a compound gas-motor comprising two high-pressure cylinders and a low-pressure cylinder, located side by side, parallel to each other, with the low-pressure cylinder between the others, and in which the said high-pressure cylinders alternately exhaust into said low-pressure cylinder during the instrokes of the alternate full strokes of the respective pistons of said high-pressure cylinders, the combination with the said several cylinders, of a single head common thereto to close the front or inward ends thereof and containing two explosion-chambers located therein re-

spectively opposite to and in open communication with said high-pressure cylinders, two ports respectively leading divergently therein from inlet-apertures at their outward ends on the front side of said head above said central cylinder to said explosion-chambers, two ports respectively leading convergently therein from said outward ends of said inlet-ports to said low-pressure cylinder and communicating with said inlet-ports by apertures which are respectively located opposedly to and registering with said inlet-apertures, and two valve-seats respectively located in said communication-apertures between said ports, and having valves which respectively work to said seats, together with a port leading downwardly in said head from said low-pressure cylinder to an outlet on the front side thereof, and a valve-seat in said outlet, with a valve working to said seat to control the exhaust from said low-pressure cylinder; substantially as and for the purpose specified.

3. In a compound gas-motor comprising two high-pressure cylinders and a low-pressure cylinder, located side by side, parallel to each other, with the low-pressure cylinder between the others, and in which the said high-pressure cylinders alternately exhaust into said low-pressure cylinder during the instrokes of the alternate full strokes of the respective pistons of said high-pressure cylinders, the combination with the said several cylinders, of a single head common thereto to close the front or inward ends thereof and containing two explosion-chambers located therein respectively opposite to and in open communication with said high-pressure cylinders, two ports respectively leading divergently therein from inlet-apertures at their outward ends on the front side of said head above the central cylinder to said explosion-chambers, and an inlet-piece on the front side of said head and common to said inlet-apertures therein and having two apertures which are respectively opposed to and register with said inlet-apertures, and two valve-seats respectively located in said inlet-piece apertures, with two valves carried by said inlet-piece and respectively working to said seats therein to control the inlet of gas to the explosion-chambers of the respective high-pressure cylinders; substantially as and for the purpose specified.

4. In a compound gas-motor comprising two high-pressure cylinders and a low-pressure cylinder, located side by side, parallel to each other, with the low-pressure cylinder between the others, and in which the said high-pressure cylinders alternately exhaust into said low-pressure cylinder during the instrokes of the alternate full strokes of the respective pistons of said high-pressure cylinders, the combination with the said several cylinders, of a single head common thereto to close the front or inward ends thereof and containing the explosion-chambers of said high-pressure cylinders, two ports respectively leading therein from inlet-apertures on the front side of said head above the central cylinder to said explosion-chambers, two ports respectively leading therein from the inlet ends of said inlet-ports to said low-pressure cylinder and communicating with said inlet-ports by apertures which respectively register with said inlet-apertures, and two valve-seats respectively located in said communication-apertures between said ports, together with a crank-shaft common to the respective pistons of the several cylinders, a cam-shaft driven by said crank-shaft, a casing which is common to and incloses the rear or outward ends of said several cylinders and within which said shafts have bearings and work, and two valves respectively working to said valve-seats and provided with stems which extend rearwardly through said head and above and parallel to said central cylinder and into said casing to operative engagement, respectively, with cams on said cam-shaft; substantially as and for the purpose specified.

5. In a compound gas-motor comprising two high-pressure cylinders and a low-pressure cylinder, located side by side, parallel to each other, with the low-pressure cylinder between the others, and in which the said high-pressure cylinders alternately exhaust into said low-pressure cylinder during the instrokes of the alternate full strokes of the pistons of said high-pressure cylinders, the combination with the said several cylinders, of a single head common thereto and closing the front or inward ends thereof, and containing the explosion-chambers of said high-pressure cylinders and in its upper part ports which act as gas-inlets to said explosion-chambers and also establish communication between the inward ends of said high-pressure cylinders and that of said low-pressure cylinder, with valves respectively governing said ports, together with an exhaust-port leading downwardly in said head from said low-pressure cylinder to an outlet on the front side thereof between said cylinder and an adjoining high-pressure cylinder, a valve working to a seat in said outlet and having a stem extending rearwardly below said cylinders, a reciprocatory rod playing in a guide above said cylinders and actuated by a cam on a shaft having bearings at the rear or outward ends of said cylinders, and a lever extending transversely of the cylinders and operatively connecting said rod and said valve-stem; substantially as and for the purpose specified.

Signed at New York, in the county of New York and State of New York, this 31st day of May, A. D. 1899.

CHARLES L. MAYHEW.

Witnesses:
ARDEN S. FITCH,
I. JOHNSON.