(No Model.) 4 Sheets—Sheet 1.

W. E. CRIST.

VIBRATING PISTON ENGINE.

No. 316,606. Patented Apr. 28, 1885.

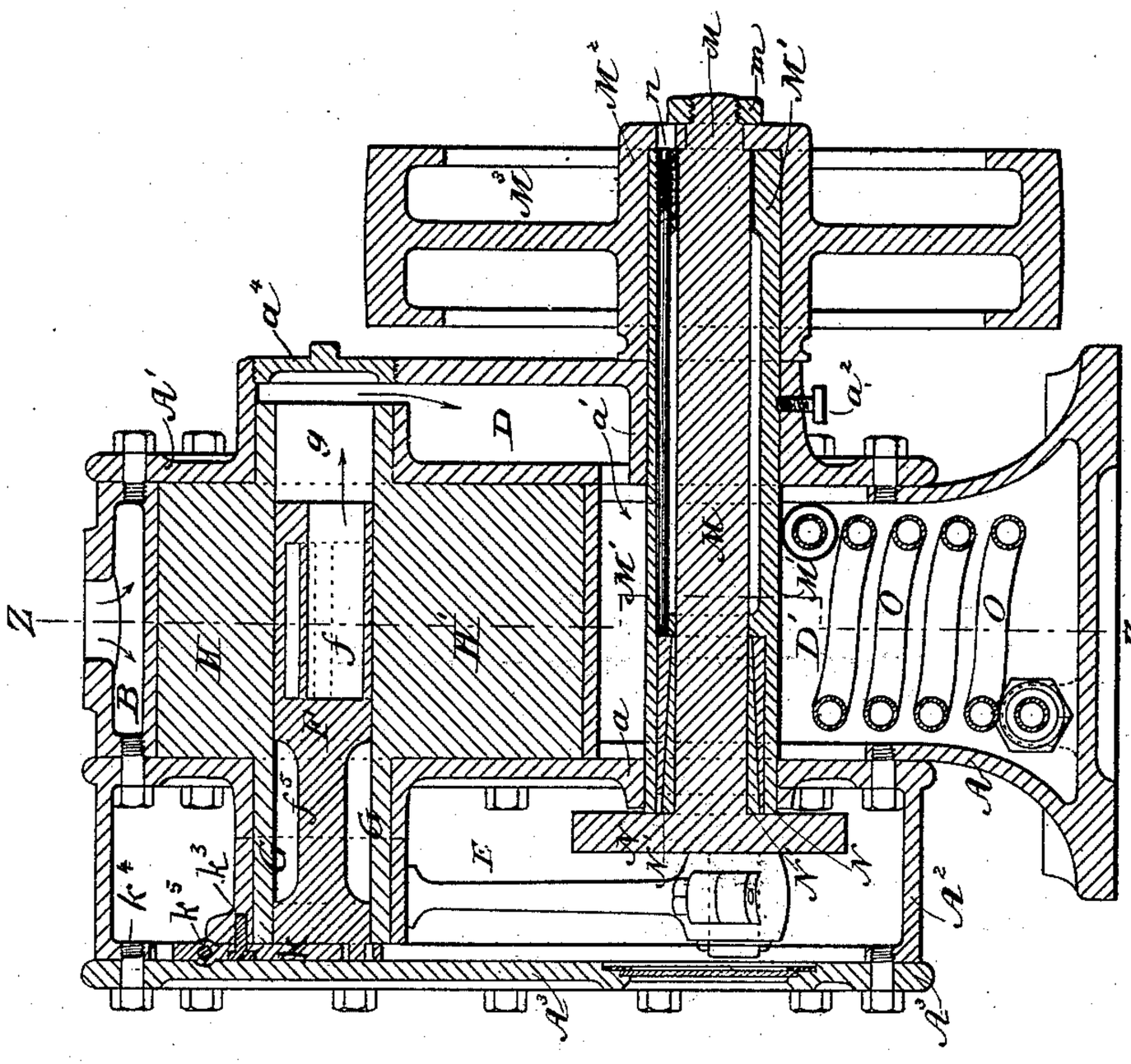

Fig. 2.

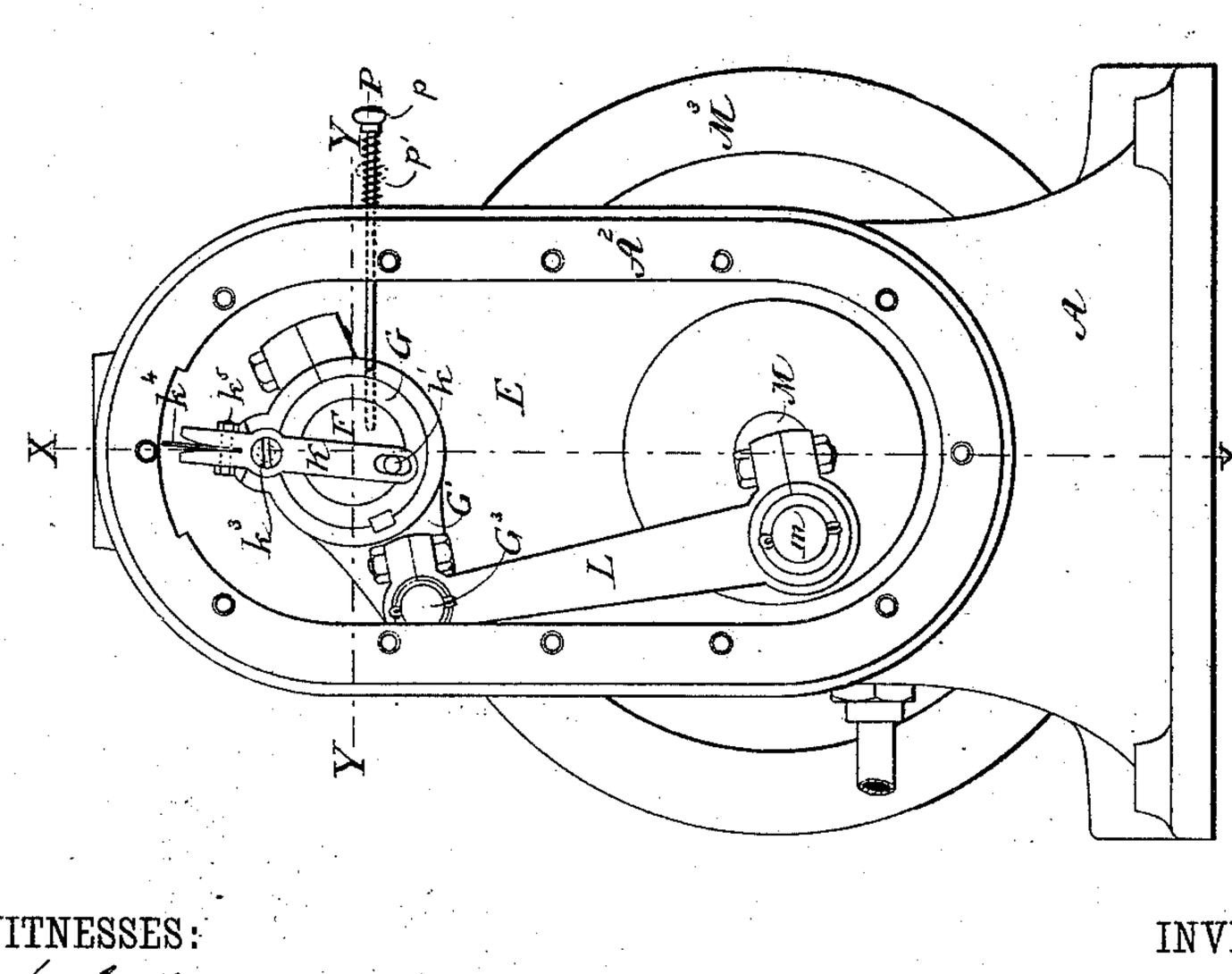

Fig. 1.

WITNESSES:

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A. H. Rowz

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BY David A. Burr

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(No Model.)

4 Sheets—Sheet 2.

W. E. CRIST.

VIBRATING PISTON ENGINE.

No. 316,606. Patented Apr. 28, 1885.

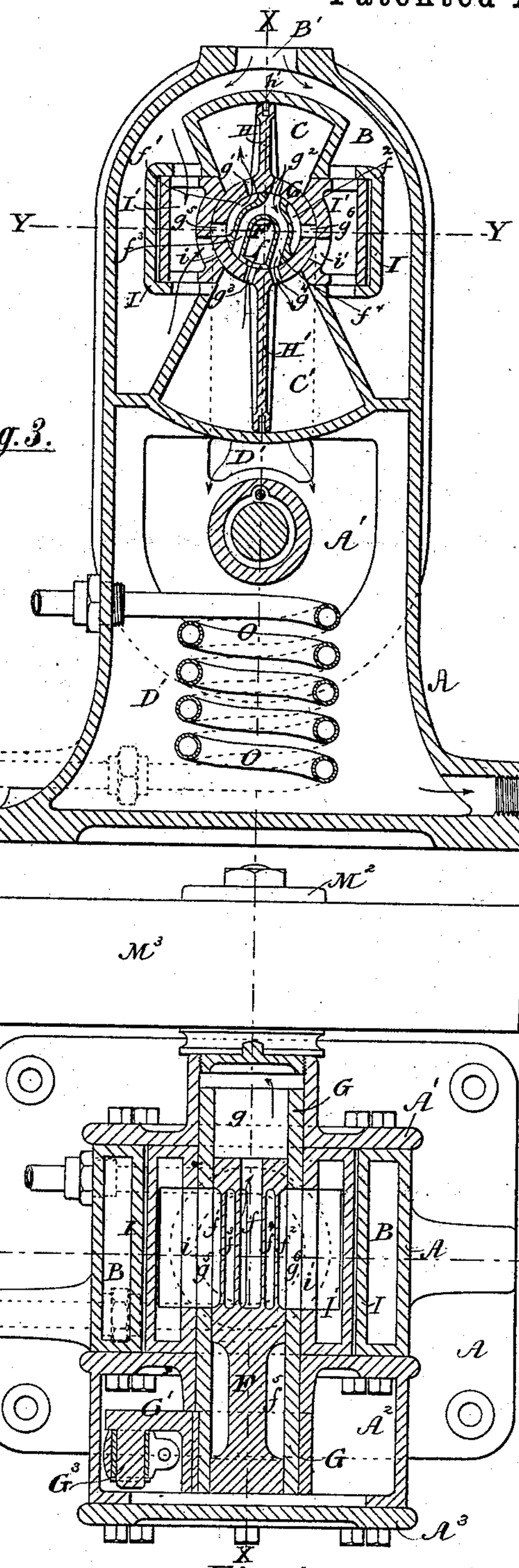

Fig. 3.

Fig. 4.

WITNESSES:

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(No Model.)

4 Sheets—Sheet 3.

W. E. CRIST.

VIBRATING PISTON ENGINE.

No. 316,606. Patented Apr. 28, 1885.

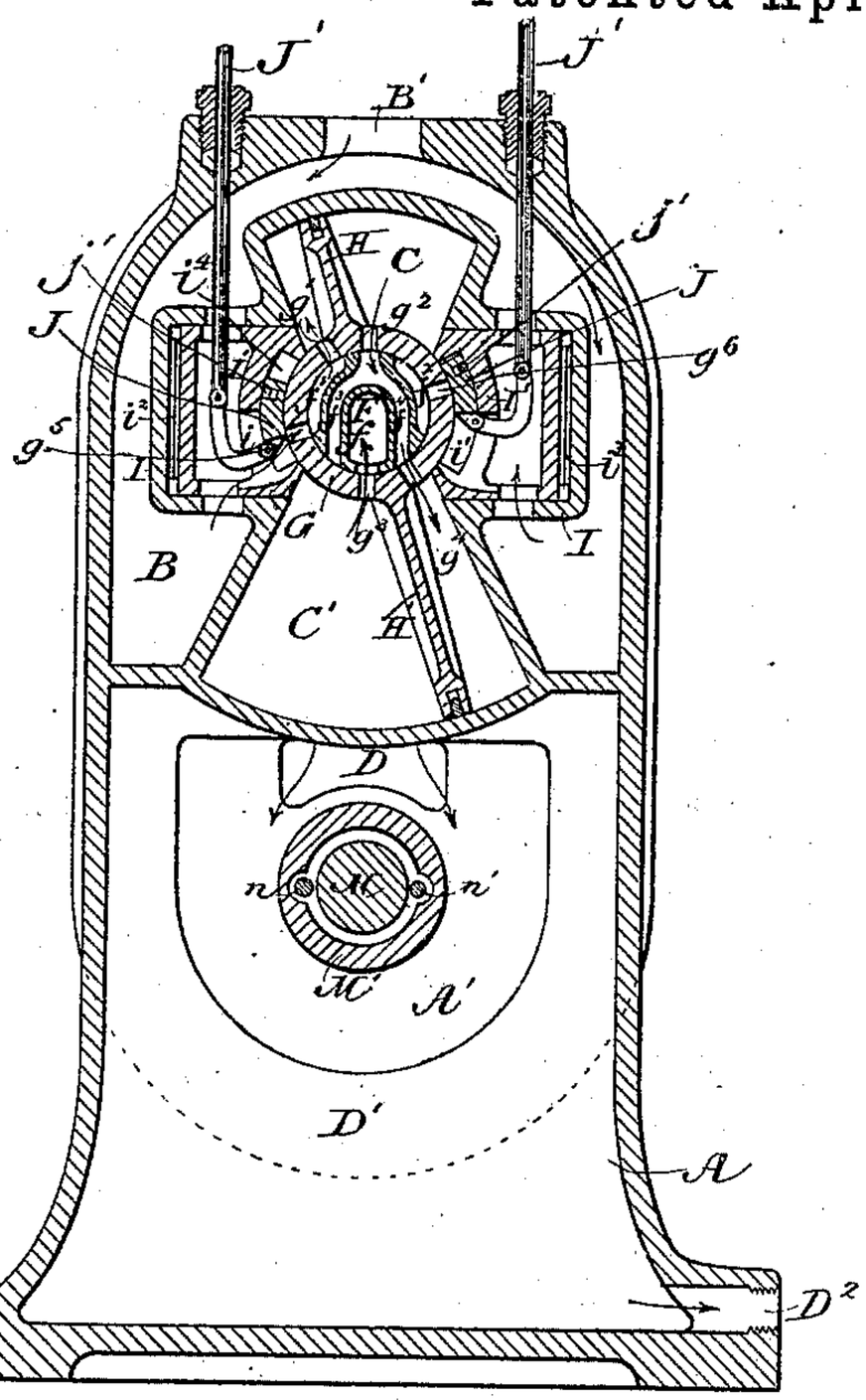

Fig. 5.

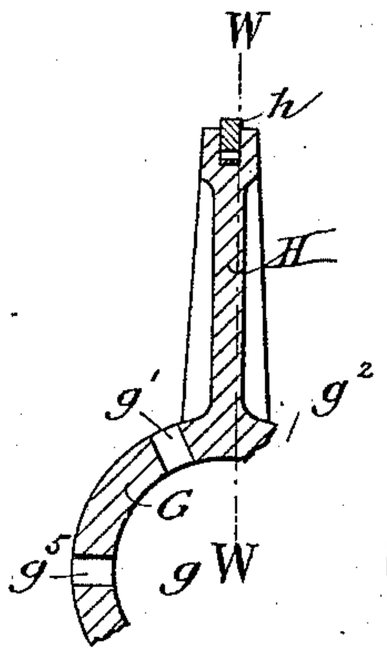

Fig. 6.

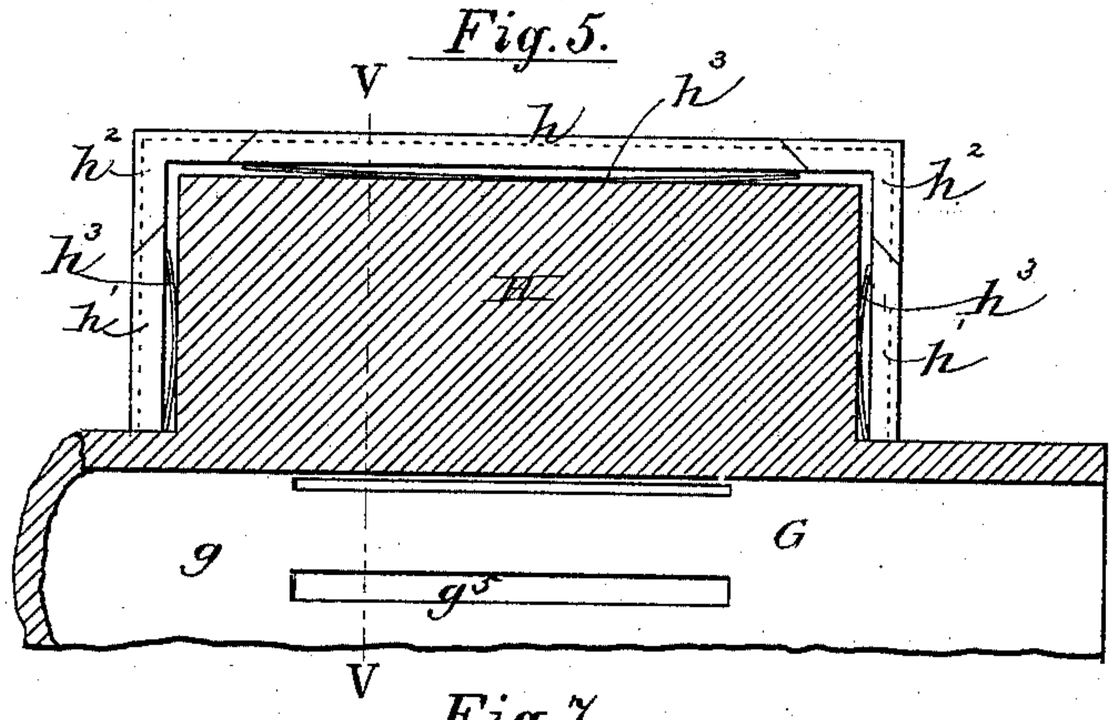

Fig. 7.

WITNESSES:

H. W. Hubbard.

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(No Model.)

4 Sheets—Sheet 4.

W. E. CRIST.

VIBRATING PISTON ENGINE.

No. 316,606. Patented Apr. 28, 1885.

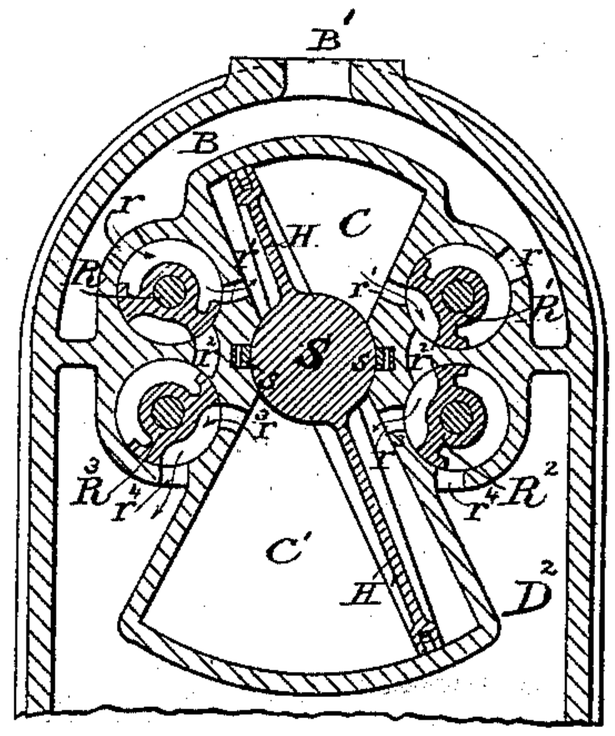

Fig. 8.

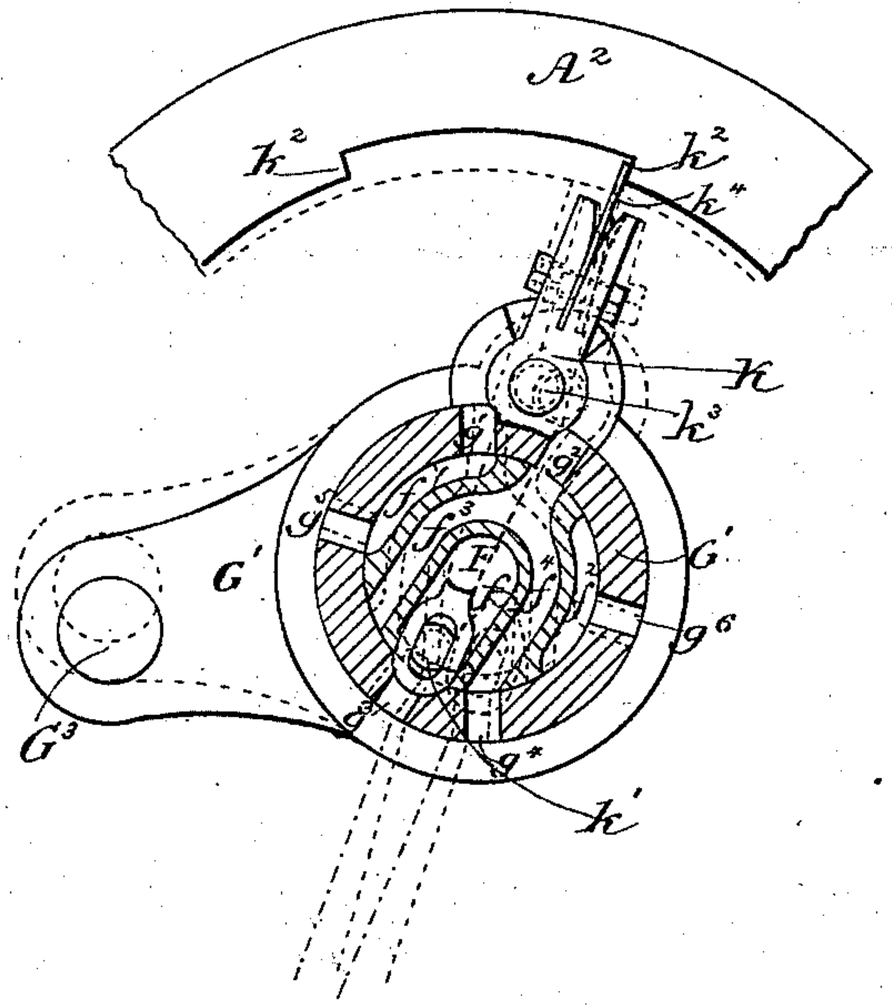

Fig. 9.

WITNESSES:

W. W. Hubbard.

D. H. Rowe

INVENTOR

William E. Crist

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UNITED STATES PATENT OFFICE.

WILLIAM E. CRIST, OF NEW YORK, N. Y.

VIBRATING-PISTON ENGINE.

SPECIFICATION forming part of Letters Patent No. 316,606, dated April 28, 1885.

Application filed August 29, 1883. (No model.)

To all whom it may concern:

Be it known that I, WILLIAM E. CRIST, a citizen of the United States, residing in New York city, in the county and State of New York, have invented certain new and useful Improvements in Vibrating-Piston Engines; and I do hereby declare that the following is a full and exact description thereof, reference being had to the accompanying drawings, and to the letters of reference marked thereon, making a part of this specification.

My invention relates to that class of engines wherein a vibrating piston or diaphragm is secured upon an oscillating shaft to work within a sector-shaped chamber whose converging walls radiate from the shaft.

The principal object of my invention is to provide a simple, compact, well-balanced, direct-acting, compound engine wherein the pressure of steam or air shall be utilized successively in two chambers of unequal capacity—first, in a small high-pressure chamber, and, second, in a larger low-pressure chamber into which the exhaust from the first is carried, or wherein air may be compressed by a reverse movement, forcing air from the larger into the smaller chamber, many features of the invention being equally applicable to a single-acting engine.

My improvement consists, primarily, in forming within a suitable casing, and on diametrically-opposite sides of a central oscillating shaft supported by the casing, two sector-shaped chambers of unequal capacity, because of unequal radial section, and within each of which is fitted a piston secured to the rock-shaft as its pivotal support, and in combining therewith means for admitting steam or air alternately upon opposite sides of the piston in the smaller chamber to exhaust therefrom into the larger chamber upon the opposite sides alternately of its piston, and thence pass out freely from the engine, the oscillating movement of the rock-shaft thus obtained being converted into a continuous rotary movement by well-known devices.

The improvement further consists in a novel construction of steam-exhaust and cut-off valves; in a self-adjusting valve-seat; in means for steam-jacketing and inclosing the working-chamber, shaft, and connecting-rods, and for lubricating the working parts; and, also, in certain details of construction hereinafter particularly specified.

In the accompanying drawings, Figure 1 is an end elevation of the engine with its end plate removed, showing the valve and crank-gearing; Fig. 2, a vertical longitudinal sectional elevation in the line *x x* of Figs. 1, 3, and 4, showing a feed-water heater-coil arranged in the exhaust-chamber formed in the base of the engine; Fig. 3, a transverse sectional elevation in the line *z z* of Fig. 2; Fig. 4, a horizontal sectional view in the line *y y* of Figs. 1 and 3; Fig. 5, a vertical transverse sectional elevation in the line *z z* of Fig. 2, showing a separate cut-off valve and means for operating it; Fig. 6, a transverse section of one of the pistons and part of its hollow rock-shaft in the line *v v* of Fig. 7; Fig. 7, a longitudinal sectional elevation of the piston in the line *w w* of Fig. 6; Fig. 8, a transverse sectional elevation through the working-chamber, steam-chamber, and valve and exhaust chambers, showing a modification in the form of valves adapted to this form of engine; and Fig. 9, a transverse sectional view in detail upon an enlarged scale, illustrating the operation of the central oscillating valve and its gearing shown in the various figures of the drawings other than Fig. 8.

The casing of the engine herein described is preferably made in four divisions, A, A′, A^2, and A^3, embracing four distinct chambers, (see Figs. 2 and 3,) viz: the steam-chamber B, working-chambers C C′, exhaust-chambers D D′, and crank-chamber E.

The working and exhaust chambers communicate with each other through suitable ports and passages, which are controlled by an oscillating valve, F, of peculiar construction, to admit the steam from the chamber B to the chamber C, then to chamber C′ at a reduced pressure and in an increased volume, and finally to the exhaust-chambers D D′, from which it escapes into the atmosphere.

In the construction shown in the drawings the working-chambers C C′ (see Fig. 3) are sector-shaped, and arranged diametrically opposite each other to radiate from an intermediate cylindrical casing, through which they communicate freely with each other. This

free opening between the chambers is closed and their communication controlled by means of a tubular shaft, G, fitted within the cylindrical casing to oscillate freely therein. The chambers C C′, thus located on opposite sides of the rock-shaft G, are of unequal radial section, the piston-area of the lower chamber, C′, being illustrated as about three times greater than that of the upper chamber, C. Flat wings or plates H H′ are secured radially to project from diametrically-opposite sides of the hollow rock-shaft G, respectively, into the chambers C C′, and are made to fit and move closely against the walls thereof, so as to serve as the vibrating pistons of the engine. The open end *g*, Figs. 2 and 4, of the hollow shaft serves as an exhaust-port, and communication is established between the working-chambers and the interior of the shaft by ports g' and g^2, g^3 and g^4, Figs. 3 and 4, cut on each side of the base of each piston, and by central ports, g^5 and g^6, cut diametrically opposite each other at a right angle with said piston.

Within the hollow shaft G is fitted the cylyndrical valve F, which extends from the outer crank end of the shaft to beyond its ports g' to g^6. The outer cylindrical face of this valve is flattened or cut away sufficiently at opposite points to form passages f' and f^2, Fig. 3, to connect alternately in the oscillating movement of the valve the ports g' or g^3 with the port g^5 on one side, and the ports g^2 or g^4 with the port g^6 on the opposite side when properly brought into register therewith. A central recess in the valve communicates with its open end *g*, and radially with a port or opening, *f*, which connects alternately in the movement of the valve with the ports g^3 and g^4. A three-way passage is cut through the valve to encircle partially the central recess therein, and to open outwardly through the face of the valve between the approximate edges of the outer channels, f' and f^2, and between the opposite edges of said channels and the intermediate central port, *f*, so that communication shall be constantly established through the same by means of the two diverging passages, f^3 and f^4, therein, either between the ports g^2 and g^4 or the ports g' and g^3 on the same or corresponding side of the two pistons H H′. The solid outer end of the valve-stem is reduced by a circumferential recess, f^5, (see Figs. 2 and 4,) cut therein to diminish its weight and thereby facilitate its movement. The sides or walls of the cylindrical casing which incloses the rock-shaft G and covers the same, intermediate the central open inner end of the working-chambers, are detached and made movable, so as to become self-adjusting against the rock-shaft to serve as bearings therefor, and are made to constitute the inner walls of hollow boxes I′ I′, which are borne and held against the shaft with a constant pressure, to form a steam-tight joint therewith, by means of springs i^2 i^3, Fig. 5, inclosed between the outer face of each and a steam-chest, I, within which the box is fitted. Ports *i i* are cut through the bearings of these valve-boxes to establish communication between the ports g^5 and g^6 in the rock-shaft and the interior of the box when brought in proper register, as hereinafter set forth. The bearing-boxes I′ I′ and the inclosing steam-chests I I are left open at the top and bottom, to admit of a free passage thereinto of steam from the steam-chamber B, formed in the casing of the engine to inclose and jacket its working-chambers and steam-chests, as shown in Figs. 3 and 5. Live steam being freely admitted from the steam-pipe B′ into the steam-chamber B will pass freely into the steam-chests I I and bearing-boxes I′ I′. If, now, the port g^5 or g^6 in the rock-shaft, which is in register for the time being with the passage f' or f^2 of the valve G, is brought into register with either the port i' or i' in the bearing-boxes or valve-seats I′ I′, the steam will pass through said port and passage to the port g' or g^2 in the rock-shaft and through the same into the smaller or high-pressure working-chamber C of the engine to drive its piston H over, the steam in front of said piston meantime escaping into the larger low-pressure working-chamber C′, (to bear against its piston and drive it forward,) through the exhaust-way opened through the port on that side of the piston, the three-way passage in the central valve, G, and either the port g^3 or g^4 opening into the chamber C′, the steam in front of said low-pressure piston H′ being left free to exhaust through the connection of the central exhaust-passage, *f*, in the valve with the port g^3 or g^4 on the other side of said piston and with the open exhaust end *g* of the rock-shaft. In the drawings the radial section or piston area of the small high-pressure chamber C is represented as about one-third that of the larger low-pressure chamber C′, although any other relative proportions may be employed. The connection of the several ports is changed to produce the alternate pressure and exhaust upon opposite sides of each piston required to cause its vibration by means of the oscillating movement of the valve F within the hollow rock-shaft G. The valve F moves with the rock-shaft G during the principal part of each stroke of the pistons, the admission of steam during the stroke being determined by the relation of the supply-port g^5 or g^6 in the rock-shaft to the stationary supply-port i' in the valve seat or bearing I, and governed by the length of opening in said port i'. When the high-pressure piston is sufficiently near the end of the stroke in either direction to require its reversal, and yet allow sufficient steam in front of it to serve as a cushion therefor in completing its movement, the valve is intercepted and its movement arrested by the following-described instrumentalities, the continued movement of the rock-shaft, as the piston finishes its stroke serving to change the relative positions of its ports with reference to those in the valve, and thus change the direction of the currents of live and exhaust steam: A lever, K, (see Figs.

1 and 9,) is pivoted eccentrically to the end of the rock-shaft G to vibrate therewith. Its inner end, extending diametrically over the center of the shaft, engages, by means of an extended longitudinal slot therein, a pin, k', projecting eccentrically from the outer face of the valve F. Its outer end is prolonged to strike at either end of the arc of its vibration as it sweeps back and forth under the oscillation of the rock-shaft against a stop or a projection, k^2 k^2, formed in the casing. When the lever is arrested in its concurrent movement with the rock-shaft by the contact of its outer end with either shoulder k^2, the continued forward movement of its pivotal center at k^3 will cause a quick movement of its inner end, k', in the opposite direction, and consequently a sudden rotation of the valve within the rock-shaft in that direction, (see dotted lines, Fig. 9,) which will operate to produce an immediate reversal of the supply and exhaust connections, resulting in a reversal of the movement of the pistons and rock-shaft, the valve being carried back by the rock-shaft until it is again shifted by the contact of the upper end of the lever with the opposite shoulder k^2. The outer end of the rock-shaft G projects into the end chamber, E, of the casing and is fitted with a ring, which is firmly clamped and keyed thereto and which carries an arm, G, fitted with a wrist-pin, G^3, upon which is journaled the connecting-rod, coupling the rock-shaft with the crank-pin m on the inner end of the main shaft M, supported within the base of the engine in line parallel with the rock-shaft G, as shown in Fig. 2. The crank m and disk m' on the end of the shaft revolve in said crank-chamber E, which is closed by the detachable face-plate A^3 of the casing. The lower part of the chamber is filled with oil, which, being constantly agitated by the movement of the cranks, is made to distribute itself thoroughly over the bearings and journals of the engine projecting into said chamber. A glass plate, a^3, may be fitted in the lower end of the covering-plate A^3, through which the level of the oil will be at all times visible. The shaft M is supported and its bearings are preferably adjusted as illustrated in the drawings. The open end g of the rock-shaft G is made to communicate by means of a passage, D, (see Fig. 2,) with a chamber, D', formed within the base or pedestal of the engine to receive the exhaust-steam. A feed-water pipe, O, may be arranged in a coil in this lower exhaust-chamber, D', and being therein surrounded by the exhaust-steam will furnish in a simple compact form means for heating the feed-water without additional expense. The ends of the pipe O may be connected to the pump and water-supply in any well-known manner. The lever K (see Fig. 9) for operating the oscillating valve F is pivoted in a box, k^6, formed in an offset on the hub of the arm G', to vibrate between radial shoulders, against which it strikes and rests at the end of its movement in each direction. In order that this lever K may be shifted noiselessly or without clacking when it strikes the shoulders k^2 k^2, which limit its movement, a spring-plate, k^4, is inserted in the end of the lever and clamped between the ears thereof by a bolt and nut, k^5. The inner surfaces of the ears may be rounded, as shown, and will allow the spring a limited swaying movement, sufficiently rigid, however, to move the valve with an elastic pressure.

Provision is made for the reversal of the engine in a simple and effective manner, by means of a rod, P, (see Fig. 1,) led through a steam-packed opening in the casing A into the crank-chamber E, in position to be projected, when pushed endwise, across or within the path of the lever K. A spiral spring, p', is fitted to encircle the rod between a knob or handle, p, on its outer end and the casing, and serves to withdraw the rod automatically from within reach of the lever K. By pushing the rod inwardly it is made to intercept the lever K, and to carry it, with the valve attached thereto, in a direction opposite to that of its movement, so as to cause the valve to admit the steam to and exhaust it from the reverse sides of the pistons, and thereby immediately reverse their movements.

A cut-off or combined cut-off and throttle valve may be applied and used in connection with the hollow rock-shaft G, provided with steam-ports communicating with the high-pressure chamber C, for controlling the admission of live steam thereto in the following manner: In this case the self-adjusting valve seats or bearings I' I' are formed with recesses i^4, into which segmental valves J, provided with packing j', are snugly fitted to bear and move freely, with a steam-tight joint upon the outer surface of the hollow shaft G. The valves J are moved and adjusted upon the shaft G by means of vertical-moving rods J', and operate by their adjustment to increase or decrease the size of the steam-supply openings i or i', and thereby determine the point at which the steam will be cut off from the ports g^5 and g^6 in the oscillation of the rock-shaft. The valves J may be opened to full width to admit steam during nearly the entire stroke of the piston, as shown upon the right side of Fig. 5, or may be partially opened, as shown upon the left side of the same figure; or the valves may be dropped so far as to entirely close the ports i or i', and serve as a throttle to completely cut off the admission of steam to the engine.

The valve-rods J' may be provided with any desired means for actuating them, and I contemplate connecting them to the governor of the engine in any well-known or desired manner to secure their movement by the action of the governor, so as to regulate thereby the point of cut-off in conformity to the requirements of the engine.

The pistons H H are packed by means of side strips, h, end strips, h', and corner pieces, h^2, adapted to fit snugly into the grooves or channels in the edges of the pistons. The

side and end strips are forced outward against the walls of the working-chamber by the pressure of springs h^3, interposed between the strips and the bottom of the channels. The angular corner pieces, h^2, are fitted against the ends of the side and end strips with an overlapping beveled joint (see Fig. 5) adapted to produce an outward movement of the corner pieces simultaneously with the outward movement of the spring-actuated strips.

The packing-strips may be made of phosphor-bronze, steel, or other metal which will preserve its edge truly. The corner pieces, being acted upon with pressure corresponding to that of the side and end strips, are held with equal force against the inner surface of the working-chambers, and thereby prevent unequal friction and consequently unequal wear at any one point. A screw-plate, a^4, may be fitted in the end plate, A^2, of the casing (see Fig. 2) directly opposite the free exhaust end of the hollow rock-shaft G, by which means access may be readily had thereto and connections be made for an exhaust-pipe, if desired.

Various changes may be made in the details of construction of the engine without departing from my invention, and old or well-known devices may be substituted for the novel devices peculiarly adapted to my invention without departing from its general scope—as, for instance, two or more steam-valves may be employed to govern the supply and exhaust ports of the working-chambers, to be operated according to the Corliss or other well-known systems of valve-movement.

In Fig. 8 an example is given of the use of four oscillating valves, R R′ R^2 R^3, in combination with the remaining features of my compound engine. The valves R R′ control the admission of the steam first through the ports r r' from the steam-supply chamber B to the upper working-chamber, C, and then through the ports r' r^2 r^3 and valves R^2 R^3 from the upper or high-pressure chamber, C, to the lower or low-pressure chamber, C′. The valves R^2 R^3 operate in unison with the valves R R′, and first admit steam through the ports r' r^2 r^3 and valves R′ R^2 to the low-pressure chamber from the higher-pressure chamber, and then, by means of the ports r^3 r^4, to the exhaust-chamber D^2, in this instance arranged around the lower or low-pressure working-chamber.

Where separate valves of the above-described arrangement are employed, the rock-shaft S, to which the pistons H H′ are connected, may be made solid and the pistons bolted thereto instead of being cast thereon. The self-adjusting steam-balanced seats I′ I′, described in connection with the remaining figures of the drawings, may also be dispensed with in this case, as a simple spring-actuated packing-strip, s, may be employed in lieu thereof.

When the engine is to be employed as an air-compressor, it is only necessary to reverse the action of the valves, so as to receive through the exhaust-pipe and exhaust through the induction-pipe, the air being taken into the larger or receiving chamber C′, and forced therefrom into the smaller or compressing chamber C. The valve F is reversed in its operation by simply revolving it until the diverging ends of the ports f^3 f^3 will communicate with the ports g' g^2, and the converging ends will communicate alternately with the ports g^3 g^4. The exhaust-port f of the valve F will then necessarily communicate with the upper or smaller chamber, C, and a suitable air-reservoir.

The valve F may be operated in its reverse position in the same manner as in the position first described, and by precisely the same instrumentalities, only that the pin of the valve is connected with the lever near its pivotal point.

I do not limit myself to the exact arrangement of ports herein shown, as my invention includes any arrangement or method of connecting two sector-shaped chambers of unequal capacity, when in combination with vibrating pistons of unequal area, operating or to be operated upon by air, gas, or steam contained alternately in the chambers and expanded from high pressure to low pressure or compressed from low pressure to high pressure.

I claim as my invention—

1. A compound vibrating-piston engine, constructed with two sector-shaped working-chambers of unequal piston-area, pistons vibrating therein about a common axis, and communicating channels adapted and arranged to conduct the steam or air expelled from one chamber by the forward movement of its piston into the second chamber against its moving piston, substantially in the manner and for the purpose herein set forth.

2. In a vibrating-piston engine, the combination, with communicating chambers of unequal piston-area, of vibrating pistons working within said chambers and secured to and radiating from a common axial shaft to be subjected jointly and successively to unequal pressures upon their opposite faces, substantially in the manner and for the purpose herein set forth.

3. The combination, with the two piston-chambers, of a compound vibrating-piston engine, and with its exhaust and supply pipes and ports, of an oscillating valve interposed between said chambers and adapted to connect in its movements said exhaust and supply pipes and the supply and exhaust ports of said chambers, and to establish communication between the latter, substantially in the manner and for the purpose herein set forth.

4. The combination, in a compound vibrating-piston engine, with its working-chambers and with a hollow oscillating shaft, ports therein communicating with the supply and exhaust pipe of the engine and with said chambers, and an oscillating valve fitted within the shaft to participate in its movement, yet be free to oscillate independently thereof, of a valve-le-

ver pivoted to said shaft, and devices for reversing the lever and valve in the movement of the shaft and pistons, substantially in the manner and for the purpose herein set forth.

5. The combination, in a vibrating-piston engine, with its steam-chest, working-chamber, and with a vibrating piston secured to a hollow rock-shaft, through which are formed the ports adapted to establish, in the movements of the shaft and piston, communicating passages between the steam-chest and working-chamber and the working-chamber and exhaust-pipes, of an automatic cut-off valve fitted upon the outer side of the shaft and adapted, in the movement of the latter, to cut off the admission of steam to its supply-ports, substantially in the manner and for the purpose herein set forth.

6. In a vibrating-piston engine, the combination, with two working-chambers arranged on either side of a common center, of two steam-chests placed opposite each other on either side of said center intermediate the working-chamber, and adapted to inclose self-adjusting balanced valve-seats supporting a central oscillating hollow piston-shaft, substantially in the manner and for the purpose herein set forth.

7. The combination, in a vibrating-piston engine, with its working-chamber, its hollow oscillating piston-shaft and pistons, the steam-supply ports in the shaft, and a steam-supply chamber or jacket inclosing the same, of self-adjusting balanced valve seats or bearings adjusted to the oscillating shaft on opposite sides thereof, and fitted with ports for the admission of steam to the shaft, substantially in the manner and for the purpose herein set forth.

8. The combination, in a vibrating-piston engine, of an exhaust-chamber and feed-water heater, with a base or pedestal supporting the main shaft of the engine, and its oscillating shaft, piston-chambers, and steam-supply chamber, all disposed and arranged relatively to each other, substantially in the manner and for the purpose herein set forth.

9. The combination, in a vibrating-piston engine, with its oscillating piston-shaft, main driving-shaft, crank-connections on said shafts, and the connecting-rod coupling the same, of a casing or chamber inclosing said connecting rod and connections, and adapted to contain and retain a lubricating material to be automatically applied to said parts, substantially in the manner and for the purpose herein set forth.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

WILLIAM E. CRIST.

Witnesses:
W. H. ROWE,
WM. H. DRAKE.