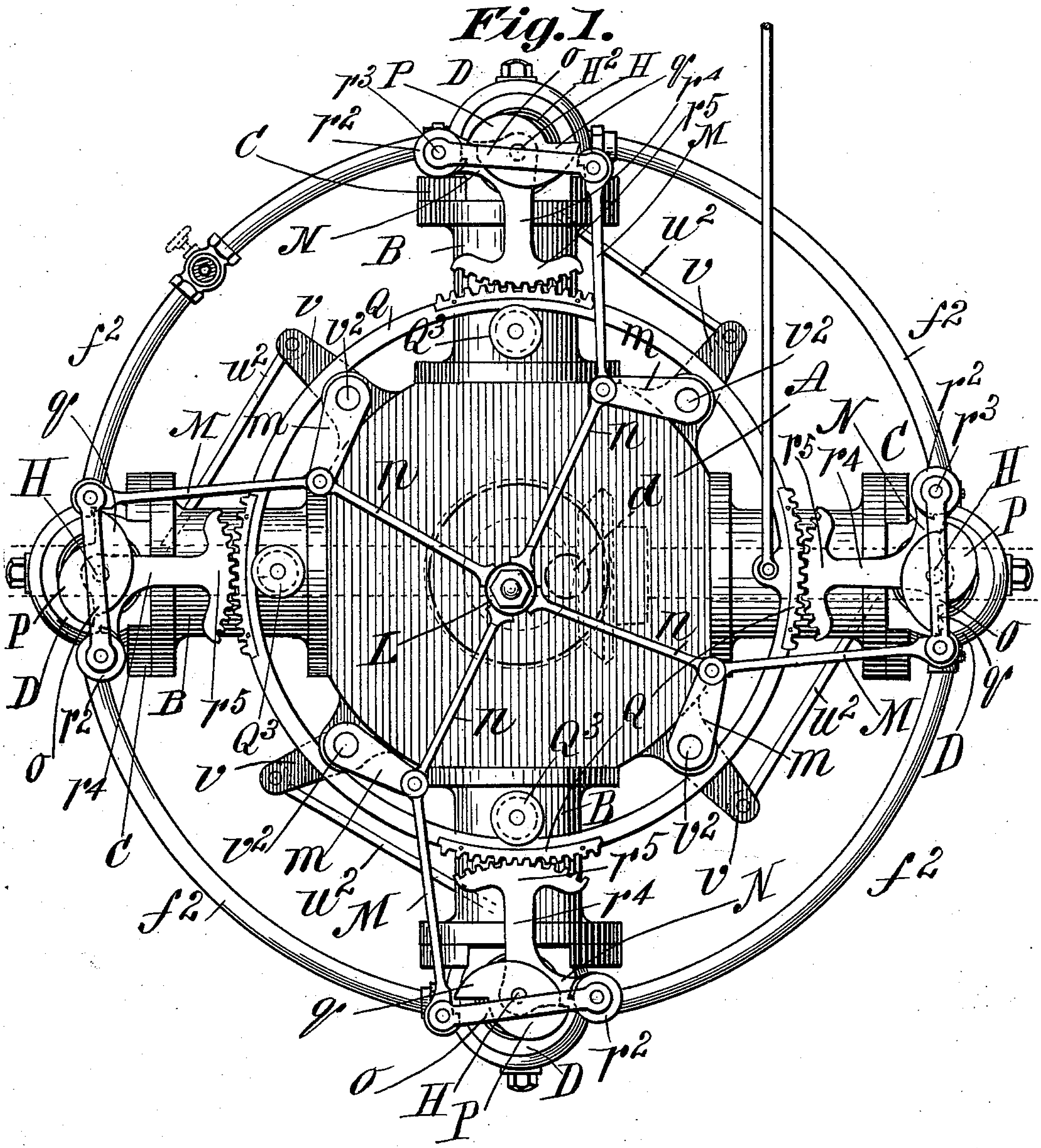
(No Model.) 4 Sheets—Sheet 1.

E. B. BENHAM.

MULTIPLE CYLINDER MOTOR.

No. 539,026. Patented May 14, 1895.

Fig. 1.



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(No Model.) 4 Sheets—Sheet 2.

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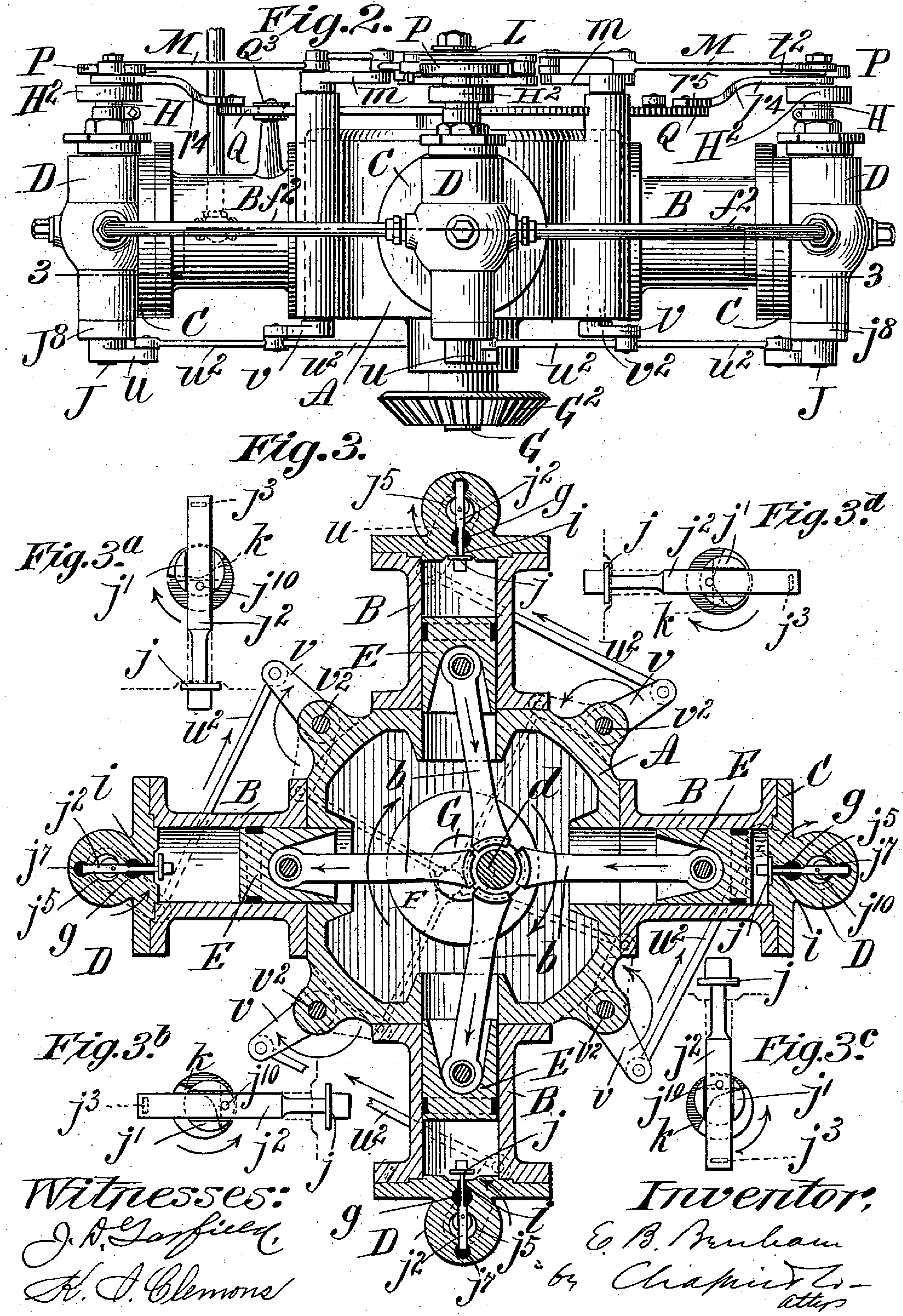


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(No Model.) 4 Sheets—Sheet 3.

# E. B. BENHAM.

## MULTIPLE CYLINDER MOTOR.

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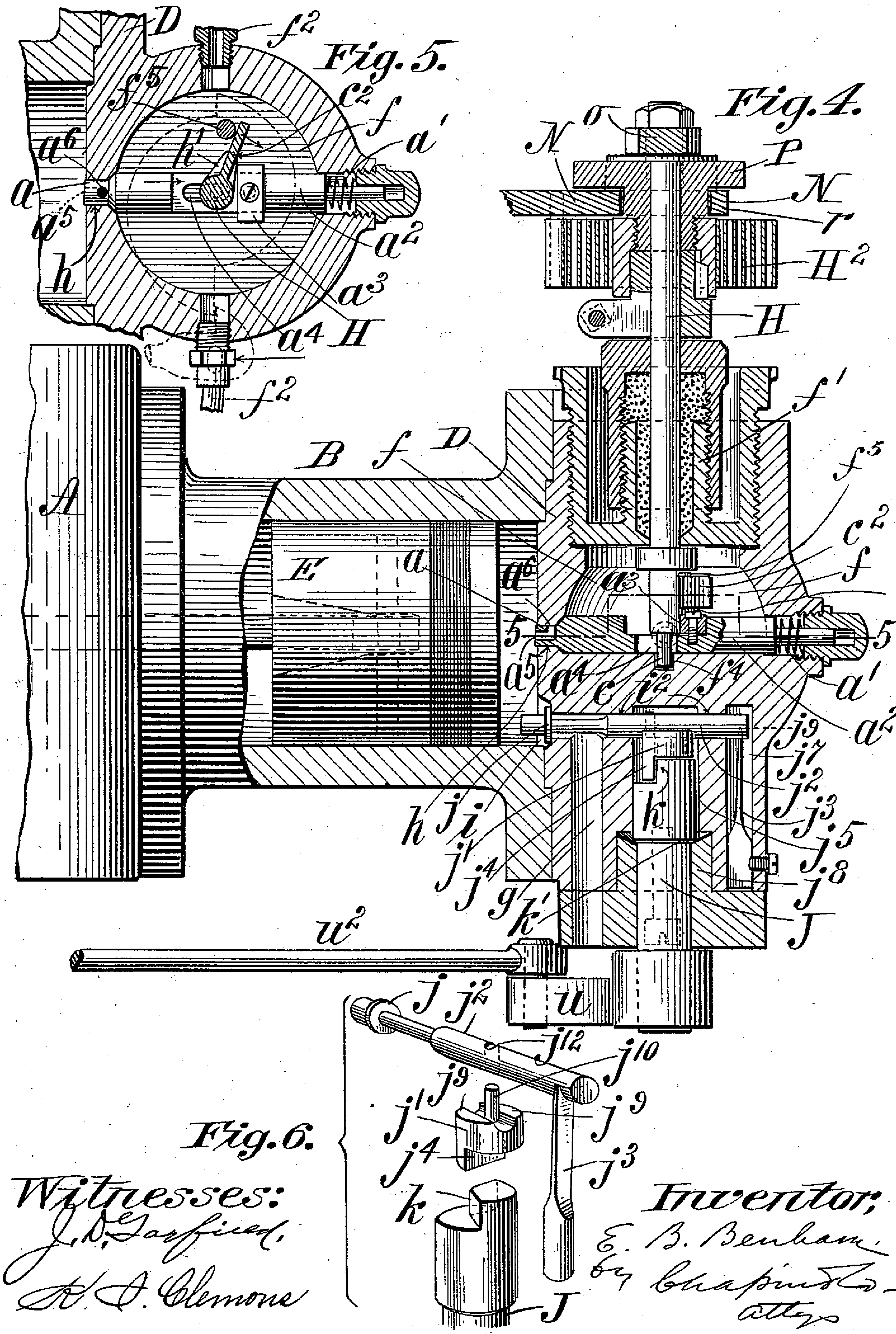


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(No Model.) 4 Sheets—Sheet 4.

# E. B. BENHAM.

## MULTIPLE CYLINDER MOTOR.

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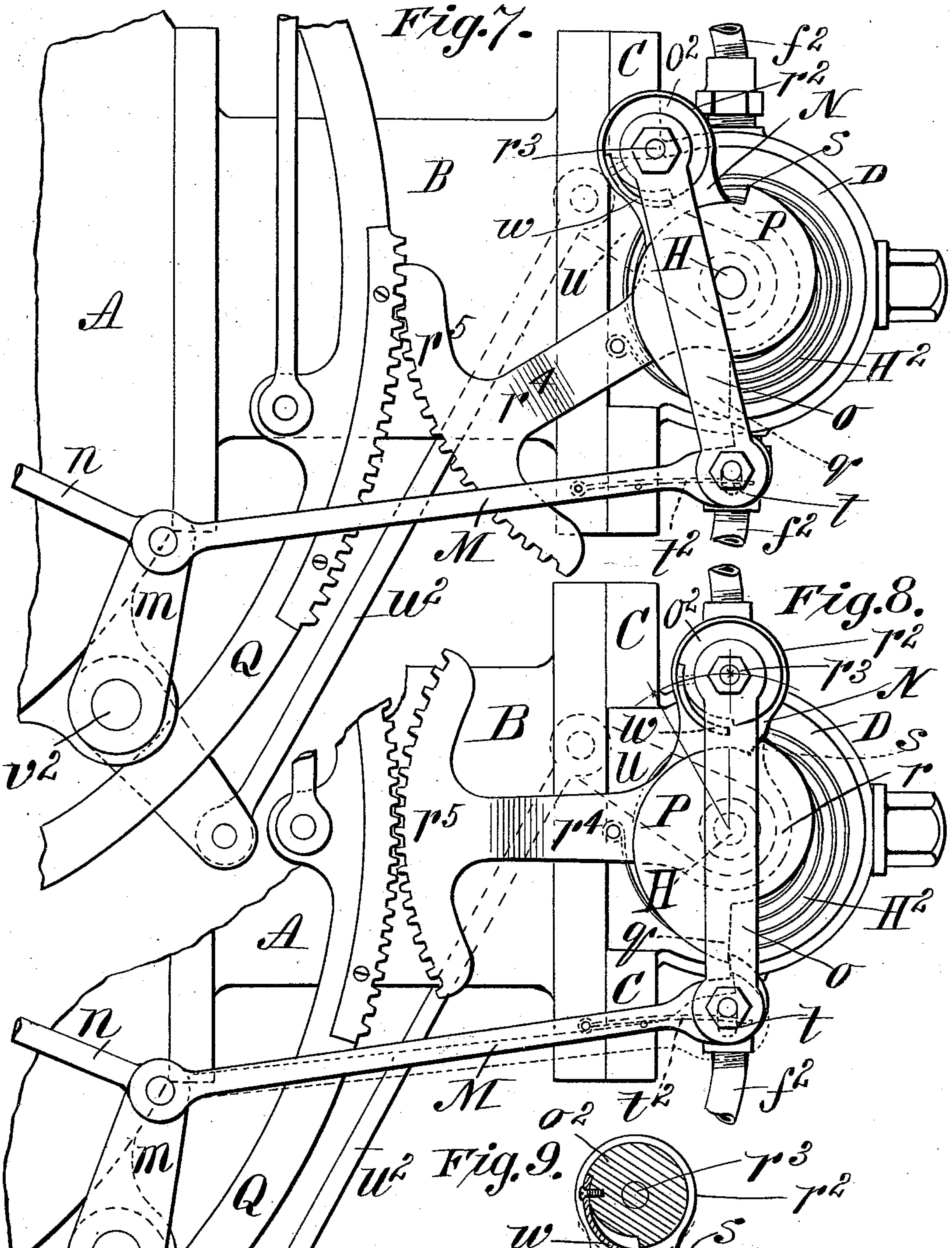


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# UNITED STATES PATENT OFFICE.

ELIJAH B. BENHAM, OF MYSTIC, CONNECTICUT.

## MULTIPLE-CYLINDER MOTOR.

SPECIFICATION forming part of Letters Patent No. 539,026, dated May 14, 1895.

Application filed May 7, 1894. Serial No. 510,361. (No model.)

*To all whom it may concern:*

Be it known that I, ELIJAH B. BENHAM, a citizen of the United States, residing at Mystic, in the county of New London and State of Connecticut, have invented new and useful Improvements in Multiple-Cylinder Motors, of which the following is a specification.

This invention relates to improvements in multiple cylinder motors of a kind which are to be operated through the agency of an expansive agent, as carbonic acid gas, or steam which may be successively introduced into the piston cylinders of the motor.

The invention more particularly relates to the multiple cylinder motor having novel valve mechanism for governing both the pressure and exhaust ports, and the invention consists in combinations, or arrangements, of devices, and parts, and of the construction of certain of the devices, or parts, all substantially as will be hereinafter fully described and set forth in the claims.

Reference is to be had to the accompanying drawings, in which—

Figure 1 is a plan view of the motor. Fig. 2 is a side elevation of the same. Fig. 3 is a horizontal section taken about on the line 3 3, Fig. 2, which is coincident with the horizontally-movable exhaust-valves. Figs. $3^a$, $3^b$, $3^c$, and $3^d$ are plan views, somewhat enlarged, illustrating the relative positions of the four exhaust-valves and their actuating mechanism at an instant when the pistons are in their relative positions, as seen in Fig. 3. Fig. 4 is a vertical section on line 4 4, Fig. 1, centrally through one of the valve-cases and through a portion of one of the cylinders, showing the valves for the pressure and exhaust ports for such cylinder, while Fig. 5 is a horizontal section about on line 5 5, Fig. 4, for showing the valve and a portion of its operating devices for the pressure-port for one cylinder. Fig. 6 is a perspective view of parts detached—namely, one of the valves for an exhaust-port and its closing-spring and portions of the valve-operating device which are applied next to said valve. Fig. 7 is a plan view on a large scale, showing a portion of the controlling mechanism for the pressure-valves as in a position to effect the stoppage of the motor. Fig. 8 is a similar plan view to Fig. 7, but showing the mechanism as in a position to insure the running of the motor. Fig. 9 is a sectional view of a part in detail to be hereinafter referred to.

Similar characters of reference indicate corresponding parts in all of the views.

The motor comprises an annular body, A, with a series, say four, of radial cylinders, B, opening to the interior of the said body and having the outwardly closing heads, C, at which are provided valve casings, D, for the valves, $a$, which admit, at the proper periods, or instants, the motor fluid into the outer ends of the cylinders against the pistons, E, thereof, to which pistons are connected the pitman rods, $b$, which all engage the common crank-pin, $d$, carried by the crank-arm, or crank-disk, F, of the main-shaft, G, which is mounted in suitable bearings axially within the annular motor body.

The valve casings, D, at the outer ends of the cylinders, are of a generally cylindrical, or semi-cylindrical form being cast, or produced, integrally with the cylinder heads, and standing axially at right angles to the length of the cylinders, and each comprises an upper, closed compartment, $f$, and a lower passage, $g$.

The upper compartments, $f$, of the four valve casings constitute the pressure chambers for the respective cylinders and they are, by pipes, $f^2$, connected, the one with another, so that they may all contain, at all times, the motor fluid derived from the supply whatever and wherever such may be. There is no connection between each upper compartment, $f$, and the lower exhaust passage, $g$, next thereto, except by way of the cylinder.

There is a port, $h$, leading from each compartment, $f$, through the wall which forms the cylinder head, into the cylinder, which port is closed by the valve, $a$, formed at the one end of a bar, or valve-stem, $a^2$, which is adapted to slide across the bottom of the compartment to carry the valve-end, $a$, away from its seat within the walls of said port. Each valve-stem, $a^2$, in opening longitudinally and radially outward, moves against its spring $a'$, which spring insures the closing of the valve when the latter is, by the valve-controlling mechanism, permitted to close.

Each pressure port, $h$, as seen in Figs. 4 and 5 is, between the compartment, $f$, and the cylinder chamber, in the form of a cylindrical hole with an outwardly flaring orifice, while the valve at the end of the valve-stem is exteriorly of a form to fit the said port. The valve has, however, the axial hole, $a^5$, extending from its end toward the cylinder and which leads to the side of the valve by the branch, $a^6$. When the valve is closed this branch is just inside of the flaring orifice of the port so that of course the gas is admitted to the cylinder the instant the valve has begun its opening movement. This construction of valve has been found especially advantageous in this class of motor, in that it will not leak after protracted use, and because the port really forms the guide for the movement of the valve. The valve-stem is moved to open through means of the rotational movement of a valve-operating shaft, H, which extends from within a lower end-bearing within the base of the said pressure chamber, axially through a stuffing-box, $f'$, in its top, and in a direction at right angles to the length of the valve-stem. This shaft, H, has at its portion which is within the compartment, $f$, a cam projection, $h'$, which impinges against a suitable shoulder, here shown as constituted by the hardened block, $a^3$, on the valve-stem, so that when the shaft is partially turned, its projection will force the valve-stem endwise to open.

As seen in Figs. 4 and 5, the shaft, H, has its lower extremity, $c$, very much attenuated so as to pass freely down through the longitudinal slot, $a^4$, formed in the middle of the valve-stem, and down into the socket, $f^4$, in the base of the pressure compartment, $f$. The cam, $h'$, at the side of the shaft, H, is next above the said attenuated shaft extremity, $c$, and at the same level as the shoulder-block, $a^3$, on the valve-stem, while above this cam, $h'$, is the arm, $c^2$, to constitute in its abutment against the fixed stud, $f^5$, a means for limiting the valve-operating shaft in its rotational movement to resume its normal position after having been moved to open the valve and then released to close. There is an exhaust-port, $i$, leading through the end-closing head of the cylinder at right angles to, and which communicates with, the aforementioned exhaust passage, $g$. A valve, $j$, on, or as a part of, a stem, $j^2$, (mounted in a socket which is within the part which constitutes the cylinder head and below the base of the pressure chamber, for a slide movement) holds the exhaust-port closed, a spring, $j^3$, being applied to insure the closure, except as the valve, $j$, is positively moved which is insured periodically in proper time by reason of a rotational movement to the exhaust-valve-operating-shaft, J, which has a cam, or projection, $k$, at its upper end which impinges against a shoulder, $j^4$, on the block, $j'$, which is under, and has an engagement with, the valve-stem, $j^2$.

It will be seen that the solid base of the valve-casing, D, is drilled, as seen at $j^5$, from the bottom axially and parallel with the exhaust passage, $g$, to form the bearing for the exhaust-valve-operating-shaft, the exhaust-valve, $j^2$, playing in a horizontal hole, or socket, $i^2$, which is a continuation of the exhaust-port, $i$. Another hole, $j^7$, is drilled in the base of each valve casing, D, upwardly from the bottom, its position being outwardly beyond the bearing holes, $j^5$, for the shaft, J, and parallel therewith, which hole, $j^7$, intersects the socket, $i^2$, for the exhaust valve-stem, and in this hole, $j^7$, the aforesaid spring, $j^3$, is set. The flanged thimble, $j^8$, is set within the rabeted mouth of the bearing hole for the shaft, J, and overlies the lower end of the valve-casing-base, being bolted or otherwise attached, and the inner upper end of this thimble, together with the shoulder $k'$, on the shaft, J, constitute the means for the support of said shaft. The upper cam-provided end of the shaft, J, terminates below exhaust valve-stem, $j^2$, so that the block, $j'$, which is engaged with the stem may be accommodated. This block is in the form of a short cylinder, with the downwardly extending lug, $j^4$, also with upwardly projecting parallel ribs, $j^9$, $j^9$, to lie against either side of the valve-stem to prevent the rotation of the block, and it is also provided with the axial upwardly extending stud, $j^{10}$, to enter the vertical transverse hole, $j^{12}$, in the valve-stem, $j^2$.

The pressure valves are all held closed for the greater part of the time, they being quickly opened and closed in regular succession, so as to admit the motor fluid into the cylinders, properly, one after another.

The instant which a pressure valve is open relative to the time it remains closed is infinitesimal, although each exhaust port is open, of course, during the entire period of the exhaust of the cylinder at which it is provided.

The means for successively opening, for instance, the pressure valves and which is dependent on the rotation of the main shaft, will be now described. Upon the main shaft, above the motor body, is an eccentric, L, which rotates with the main shaft. Near the outer periphery of the motor body are pivoted levers, $m$, one of each being midway between two of the cylinders. Connecting-rods, $n$, are pivotally secured to these levers, $m$, and they have their inner ends in engagement with said eccentric, E, for deriving thereby radial reciprocating movements for swinging the aforesaid levers. The swinging of the levers, $m$, imparts swinging reciprocatory movements to hook-rods, or pawls, M, which have their inner ends pivoted to said levers, $m$. Each of these hooked rods is, at its hooked, outer end, which is near a valve-operating shaft, H, pivoted to one end of a link, $o$, mounted on a shiftable support, N, whereby the arc through which the hook-end will swing will be properly insured to give the proper "lead" or opening movement to the valve, or if desired through further means, to be hereinafter mentioned, to fail to engage the projections of the valve-shafts whereupon the motor will stop.

The hook-ends of the rods, M, each engage a projection, or tooth, $q$, at the edge of a disk, P, at the upper end of, and as a fixed part of, the valve-operating-shaft, H. The hook, in its forward swing, acts as a pawl upon said edgewise projection to effect the opening of the valve, and then as the hook-pawl slips, or snaps off, past the said edgewise projection, the shaft turns back to its original position by reason of the clock spring, $H^2$, and the valve, $a$, closes by reason of its spring, $a'$; and the hook-rod, as it has its retracting movements for the next engagement with the tooth, $q$, as occurs upon the continued turning of the eccentric, is adapted to snap by the disk-projection without effect thereupon. This is by reason of the pin-and-slot connection seen at $t$, between the hook-rod, M and link, $o$, which permits the lateral yield of the rod, and of the provision of the spring, $t^2$, which keeps the pawl-end of the rod up to its work.

The exhaust mechanism is operated by means, substantially as follows:—Each of the exhaust valve-shafts, J, has a radial arm $u$, at its lower end which is connected by link, $u^2$, with a lever-arm, $v$, which is on the vertical rock-shaft, $v^2$. Each of these rock-shafts, $v^2$, in the motor which has been constructed as in the arrangement here shown, constitutes the pivotal support for the lever arms, $m$, heretofore referred to as comprised in the pressure-valve-operating mechanism, so that the single eccentric, L, gives the respective motions, and all in proper time, to the controlling mechanisms for both sets of valves, viz., pressure and exhaust.

The exhaust-valve-controlling connections have their movements properly relatively to the action of the pressure-valve-controlling-mechanism by reason of the adjustment of the levers, $v$ and $u$, at the required angles to the levers, $m$, all as may be readily performed at the time of setting up the motor so that the exhaust of the cylinders is accurately established at the correct intervals.

The aforementioned shiftable supports, N, for one end of the links, $o$, to which the valve-shaft-operating hook-rods, M, are connected, consist, as to each, of a sleeve, or collar, $r$, loosely surrounding the valve-operating-shaft and having the radial arm, or projection, $r^2$, on which the link is pivoted at $r^3$. This collar has another radial arm, $r^4$, the extremity of which is a sector-gear, $r^5$. A ring, Q, with rack teeth on its periphery, engages by such teeth, the sector gears forming part of each of the shiftable supports. The ring is mounted upon the flanged rollers, $Q^3$, which are journaled on studs of the motor body.

The turning of the rack-ring, as accomplished, for instance, through means of the rod, $Q^2$, insures the placing of the shiftable supports, N, in such positions that the paths of the hook-rods linked to said supports will be variable, so that they will have, in their reciprocatory swinging movements, longer or shorter instants of engagement with the disk projections, or under some positions into which they are brought, no engagement at all.

Fig. 8 of the drawings shows the rack-ring and the shiftable support, N, which comprises the sector arm, as in the running position,—so that each thrust of the hook-rod, M, will engage the tooth, $q$, and effect the partial rotation of shaft, H. Fig. 7 shows the shiftable support, N, as moved by means of the rack-ring, so that the arm, $r^2$,—which carries the pivot, $r^3$, to which one end of the link, $o$, is hung,—is swung to such a position that the hooked end of the rod, M, is constrained to have its reciprocatory movement in a path which is free and clear from the tooth, $q$. Hence the pressure-valves will not be opened and the motor will stop.

Now it will be perceived that on the hub-like extremity of each link, $o$, is a projection, $w$, which constitutes, in substance, a pawl, and on the disk, P, of each valve-operating-shaft, H, is a second tooth, $s$. Now, as seen, for instance, in Fig. 8, when the connections are in their engine running positions, or arrangements, the tooth, $s$, of each valve-shaft-disk is so far removed and free from the hub, $o^2$, of the link, $o$, that in the oscillations of the hub its pawl, $w$, will not engage the tooth, $s$. These oscillations of the hub pawls, $w$, when the engine is running, are in arcs generated from the link pivots, $r^3$, and under any running adjustment or setting of the valve-controlling connections, the pawls will never have any engagement with the back teeth, $s$; but after the engine has been stopped, by the swinging of the shiftable supports, N, to positions as seen in Fig. 7, and it is desired to again start up the engine, the ring, Q, is moved so far as not only to carry the shiftable supports back to their original positions, as seen in Fig. 8, but a little beyond them; the hubs, $o^2$, of the links are moved bodily with the arms, $r^2$, of the shiftable supports in arc-paths generated from the axis of the valve shafts, H, as centers and now the pawl, $w$, of one of the link hubs, $o$, will have a forcing engagement on the adjacent tooth, $s$, to open the valve for that cylinder which is then properly to take steam.

When it is remembered that the crank, $d$, and eccentric, L, determine the swung positions of the links, and therefore the oscillations, or partial revolutions of the pawls, $w$, it will be perceived how it is that some of the links, $o$, will be so swung that the pawl, $w$, will be in a line so truly radial relative to the arc of its swing from axis of shaft, H, as its center, that it will engage the back-tooth, $s$, of the valve-shaft corresponding to that particular cylinder which is to properly take pressure, while other of the links will, by their then swung positions, cause their pawls, $w$, to assume positions in lines from pivots, $r^3$, which so approach tangents to the arcs generated from the axes of the shafts, H, that in their movements on and with the supports, N, they will have no engagement with the adjacent teeth, *s*. So soon as one, (or in some cases two) of the pawls, *w*, engages and forces tooth, *s*, around to give pressure to the shaft, and the motor starts, the ring, Q, is quickly brought back to an intermediate position, and the running continues as before.

It is possible, by a setting of the shiftable supports, N, to have the reciprocatory movements of the pawl-rods, M, on their forward thrust constrained in such paths that they will fail to trip off from, or disengage, the teeth, *q*, of valve-shaft-disks, P, whereupon, comparatively, a very long period of opening of each pressure valve may be established.

It will be understood that during the running of the motor which has been hereinabove described, the systems of lever-arms, *m*, *v*, and *u*, have regular swinging reciprocatory movements and that the shafts, J, having at their upper ends the cams, *k*, have the regular rotary reciprocatory movements. The subviews, Figs. $3^a$ to $3^d$, inclusive, show the positions at a given period, during the exhaust, of the forcing portions of the cams, *k*, relative to the abutment pieces, $j^4$, of the exhaust valves which are forced thereby. It will be seen that when each shaft, J, is so turned that the part of the cam nearest the axis of the shaft is next to the valve shoulder, $j^4$, the valve remains closed, while as the portions of the cam outwardly from said last specified part come to impingement against the said shoulder, $j^4$, the exhaust valve is forced open.

The vertical main-shaft, G, is shown as having a bevel gear wheel, $G^2$, upon its lower end by means of which to utilize the power of the motor, but this gear of course might as well, in some cases, be substituted by a pulley.

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

1. In a multiple cylinder motor, the combination with the series of pressure-valve-operating-shafts, H, having toothed projections, of a series of reciprocatory pawl-rods, connections between these rods and the main shaft for imparting the reciprocatory movements to the rods, links, each pivoted at its one end to a suitable support and at its other to the pawl-rod whereby the constraint of the reciprocatory movement of the pawl-rod may be such as to insure the temporary engagement of its pawl with the projection of the valve-operating-shaft, substantially as described.

2. In a multiple cylinder motor, the combination with the series of pressure-valve-operating-shafts having toothed projections, of the reciprocatory pawl-rods, means for imparting their reciprocatory movements for periodical and temporary engagements with the shaft projections, and means for controlling or modifying the paths of movement of said pawl-rods whereby they will have in their swinging reciprocatory movements, as determined, either longer or shorter instants of engagement with the shaft projections, or no engagements at all therewith, substantially as and for the purpose set forth.

3. In a multiple cylinder motor, the combination with the series of pressure-valve-operating-shafts, H, having toothed projections, of a series of reciprocatory pawl-rods, connections between these rods and the main shaft for imparting the reciprocatory movements to the rods, links, each pivoted at its one end to a shiftable support and at its other to the pawl-rod, and means for moving said shiftable supports whereby the constraint of the reciprocatory movement of the pawl-rod may be such as to insure a longer or shorter period of temporary engagement of its pawl with the projection of the valve operating-shaft, or to insure in its movement no engagement of the projection, substantially as described.

4. In a multiple cylinder motor, the combination with a series of piston cylinders having pressure ports, and valves therefor, operating shafts for said valves having the toothed projections, the rock-shafts, $v^2$, having the lever-arms, *m*, and the pawl-rods, M, which are hung thereto and constrained for reciprocatory movements for periodically engaging the toothed projections of the pressure valve-shafts, the eccentric and eccentric rods connected with arms of said rock-shafts for imparting the rocking movements thereto, substantially as described.

5. In a multiple cylinder motor, the combination with the series of piston cylinders having pressure ports and valves therefor, operating shafts for said valves having the toothed projections, *q*, the shiftable supports, N, each comprising a collar, or sleeve, loosely surrounding the shaft, the arm, $r^2$, and the sector gear, $r^5$, a link, *o*, pivoted to each of said arms, $r^2$, and the pawl-rods, M, connected to said links, levers to which said pawl-rods are connected and means actuated by the running of the engine for imparting the movements to said levers, and the rack-ring, Q, engaging said sectors of the shiftable supports, substantially as described.

6. In a multiple cylinder motor, the combination with a series of piston cylinders having pressure and exhaust ports, and valves therefor, operating shafts for both sets of valves, the pressure valve shafts having the toothed projections while the exhaust valve shafts have the radial arms, the rock-shafts, $v^2$, having the arms, *v*,—which are connected with exhaust-valve-shaft-arms,—and having the lever-arms, *m*, and the pawl-rods, M, which are hung thereto and constrained for reciprocatory movements for periodically engaging the toothed projections of the pressure valve-shafts, the eccentric, and eccentric rods con-

nected with arms of said rock-shafts for imparting the rocking movements thereto, substantially as described.

7. In a multiple cylinder motor, the combination with the pressure-valve-operating-shafts, each having the tooth, $q$, of the links, $o$, lever arms, $m$, and pawl-rods, M, pivoted to the lever-arms and having pin-and-slot engagements with the links, and provided with the springs, $t^2$, together with means for imparting the swinging movements to the said lever-arms, substantially as described and for the purpose set forth.

8. In a multiple cylinder motor, the combination with the motor body and valve-operating shafts, H, the shiftable supports comprising the collar portions, $r^2$, and sector geared arms, $r^5$, of the rollers, $Q^3$, the racked ring, Q, guided thereon, and means for conveniently turning the ring, substantially as described.

9. In a multiple cylinder motor, the combination with the valve-shafts, H, having the projections, $q$, the shiftable supports, N, and valve-operating and controlling connections, $m$, M, $o$, and means for shifting the supports to cause movements of the pawl-rods, M, to be constrained in paths clear of the projections of the valve-shafts, and pawl devices which act in conjunction with said shiftable supports so that as such supports are returned to the positions which they occupy during the running of the motor, one of the said pawl devices will come to an engaging position relative to a valve-operating-shaft, so that its valve may be, through the action of the pawl, opened to admit pressure to one of the cylinders for starting up the motor.

10. In a multiple cylinder motor, the combination with the piston cylinder and the pressure compartment with the communicating pressure port of the valve for closing said port having the shoulder, the valve-operating-shaft, H, having the cam, $h'$, the spring, $H^2$, applied to the shaft and the spring $a'$, applied to the valve, substantially as described.

11. In a multiple cylinder motor, the combination with the piston cylinder and the pressure compartment with the communicating pressure port of the valve for closing said port having the shoulder, the valve-operating shaft, H, having the cam, $h$, and the arm, $c^2$, the spring, $H^2$, applied to the shaft the spring, $a'$, applied to the valve, and the stud, $f^5$, in the pressure compartment for limiting through said arm, $c^2$, the rotational movement of the shaft, substantially as described.

12. The piston cylinder having at its end the casing, D, with a wall which forms the cylinder head and which comprises the pressure compartment, $f$, and has at the base thereof the passage, $g$, and also having the pressure port leading from the cylinder to the pressure compartment, and the exhaust port leading from the cylinder to said passage, $g$, the pressure valve movable transversely across the base of the pressure compartment and the exhaust valve movable in a transverse way therefor which is in communication with the exhaust port, and means for periodically producing the opening movements of said valves, substantially as described.

13. The piston cylinder having at its end the casing, D, with a wall which forms the cylinder head and which comprises the pressure compartment, $f$, and which has at the base thereof the passage, $g$, and the hole, $j^5$, and provided with the pressure port leading from the cylinder to the pressure compartment and the exhaust port leading from the cylinder to said passage, $g$, the pressure valve movable transversely across the base of the pressure compartment and the exhaust valve movable in a transverse way therefor which is in communication with the exhaust port, the cam-provided pressure-valve-operating-shaft and the operating shaft, J, having its bearing within said hole, $j^5$, and provided with a cam, $k$, which has an impingement against a depending member of the exhaust valve, substantially as described and means for periodically imparting rotary reciprocatory movements to the said shafts, H, J, substantially as described.

14. The piston cylinder having at its end the casing, D, with a wall which forms the cylinder head and which comprises pressure compartment, $f$, and which has in the base thereof the vertical passage, $g$, the transverse socket, or way, $i^2$, which terminates in the exhaust port, $i$, and which is in communication with passage, $g$, and said casing head also having the vertical holes, $j^5$, and $j^7$, the exhaust valve movable in said transverse way, $i^2$, the valve-operating cam-shaft, J, in the hole, $j^5$, and the spring for the valve in the hole, $j^7$, all substantially as described and shown.

15. The piston cylinder having the casing head, D, with the pressure compartment, $f$, and port, $h$, the base socket, $f^4$, and stud, $f^5$, of the valve stem, $a^2$, having the valve for closing the said port and having the shoulder, $a^3$, and slot, $a^4$, in combination with the valve-operating-shaft, H, having the arm, $c^2$, the cam, $h'$, and the attenuated lower extremity which passes through said slot, $a^4$, and into said socket, substantially as described.

16. The combination with the casing head, D, having the exhaust port, $i$, valve-way, $i^2$, exhaust passage, $g$, and hole, $j^5$, of the exhaust valve having, as a part thereof, a depending member with shoulder, $j^4$, the shaft, J, in said hole, $j^5$, having the cam, $k$, and the shoulder, $k'$, and the flanged thimble, $j^8$, all substantially as described.

17. The combination with the casing-head for the cylinder having exhaust port, $i$, and valve-way, $i^2$, exhaust-passage, $g$, and hole, $j^5$, of the valve-stem, $j^2$, with exhaust valve, $j$, and having the perforation, $j^{12}$, the block, $j'$, having the depending shoulder, $j^4$, the stud upwardly extending through said perforation and the opposite ribs, $j^9$, $j^9$, and the valve-op-

erating shaft, J, having the cam, $k$, all substantially as described.

18. In a motor, the combination with the cylinder and the casing at the head thereof having the pressure compartment with the port comprising a cylindrical passage with a flaring orifice, of the valve stem having the valve, $a$, of a corresponding form to said port and provided with the longitudinal passage, $a^5$, and the transverse sidewise opening branch, $a^6$, and means for moving the valve-stem longitudinally, substantially as described.

19. In a multiple cylinder motor, the combination with the main shaft having the eccentric, L, and the motor-body having the series of rock-shafts, $v^2$, with angularly arranged lever arms, $m$ and $v$, of the pressure-valve-operating-shafts, H, having the projections, $q$, and the exhaust valve-operating shafts having the arms, $u$, the shiftable supports, N, comprising the sector-geared arms, $r^5$, the rods, $n$, working from the eccentric and connected to said lever arms, $m$, the rods, $u^2$, connecting arms, $v$, with $u$, the links, $o$, pivotally mounted on said shiftable supports, N, the pawl-rods, M, hung to arms, $m$, and having connections, for their constraint of movement, with said links, and the rack-ring, Q, all arranged for operation substantially as and for the purposes set forth.

20. The combination with the valve-shafts, H, having disks, P, with teeth, $q$ and $s$, of the shiftable supports, N, rotatably adjustable about the axes of said shafts, H, the links pivoted to arms of the supports having the pawl-provided hubs, $o^2$, the pawl-rods, M, having connections with the links, the eccentric, and mediums of connection operated by the eccentric and intervening between same and the said pawl-rods, substantially as and for the purposes set forth.

ELIJAH B. BENHAM.

Witnesses:
WM. S. BELLOWS,
J. D. GARFIELD.