No. 673,284. Patented Apr. 30, 1901.

H. C. OSBORN.

COMBINED EXPLOSION ENGINE AND SPRING MOTOR.

(Application filed June 22, 1900.)

(No Model.) 5 Sheets—Sheet 1.

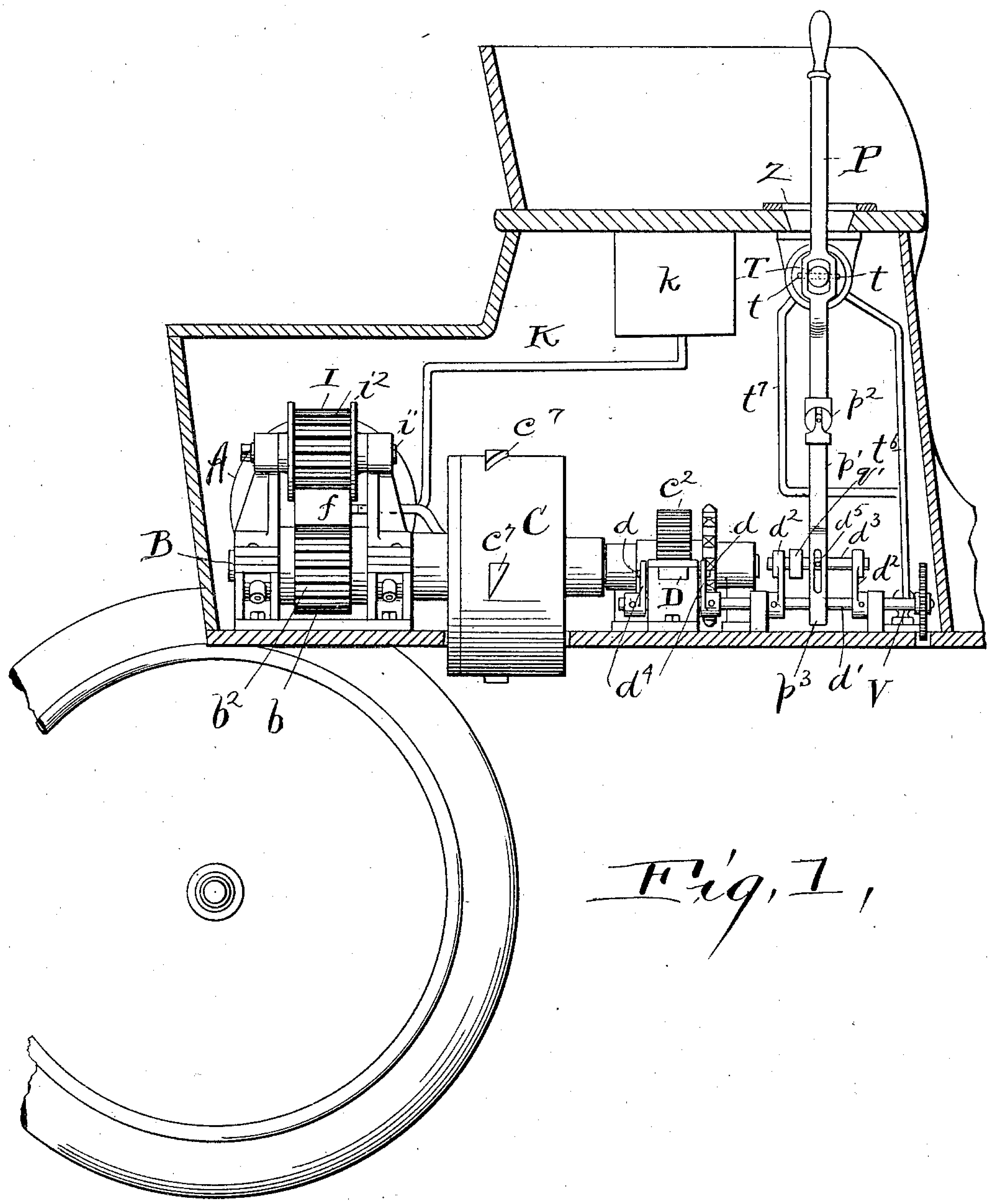

Fig. 1,

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By his Attorneys,
Thurston & Bates

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

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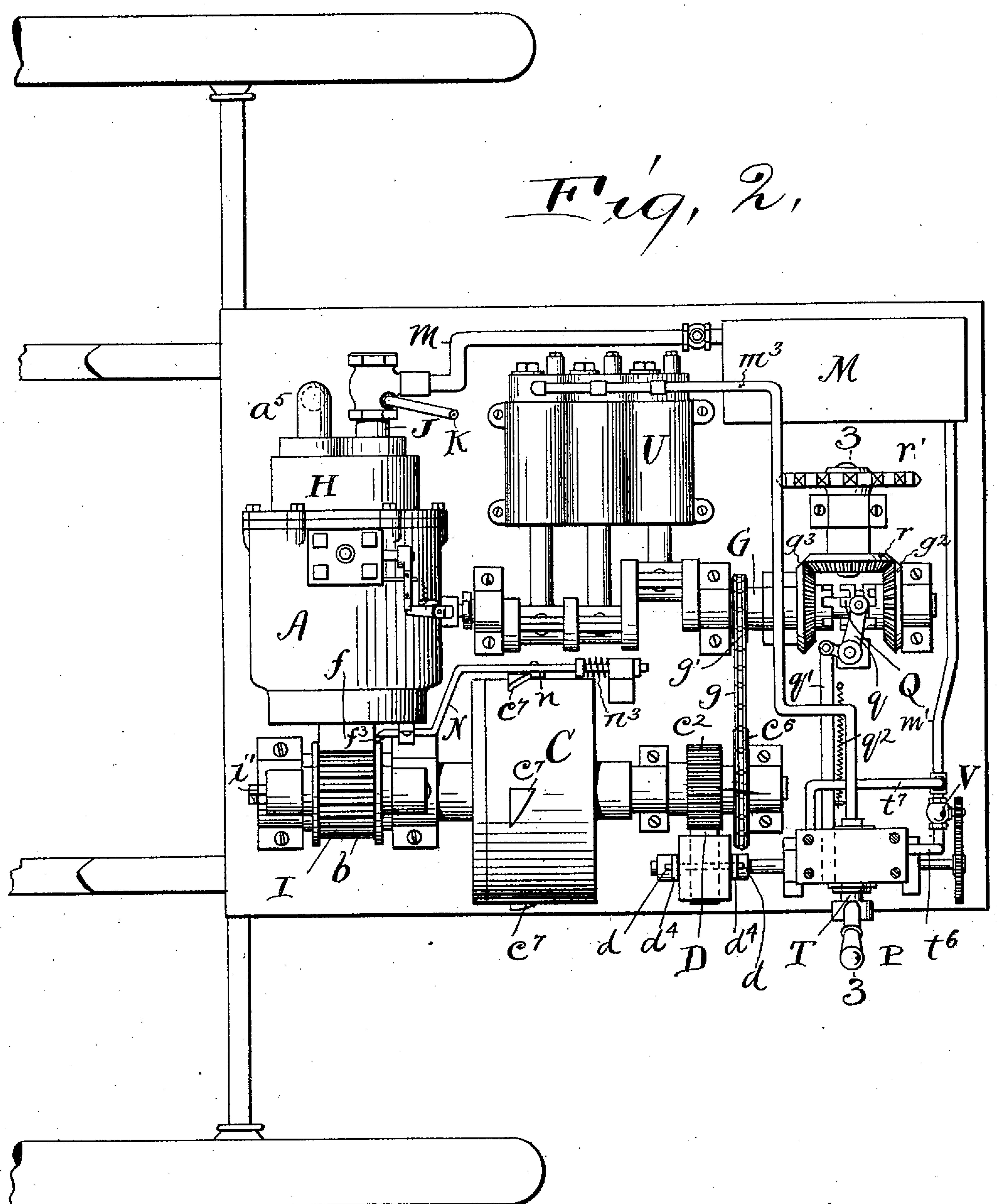
(No Model.) 5 Sheets—Sheet 2.

Fig. 2.



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(No Model.) 5 Sheets—Sheet 3.

Fig. 3,

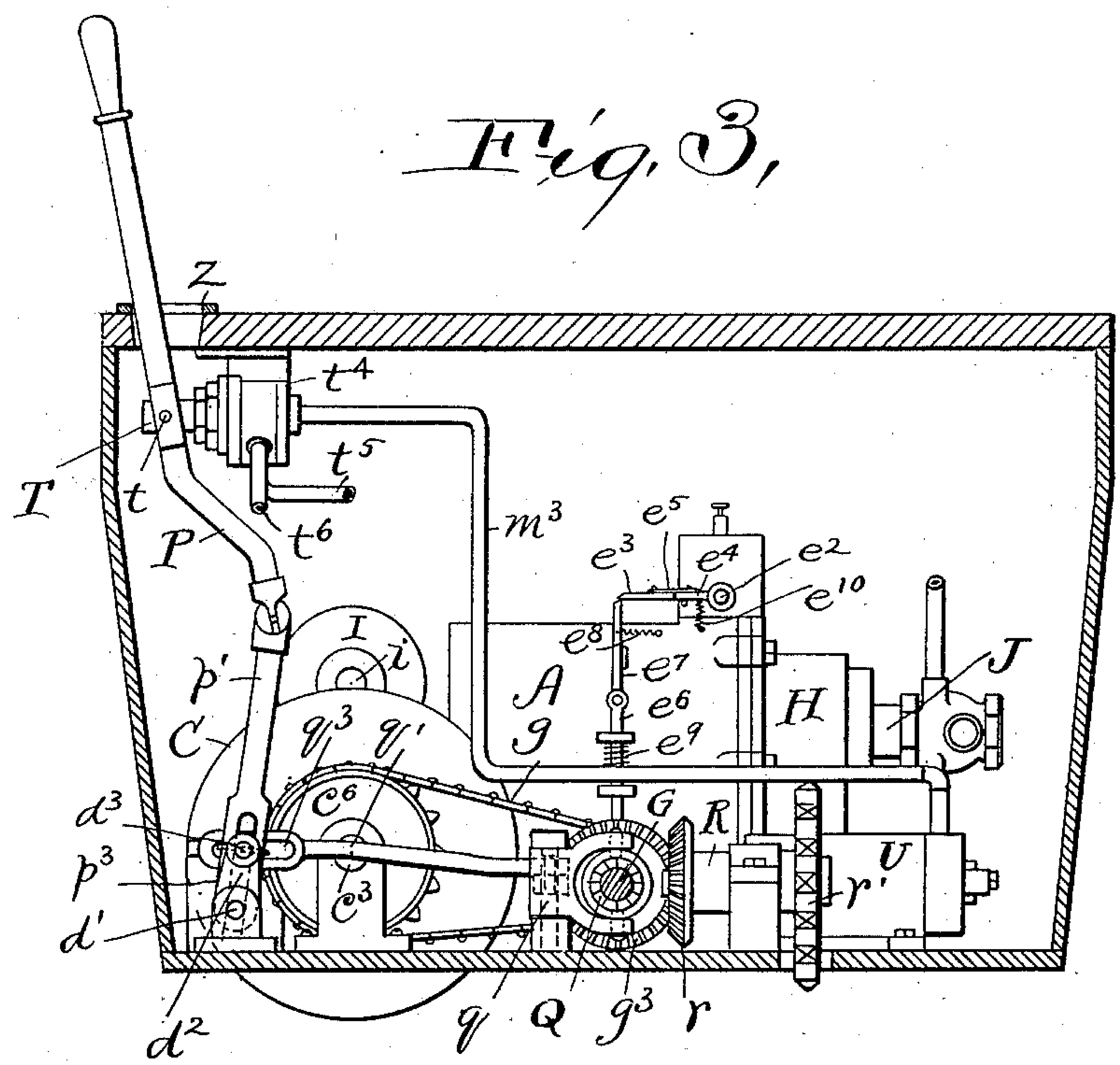
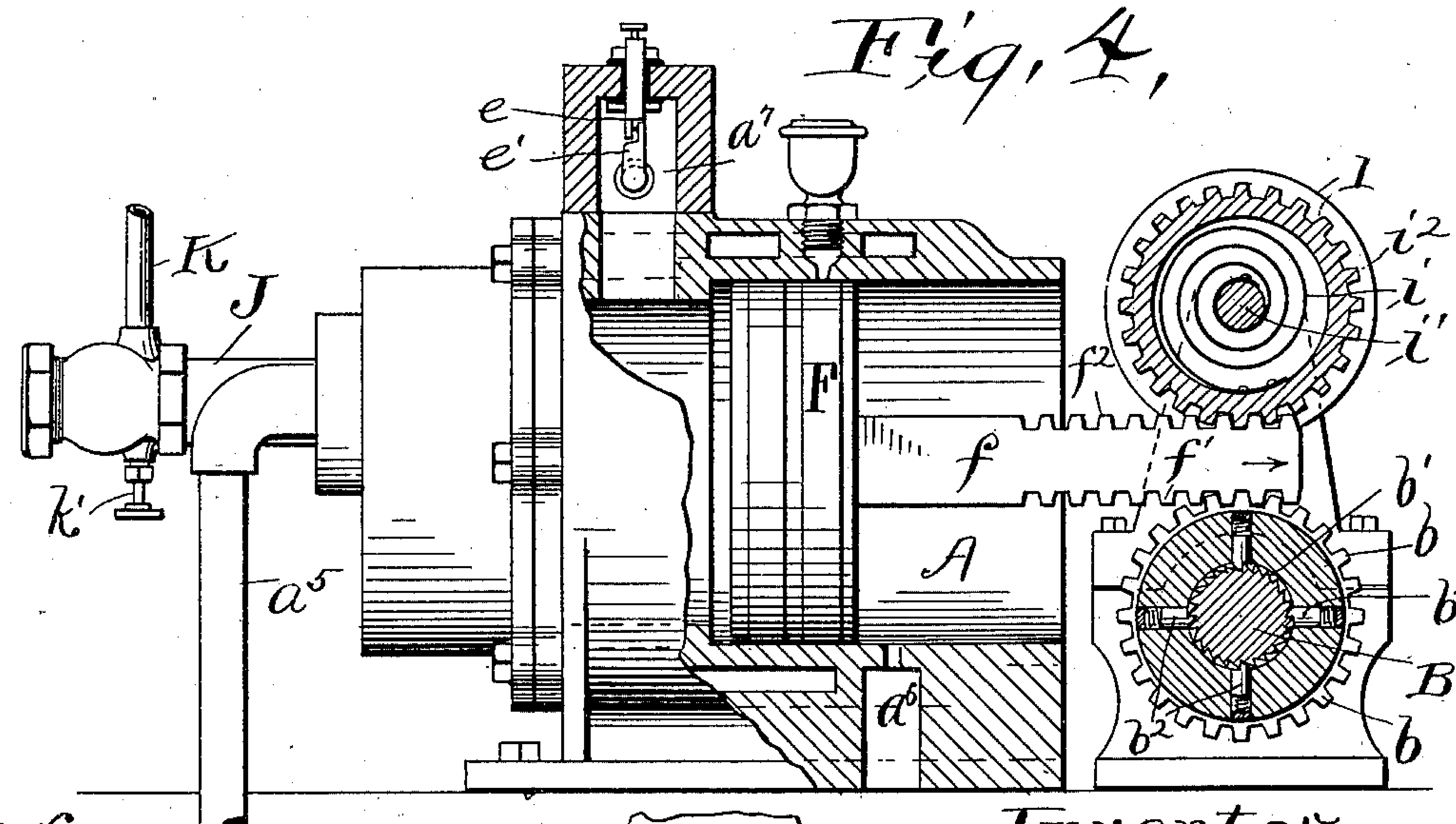


Fig. 4,



Witnesses.
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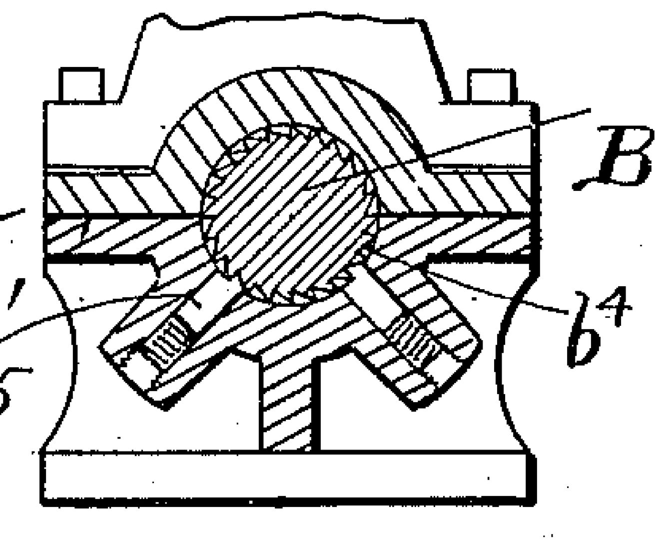
Fig. 5,



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(No Model.) 5 Sheets—Sheet 4.

Fig. 6,

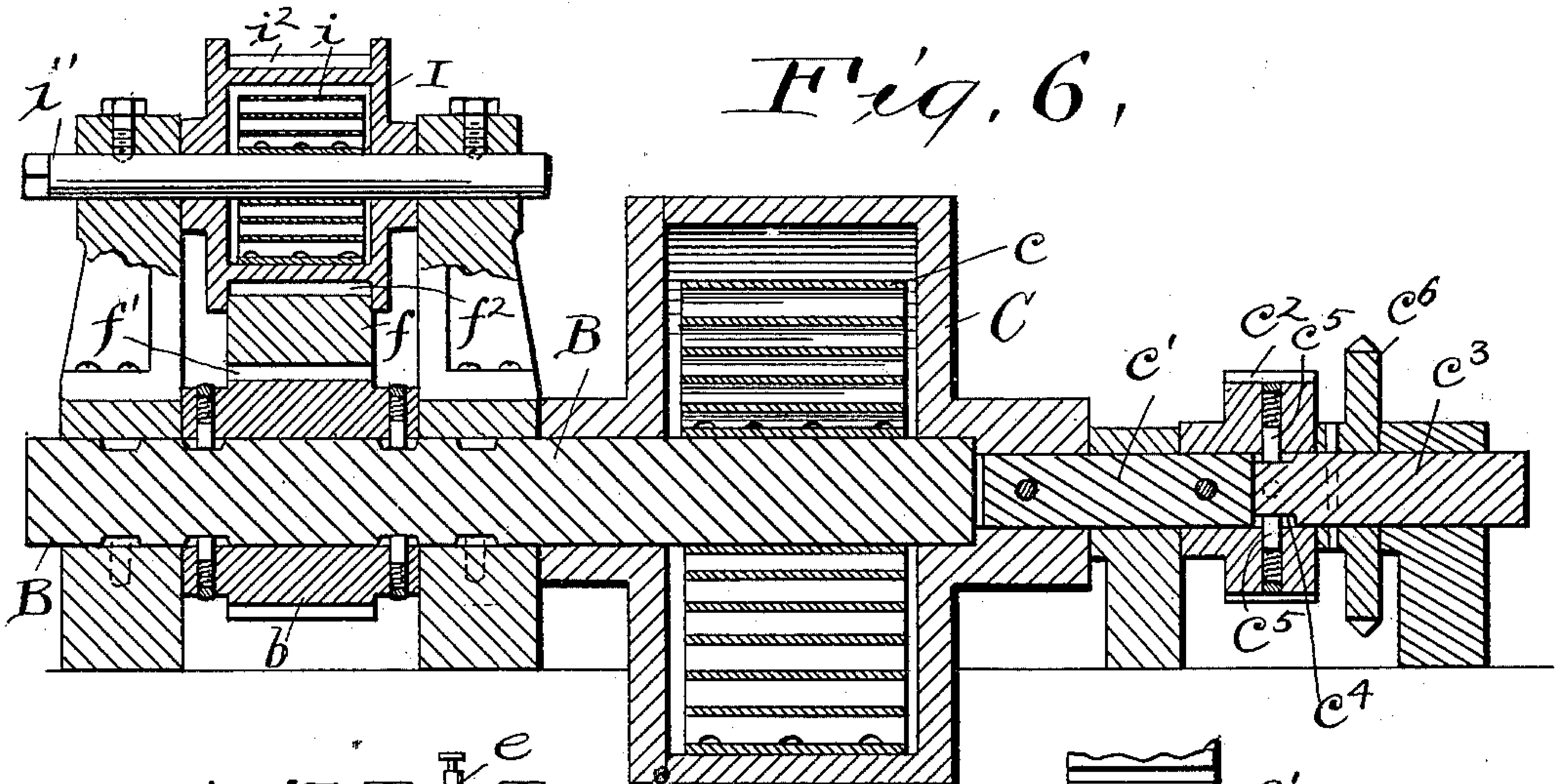
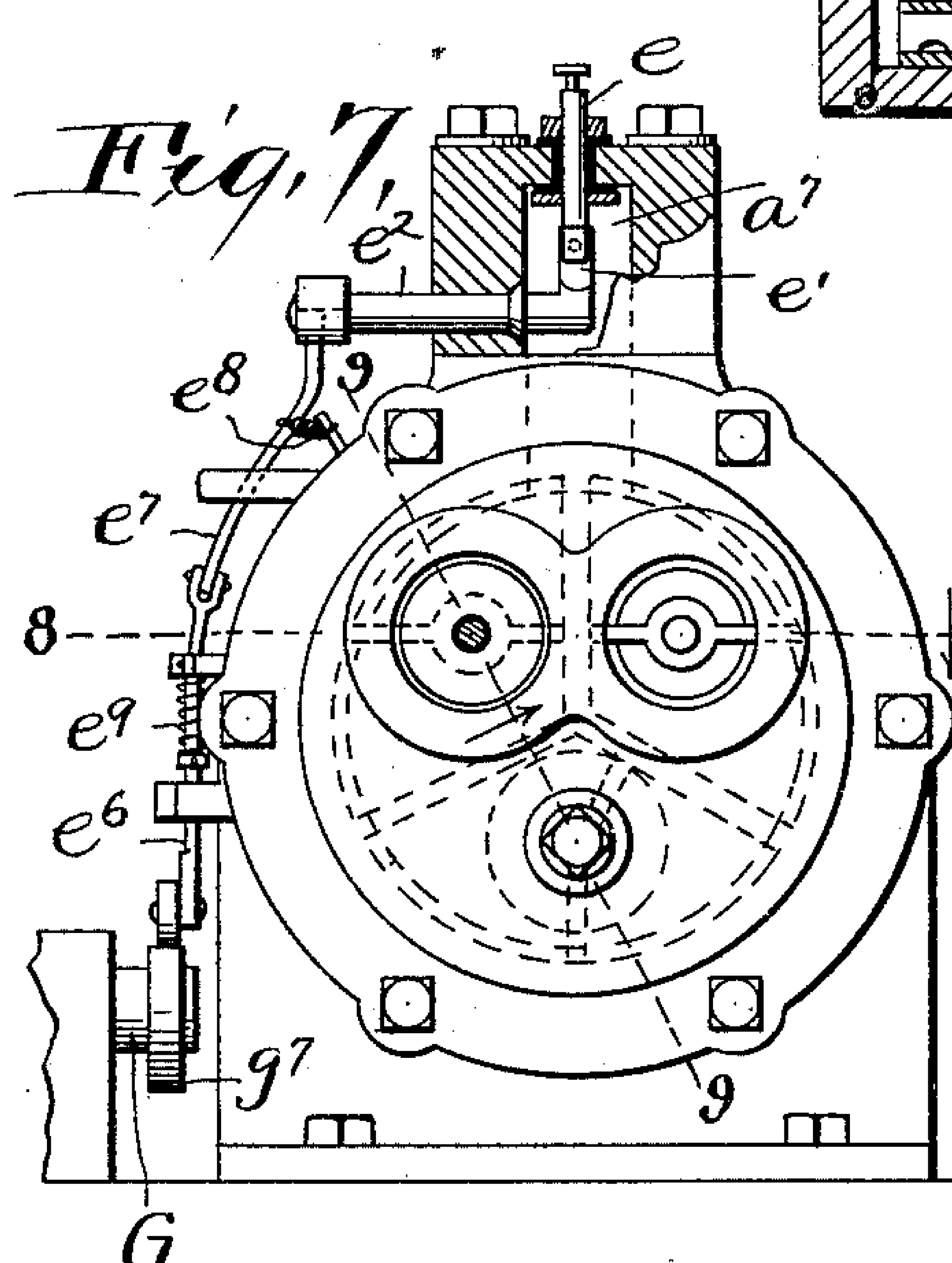


Fig. 7,



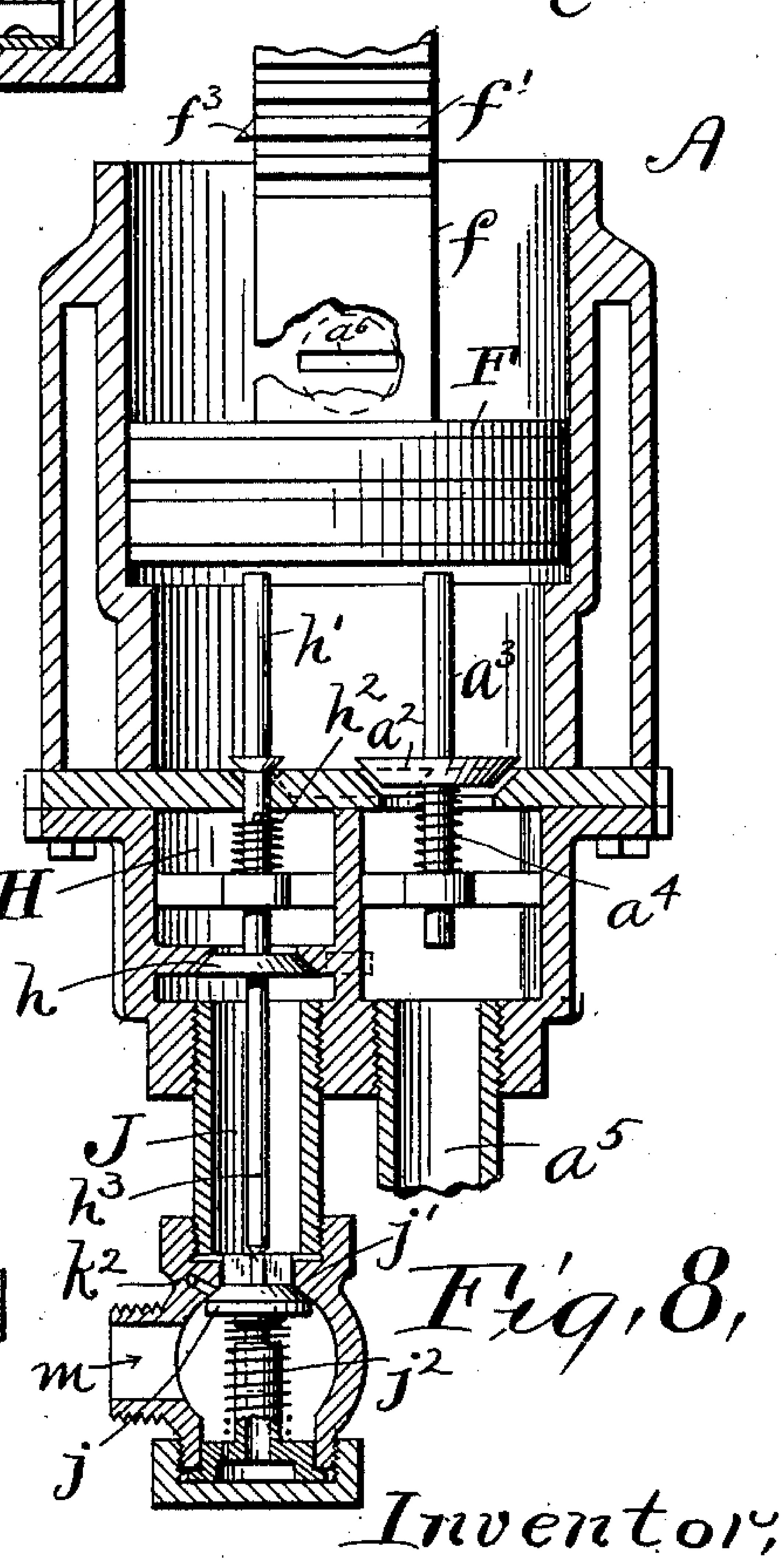
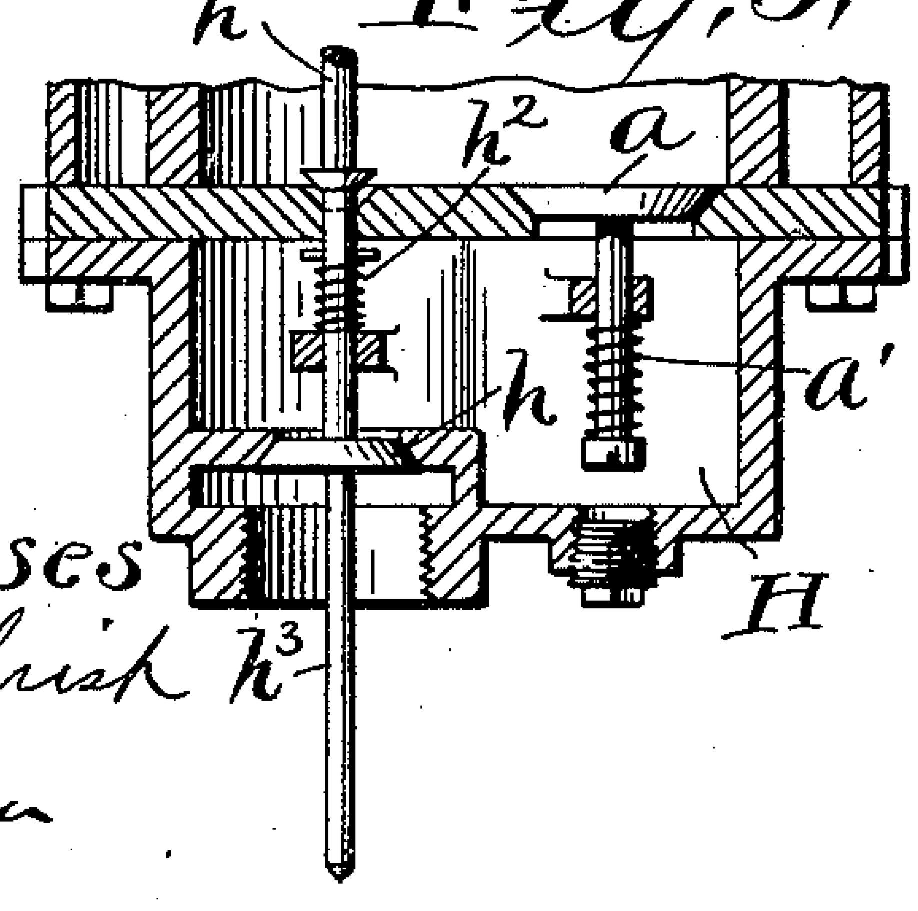


Fig. 8,

Fig. 9,



Witnesses

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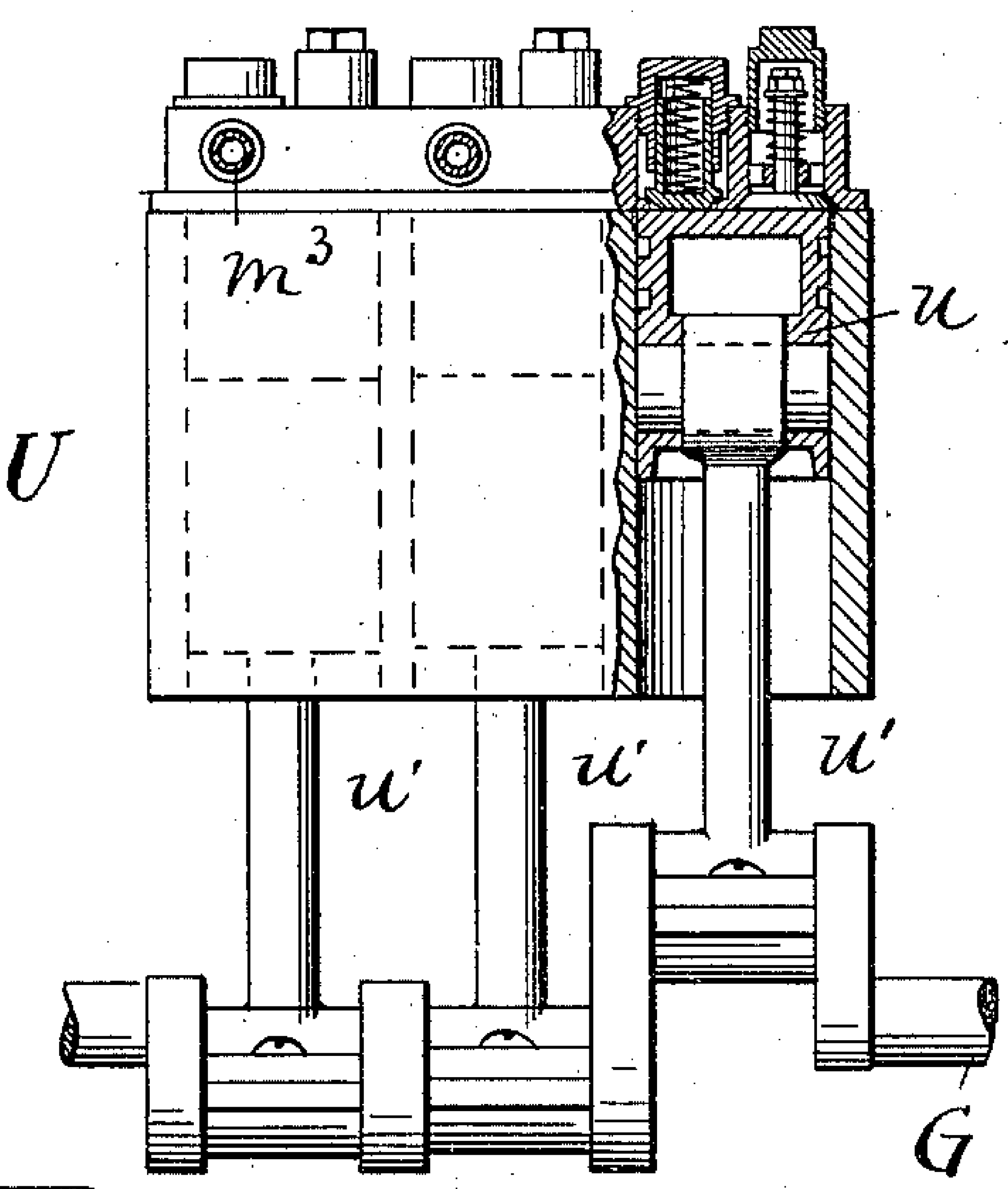

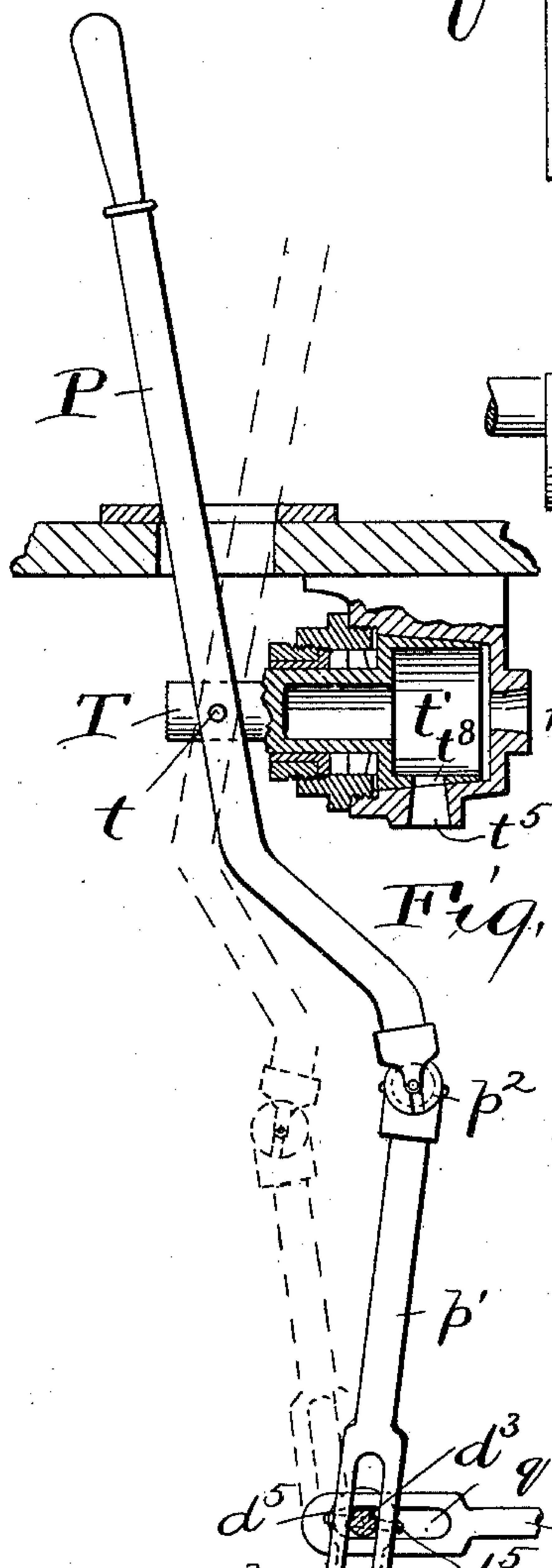

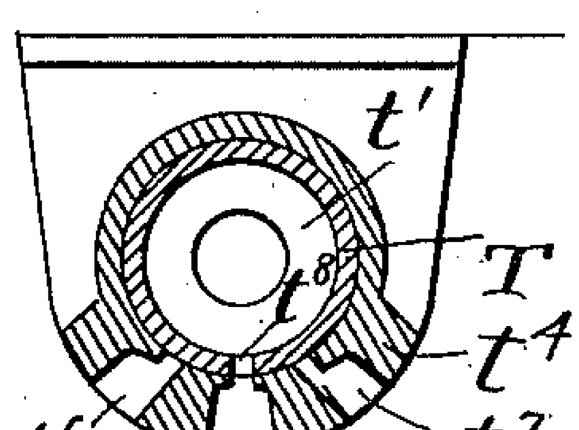

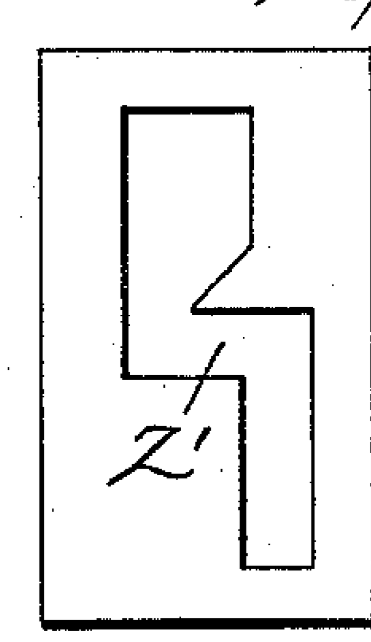

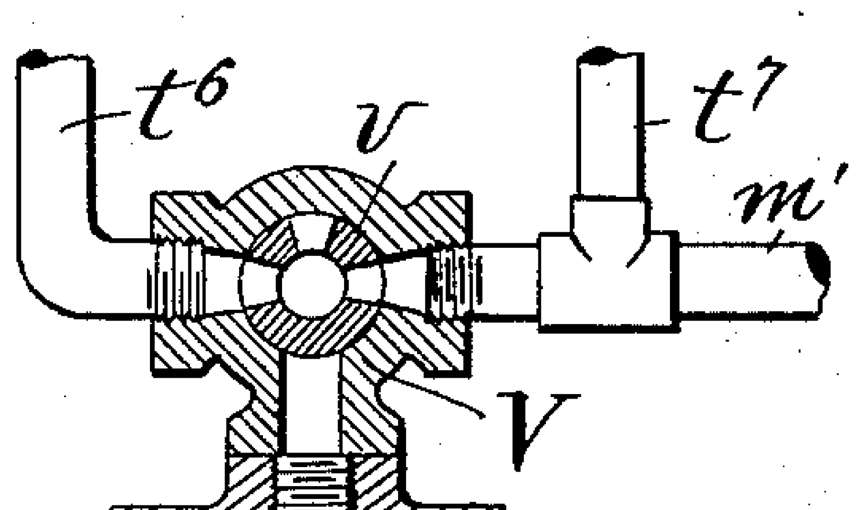

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UNITED STATES PATENT OFFICE.

HENRY C. OSBORN, OF CLEVELAND, OHIO.

COMBINED EXPLOSION-ENGINE AND SPRING-MOTOR.

SPECIFICATION forming part of Letters Patent No. 673,284, dated April 30, 1901.

Application filed June 22, 1900. Serial No. 21,149. (No model.)

To all whom it may concern:

Be it known that I, HENRY C. OSBORN, a citizen of the United States, residing at Cleveland, in the county of Cuyahoga and State of Ohio, have invented a certain new and useful Improvement in a Combined Explosion-Engine and Spring-Motor, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings.

The invention relates to a motor especially adapted for propelling autovehicles, launches, and the like. The prime mover is an explosion-engine, a machine which generates power by impulses. As commonly used heretofore such a power-generator transmits its power in impulses to the vehicle, the result being that said vehicle advances by a series of jerks, which are commonly referred to as vibrations.

The primary object of my invention is to provide motor mechanism which includes an explosion-engine as a prime mover, but which drives the vehicle with a substantially uniform force. To effect this result, the impulses of the motor act to wind up a spring, which spring as it unwinds exerts a substantially uniform force for driving the vehicle.

The invention consists in the construction and combination of parts hereinafter described, and pointed out definitely in the claims.

In the drawings, Figure 1 is a side elevation of my improved motor mechanism contained in the body of a vehicle which is shown in section. Fig. 2 is a plan view of said mechanism with the top of the wedge-box removed. Fig. 3 is a transverse sectional view on line 3 3 of Fig. 2 of said mechanism. Fig. 4 is a side elevation, partly in section, of the explosion-engine. Fig. 5 is a transverse sectional view of the bearings of the shaft B when the shaft is in the same. Fig. 6 is a longitudinal sectional view of the shafts B, c', and c^3 and parts attached thereto. Fig. 7 is a rear end elevation of the explosion-engine. Fig. 8 is a longitudinal sectional view of the same on line 8 8 of Fig. 7. Fig. 9 is a longitudinal sectional view of the head end of said cylinder on line 9 9 of Fig. 7. Fig. 10 is a view, partly in section, of the air-pumps. Fig. 11 is an enlarged front view of the throttle-lever and parts immediately associated therewith. Fig. 12 is a transverse sectional view of the throttle-valve. Fig. 13 is a transverse sectional view of a supplemental valve, and Fig. 14 is a plan view of the guide-plates of the throttle-lever.

Referring to the parts by letters, A represents the cylinder of an explosion-engine, F its piston, and f the piston-rod. This engine operates according to the Otto cycle, and its specific construction, whereby it is especially adapted for combination with the other parts of the machinery and is also adapted to operate without a fly-wheel, will be presently explained.

The forward stroke of the piston, due to the explosion, is utilized to turn a shaft B. This result is attained in the construction shown by forming rack-teeth f' on the piston-rod, which rack-teeth engage with a gear b, which in turn is so secured to said shaft that the shaft is rotated when the piston moves outward, but is not turned when the piston moves inward. A spring-barrel C is mounted concentrically with this shaft, and it incloses a spiral spring c, of which one end is attached to the spring-barrel and the other to the shaft B. This spring-barrel is connected by suitable mechanism, which will be presently described, with the machinery which it is designed to drive.

The explosions in the engine do not take place with regularity, but at irregular intervals determined by the turning of the spring-barrel by its spring. When the spring c has turned the spring-barrel a predetermined distance, (whereby the tension of the spring has been reduced,) an explosion takes place in the engine, which results in winding up the spring to a predetermined maximum tension. The force of the spring will therefore be at all times somewhere between this maximum tension and the minimum tension, which it will reach when the spring-barrel has made one revolution more or less, according to the specific construction adopted. In the construction shown the engine operates—that is to say, an explosion takes place—when the spring-barrel has made a quarter of a revolution independent of the shaft B. The force which is employed to propel the vehicle is therefore approximately constant.

The engine has at its closed end a mixing-chamber H, into which hydrocarbon vapor and air imperfectly mixed is admitted from a carbureter J. The admission of this mixture from the carbureter to the mixing-chamber is governed by the outwardly-opening valve h, the stem h' of which extends into the cylinder to a position where it will be engaged by the piston when the latter is near the end of its inward stroke. This valve is normally held closed by a spring h^2. The admission of the mixture from the mixing-chamber H to the cylinder is controlled by an inwardly-opening valve a, which is normally held closed by the spring a'.

The explosive mixture is obtained by allowing a suitable hydrocarbon—as, for example, gasolene—to drip into the carbureter and by admitting to the carbureter air under pressure. This air comes through the pipe m from a compressed-air tank M, and the hydrocarbon flows by gravity through another pipe K from a suitable reservoir k. The flow of hydrocarbon to the carbureter may be prevented or regulated by a needle-valve k'. The hydrocarbon enters the carbureter through a small opening k^2 in the seat j' of a valve j, which opens outwardly in opposition to a spring j^2 and is interposed between the air-pipe m and the carbureter J. This valve is normally held closed by a spring j^2; but it is adapted to be engaged by a stem h^3 of the valve h. In the side of the cylinder is an exhaust-opening a^6, which is either in front of the piston or is covered by the piston until the piston has nearly reached the end of its forward stroke. This exhaust-opening is then uncovered, and much of the exploded gas is permitted to escape. When this is uncovered, the outward movement of the piston will be checked by the resistance offered by the spring c in the spring-barrel C—that is to say, this is the force mainly relied upon and which might be wholly relied upon to effect this result. As a matter of fact, however, a second spring-barrel I is provided, which contains a helical spring i, fastened at one end to the spring-barrel and at the other end to the shaft i', upon which it may turn. This spring-barrel has peripheral gear-teeth i^2, which engage with the rack-teeth f^2 in the top side of the piston-rod f. The function of the spring i is mainly to move the piston inward. It acts after a sufficient quantity of the exploded gas has escaped through the outlet-opening a^6 and the piston is moved inward thereby. When it has nearly reached the end of its inward stroke, it is stopped by the engagement of a latch-bar N with a lug f^3 on the side of the piston-rod. It is in the position referred to, as shown in Figs. 1 and 8. This latch-bar is movable only in a path parallel with the shaft B, and it extends alongside of the outer periphery of the spring-barrel C. It has on its side a friction-roller n, adapted to engage with cam-blocks c^7 on the periphery of the spring-barrel, which cam-blocks are placed, preferably, at intervals of ninety degrees. These cams are adapted to engage with said friction-roller and withdraw said latch-bar, whereupon the spring-barrel I exerts a force sufficient to move the piston inward to the end of its inward stroke. This latch-bar is automatically moved in the opposite direction into engagement with the lug f^3 by any suitable instrumentality, as by a spring n^3. Before it reaches this end of its stroke it engages with the stem h' of the inlet-valve h, whereby both of the valves j and h are opened. The air under compression and the hydrocarbon flows into the carbureter, and the mixture flows therefrom into the mixing-chamber with a pressure sufficiently great to open the inlet-valve a to the cylinder. The space between the end of the piston and the end of the cylinder is immediately filled with the explosive mixture under sufficient compression, and when the pressures inside and outside of the cylinder are substantially equal the valve closes. The said movement of the piston to the end of its inward stroke has also brought the piston into engagement with the stem a^3 of the exhaust-valve a^2 and has forced said valve to its seat. This gas is now ignited and exploded, the result of the explosion being to hold the valve a and the exhaust-valve closed and to force the piston forward, with the results heretofore pointed out. The exhaust-valve a^2 is opened inwardly by a spring a^4 and is closed by the contact of the piston with a stem a^3 of said valve. When the piston passes the exhaust-opening a^6, much of the exploded gas escapes, and the pressure in the cylinder is so reduced that the spring of the outlet-valve is able to open it, and does open it, and it remains open while the piston is being moved inward. The exhaust-pipe is indicated by a^5.

Any suitable igniting devices, of which a great variety are known and used, may be employed to ignite the explosive mixture in the cylinder. The means shown consist of one fixed terminal e of a sparking-circuit, which projects into an explosion-chamber a^7, which is on top of the cylinder and in open communication with the closed end thereof, and a movable terminal e' of said circuit, which is secured to the inner end of a rock-shaft e^2, which extends into said chamber. The outer end of this rock-shaft has an arm formed of two pieces e^3 e^4, held in line by a stiff spring e^5. A vertically-movable bar e^6 has an arm e^7 hinged to its upper end, which arm is held underneath the arm e^3 of the rock-shaft by a spring e^8. A coiled spring e^9, surrounding the bar e^6, tends to draw it downward, and a cam g^7 on the shaft G engages with the lower end of this bar and moves it upward. The upward movement of this bar rocks the rock-shaft and presses the two terminals in the chamber together until the upper end of the vertical arm e^7 slips past the end of the arm e^3 on the rock-shaft, whereupon a spring e^{10}, attached to said rock-shaft, moves said arm in the contrary direction to a stop e^{12}. This separates the terminals and causes a spark. The upper end of the vertically-movable bar bends backward until the said bar has descended, when the spring e^8 draws the upper end underneath the arm e^3 on the rock-shaft. This sparking device is in constant operation in the construction shown; but the creation of a spark in the cylinder has no effect until the cylinder is filled with the explosive mixture, as before described.

The gear b, with which the rack on the piston-rod engages, is loosely mounted on the shaft, but is connected thereto by means of ratchet-teeth b' on the shaft and spring-pawls b^2, carried by the gear. The turning of the gear when the piston is driven outward by the explosion necessarily turns the shaft; but when the piston moves into the cylinder the gear may turn independently of the shaft, which is prevented from turning backward by ratchets b^4 on the shaft and spring-pawls b^5, mounted in its bearings. The spring-barrel C is secured to a shaft c', which is mountted axially in line with the shaft B. A ratchet-wheel c^2 is fastened to this shaft, and a dog D is provided for engagement with this ratchet-wheel, whereby to prevent the backward turning of the spring-barrel by its spring. This ratchet-wheel embraces the end of a third shaft c^3, mounted in alinement with the others, and ratchet-teeth c^4 on this shaft are engaged by spring-pawls c^5, carried by the ratchet-wheel c^2, wherefore when the spring-barrel is turned by its spring this shaft must turn in unison with it. This connection, however, permits the shaft c^3 to turn in this forward direction independently of the spring-barrel—as, for example, when the vehicle is in motion after the spring-barrel has been stopped by the dog D.

A crank-shaft G is suitably mounted parallel with the shaft B and is driven from the said shaft c^3 preferably by a sprocket-chain g and the sprocket-wheels g' and c^6, which are connected to said two shafts, respectively. In this crank-shaft two bevel-gears g^2 g^3 are lossely mounted, and a jaw-clutch Q, located between them, is adapted by its movement along the shaft to connect either gear to said shaft. Another shaft R is suitably mounted at right angles to the crank-shaft G, and to its end is fastened a bevel-gear r, which meshes with both of the bevel-gears g^2 g^3. This shaft R will be rotated backward or forward, accordingly as one or the other of said bevel-gears is clutched to the crank-shaft. The power to drive the vehicle is transmitted from this shaft R preferably from a sprocket-wheel r', secured thereto.

As previously stated, when the vehicle is at rest the turning of the spring-barrel is prevented by the engagement of the dog D with the ratchet-wheel. This dog slides in suitable ways, and it has two laterally-extended pins d d, with which the mechanism for sliding it engage. The throttle-lever P is pivoted by two normally-horizontal diametrical pins t t to an oscillating valve-stem T, which will be presently described. This lever may be moved forward or backward, and in this movement will turn the valve-stem, or it may be moved to right or left, turning upon said pins as the fulcrum. A second lever p' is connected with the lower end of the throttle-lever by a universal joint p^2. The lower end of this lever is forked and embraces a rock-shaft d', which under certain circumstances serves as a fulcrum for this lever. To this rock-shaft two vertical arms d^2 d^2 are attached, and a bar d^3, which extends between and is connected with these arms, is also embraced by the fork p^3 of the lever p'. When the upper end of the throttle-lever is moved laterally, said lever p' turns on the rock-shaft d' as a fulcrum and by its engagement with said bar d^3 rocks the said rock-shaft. Attached to the rock-shaft are two vertical arms d^4 d^4, which are slotted and engage with the pins d d on the side of the dog, wherefore the rocking of this rock-shaft withdraws the dog D from engagement with the ratchet or moves it into engagement therewith, as the case may be. The fork-arms of the lever p' are slotted, and pins d^5, secured to the bar d^3, pass through these slots and serve as the fulcrum on which the lever turns when its upper end is moved forward or backward. Such movement has no effect upon the spring-barrel-releasing mechanism—viz., the dog D. In fact, it does not affect the operative relation of the lever P with the bar d^3, whereby it is able to rock the rock-shaft d' to move said dog.

The jaw-clutch Q referred to is operated by means of an operating-lever q, which is of bell-crank form, and a link q', which is connected with one arm of said lever, the other end of said link being slotted. The bar d^3, attached to the rock-shaft, engages in this slot q^3. A spring q^2 acts on the link q', so that under normal conditions the clutch is moved to connect to the crank-shaft that bevel-gear g^2 which must drive the shaft when the vehicle is to move forward the rocking of the rock-shaft.

In order to connect the other bevel-gear with the crank-shaft, the throttle-lever P must be first moved backward a short distance and then pulled to the left farther than it is pulled when it is desired to have the vehicle go forward. This releases the dog D from the spring-barrel first, and then the additional movement brings the bar d^3 to the end of the slot q^3 in the link q', and thereby the clutch Q is shifted to connect the other bevel-gear g^3 with the crank-shaft. This movement, however, is not alone sufficient to set the vehicle going backward. It is necessary to pull the throttle-lever backward to open the throttle-valve and release the brake.

It is necessary with the engine shown that the explosive mixture be admitted to the cylinder under pressure. A compression-tank M is provided and so also are air-pumps U for compressing the air and forcing it into said tank. These air-pumps, of which three are shown, are of any suitable form, and their pistons u are connected by suitable rods u' with cranks on the crank-shaft G. All of these pumps are connected with one pipe m^3, which passes to the throttle-valve, by which the passage of the compressed air may be prevented or impeded to a greater or less extent or allowed to pass on toward the tank M by either of two parallel paths or to an air-brake. The throttle-valve T has an axial recess t', and the pipe m^3 from the air-pumps is connected with said recess by a suitable swivel-joint. The throttle-valve is mounted so as to be capable of oscillating in a valve-casing t^4, with which three pipes t^5 t^6 t^7 are connected. In the valve is a port t^8, which when the valve is turned may register with one or the other of these openings, and this valve is turned by the forward or backward movement of the throttle-valve, as before described.

When the throttle-lever P is in a position midway between the ends of its possible forward and backward movements, the air is directed into the pipe t^5, which goes to the air-brake. When the throttle-valve is turned by the forward movement of the lever, the port communicating with the pipe t^6 is gradually opened and the air from the air-pumps is permitted to pass through it toward the compressed-air tank. When the throttle-lever is moved backward, the port in the valve is placed in communication with the other pipe, t^7, which leads directly to the compressed-air tank. The pipe t^6, however, does not go directly to the compressed-air tank. It passes to a supplemental valve-casing V, in which is an oscillating three-way valve v, which valve is opened, so as to permit air to pass from the pipe t^6 to the pipe m', which goes to the compressed-air tank. When the throttle-lever has been moved so as to permit the vehicle to move forward under the influence of the spring-barrel, the throttle-lever may be moved to the left now with the result of forcing the dog D into engagement with the spring-barrel, whereby it is stopped. This has no effect upon the throttle-valve, but it does turn the supplemental valve v, so that the air from the pumps instead of passing into pipe m' and on to the compressed-air tank passes out into the atmosphere through the pipe v'. This permits the vehicle to coast or go forward by reason of its own inertia. To stop it, the throttle-valve is moved to its middle position. The first effect of this movement is to impede the passage of air from the pumps through the throttle-valve, and this causes a compression of air in the air-pump cylinders and in the pipe therefor, which acts in a degree as a brake—that is, it impedes the rotation of the crank-shaft, which is mechanically connected, by the mechanism described, with the driving-axle. When the throttle-lever reaches its middle position, the compressed air from the air-pumps passes through another port in the throttle-valve on to the air-brakes, which may be of any construction and are therefore not shown.

Having described my invention, I claim—

1. The combination of an explosion-engine, with a spring-motor, and mechanism whereby the outward movements of the piston of the engine due to the explosions in the cylinder will wind up the spring-motor, means, independent of the spring-motor, for moving the piston inward, a latching device for preventing the complete inward movement of said piston, and mechanism, operated by the spring-motor as it unwinds, which withdraws said latching device, substantially as specified.

2. The combination of an explosion-engine having a piston-rod with rack-teeth on it, a spring-motor, a rotatable pinion, and ratchet-and-pawl connections between the said pinion and a shaft forming part of the spring-motor, said parts being arranged, substantially as described, whereby the outward movement of the piston due to the explosion will wind up the spring-motor and whereby a partial inward movement of the piston may take place independently of any movement of the spring-motor, substantially as specified.

3. The combination of an explosion-engine having a cylinder, piston and piston-rod, with a spring-motor having a shaft, a concentrically-mounted spring-barrel, and a spiral spring secured at its ends to the shaft and spring-barrel respectively, mechanism whereby the outward movement of the piston-rod, due to an explosion in the engine, will turn one of the two independently-rotatable parts of the spring-motor, *i. e.* the shaft and spring-barrel, mechanism for preventing the simultaneous and equal rotation of the other of said two parts, and mechanism for preventing the backward rotation of the part turned forward as stated, substantially as specified.

4. The combination of an intermittently-acting explosion-engine, a spring-motor, and intermediate mechanism whereby the engine winds up the motor, and means set into operation by the unwinding of the spring-motor to determine when the engine shall act, substantially as specified.

5. The combination of an explosion-engine having a cylinder, a piston, and piston-rod having rack-teeth, a pinion with which said rack-teeth engage, a spiral spring which resists the rotation of said pinion in one direction and acts to turn it in the opposite direction, a latch preventing the complete backward movement of the piston, a spring-motor, and mechanism whereby it will be wound up when the piston is moved outward by the explosion, and mechanism operated by said spring-motor as it unwinds to release said latch, substantially as specified.

6. The combination of an explosion-engine having a cylinder, a piston, and a piston-rod having rack-teeth, a pinion with which said rack-teeth engage, a spiral spring which re-

sists the rotation of said pinion in one direction and acts to turn it in the opposite direction, a latch preventing the complete backward movement of the piston, a spring-motor, and mechanism whereby it will be wound up when the piston is moved outward by the explosion, mechanism operated by said spring-motor to release said latch, mechanism operated by the piston to open the inlet-valve to the cylinder, and means for exploding the gas in said cylinder, substantially as specified.

7. The combination of an explosion-engine having a cylinder, piston and piston-rod having rack-teeth, a spring-motor shaft, a pinion mounted thereon which engages with the rack-teeth on the pinion, ratchet-and-pawl connections between said pinion and shaft, a ratchet and pawl preventing the backward rotation of the shaft, and a spring-barrel mounted concentrically with the shaft, a spiral spring secured at its ends to said spring-barrel and shaft respectively, substantially as specified.

8. The combination of an explosion-engine having a cylinder, piston and piston-rod having rack-teeth, a spring-motor shaft, a pinion mounted thereon which engages with the rack-teeth on the pinion, ratchet-and-pawl connections between said pinion and shaft, and ratchet-and-pawl mechanism preventing the backward rotation of the shaft, with a spring-barrel mounted concentrically with the shaft, a spiral spring secured at its ends to said spring-barrel and shaft respectively, a ratchet-wheel connected with said spring-barrel, and a movable dog for engaging with said last-named ratchet-wheel, substantially as specified.

9. The combination of an explosion-engine having a cylinder, piston and piston-rod having rack-teeth, a spring-motor shaft, a pinion mounted thereon which engages with the rack-teeth on the pinion, ratchet-and-pawl connections between said pinion and shaft, a ratchet and pawl preventing the backward rotation of the shaft, and a spring-barrel mounted concentrically with the shaft, a spiral spring secured at its ends to said spring-barrel and shaft respectively, a latch adapted to engage with the piston-rod to prevent the complete backward movement of the piston, mechanism operated by the spring-barrel to withdraw said latch, and mechanism whereby the inlet-valve to the cylinder is opened after the piston-rod is released from said latch, and means for igniting the gas in said cylinder, substantially as specified.

10. The combination of an explosion-engine having a cylinder, piston and a piston-rod having two sets of rack-teeth, a pinion engaging with one of said sets of rack-teeth, a spring resisting the movement of said pinion in one direction and impelling it to move in the other direction, a spring-motor which includes a shaft, a spring-barrel mounted concentrically therewith, a spiral spring secured at its ends to said spring-barrel and shaft, a pinion mounted upon said shaft and engaging with the other set of rack-teeth on the piston-rod, ratchet-and-pawl connections between said last-named pinion and shaft, a latch adapted to engage with the piston-rod and thereby to prevent the complete backward movement of the piston, and mechanism operated by the spring-barrel to withdraw said latch, means whereby the inlet-valve to the cylinder is opened after said latch has been withdrawn, substantially as specified.

11. The combination of an explosion-engine having a cylinder, piston, and piston-rod, a spring-motor adapted to be wound up by the outward movement of said piston due to an explosion in the cylinder, a spring-latch engaging with the piston-rod and having a lateral projection, a cam on the spring-barrel adapted to engage with said projection whereby to withdraw said latch, a spring adapted to move the piston backward, and means whereby the backward movement of the piston after it is released from said latch opens the inlet-valve to the cylinder, substantially as specified.

12. The combination of an explosion-engine, a spring-barrel, and mechanism whereby the outward movement of the piston of said explosion-engine under the influence of an explosion winds up said spring-motor, means for moving the piston backward after an explosion, a latch preventing the complete backward movement of said piston, means operated by the spring-motor to release said latch, an air-pump operated by said spring-motor, a compressed-air tank connected with said air-pump and with the cylinder of the engines, a gasolene-tank, a pipe connecting the same with the cylinder of the engine, a valve which controls admission of both the air and gasolene to the engine, and means whereby the backward movement of the piston after being released by said latch will open said valve, substantially as specified.

13. The combination of an explosion-engine having, first, a cylinder in the side of which is a port adapted to be closed by the piston; second, a piston; third, a piston-rod having rack-teeth, and, fourth, valve-controlled ports for admitting an explosion of gas into the cylinder behind the piston, with a pinion with which the rack-teeth engage, a spring-motor, and connections between the same and said pinion, substantially as specified.

14. The combination of an explosion-engine, a spring-motor, mechanism whereby the outward movement of the piston of said engine winds up said spring-motor, an air-pump operated by said spring-motor, a compressed-air tank connected with said air-pump and with the engine-cylinder, a throttle-valve interposed between the air-pump and air-tank, a throttle-lever for operating said valve, a dog preventing the operation of the spring-motor, and mechanism operated by said

throttle-lever for moving said dog, substantially as specified.

15. The combination of an explosion-engine, a spring-motor, mechanism whereby the outward movement of the piston of said engine winds up said spring-motor, an air-pump operated by said spring-motor, a compressed-air tank connected with said air-pump and with the engine-cylinder, a throttle-valve interposed between the air-pump and air-tank, and a throttle-lever for operating said valve.

16. The combination, in an explosion-engine, of a cylinder closed at one end, a mixing-chamber adjacent to the closed end, means for forcing air and gas into said mixing-chamber, a valve to control the entrance to said mixing-chamber which valve has a stem which projects into the cylinder, a valve between the mixing-chamber and the cylinder, an outlet-valve having a stem which projects into the cylinder, a piston adapted to engage with said stems to operate their valve, a piston, a spring to resist the outward movement of the piston and to move it inward, and means for exploding the gas in said cylinder, substantially as specified.

17. In a gas-engine, the combination of a cylinder closed at one end and having a port through its side near the other end, a mixing-chamber, an outwardly-opening valve to close the opening to said mixing-chamber, which valve has a stem which projects into the cylinder through the end thereof, a spring for closing said valve, an inwardly-opening valve between the mixing-chamber and cylinder, a spring for closing it, an inwardly-opening outlet-valve in the end of the cylinder having a stem which projects into the cylinder, a spring operating to open said valve, a piston adapted to engage with said stems and to open their valves, a spring which resists the outward movement of the piston and tends to move it inward, a latch preventing the complete inward movement of said piston, means for releasing said latch, means for forcing the explosive gas into the mixing-chamber when its valve is opened, and means for exploding the gas in the cylinder, substantially as specified.

In testimony whereof I hereunto affix my signature in the presence of two witnesses.

HENRY C. OSBORN.

Witnesses:
E. L. THURSTON,
ALBERT H. BATES.