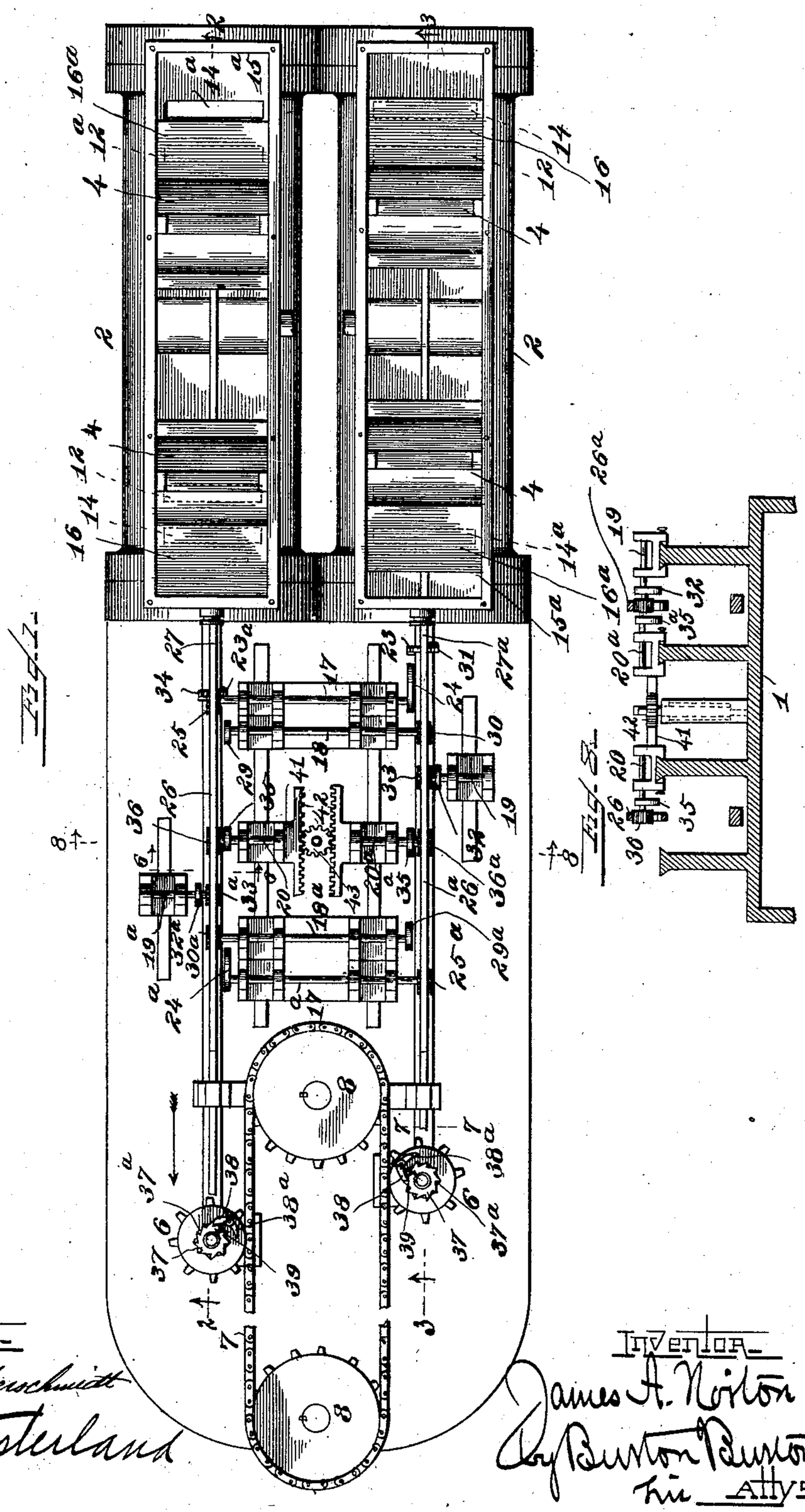
No. 729,507. PATENTED MAY 26, 1903.

J. A. NORTON.

EXPANSIVE FLUID MOTOR.

APPLICATION FILED APR. 7, 1902.

NO MODEL. 3 SHEETS—SHEET 1.



Witnesses—
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D. B. Westerland

Inventor—
James A. Norton
by Burton Burton
his Attys.

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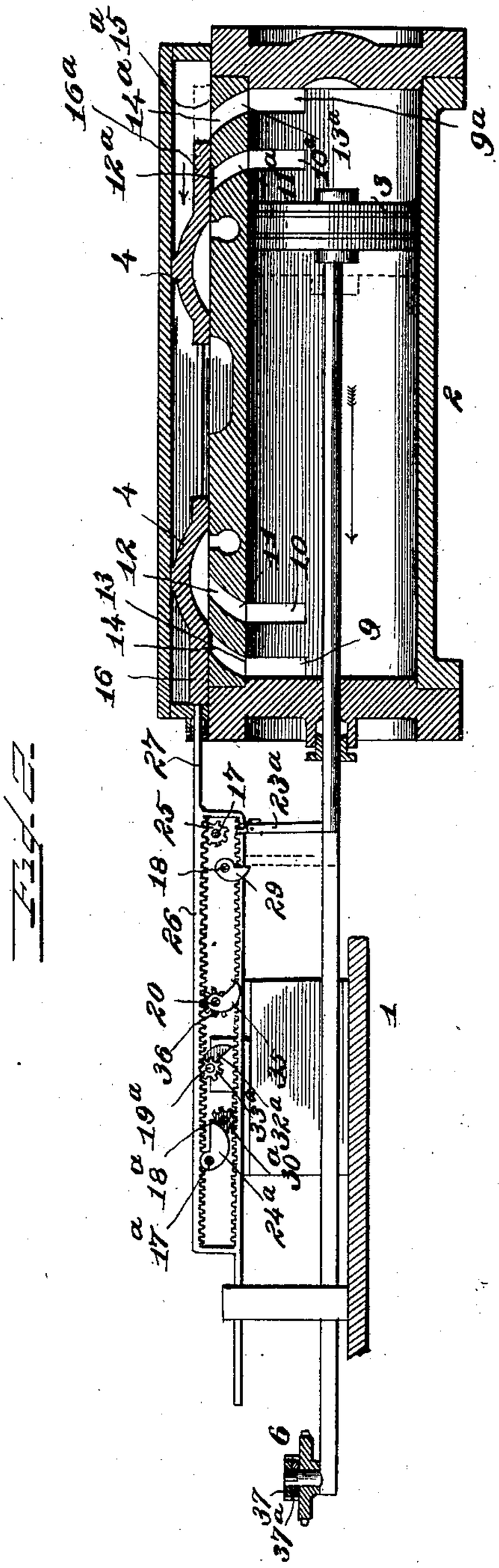

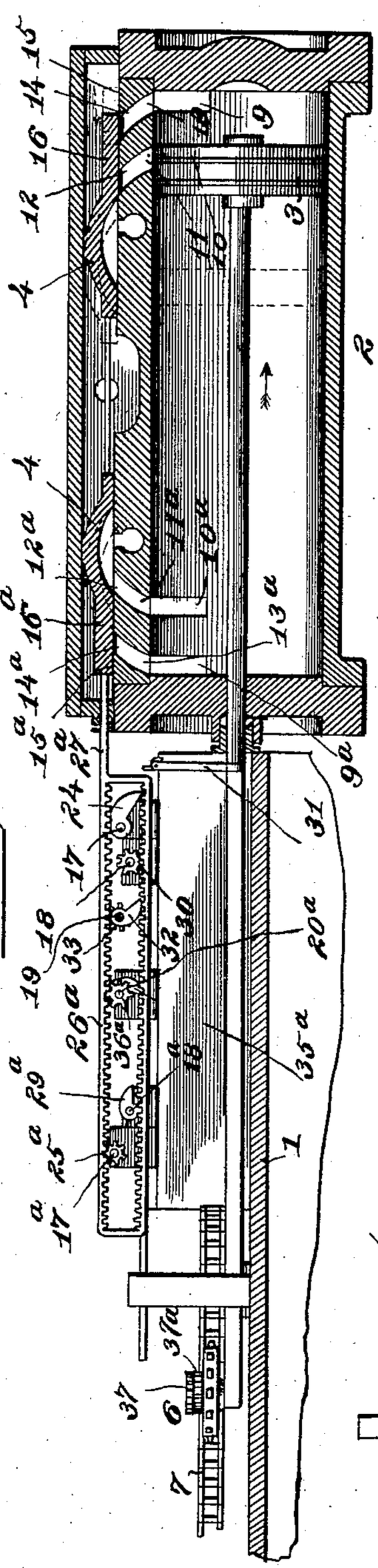

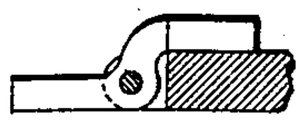

Witnesses
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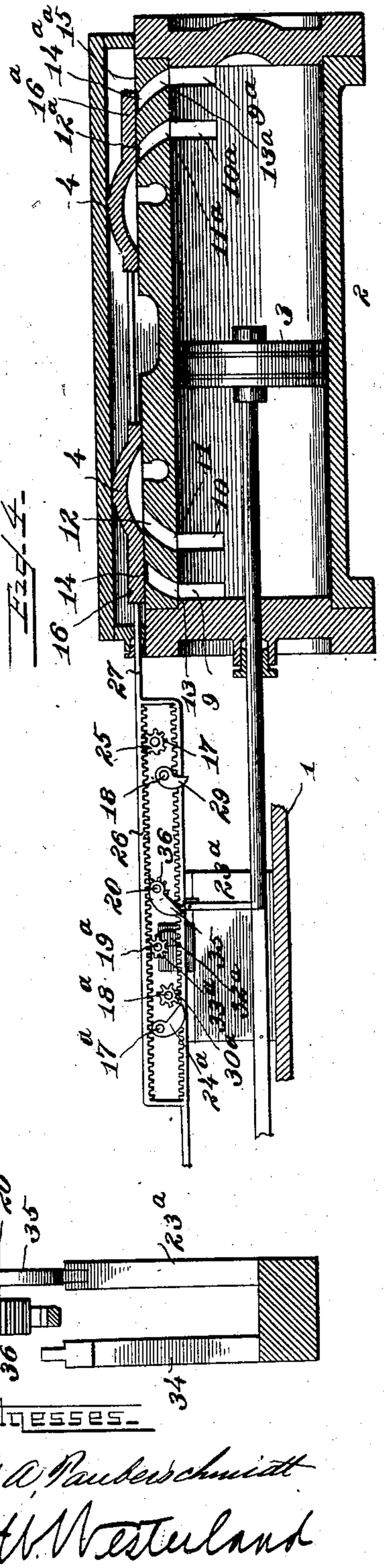
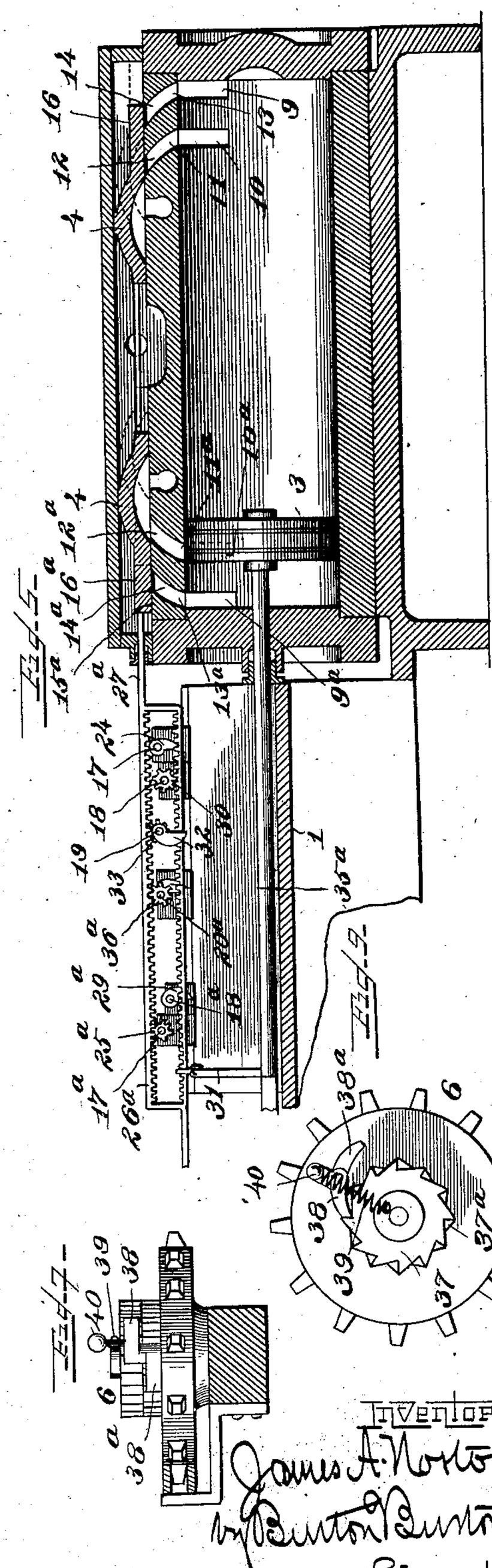
NO MODEL. 3 SHEETS—SHEET 3.





Witnesses—

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Pro Attys

No. 729,507. Patented May 26, 1903.

UNITED STATES PATENT OFFICE.

JAMES A. NORTON, OF ODEBOLT, IOWA.

EXPANSIVE-FLUID MOTOR.

SPECIFICATION forming part of Letters Patent No. 729,507, dated May 26, 1903.

Application filed April 7, 1902. Serial No. 101,763. (No model.)

To all whom it may concern:

Be it known that I, JAMES A. NORTON, a citizen of the United States, residing at Odebolt, in the county of Sac and State of Iowa, have invented certain new and useful Improvements in Expansive-Fluid Motors, of which the following is a specification, reference being had to the accompanying drawings, forming a part thereof.

This invention is designed particularly to carry out more perfectly the purpose of my invention shown in my application, Serial No. 73,516, filed in the Patent Office August 28, 1901, and now pending, relating to motors in which the motive force is an expansive fluid, as steam, gas, or compressed air, and in which two cylinders are employed having their pistons each working in one stroke and returning idle in the other, being connected to the motor mechanism so as to permit such action—as, for example, by having clutch connections with an endless chain driven around two pulleys, one piston being arranged to operate upon one ply of the chain while the other piston operates upon the other ply, the working strokes of the pistons being in opposite directions, and thereby adapted to give the chain impetus always in the same direction of travel around the axis of the wheels.

It consists of novel features of construction of the valves and valve-operating mechanism, as fully set out in the claims.

In the drawings, Figure 1 is a plan view of my motor with the cap or cover-plate of the valve-chambers removed to show the valves in operative position. Fig. 2 is a section axially through the rear cylinder. Fig. 3 is a similar section through the forward cylinder. Figs. 4 and 5 are views similar to Figs. 2 and 3, respectively, but showing the moving parts at different positions. Fig. 6 is a detail section at the line 6 6 on Fig. 4, showing the parts on an enlarged scale. Fig. 7 is a section at the line 7 7 on Fig. 1, showing certain details on an enlarged scale. Fig. 8 is a section at the line 8 8 on Fig. 1. Fig. 9 is a detail plan of the clutching device for engaging the chain.

In a simple form of my improved motor the parts are all mounted on a unitary frame 1, which supports the cylinders and the various working elements.

2 2 are the cylinders; 3 3, the pistons therein; 4 4, the slide-valves controlling the admission and exhaust of motive fluid. The pistons are operatively connected by clutches 6 6 with the opposite plies of the chain 7, which passes around the motor-wheels 8 8, from the shaft of either of which power is taken. As to the devices for engaging the chain it will be sufficient at this point in the description to state that the clutch at one side engages the chain in the inward stroke, each clutch being adapted to travel back along the chain idly in the opposite stroke from that which engages it. The means for actuating the piston in its idle stroke in the construction here shown is the motive fluid, of which a suitably-small charge only should be admitted to carry back the piston without performing any additional work. It will be seen that the admission of steam or other fluid against the idle piston at the moment it has completed its working stroke will tend to throw it back very quickly, or at least at a speed independent of the working speed of the motor, and cause it to reach the opposite end of the cylinder before it is time for it to receive its working stroke—that is, before the opposite piston has reached sufficiently near to the end of its working stroke, and inasmuch as the valves are to be operated to control the admission and cut off of the motive fluid means must be provided for cutting off the same earlier in the idle stroke of the piston than in its working stroke and also means for cushioning the idle stroke of the piston independently of the closing of the exhaust-port by the valve, as well as independently of the admission of the motive fluid to return the piston in its working stroke, which is in ordinary steam-engines accomplished by the lead of the valve. The mechanism which I will now describe for controlling the valve movements is contrived with a view of meeting these requirements.

The cylinders are provided with separate passages for inlet and exhaust of motive fluid at both ends, the inlet-passages 9 and 9^a being outside of the exhaust-passages 10 and 10^a—that is, the exhaust-ports 11 and 11^a in the cylinder and the exhaust-ports 12 and 12^a at the valve-seat are respectively inward from the inlet-ports 13 and 13^a in the cylinder and

14 and 14ª at the valve-seat. The distance of the exhaust-ports 11 and 11ª from the cylinder-heads, respectively, is sufficient to cause the piston upon passing said exhaust-ports to imprison between itself and the cylinder-head enough of the motive fluid to suitably cushion the piston, and at the end toward which the piston makes its idle stroke, in which it is uncontrolled or restrained by any work, said distance may be greater than at the other end if upon experience it is found desirable to give it a greater cushion, or, on the other hand, if the rebound from an excessive cushion should be found an inconvenience by reason of the lack of restraint upon the piston the cushion may be correspondingly less. The point to be observed is that the distances are not necessarily equal at the two ends, but may be adapted to the requirements of experience. One feature of this motor is that the working strokes of the two pistons overlap—that is, each piston takes up the work by engaging the chain before the other piston has ceased to actuate the chain, thus insuring unbroken continuity of the application of power, there being not even an instant corresponding to a dead-center or point of transfer of engagement. With these points in mind the movement of the piston and necessary action of the valve may first be considered before following the details of construction of the valve-operating devices.

In Fig. 3 the piston in the forward cylinder is shown approaching the completion of its working stroke. In this approach and just before it reached the position shown in Fig. 3 in full line it has operative means, hereinafter described, to open the valve of the other cylinder and admit the steam through port 14ª of that cylinder (see Fig. 2) to give the piston therein its working stroke. Its own valve should now be approaching the point for admitting the motive fluid to give this piston its return idle stroke, and should, therefore, be moving in the direction of the arrow shown alongside the valve in said figure, and should in such movement at this stage of the piston travel have already uncovered the exhaust-port at the other end of the cylinder. When this first movement of the valve is completed, it must have uncovered the inlet-port 14 at the end of the cylinder which the piston is approaching and the exhaust-port 12ª at the other end, and its position before such movement commences must have been such that a return movement of the cylinder to close the inlet-port 14 shall still leave the exhaust-port 12ª open. It has, therefore, the foot 16 extended so as to cover the inlet-port 14 and have a lap on the seat beyond that port equal to the width of the exhaust-port 12ª. Such lap is shown in dotted line at 15 on Fig. 3. At the other end the foot 16ª covers the exhaust-port 12ª, the inlet-port 14ª, and the portion of the seat between them. The total extent of this first movement of the valve, therefore, must be equal to the width of the inlet-port 14 plus the lap 15. Fig. 3 shows half this movement already made. When completed, the position will be as indicated in dotted line in Fig. 3. The full movement will uncover the inlet-port 14 and carry the exhaust edge of the valve-foot 16ª at the other end of the cylinder beyond the exhaust-port 12ª a distance equal to the lap 15, which will cause it to stop short of uncovering the inlet-port 14ª. The next movement, which may occur when the piston reaches the dotted-line position 3ª, (shown in Fig. 3,) will uncover the inlet-port 14, cutting off the steam. This movement of the valve must be in reverse direction from the former, and since it must leave the exhaust-port 12ª open it must be a shorter movement, or practically half only of the movement which uncovered that port and the inlet-port 14, and the position of the valve after this short reverse movement will therefore be substantially that shown in full line in Fig. 3, which represents the middle point of the longer movement in the other direction. The valve at this position must by means of its foot 16 keep the exhaust-port 12 closed, since otherwise the steam admitted before this reversing or cutting-off movement of the valve would extend into the exhaust-passage instead of operating on the piston. The length of the foot 16 must therefore be at least equal to the width of the two ports 12 and 14 and the intervening portion of the seat, with enough excess to securely close both the ports at the same time. The valve having reached this position must rest, or at least must not so change its position as to affect its influence over the ports until the piston reaches the position shown in full line in Fig. 5, where it has so nearly completed its idle stroke as to require imprisoned fluid for its cushion. A slight further movement will cause it to imprison a suitable cushion between itself and the end of the cylinder, and a separate or additional movement of the valve to close the exhaust-port 12ª for such purpose is made unnecessary by locating the exhaust-port 11ª at the proper position in the cylinder to be closed by the piston with a sufficient volume of imprisoned fluid in advance of it to afford the necessary cushion. It will be observed that in view of the fact that the piston is working idly under the impulse of the motive fluid—that is, without any control of the mechanism—the time in which it would reach the position requiring the cushion may vary in different strokes and under different conditions of the motive fluid as to tension, so that any movement of the valve controlled by the motor speed would not necessarily be properly related to the movement of the piston to effect the closing of the exhaust at the right time for cushioning the piston. Moreover, it would not be desirable to impose on the piston at this point in its idle stroke the work of operating the valve. The valve will, however, be op-

erated to close the port 12ª and at the same time open the port 12 by the working stroke of the opposite piston, as hereinafter explained, so that the release of the steam behind the piston in its idle stroke is effected, and the valve being at the next step moved further in the same direction to uncover the inlet-port 14ª (see dotted-line position of the valve in Fig. 5) the piston in the cylinder under consideration will start on its working stroke. At a suitable point in that stroke more distant from its commencement than at which the cut-off was made in the idle stroke, as indicated by dotted-line position of the piston 3ᵇ in Fig. 5, the valve will require a reverse movement to close the port 14ª and still leave open the port 12. The movement by which the port 14ª was opened and the port 12 opened must therefore have been sufficient to carry the exhaust edge of the foot 16 of the valve beyond the port 12 a distance equal to the width of the port 14ª and the foot 16ª must therefore have a lap 15ª outside the port 14ª equal to the length of the return stroke necessary to uncover said port 12. This makes the two feet 16 and 16ª of equal length, but requires that the means for reversing the valve to cut off the motive fluid in the working stroke shall be dependent upon that working stroke, each cut-off being independent of the other as to the point in the stroke at which it occurs. The cuto-ff in the working stroke having been effected by the movement described of the valve, the piston will continue its working stroke, obtaining cushion toward the end of it by passing by and closing the port 11, having thus arrived at the position described at starting.

I have above described the movement of the piston and valve pertaining to the cylinder shown in Figs. 3 and 5. In Figs. 2 and 4 are shown the respective contemporaneous positions of the corresponding parts in the other cylinder. The movement of the piston and valve may be traced in similar order in that cylinder.

Of the above-described movements all except the cutting off of the motive fluid after the piston starts in each stroke is effected with respect to each piston by the opposite piston. For the purpose of producing the various valve movements I mount upon the frame 1 rock-shafts 17, 17ª, 18, 18ª, 19, 19ª, 20, and 20ª. On the piston 3 of the forward cylinder there is a trip finger or abutment 23, which toward the finishing part of the working stroke collides with a tappet or lever-arm 24 on the rock-shaft 17 and rocks that shaft, carrying said tappet from the position shown in dotted line in Fig. 3 through about forty-five degrees to a position shown in full line in said figure, at which the trip-finger passes the end of the tappet as the piston completes its stroke. On the shaft 17 there is also a pinion 25, which meshes with the upper side of the rack 26 on the valve-operating rod 26, which pertains to the rear cylinder. Said rocking movement given to the shaft 17 by the forward piston, as described, moves the valve 4 of the other cylinder to the position shown in full line in Fig. 2 from the dotted-line position shown in that figure, uncovering the inlet-port 14ª at one end and the exhaust-port 12 at the other end of said rear cylinder, thus admitting the motive fluid at the end to give the piston its operating stroke inward and permit free exhaust at the other side of the piston throughout that stroke. On the stem of that piston there is a trip-finger or abutment 23ª, which collides with the tappet or lever-arm 29 on the rock-shaft 18. This rock-shaft has also fast on it a pinion 30, which meshes with the lower side of the rack 26ª of the valve-operating rod 27ª pertaining to the forward cylinder, and the rocking movement which said shaft 18 receives from the encounter of the tappet 23ª with the lever-arm 29 gives to the valve of the forward cylinder a movement which uncovers the inlet-port 14 and the exhaust-port 12ª, carrying the exhaust-corner of the valve beyond the port 12ª half-way to the port 14ª by the time the inlet-corner of the foot 16 has cleared the port 14, thus admitting the motive fluid at the proper end to give the piston in said forward cylinder its idle stroke. Shortly afterward in the action, the idle stroke of the piston in the forward cylinder having commenced, a trip-finger or abutment 31 on the stem of that piston encounters a tappet 32 on a rock-shaft 19 and rocks said shaft through a suitable angle to cause a pinion 33 on the same shaft, engaging the upper side of the rack 26ª on the valve-rod 27ª of the forward cylinder, to reverse the movement of the rack and return the valve of the forward cylinder one step to a position at which it will cut off the inlet-port 14, but not close the exhaust-port 12ª. (See full-line position of the valve, Fig. 3). This reverse movement of the rack 26ª rocks the shaft 19 back and carries the tappet 24 half-way around toward its initial position, this occurring, it will be noticed, after the trip-finger 23 has been withdrawn past the tappet while the path for it was clear. Either before or after this action, according to whether the working stroke is being made with the shorter or longer cut-off, a similar action occurs in the other cylinder by trip-finger or abutment 34, which is carried by the stem of the piston in the rear cylinder, encountering a tappet or lever-arm 35 on the shaft 20, causing the pinion 36 on that shaft which engages the upper side of the rack 26 to reverse the movement of the valve in the rear cylinder, carrying it to a position shown in full line in Fig. 4, where it closes the inlet-port 14ª, but not the exhaust-port 12. Just before the piston in the rear cylinder completes its working stroke the trip-finger or abutment 23ª encounters the tappet 24ª on the shaft 17ª, and rocking that shaft causes the pinion 25ª, which it carries, engaging the rack 26ª, to operate the

forward valve, carrying it to a position where it uncovers the inlet-port 14ª and the exhaust-port 12, which causes its exhaust edge to travel beyond the port 12 half-way or more toward the port 14. From this point on the action continues substantially in repetition of that above described, but reversed as to the position of the actions—that is, each action occurring with respect to the opposite cylinder from that with respect to which above actions are described. The pistons are now at the opposite positions, respectively, from those indicated in the preceding description. It will be noticed that the reversing movements of the valves respectively restore the tappets of the rock-shafts to their original position, so that they are all in proper position to be encountered by the trip-fingers or abutments 23 and 23ª and 31 and 31ª on the two pistons—that is to say, each position of the valve corresponds to a certain position of the tappets, because the racks on the valve-operating rods are continuously in engagement with the pinions on the rock-shafts which carry the tappets. The proper relation of all the parts is thus assured throughout all the changes of movement.

The particular form of clutch employed for engaging the chain 7 with the pistons in such manner as to permit the idle stroke is not especially material. The form illustrated is a convenient one and may be described. It consists of a sprocket-wheel 6, mounted so as to rotate on the piston in the plane of travel with the chain and engaging with the latter. A ratchet-disk 37 is mounted rigidly on the axle or stud upon which the sprocket-wheel rotates, and the latter carries a pawl 38 to engage with the ratchet in one direction and ride over it in the opposite direction of rotation. The ratchets on the two pistons are arranged reversibly—that is, so that one will become engaged in the stroke in one direction while the other is engaged in the stroke in the opposite direction, as already indicated. In order to adapt the motor for reversing, the ratchet-disk may be made double, consisting of two disks, the second one being denoted by 36ª and having its teeth facing the opposite direction, and the pawl may likewise be arranged so that it may have a second nose 37ª adapted to engage the disk 36ª and the spring 38, which controls the pawl, being connected to it at a pin 39 outside the pivot of the pawl—that is, on the opposite side of the pivot from the pivot-stud of the sprocket-wheel 6. It will tend to hold either pawl in engagement with the proper ratchet-disk upon either pawl-nose being rocked over to bring the proper nose against its disk.

For convenience of assembling and adjustment the rock-shafts 17 to 20ª, inclusive, are journaled in carriages mounted on the frame or bed, as seen in the drawings. The carriages 40 40, in which the rock-shafts 20 20 are journaled, have control. The cut-off movements of the valves are made adjustable longitudinally with respect to the direction of stroke of the pistons and valves in order to vary the point of cut-off. In order that the change in point of cut-off should be made simultaneously and to equal extent in the two pistons, these two carriages are provided with connecting mechanism for adjusting them both by one action. The most convenient means for this purpose is that shown in Fig. 1, each of the carriages having a rack 41, the two racks facing each other, and a pinion 42 on a vertical shaft stepped and journaled in the frame engages with both racks, so that by rotation of the pinion the two carriages are moved in opposite directions to equal extent. Any convenient means may be employed for rotating the pinion.

I claim—

1. In an expansive-fluid motor, two cylinders and pistons operating therein, each operatively connected with the motor so as to have a working stroke and an idle stroke; valves which control the admission and exhaust of motive fluid to and from said cylinders respectively; and mechanism by which each piston in its working stroke operates the opposite valve for inlet for both the working and idle strokes.

2. In an expansive-fluid motor, two cylinders and pistons operating therein, connected with the motor so as to have each a working and an idle stroke, the working strokes being in opposite directions; valves which control the admission and escape of motive fluid to and from the cylinders respectively; and mechanism for operating said valves comprising connections by which each piston in its idle stroke operates its own valve to cut off the motive fluid.

3. An expansive-fluid motor comprising two cylinders and pistons operating therein, connected with the motor so as to have each a working and an idle stroke, the working strokes being in opposite directions; valves which control the admission and escape of motive fluid for the cylinders respectively; and connections by which each piston in the early part of its working stroke operates the opposite valve to admit the motive fluid at the end to drive the piston in said opposite cylinder in the same direction as said working piston is moving, whereby the idle stroke of each piston is concurrent with the working stroke of the other piston in the same direction, but commences a little later than said working stroke.

4. An expansive-fluid motor comprising two cylinders and pistons operating therein, each having a working and an idle stroke, the working strokes being in opposite directions; valves which control the admission and escape of motive fluid for operating said pistons respectively; mechanism for operating said valves; and connections by which each piston in its working stroke operates its own valve to cut off the steam.

5. An expansive-fluid motor comprising two cylinders and pistons operating therein, and valves which control the motive fluid therefor respectively, each piston having a working and an idle stroke, the working strokes being in opposite directions; mechanism for operating the valves; and connections by which each piston before the conclusion of its own working stroke operates the opposite valve to admit the motive fluid to cause the working stroke of the other piston, whereby said working strokes overlap.

6. An expansive-fluid motor comprising two cylinders and pistons therein; the valves which control the motive fluid therefor respectively, each piston having a working and an idle stroke, the working strokes being in opposite directions; mechanism for operating the valves; and connections by which each piston in its working stroke operates the opposite valve to admit the motive fluid for the working stroke of the other piston, and in both its strokes cuts off the motive fluid which actuates it.

7. In an expansive-fluid motor two cylinders and pistons operating therein, and valves which control the inlet and outlet ports in the cylinders respectively; racks on the valve-operating rods; rock-shafts extending transversely with respect to the stroke of the pistons across the said rods having pinions engaging the racks respectively; tappets carried by the piston-rods; and tappets or lever-arms on the rock-shafts encountered by the tappets on the piston-rods to rock the shafts and operate the pistons, whereby the movements are abrupt and the valves dwell on their seats in the intervals between such abrupt movements.

8. In an expansive-fluid motor, two valves and the pistons operating therein, and valves which control the inlet and outlet ports for the cylinders respectively; racks on the valve-operating rods, and rock-shafts, one for each movement of each valve, extending transversely with respect to the direction of the stroke of the pistons, having pinions which engage the racks respectively; tappets carried by the piston-rods, and tappets or lever-arms on the rock-shafts encountered by the piston-rod tappets to rock the shafts and operate the valves; whereby each movement of each valve may be controlled as to time and duration independently of every other movement of either valve.

9. In an expansive-fluid motor, two cylinders and pistons operating therein; valves controlling the inlet and outlet ports for the cylinders respectively; racks on the valve-operating rods; rock-shafts extending transversely to the direction of stroke of the pistons, having pinions engaging the racks respectively; tappets carried by the piston-rods, and tappets or lever-arms on the rock-shafts encountered by the piston-rods; tappets to rock the shafts and operate the valves, a separate rock-shaft being provided for each cut-off movement of each valve; carriages in which the rock-shafts controlling the cut-off of the working strokes of the two pistons are mounted respectively, said carriages being movable along the path of the piston-stroke to vary the time at which the cut-off is made.

10. In an expansive-fluid motor, two cylinders and pistons operating therein; valves controlling the inlet and outlet ports for the cylinders respectively; racks on the valve-operating rods; rock-shafts extending transversely to the direction of stroke of the pistons, having pinions engaging the racks respectively; tappets carried by the piston-rods, and tappets or lever-arms on the rock-shafts encountered by the piston-rods; tappets to rock the shafts and operate the valves, a separate rock-shaft being provided for each cut-off movement of each valve; carriages in which the rock-shafts controlling the cut-off of the working strokes of the two pistons are mounted respectively, said carriages being movable along the path of the piston-stroke to vary the time at which the cut-off is made; mechanism connecting said carriages to give them simultaneous adjustment for change of cut-off.

In testimony whereof I have hereunto set my hand, in the presence of two witnesses, at Chicago, Illinois, March 4, 1902.

JAMES A. NORTON.

In presence of—
MELVIN SMITH,
MEL. J. SMITH.