No. 625,800. Patented May 30, 1899.

J. W. PICKEL & R. SNYDER.

ROTARY ENGINE.

(No Model.) (Application filed Oct. 31, 1898.) 2 Sheets—Sheet 1.

Fig. 1.

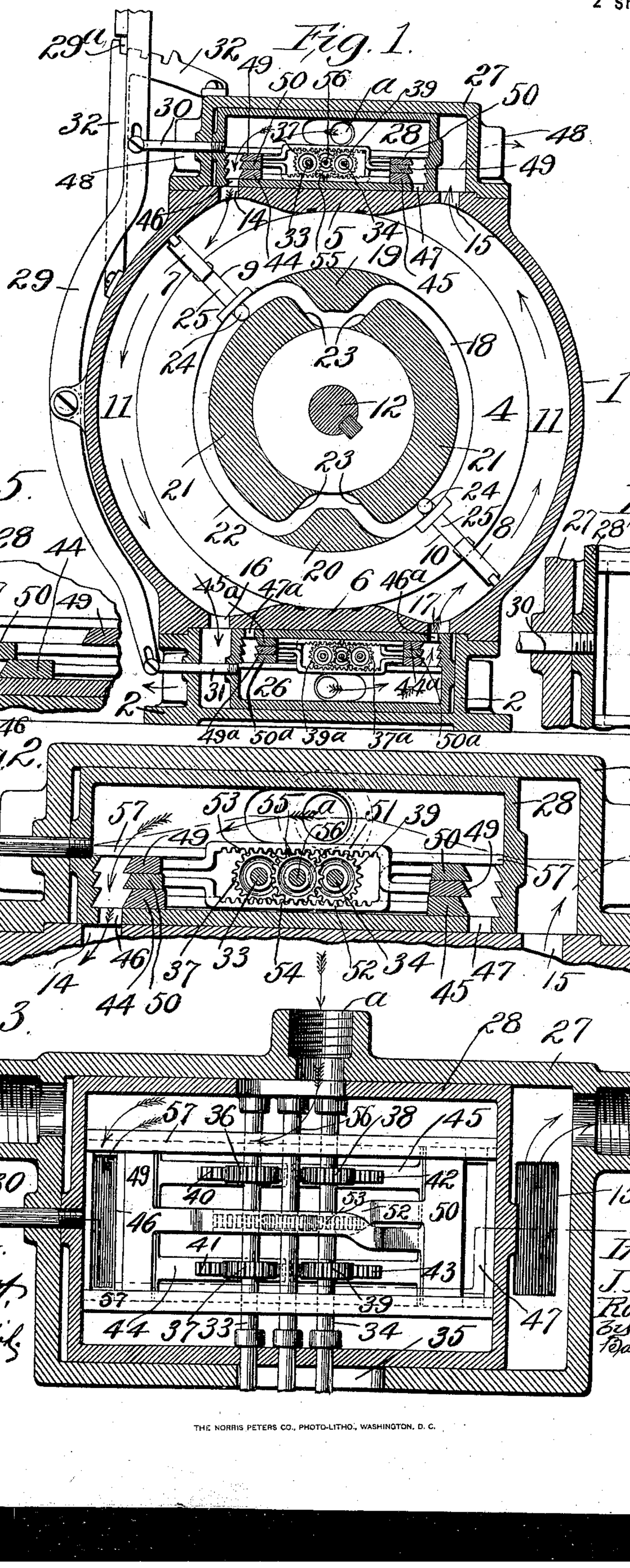


Fig. 5.

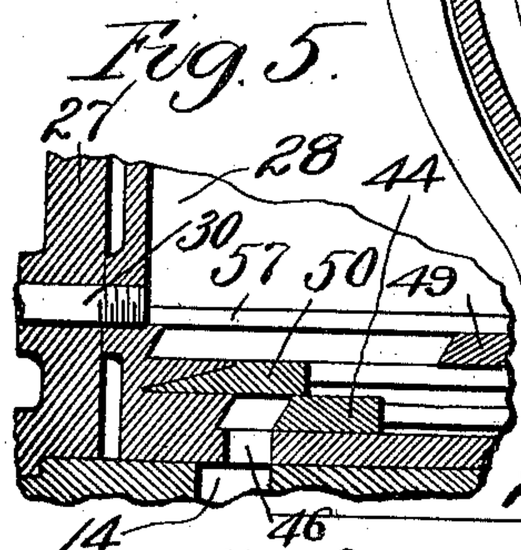


Fig. 6.

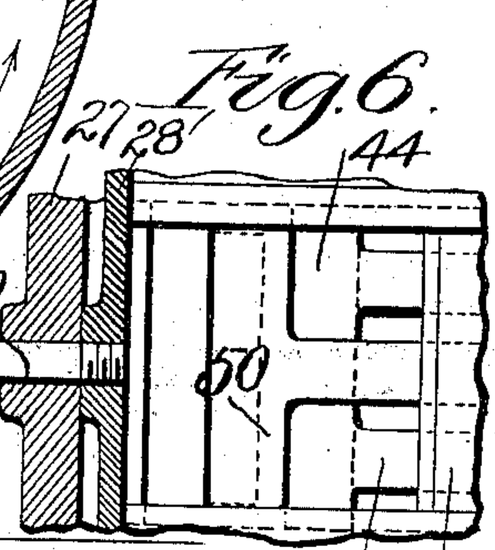


Fig. 2.

Fig. 3.

Attest:
Wm. H. Scott.
Ralph Nelis

Inventors
J. W. Pickel.
Robt. Snyder.
By
Bakewell & Cornwall
Attys

No. 625,800. Patented May 30, 1899.

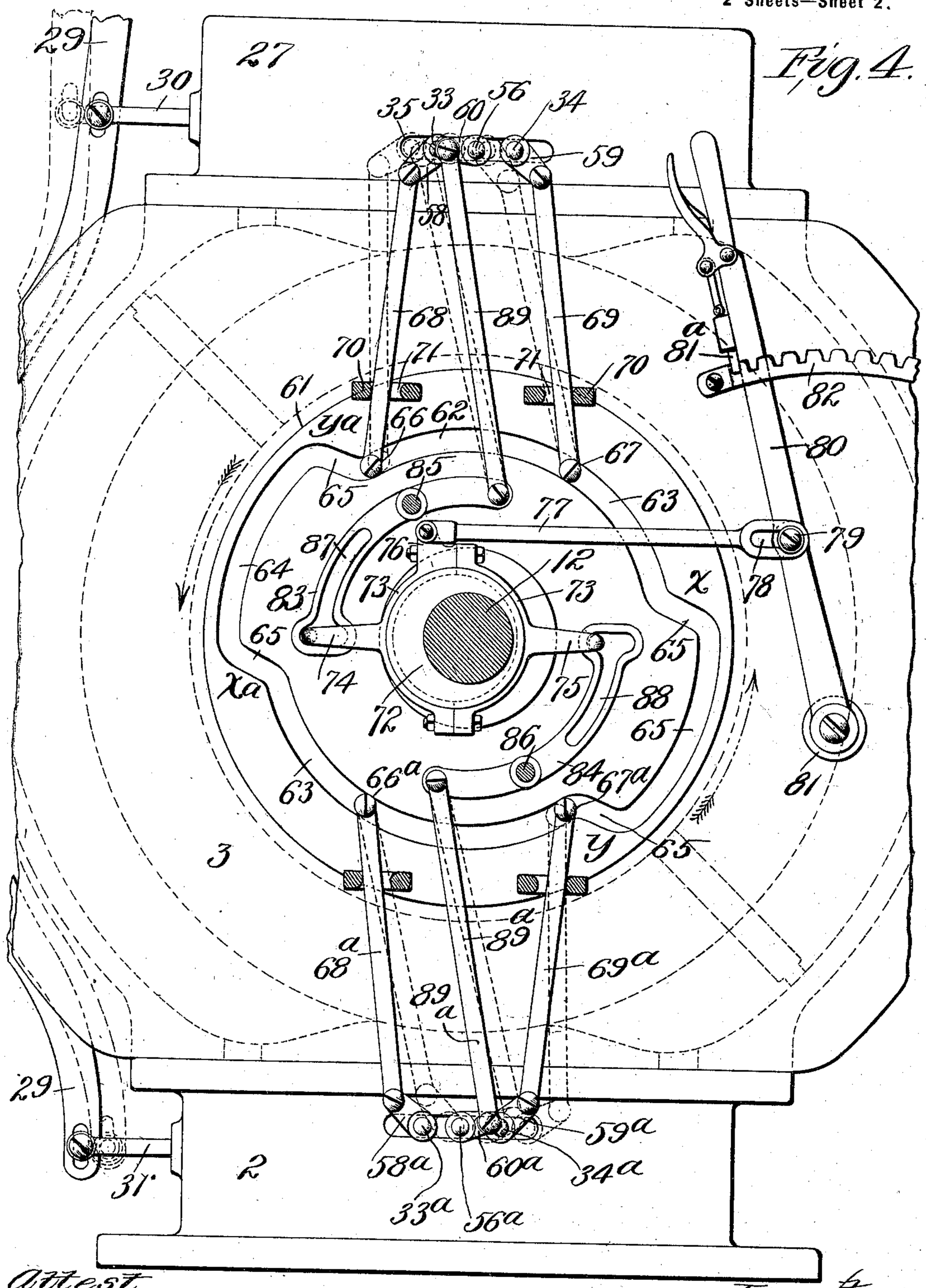
J. W. PICKEL & R. SNYDER.

ROTARY ENGINE.

(No Model.) (Application filed Oct. 31, 1898.)

2 Sheets—Sheet 2.

Fig. 4.



Attest
Wm. A. Jeffrey
Ralph Talbot.

Inventors.
John W. Pickel.
Robert Snyder.
by Bakewell & Cornwall Attys

UNITED STATES PATENT OFFICE.

JOHN W. PICKEL AND ROBERT SNYDER, OF CRYSTAL CITY, MISSOURI.

ROTARY ENGINE.

SPECIFICATION forming part of Letters Patent No. 625,800, dated May 30, 1899.

Application filed October 31, 1898. Serial No. 695,075. (No model.)

To all whom it may concern:

Be it known that we, JOHN W. PICKEL and ROBERT SNYDER, citizens of the United States, residing at Crystal City, in the county of Jefferson and State of Missouri, have made a certain new and useful Improvement in Rotary Engines, of which the following is a full, clear, and exact description, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, forming part of this specification, in which—

Figure 1 is a vertical sectional view of our improved rotary engine. Fig. 2 is an enlarged vertical sectional view through one of the slide-valves employed in our improved rotary engine, the same being on line 2 2, Fig. 3. Fig. 3 is a horizontal sectional view on line 3 3, Fig. 2. Fig. 4 is an enlarged front elevational view, partly in section, of our improved rotary engine, together with the cut-off mechanism employed therein. Fig. 5 is an enlarged detail vertical sectional view of a slightly-modified form of construction of the second and third auxiliary slide-valves, and Fig. 6 is horizontal plan sectional view of the same.

This invention relates to a new and useful improvement in rotary engines, the object being to construct an engine of the character described in a simple and cheap manner and provide the same with reversing mechanism, as well as a variable governing mechanism, the latter being manually adjustable, according to the load, but automatic when operative with respect to its action.

With these objects in view the invention consists principally in the construction of the main or throttling valve, which carries the positive cut-off, and governing or variable cut-off valves. Incidental to this are the novel means employed for positively operating the primary cut-off valve, the novel means employed for throwing the operating mechanism into and out of engagement with the variable cut-off valves, and for varying the stroke of said valves when in operative relation to the engine.

Finally, the invention consists in the novel construction, arrangement, and combination of the several parts of our engine, all as will hereinafter be described, and pointed out in the claims.

In the drawings, 1 indicates a suitable casing forming the cylinder of our improved rotary engine, which cylinder is mounted upon a suitable base 2.

3 indicates a suitable cylinder-head bolted or otherwise secured to the open end of the casing 1 and which, together with the rear face of the cylinder or casing, houses in a suitable piston 4. The interior of the cylinder is provided with abutments 5 and 6, of which there are preferably two, and the piston 4 is provided with piston-heads (preferably two in number) 7 and 8, which slide in suitable grooves 9 and 10, preferably radially disposed in said piston. The piston proper is of a diameter considerably less than the inside diameter of the cylinder, which leaves a space 11 between said piston and the cylinder. The abutments 5 and 6 are formed with their inner edges concentric with the main shaft 12 of the engine, the radius of said concentric portions of the abutments 5 and 6 being equal to the radius of the piston 4, and said abutments 5 and 6 are provided with suitable packings to form a steam-tight joint between the periphery of the piston and said abutments. We will state here that piston 4 is of a width to fill the interior of the casing from head 3 to back plate. The concentric portions of the abutments 5 and 6 occupy but a short space, and from the point where the inner faces on these abutments cease to be concentric a tapered face or faces gradually recede and finally blend by suitable curves into the inner periphery of the cylinder. Preferably at this juncture of the receding tapered portions and the internal diameter of the cylinder are formed ports 14, 15, 16, and 17.

18 indicates a cam-groove which is formed, preferably, by inwardly-projecting portions 19, 20, and 21, formed on the cylinder-head 3 and also on the inside face of the rear wall of the engine, the latter not being shown. The piston 4 is provided with a concentric groove 22, into which said projections 19, 20, and 21 fit, and when the piston is properly placed in position within the cylinder of the engine the cam-groove 18 is thus formed. Suitable inwardly-disposed inclined or curved

faces 23 are arranged at the ends of the projections 21, and the inner faces of the projections 19 and 20 conform to the curved faces 23. The outer edges of the projections 19 and 20 only extend through about sixty degrees of a circle or terminate at about a radial line from the center of the shaft to the ports 14, 15, 16, and 17.

Piston-heads 7 and 8 are provided upon their inner edges with cylindrical projections 24, and between the inner edges of these projections 24 and the outer ends of the piston-heads 7 and 8 are formed recesses or notches 25, the cylindrical portions 24 being designed to travel in the cam-groove 18, while recesses 25 in the piston-heads 7 and 8 are for the purpose of permitting the piston-heads 7 and 8 to be drawn inwardly by the projections 19 and 20 and the corresponding faces 23 when the piston passes this point, and as the projections 19 and 20 (as well as 21) are stationary it is essential that these cut-out portions 25 must occur in the piston-heads in order that the piston-heads may pass these projections 19 and 20.

The base 2, while acting as a support for the engine and its carried parts, is made hollow and is designed to also act as a valve-casing for a throttle-valve 26, shown here as a slide-valve, and diametrically opposite is provided a second valve-casing 27, containing therein a corresponding throttle-valve 28, the internal length of the valve-casings being as much longer than the length of these valves as the designed movement of said valve, the purpose of which will be hereinafter explained. These casings 2 and 27 are wholly occupied transversely by the throttle-valves, which are hollow, containing the cut-off valves, and said hollow valves also form steam-chests, into which steam is admitted through the openings *a* in the casings 2 and 27, said openings always communicating with the interior of the throttle-valves, as will be well understood.

29 indicates an operating-lever connecting valves 26 and 28, which lever is pivoted to suitable lugs formed, preferably, on the outside of casing 1, said pivot-point being midway the distance between said valves in order to impart a like movement to each, but in opposite directions.

30 and 31 indicate suitable connections secured in any suitable manner to the throttle-valves, their outer ends being loosely connected to the lever 29 to accommodate the arc of movement described by the lever.

32 indicates a notched segment designed to coöperate with a suitable latch 29^a, carried by the lever 29, and which when said latch cooperates with said notches in the notched segment holds said lever in one position or the other, which in turn causes the throttle-valves to occupy different positions within their casings, depending upon the direction in which it is desired to rotate the engine.

As the throttle-valves and their associate parts are duplicated on each side of the engine, we will confine our description to but one, (the upper,) it being understood that it applies equally to the lower.

33 and 34 indicate shafts suitably journaled in the valve 28, said shafts protruding out through one side of said valve and passing through suitable slots 35, formed in the valve-casing.

36 and 37 indicate pinions secured to the rock-shaft 33 within the valve 28, and 38 and 39 indicate suitable pinions similarly mounted upon and secured to the rock-shaft 34. These pinions are designed to mesh upon one side with racks 40, 41, 42, and 43, respectively secured to the primary cut-off valves 44 and 45.

46 and 47 indicate ports so arranged in one of the faces of the throttle-valve 28 as to coöperate with the ports 14 and 15 in the cylinder of the engine. Ports 46 and 47 are arranged closer together than the ports 14 and 15 in order that when the throttle-valve 28 is in a central position neither of the ports 46 or 47 will be in registration with the ports 14 and 15; but when said valve 28 is moved from a central position to one side or the other one or the other of said ports 46 or 47 will register with the port 14 or 15—that is, if the port 46 is in registration with the port 14, as shown in the drawings, the port 47 will have moved in such position as to be blinded. This movement will also permit the end of the valve 28 to clear the port 15, which will allow the exhaust from the steam-space 11 to enter the valve-casing of the slide-valve 28 and outside the same, from whence it escapes to the atmosphere through the exhaust-opening 48, it being understood that there is an exhaust-port 48 at each end of the valve-casing in order that when the valve is at the opposite end of the casing the exhaust may pass from the opposite end, as is obvious.

The cut-off valves 44 and 45 when the engine is running normally have their outer edges just clear of the ports 46 and 47, and should either of the rock-shafts 33 or 34 be rocked in the proper direction the valves 44 and 45 will close either port 46 or 47.

49 and 50 indicate variable cut-off valves arranged above the primary cut-off valves 44 and 45. While the outer ends of these variable cut-off valves 49 and 50 are substantially of the same construction as the primary cut-off valves 44 and 45, their operation is different, inasmuch as they work in unison—that is, move in opposite directions at the same time. As the primary cut-off valves must be positively operated, their being "off center" involves independent mechanism for their separate operation, which has been described. The unitary movement of the variable cut-off valves is accomplished by a suitable rack 53, formed on the under face of the bar 51 of the valve 49, and a rack 54 on the upper face of the bar 52 of the valve 50, said bars and their carried racks being in vertical alinement with each other and designed

to coöperate with a single pinion 55, secured to a rock-shaft 56, said rock-shaft being journaled in the throttle-valve 28 in like manner as are the shafts 33 and 34. Suitable guides 57 may be employed in connection with the cut-off valves for the purpose of insuring their perfect alinement. The manner in which these rock-shafts 33, 34, and 56 are operated is best illustrated in Fig. 4, wherein it will be noticed that the shaft 33 is provided upon its outer end, which protrudes through the casing passing through the slot 35, with a crank 58, and upon the shaft 34 is a crank 59. The shaft 56 is also provided with a similar crank 60.

61 indicates a cam-disk keyed or otherwise secured to the main shaft 12. This disk is provided with a cam-groove 62, said groove being formed in part of concentric grooves 63, arranged diametrically opposite each other, and in part of concentric grooves 64, likewise arranged diametrically opposite each other. These last-mentioned grooves have greater radii than the grooves 63, said grooves 64 being also shorter than the grooves 63. These grooves 63 and 64 communicate with each other at 65.

66 and 67 indicate cam-rolls designed to travel in the cam-groove 62, said cam-rolls being journaled on the ends of link-rods 68 and 69, respectively. The upper end of link-rod 68 is pivotally secured to the free end of the lever 58, and the upper end of the link-rod 69 is secured to the free end of the crank 59.

70 indicates suitable guides or supports provided with openings or slots 71, through which the arms 68 and 69 pass. The purpose of these guides or supports is to compel the lower ends of the rods 68 and 69 to occupy a given position in order that the cam-rolls journaled upon the ends of said rods will bear a fixed relation to the cam-groove 62.

72 indicates an eccentric keyed or otherwise secured to the main shaft 12 and preferably located close to one side of the cam 61. This eccentric carries a strap 73, and radially extending from this strap are preferably two arms 74 and 75, arranged diametrically opposite each other.

76 indicates a lug formed on the strap 73, and to said lug is pivotally secured one end of a rod or link 77. The outer end of this rod 77 is provided with a slot 78, and through this slot it is pivotally connected by a screw 79 to a regulating-lever 80, which is pivoted to a boss 81, formed on the cylinder-head, and is designed to coöperate with a notched segment 82. The upper end of the rod 80 is preferably provided with a manually-operated retaining-latch 81ª, coöperating with the notches in segment 82 for the purpose of holding the lever in its adjusted positions. It is obvious that in lieu of lever 80 a centrifugal ball-governing device could be used, if desired, to throw the eccentric-strap when the speed of the engine is excessive.

83 and 84 indicate curved levers pivoted at 85 and 86, respectively. These pivot-points, as well as the levers themselves, are arranged, preferably, diametrically opposite each other. The longer end of the lever 83 is provided with a slot 87, said slot being T-shaped at its outer end, and into said slot the outer end of the arm 74 is bent. The longer end of the arm 84 is also provided with a slot 88, which is also T-shaped at its outer end, and through said slot 88 extends the outer bent end of the arm 75. The shorter member of the arm 83 has pivotally secured thereto a link-rod 89, the other end of which is secured to the crank 60, and the shorter member of the arm 84 has pivotally secured thereto a link-rod 89ª, the other end of which rod 89ª is secured to a crank 60ª, which corresponds with the crank 60, only at the other side of the engine.

68ª and 69ª indicate link-rod connections, one end of each being secured to the cranks 58ª and 59ª, respectively. The other or upper ends of said link-rods 68ª and 69ª are provided with cam-rolls 66ª and 67ª, said cam-rolls being located within the cam-groove 62 and upon the opposite side of the disk 61 from the cam-rolls 66. These parts are designed to operate the lower set of valves similar to the corresponding parts just described.

The operation of the engine is as follows: The engine is started in either direction by the manipulation of the controlling-lever 29, and in Figs. 1 and 2 this controlling-lever has been thrown in the proper direction to cause the throttle-valve 26 to be thrown to the right and the throttle-valve 28 to the left. This operation will cause the piston of the engine to travel in the direction indicated by the arrows. The port 46 of valve 28 is now in registration with the port 14 of the cylinder, and the port 46ª of the valve 26 is in registration with the port 17 of the cylinder, and the valve 28 has moved in such a direction as to open the cylinder-port 15, making this port an exhaust-port. Likewise the port 16 of the cylinder is opened as an exhaust. The movement of the valves in the direction before mentioned will blind the port 47 of the valve 28 and also the port 47ª of the valve 26, and when the cut-off valves contained within the throttle-valves 26 and 28 are in the position shown in Fig. 2 an uninterrupted steam communication will be made between the interior of the throttle-valves and the steam-space of the engine. The feathered arrows in Figs. 1 and 2 indicate live steam and the featherless arrows indicate exhaust-steam. It will be seen that the steam, as indicated by the feathered arrows, is entering the cylinder of the engine behind the piston-heads 7 and 8 in such a direction as to cause said steam to exert pressure behind said piston-heads and force the piston to revolve in the direction indicated. As the engine takes and exhausts steam simultaneously twice during every revolution of the main shaft, it is essential to cut off the steam from the steam-space 11 when the piston-heads are under the abutments 5 and 6

in order to prevent live steam from running through the engine, as will be readily understood by a glance at Fig. 2. In order to close the admission-ports when the piston-heads are not in the proper position to receive the pressure of steam behind them, we provide the primary cut-off valves 44 and 45, which, as stated, are provided with suitable racks, which racks are in mesh with pinions arranged on the shafts 33 and 34, and as these shafts 33 and 34 have arranged on their outer ends cranks 58 and 59, the outer ends of which are connected to the link-rods 68 and 69, said rods 68 and 69 being also provided with the cam-rolls 66 and 67, which travel in the cam-groove 62, the cam 61 will cause the shafts 33 and 34 to rock, the fluctuation in the cam-groove 62 being so located with respect to the position of the piston-heads 7 and 8 that steam will be cut off from the steam-space 11 just before the piston-heads pass the exhaust-ports in the cylinder of the engine, and during the travel of the piston-heads 7 and 8 from the exhaust-port until they again pass the live-steam port. Steam will thus be cut off until the next fluctuation in the cam-groove causes the shafts 58 and 59 to rock in the opposite direction, which will be done just after the piston-heads 7 and 8 have passed said live-steam ports, or, in other words, if the piston-heads are traveling in the direction indicated by the arrows in Figs. 1 and 2 the cam 61 will bear the relation to the piston-heads 7 and 8 as it does in Fig. 4, and when the portion of the cam-groove marked *x* coöperates with the cam-rolls 67 on the link-rod 69 the shaft 34 will rock and operate the primary cut-off valve 45, which will not accomplish anything, for the port which said valve 45 closes has already been blinded by the movement of the throttle-valve 28, and likewise when the portion marked *y* operates the cam-roll 67 and link 69 and shaft 34, which controls said valve 45, and throws it in the opposite direction to open the blind port nothing will be accomplished; but when the portion *x* of the cam-groove coöperates with the roll 67 on the link 68 the shaft 33 will be rocked, which will throw valve 44 to close the port 46. Likewise when the portion x^a of the cam-groove and the portion marked y^a coöperate with the link-rods 68^a and 69^a the primary cut-off valves 44^a and 45^a in the throttle-valve 26 will coöperate with their ports 46^a and 47^a in the same manner. As the rods 68 and 68^a and 69 and 69^a are arranged at equal distances from a vertical line through the center of the engine and as the cam-groove is regular, inasmuch as its portions 63 and 64 are concentric, it is obvious that the same result will be attained when the engine is caused to revolve in the opposite direction.

After the engine is started should the pressure be in excess of what is required by the load being carried and it is desired to have the engine travel partially upon expansion the lever 80 is thrown outwardly a notch or two, which brings the arms 74 and 75 into operative relation to the slots 87 and 88 of the arms 83 and 84. The T-heads of the slots 87 and 88 permit the arms 74 and 75 to move idly until the rotative position of the strap is changed, as above described, which will cause the arms 83 and 84 to rock or vibrate and, through their link connections, cause the shaft 56 to rock and throw the secondary cut-off valves through the intermediacy of the racks and pinions coöperating therewith, thus partially throttling the steam to the engine. When it is desired to rely upon expansion to a still greater extent, the lever 80 may be adjusted another notch or two, which will rock the eccentric-strap on its eccentric a still greater distance. This will bring the arms 74 and 75 closer to the pivot-points 85 and 86 of the arms 83 and 84 and give said arms a greater vibration or rocking movement, which will move the secondary cut-off valves a greater distance, as is obvious. By adjusting the position of lever 80 the throw of these valves is regulated or varied.

In Figs. 5 and 6 of the drawings we have shown a slight modification in the auxiliary or secondary cut-off valves, wherein we give said valves a lap in their closed position over the port or ports in the throttle-valve. While the construction shown in Figs. 1, 2, and 3 of the drawings illustrates the principle of throttling these ports, still the operation or movement of the eccentric and its strap is such that in the first eighth of a revolution, starting from the position shown, the eccentric-strap travels in a right line quite slowly and only about one-half the distance that it does in its more rapid travel in the second eighth of the revolution—that is, when the eccentric and its strap, together with the arms on said strap, are in the position shown in Fig. 4 said strap and its arms have been thrown to its extreme limit to the left—and when the eccentric rotates through its first eighth the end of the arm is moved, we will say, one-half an inch in a horizontal line; but when the eccentric proper rotates its second eighth the end of the arm on the eccentric-strap will have moved one and one-half inches altogether, or one inch more. In its first eighth the eccentric-strap only traveled one-half an inch and that quite slowly when compared with its greater movement in the next eighth. The third eighth is correspondingly rapid, gradually decreasing until the turning-point of the strap is reached at the end of the fourth eighth, or one-half a revolution. It is the second and third eighths which we wish to take advantage of in having the secondary auxiliary cut-off valve pass the port, as it is desirable that this port should be throttled quickly when the valve moves its full stroke—that is, the lever 80 is thrown to its last notch—and it is desired to throttle the steam to the greatest extent, and to accomplish this we have made the ends of the secondary slide-valves considerably longer than the ports

which they are intended to cover, whereby the slow movements of the first and last eighths of the eccentric in the half-revolution under consideration are utilized in traveling over the lap, and when it passes the port, either in opening or closing the same, the second and third eighths impart a quick movement thereto. When the lever 80 is in its first notch, the stroke of the valves is very slight, not even covering the port; but as lever 80 is moved farther back the stroke is increased until the valves vibrate quickly over the port, opening and closing the same twice during each revolution of the piston and admitting comparatively but little steam to the engine and that immediately after the piston-heads pass their respective ports and abutments, after which when the steam is cut off the expansion of the steam in the spaces 11 is utilized to drive the piston.

While we have shown a duplex engine in the drawings—that is, the valves are duplicated for the two piston-heads—it will be obvious that if three or more piston-heads were employed the parts could be triplicated or multiplied to correspond with the required conditions. On the other hand, it might be found desirable in some instances to construct an engine with a single piston-head and valve motion, all of which changes, with their accompanying details, will be readily understood by skilled mechanics. Also, it is desirable, as the engine shown has a dead-point, when the two piston-heads are on the abutments to couple two engines on the same shaft, the piston-heads of said engine being out of alinement or arranged at an angle to each other.

We are aware that many minor changes in the construction, arrangement, and combination of the several parts of our engine can be made and substituted for those herein shown and described without in the least departing from the nature and principle of our invention.

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

1. In a rotary engine, the combination with the cylinder formed with an abutment and ports, of a main shaft, a rotating piston in said cylinder and mounted on said shaft, a piston-head slidingly mounted in said piston, a hollow throttle-valve coöperating with the cylinder-ports, said valve forming a steam-chest, a plurality of cut-off valves arranged in said throttle-valve for controlling the cylinder inlet-port, and valve-operating mechanisms for actuating said cut-off valves independently of each other, substantially as described.

2. In a rotary engine, the combination with the cylinder formed with an abutment and ports, of a main shaft, a rotating piston in said cylinder and mounted on said shaft, a piston-head slidingly mounted in said piston, a hollow throttle-valve coöperating with the cylinder-ports, said valve forming a steam-chest, a primary cut-off valve in the throttle-valve for controlling the admission of pressure into the cylinder, means operated by the main shaft for positively operating said primary cut-off valve at each rotation of the piston, a secondary cut-off valve which, likewise, coöperates with the cylinder inlet-port, mechanism for operating this last-named valve, and means for throwing said mechanism into, or out of, operative engagement with said valve, substantially as described.

3. In a rotary engine wherein steam is admitted and exhausted more than once in every revolution of the main shaft, the combination with a cylinder, of a plurality of abutments formed therein, ports arranged on each side of said abutments, a rotary piston arranged inside of said cylinder and bearing against said abutments, a plurality of sliding piston-heads arranged in said piston, a plurality of reciprocating throttle slide-valves for admitting and exhausting pressure to and from the cylinder at different points, and a plurality of cut-off valves for cutting off said pressure fluid when the pistons are passing the abutments to prevent pressure fluid from running through the engine, substantially as described.

4. In a rotary engine wherein steam is admitted and exhausted more than once in every revolution of the main shaft, the combination with a cylinder, of a plurality of abutments formed therein, ports arranged on each side of said abutments, a rotary piston arranged inside of said cylinder and bearing against said abutments, a plurality of sliding piston-heads arranged in said piston, throttle slide-valves for admitting and exhausting pressure to and from the cylinder at different points, a plurality of cut-off valves arranged in said throttle slide-valves for coöperating with the ports thereof, means for reciprocating the throttle slide-valves to reverse the engine, and valve-operating mechanism for actuating said cut-off valves, substantially as described.

5. In a rotary engine wherein steam is admitted and exhausted more than once in every revolution of the main shaft, the combination with a cylinder, of a plurality of abutments formed therein, ports arranged on each side of said abutments, a rotary piston arranged in said cylinder and bearing against said abutments, a plurality of sliding piston-heads arranged in said piston, throttle-valves for admitting and exhausting pressure to and from the cylinder at different points, cut-off valves arranged in said throttle-valves for coöperating with the ports thereof, racks formed on said cut-off valves, pinions meshing with said racks, shafts upon which said pinions are secured, and means for coöperating with said cut-off valves for throttling the pressure fluid when said piston-heads are passing the abutments, substantially as described.

6. In a rotary engine wherein steam is admitted and exhausted more than once in every

revolution of the main shaft, the combination with a cylinder, of a plurality of abutments formed therein, ports arranged on each side of said abutments, a rotary piston arranged inside of said cylinder and bearing against said abutments, a plurality of sliding piston-heads arranged in said piston, throttle-valves for admitting and exhausting pressure to and from the cylinder, primary cut-off valves arranged in said throttle-valves for coöperating with the inlet-ports thereof, racks formed on said cut-off valves, pinions meshing with said racks, shafts upon which said pinions are secured, cranks on said shafts, a disk secured to the main shaft of the engine, a cam-groove formed in the face of said disk, cam-rolls cooperating with said cam-groove, and links on which said cam-rolls are journaled, said links being, also, connected to the cranks on the shafts controlling the cut-off valves, whereby, when a proper fluctuation in the cam-groove coöperates with the cam-rolls on the end of the links, the cut-off valves will be moved in the proper direction to throttle the pressure fluid when the piston-heads are passing the abutments, substantially as described.

7. In a reversible rotary engine, the combination with a cylinder, of a piston, piston-heads, abutments in said cylinder, a cam-groove for causing said piston-heads to pass the abutments, ports arranged on each side of said abutments, hollow throttle-valves, primary cut-off valves arranged inside of said throttle-valves for cutting off the pressure fluid when the piston-heads are passing the abutments, secondary cut-off valves for throttling the pressure fluid to utilize the expansive properties of the motive fluid, and means for regulating the throw of said secondary cut-off valves, substantially as described.

8. In a reversible rotary engine, the combination with a cylinder, of a piston, piston-heads, abutments in said cylinder, a cam-groove for causing said piston-heads to pass the abutments, ports arranged on each side of said abutments, hollow throttle-valves, primary cut-off valves arranged inside the throttle-valves for cutting off the pressure fluid when the piston-heads are passing the abutments, secondary cut-off valves for throttling the pressure fluid to utilize the expansive properties of the motive fluid, a rack formed on each of said secondary valves, a pinion meshing with both of said racks, a shaft upon which said pinion is mounted, and means for regulating the throw of said secondary valves, substantially as described.

9. In a rotary engine, the combination with a cylinder, of a piston, piston-heads, abutments in said cylinder, a cam-groove for causing the piston-heads to pass the abutments, ports arranged on each side of the abutments, throttle-valves, primary cut-off valves arranged inside the throttle-valves for cutting off the pressure fluid when the piston-heads are passing by the abutments, secondary cut-off valves for throttling the pressure fluid to utilize the expansive properties of the motive fluid, a rack formed on each of said secondary cut-off valves, a pinion meshing with both of said racks, a shaft upon which said pinion is mounted, an eccentric mounted on the main shaft of the engine, an eccentric-strap provided with arms, coöperating with said eccentric, curved levers so pivoted and arranged in juxtaposition to said eccentric as to coöperate therewith, slots formed in one of the ends of said levers, said slots receiving the outer or free ends of the arms formed on the eccentric-strap, cranks secured to the shaft which controls the secondary cut-off valves, links connecting the free ends of said cranks to one of the ends of said slotted curved levers, and means for adjustably moving said eccentric-strap and its carried arms on said eccentric, whereby, when said eccentric-strap is moved in the proper direction, the throw of the eccentric will cause the slotted pivoted levers to rock, which, in turn, actuate the secondary cut-off valves, causing the same to throttle the pressure fluid, substantially as described.

10. In a rotary engine, the combination with a cylinder, of a piston, piston-heads, abutments in said cylinder, a cam-groove for causing the piston-heads to pass the abutments, ports arranged on each side of the abutments, throttle-valves, primary cut-off valves arranged inside the throttle-valves for cutting off the pressure fluid when the piston-heads are passing the abutments, secondary cut-off valves for throttling the pressure fluid to utilize the expansive properties of the motive fluid, a rack formed on each of said secondary cut-off valves, a pinion meshing with both of said racks, a shaft upon which said pinion is mounted, an eccentric mounted on the main shaft of the engine, an eccentric-strap provided with arms, coöperating with said eccentric, curved levers so pivoted and arranged in juxtaposition to said eccentric as to coöperate therewith, T-shaped slots formed in one of the ends of said levers, said slots receiving the outer ends of the arms formed on the eccentric-strap, whereby said arms normally move idly in the wider spaces of the slots, cranks secured to the shaft which controls the secondary cut-off valves, links connecting the free ends of said cranks to one of the ends of said slotted curved levers, and means for adjustably moving said eccentric-strap and its carried arms on said eccentric, whereby, when said eccentric-strap is moved in the proper direction, said arms will be thrown into the narrower spaces of the slots, and the throw of the eccentric will engage the arms, and cause the slotted pivoted levers to rock, which, in turn, actuate the secondary cut-off valves, causing the same to throttle the pressure fluid, substantially as described.

11. In a valve mechanism, the combination with a hollow throttle-valve and its ports, of

primary cut-off valves arranged therein, racks formed on said cut-off valves, pinions meshing with said racks, a shaft journaled in the throttle-valve, and upon which are mounted said pinions, secondary cut-off valves, a rack formed on said secondary valves, a pinion so meshing with said racks that a rotary movement of said pinion in one direction will cause said racks and their respective valves to move in opposite directions, and a shaft which is journaled in said throttle-valve and upon which said last-mentioned pinion is secured, substantially as described.

In testimony whereof we hereunto affix our signatures, in the presence of two witnesses, this 28th day of October, 1898.

JOHN W. PICKEL.
ROBERT SNYDER.

Witnesses:
JOHN V. HAEFNER,
FRANK HAEFNER.