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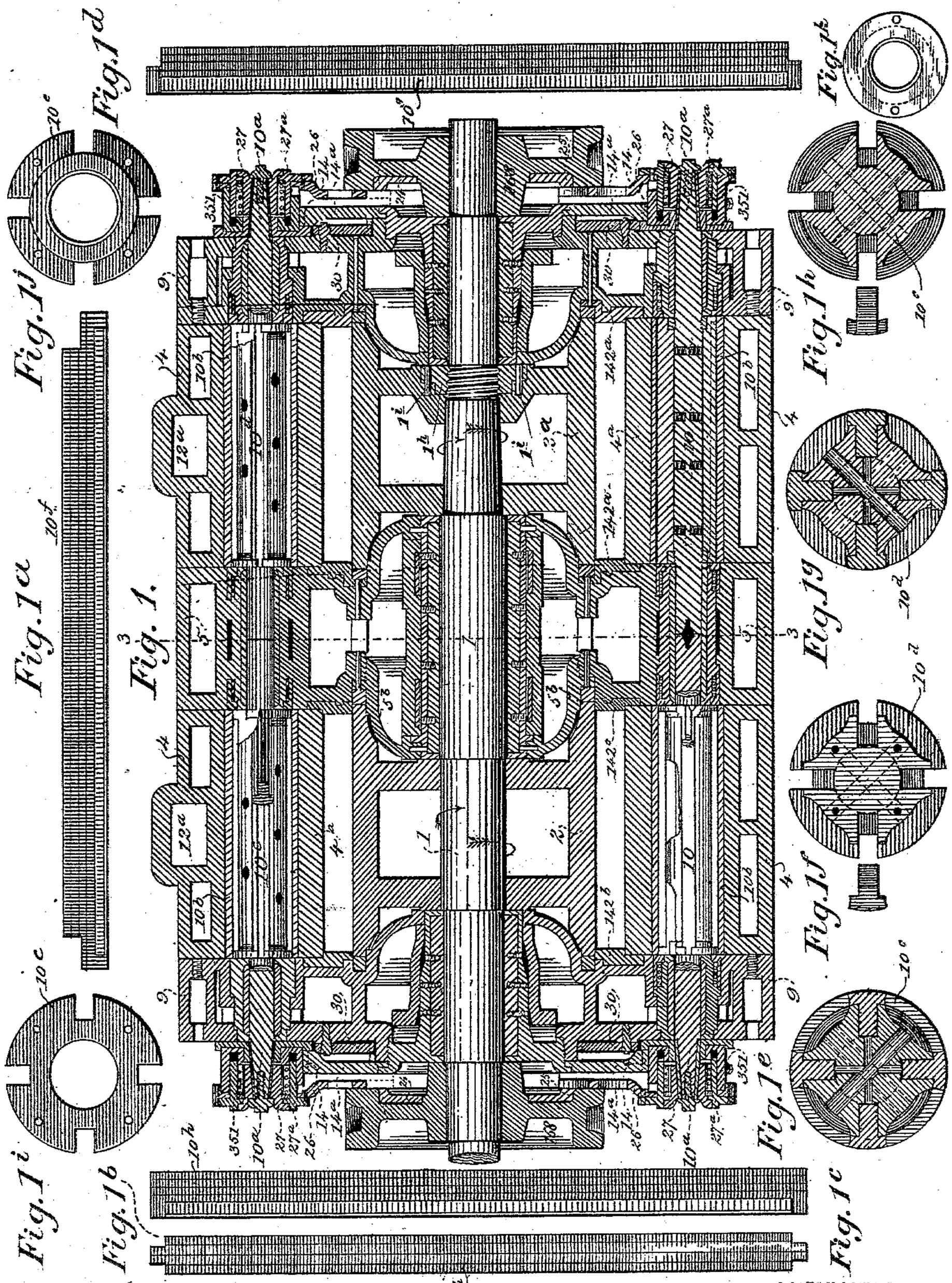
I. N. FORBES.

ROTARY ENGINE.

No. 274,477. Patented Mar. 27, 1883.



WITNESSES:

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Fred'k L. Foster.

INVENTOR

Isaac N. Forbes.

By his Attorneys Knight Bros

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6 Sheets—Sheet 2.

I. N. FORBES.

ROTARY ENGINE.

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Fig. 21.

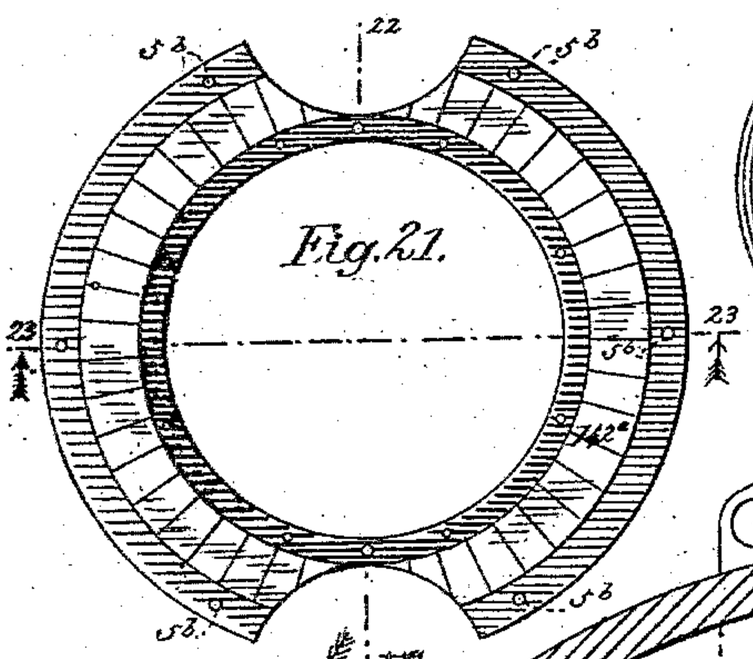


Fig. 27.

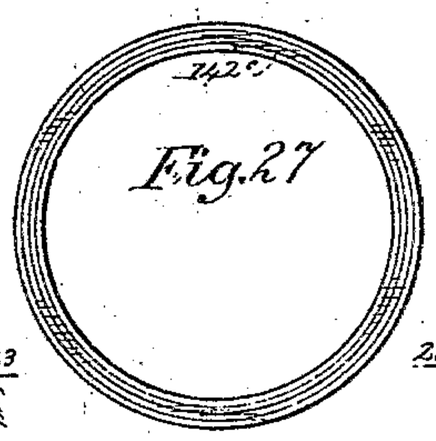


Fig. 24.

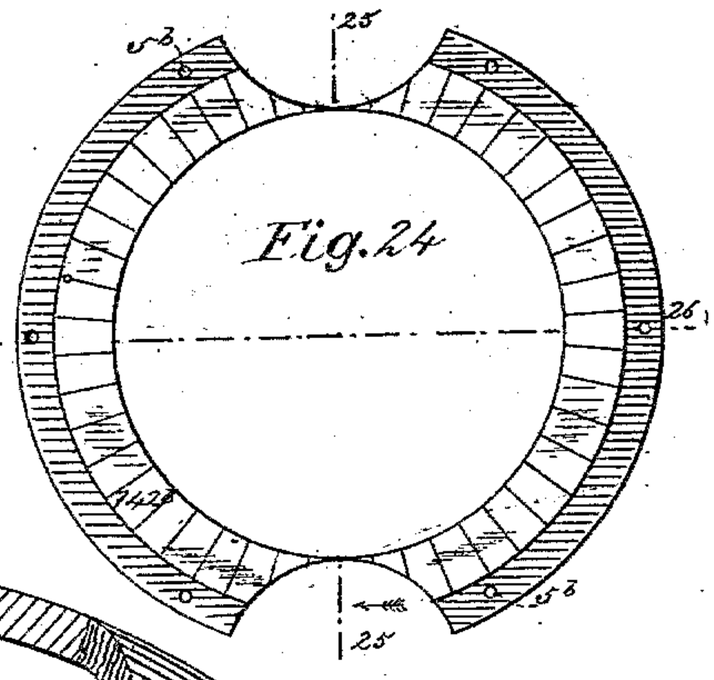


Fig. 2.

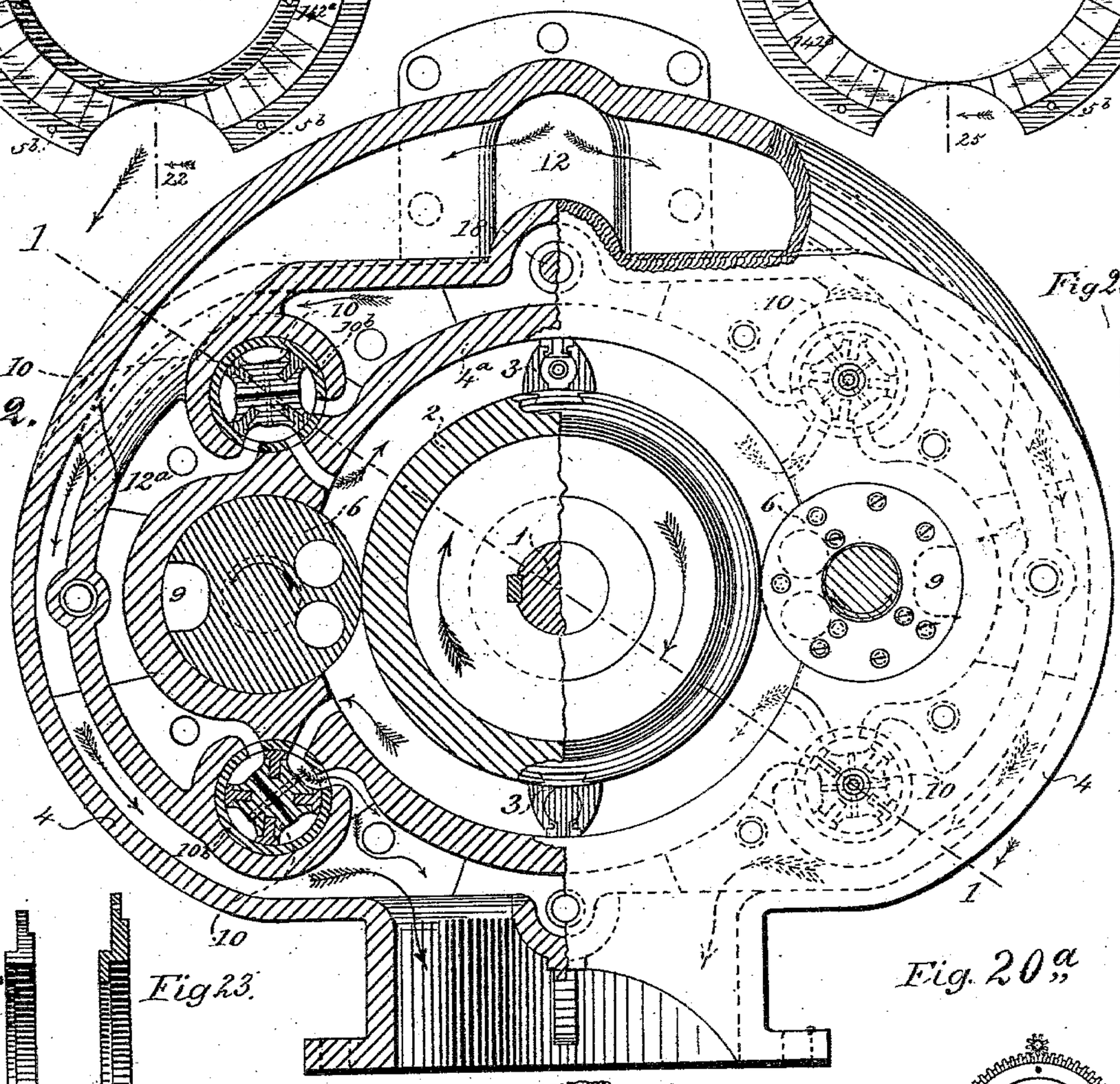


Fig. 26.

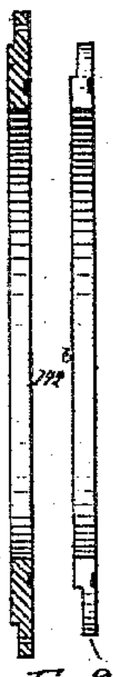


Fig. 25.

Fig. 22.

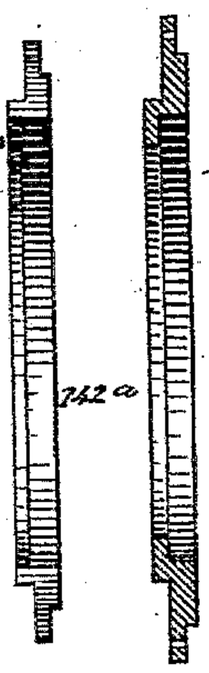


Fig. 23.

Fig. 20a.

Fig. 20.

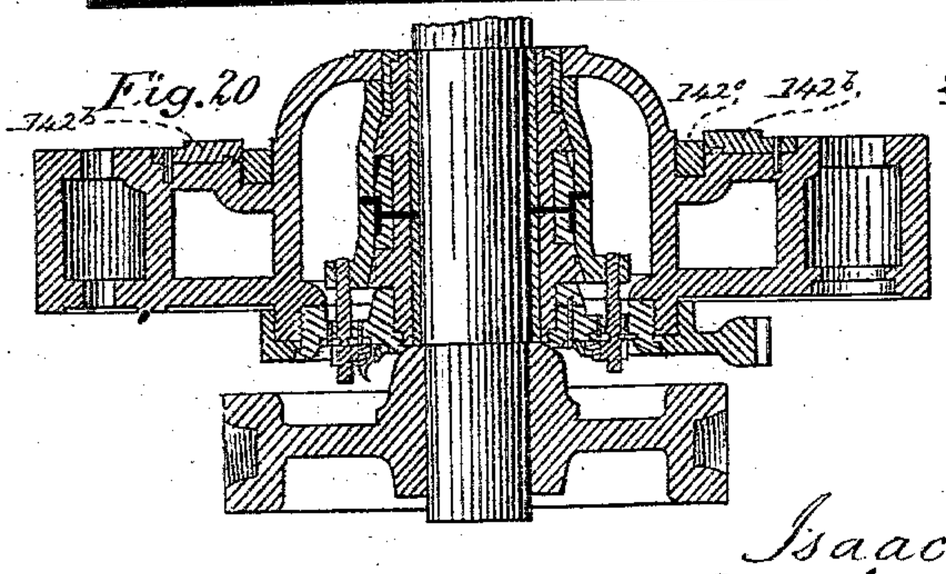
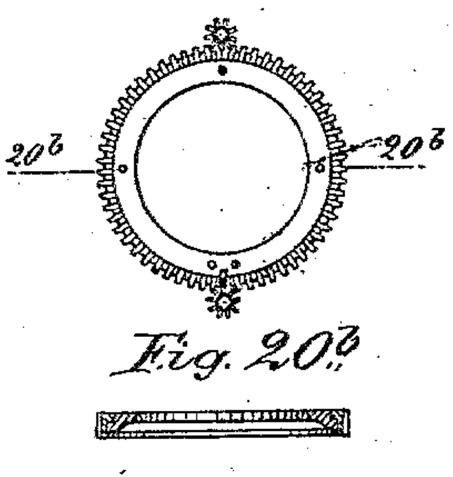


Fig. 20b.



WITNESSES

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ROTARY ENGINE.

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Fig. 4.

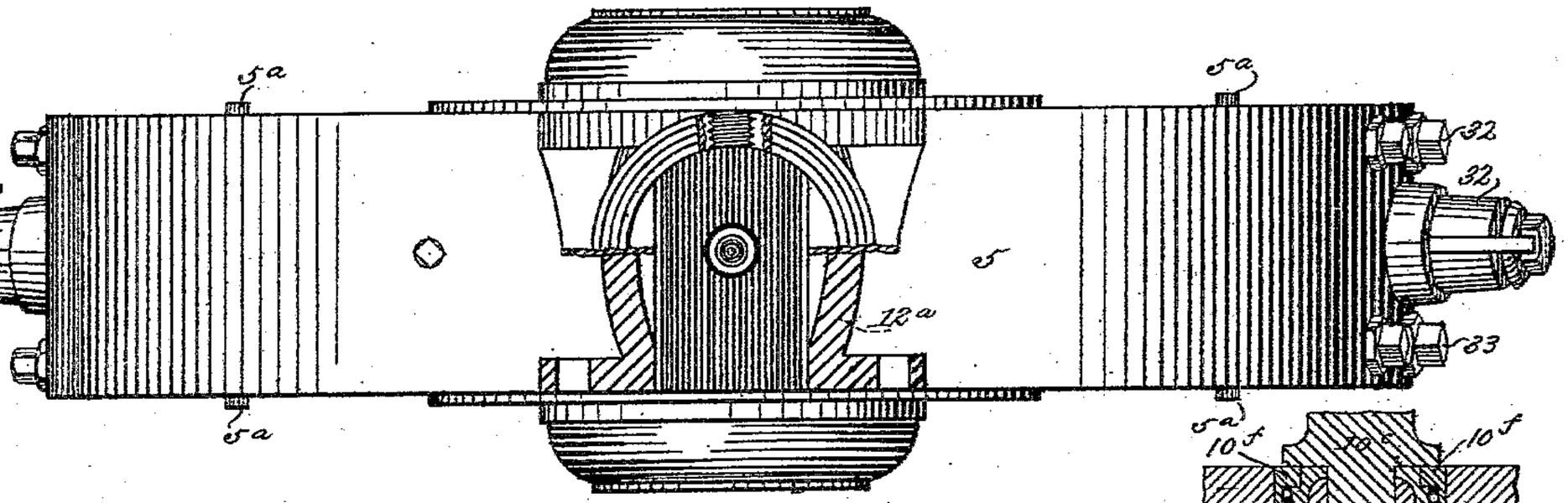

Fig. 19.

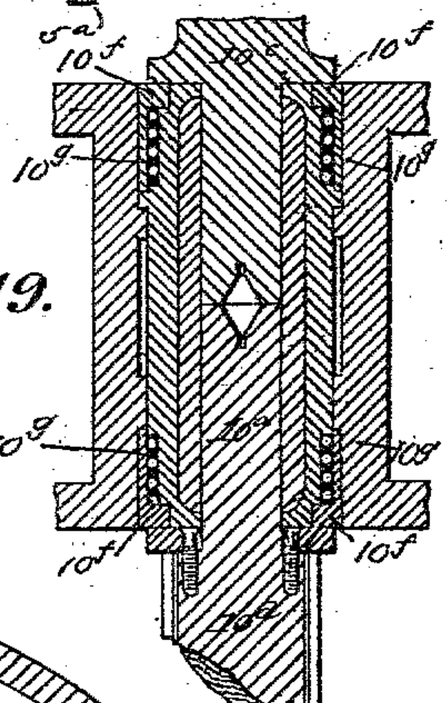

Fig. 3.

WITNESSES

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ROTARY ENGINE.

No. 274,477. Patented Mar. 27, 1883.

Fig. 5.

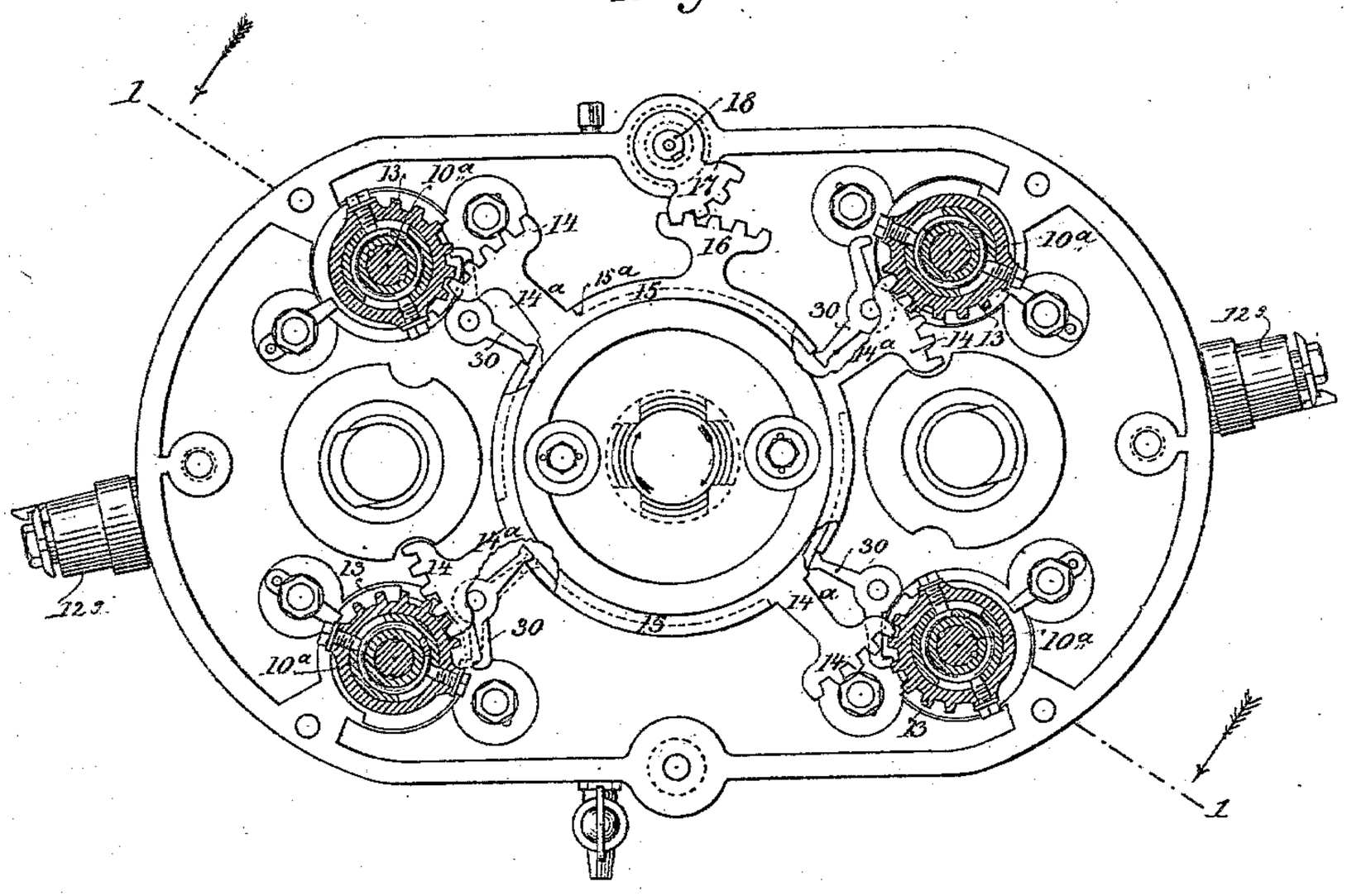


Fig. 6.

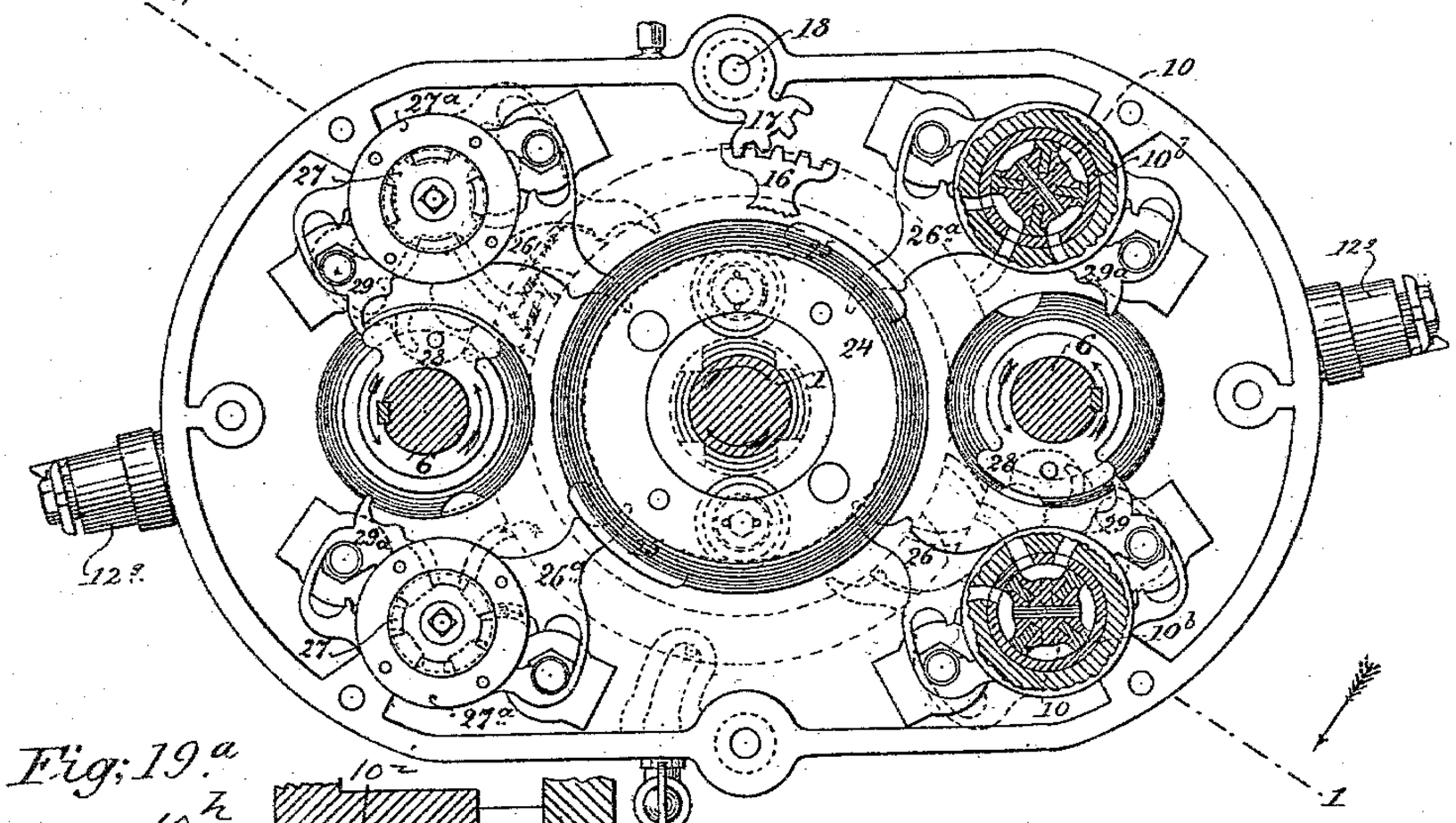
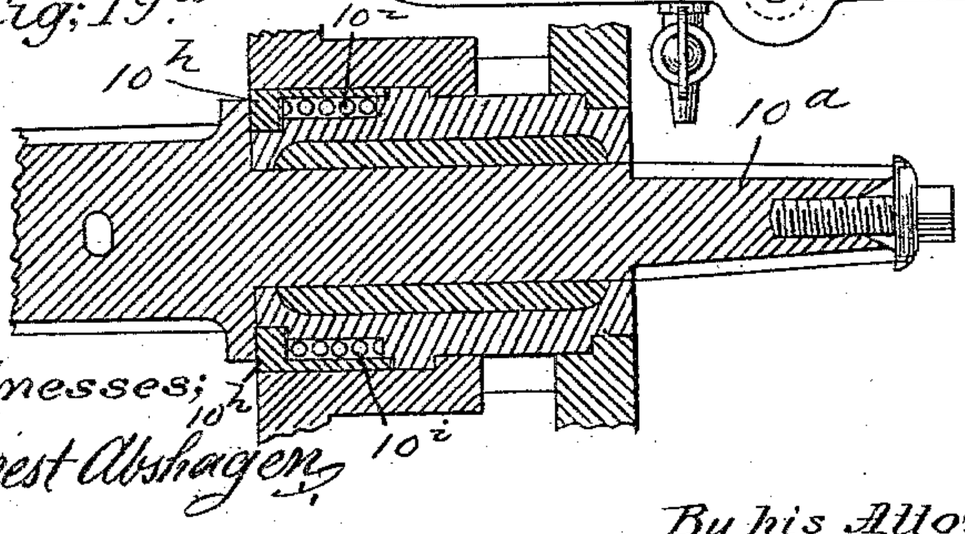


Fig. 19a



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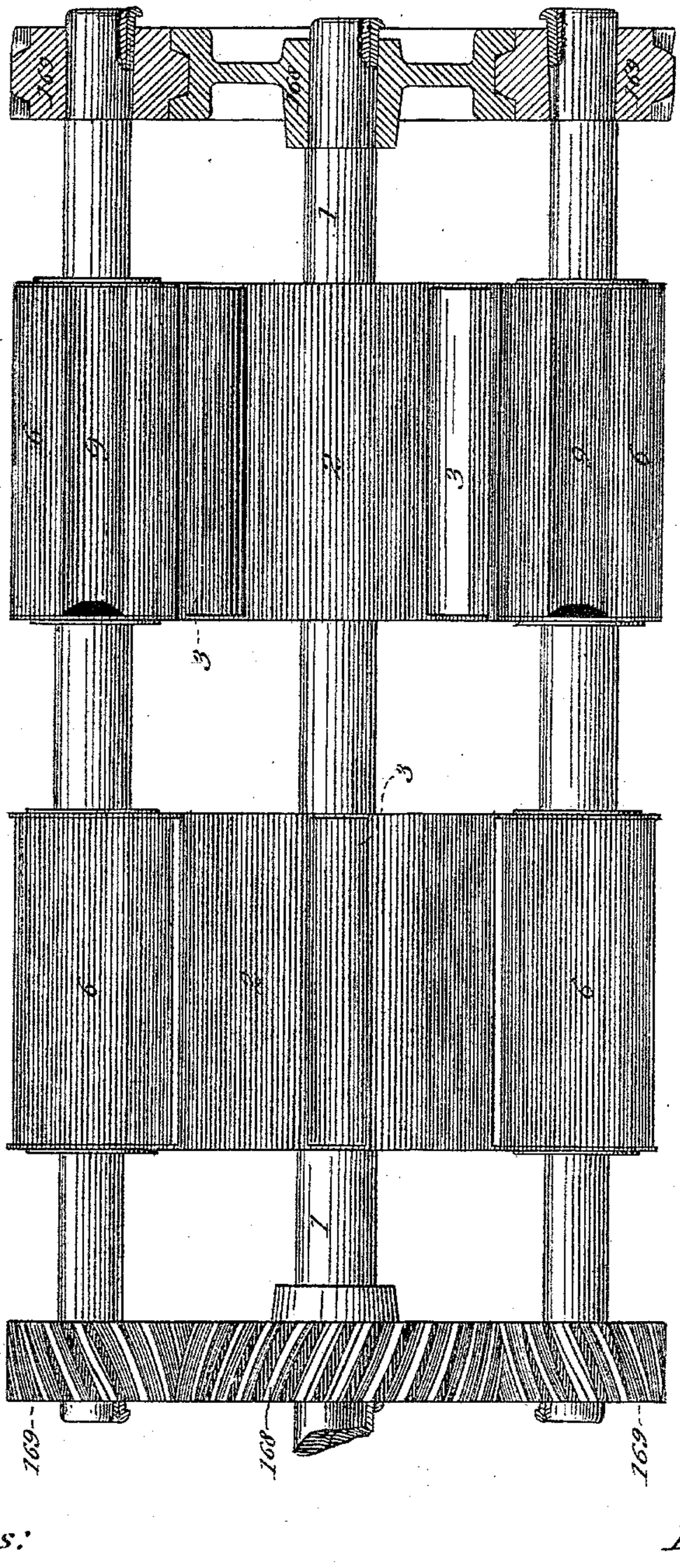
I. N. FORBES.

ROTARY ENGINE.

No. 274,477. Patented Mar. 27, 1883.

Fig. 7.



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(No Model.) 6 Sheets—Sheet 6.

I. N. FORBES.

ROTARY ENGINE.

No. 274,477. Patented Mar. 27, 1883.

Fig. 8.

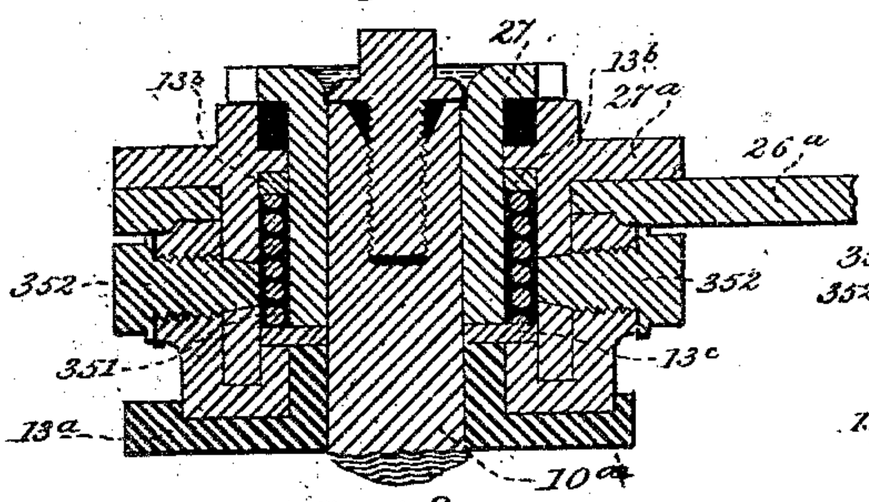


Fig. 9.

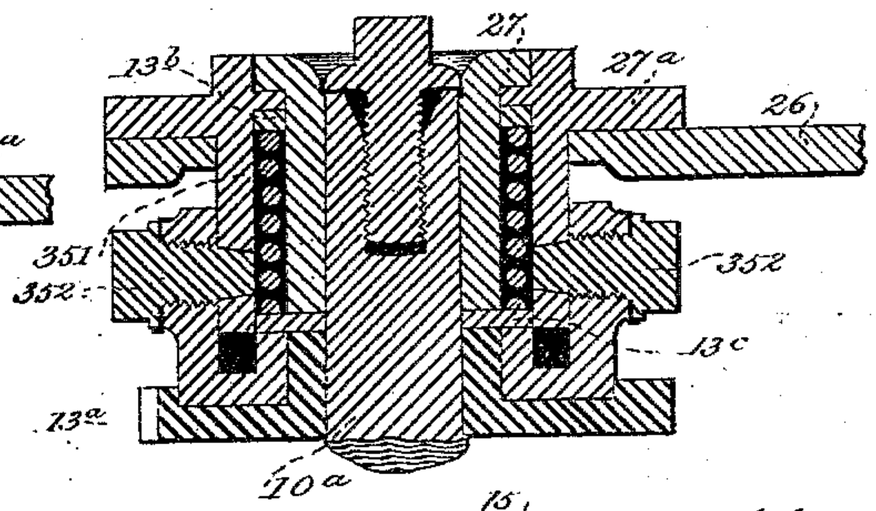


Fig. 10.

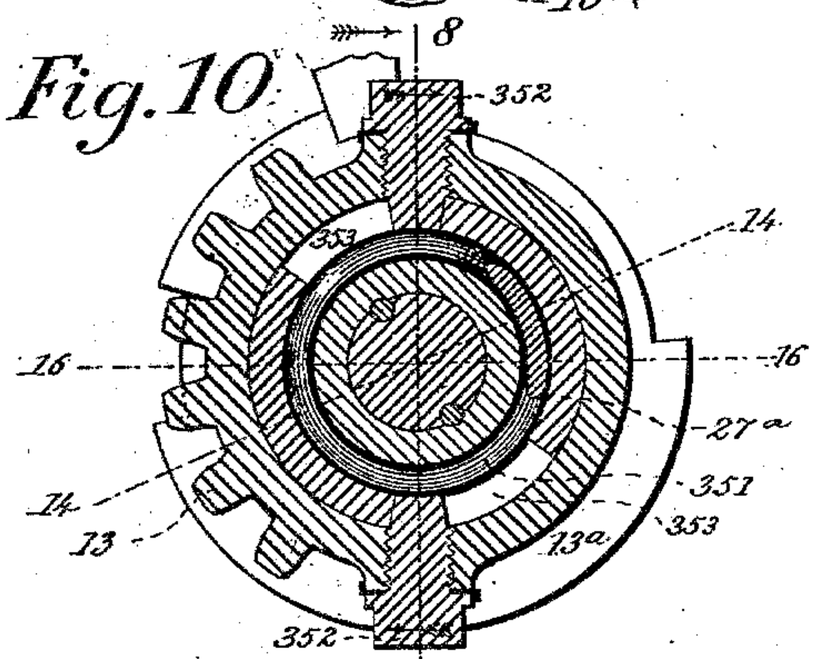


Fig. 11.

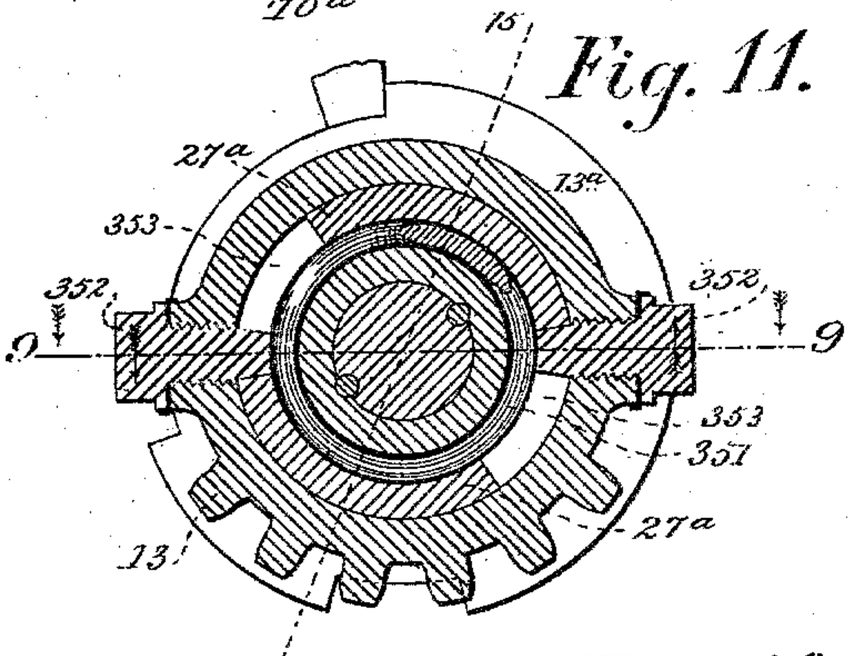


Fig. 12.

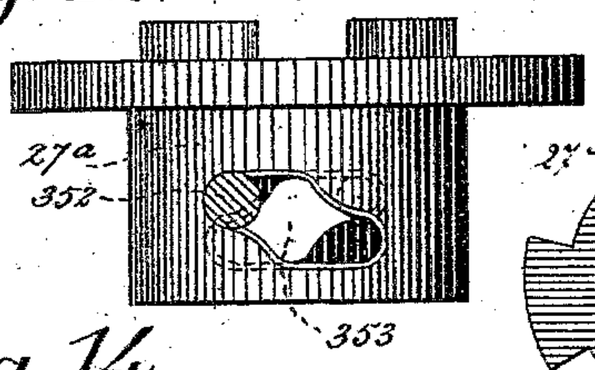


Fig. 13.

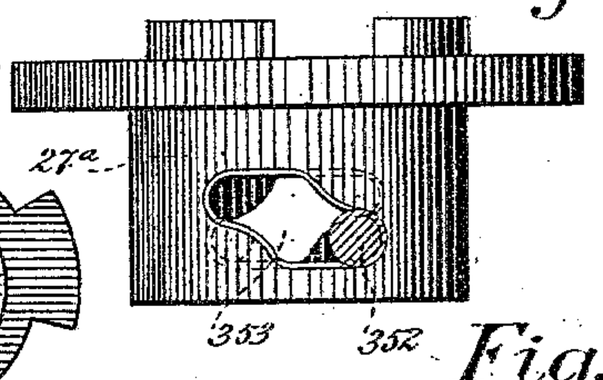


Fig. 18.

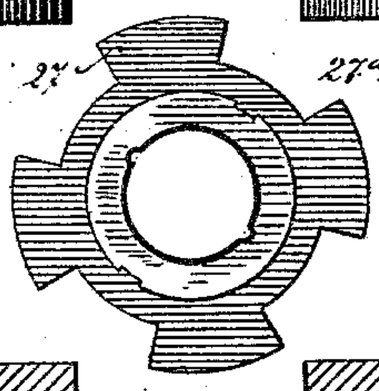


Fig. 14.

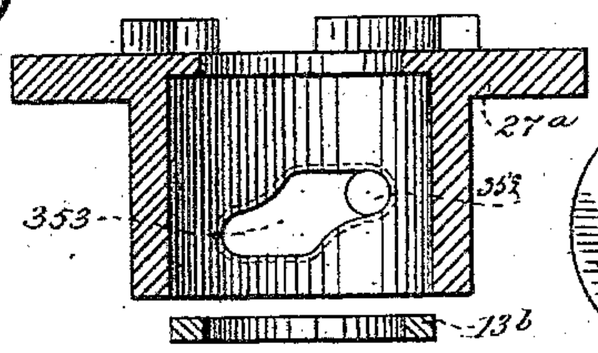


Fig. 18a.

Fig. 15.

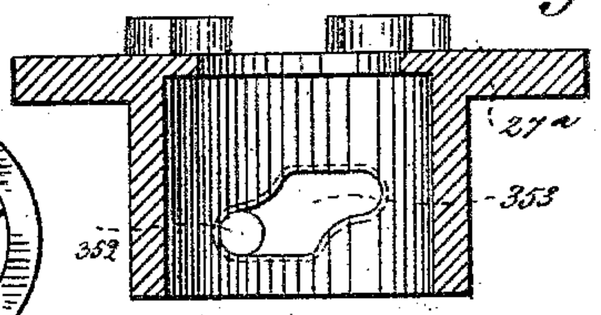


Fig. 16.

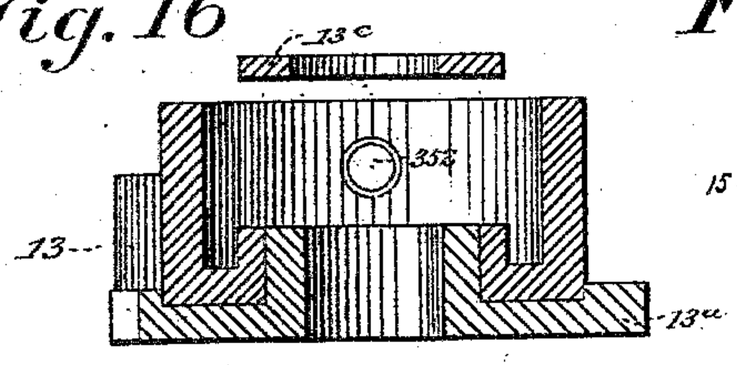
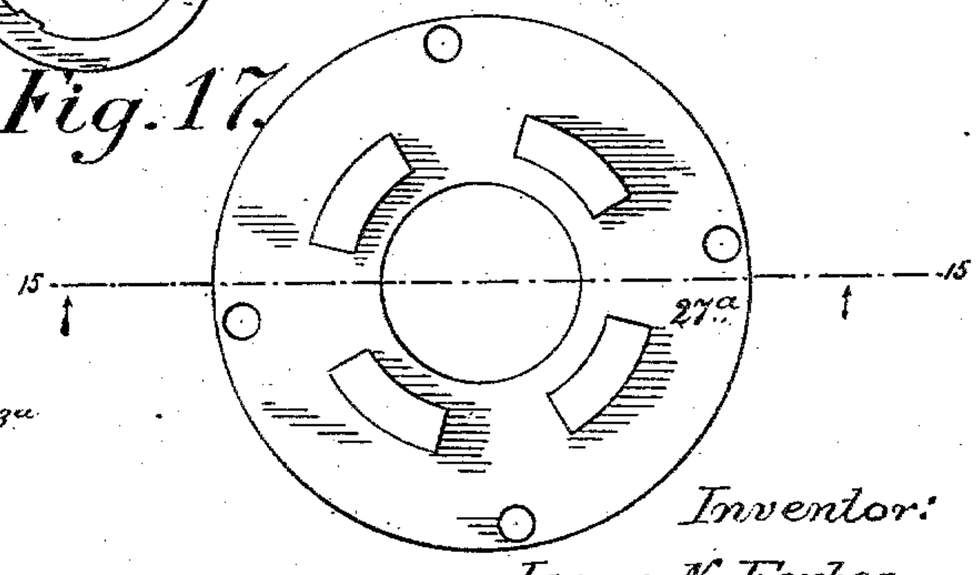


Fig. 17.



Witnesses.
Ernest Olshagen.
Fred: L. Foster.

Inventor:
Isaac N. Forbes,
By his Attorneys Knight Bros

UNITED STATES PATENT OFFICE.

ISAAC NEWTON FORBES, OF LAWRENCE COUNTY, DAKOTA TERRITORY.

ROTARY ENGINE.

SPECIFICATION forming part of Letters Patent No. 274,477, dated March 27, 1883.

Application filed July 26, 1882. (No model.)

To all whom it may concern:

Be it known that I, ISAAC NEWTON FORBES, of Lawrence county, in the Territory of Dakota, temporarily residing at Washington, in the District of Columbia, have invented a new and Improved Trochilic or Rotary Engine, of which the following is a specification.

The subject of my invention is a double reversible cut-off trochilic or rotary engine admitting steam or other motor-fluid into the cylinders at the most desirable points between the heads thereof.

The main features of this invention consist in the construction of a double engine with two cylinders and three heads, with two piston-wheels upon the same shaft, and two piston-teeth at diametrically opposite points from each other on the same piston-wheel, in combination with four abutment-rollers, two for each respective piston-wheel, which abutment-rollers are recessed for the passage of the piston-wheel teeth, and four fourfold cut-off valves for each cylinder. The positions of each pair of teeth in the respective wheels are at right angle to each other. Steam is admitted into an annular space in the cylinder, in which the piston-teeth rotate in close proximity to the abutment-rollers, and is exhausted at diametrically-opposite points from each other.

In the accompanying drawings, Figure 1 is a longitudinal section through the valves on the line 1 1, Fig. 2. Fig. 1[a] to 1[h], inclusive, illustrate detail views of the valves used in this engine. Fig. 1[k] is a full face view of the nut securing the piston-wheel to its longitudinal position upon the main shaft. Fig. 2 is a cross-section through the casing and cylinder, illustrated partly in full, with abutment-rollers, piston-wheels, valves, &c. Fig. 3 is a cross-section, partly in full, through the center head of the engine. Fig. 4 illustrates a top view of the same, partly in section. Fig. 5 is an outside view of one of the outer heads, illustrating the reversing-gear and the valve-stems in place, partly in section. Fig. 6 is an outer view of an outer head, with a part of the cylinder beneath, with valves in position, piston-wheel, and abutment-rollers and their tappets and their valve-lever arms in position relative to the valves and the parts in the cylinder, with the head over two valves broken through down into the cylinder, showing the steam-ports and valves in position and the valve and valve-casing in section. Fig. 7 is a plan view of the piston-wheels complete, with abutment-rollers and helical gearing upon one end illustrated in section. Fig. 8 is a longitudinal section, on the line 8 8, Fig. 10, of mechanism for throwing the cut-off-valve levers in and out of gear in reversing the engine, as hereinafter described, the mechanism being here shown out of gear. Fig. 9 is a longitudinal section of the same parts on the line 9 9, Fig. 11, showing the mechanism in gear. Figs. 10 and 11 are transverse sections of the same parts in the position shown in Figs. 8 and 9, respectively. Figs. 12 and 13 are elevations of a cam-sleeve clutch for throwing the valves in and out of gear, showing the cam-pins in the different positions which they occupy in throwing the valves in and out of gear, Fig. 12 being viewed at right angles to dotted lines 14 14, Fig. 10, and Fig. 13 being viewed at right angles to dotted lines 15 15, Fig. 11. Figs. 14 and 15 are longitudinal sections of the same parts in the position shown in Figs. 12 and 13, respectively. Fig. 16 is a longitudinal section of the reversing toothed gear on dotted lines 16, Fig. 10, of the reversing-gear case 13[a]. Fig. 17 is a top view of the clutch-sleeve 27[a]. Fig. 18 is a bottom face view of the clutch-sleeve 27. Fig. 18[a] is a feathered ring fitting on the sleeve part of the clutch 29. Fig. 19 is a sectional view of the ends of the valve-stems, showing portions of the two kinds of frames, valve-journals and their bearings, packing-rings, springs, and a broken portion of the center head. Fig. 19[a] is a sectional view of the end of the valve-frame broken away, valve and stem and bolt, with bearings, packing-ring, spring, and part of the outside head. Fig. 20 is a detached vertical central sectional view of one of the end heads with main shaft bearing complete, and a portion of the main shaft broken, in position, reversing-gear and adjustable bolts, and main gear, which connects the abutment-roller gears and drives them, also the surface-bearing pieces and packing-rings. Fig. 20[a] is a full view of a toothed gear connecting the two adjusting screw-bolts for turning both by the application of the wrench to one, if desired, thus insuring the equal draft upon both sides of the adjusting-ring for pressing the bearings alike upon each side of the main shaft at the same

time, shown in position in Fig. 20. Fig. 20[b] is a section of the same on dotted line 20[b] in Fig. 20[a] in position in a broken portion of the bearing-case. Fig. 21 is a plan view of the removable surface-piece constructed in one part. Figs. 22 and 23 are sectional views of the same on the lines 22 23, respectively, Fig. 21. Fig. 24 is a plan view of the surface-piece constructed in two parts, designed for the same purpose. Figs. 25 and 26 are sectional views of the same on lines 25 and 26, respectively, Fig. 24. Fig. 27 is a plan view of one of the main packing-rings, showing water-creases.

To the main shaft 1 are secured two piston-wheels, 2 2[a], each provided with two diametrically-opposite piston-teeth, 3, rotating within cylinders 4, separated by a central head, 5, so as to form a double engine, the teeth 3 on one piston-wheel being arranged opposite the center of the spaces between the teeth of the other wheel.

6 6 are abutment-rollers, provided with a recess, 9, to permit the passage of teeth 3 in each one, respectively. The said abutment-rollers are connected by gearing 168 169 with the piston-wheels 2 2[a], so as to rotate in unison therewith, avoiding slip between their peripheries. One of the piston-wheels, 2, is preferably keyed firmly to the shaft, while the other, 2[a], is being pressed upon a tapered part of the shaft, being properly fitted and grooved at the inner end, which fits on stops secured in the shaft. The shaft is provided at the small end of the tapered portion with a screw-thread, and a nut (see Figs. 1 and 1[k]) is screwed on the thread against the head of the piston-wheel. The piston-wheel is provided with a boss inside corresponding with the recess for the nut outside, and, being properly tapered, will fit tightly upon the shaft. The nut 1[h] is prevented from unscrewing by means of a hollow pin, 1[i], which fits a hole through the nut, passing into the wheel. This pin is provided with a thread inside, by which it is withdrawn when required. The inlets 12 admit steam to the induction-passages 12[a] at points in the respective cylinder-casing 4 4 midway or at other desirable points between the central and end heads thereof. The center head is cast hollow for the reception of oil or other lubricant, the outer surfaces being properly connected within, as illustrated, thus affording strength. These connections are more fully shown and described in other applications of even date herewith. One of the convex surfaces of this head is formed of a separate piece for the purpose of inserting the center bearing, after which the separable convex piece 5[b] (see Fig. 1) is screwed in the head on the end of the bearing-case, thus completing the head as though cast in one piece. The movable part is held from turning by pins extending into the head. The bearing-case is also held from turning by pins in the head, as shown in Fig. 1. The convex projections on each face of the center head extend in the concaved ends of the piston-wheels. The outer heads are provided with like convex projections upon their inner surfaces, which extend into the opposite concaved ends of the piston-wheels. The main-shaft bearings are located in the respective heads, and extend in the convex portions of the heads, thus allowing length of bearings and length and area of piston-teeth, and consequently the greatest possible capacity of engine, without increasing the diameter or length thereof.

The surface-pieces 142, 142[a], 142[b], and 142[c] vary a little in their construction, as shown in Figs. 1, 21, 24, &c. They form surfaces for the ends of the teeth to work against, and are fitted in their respective heads, and project in the cylinders beyond the surface of their heads, and form concentric guides for the heads in relation to the cylinders, which insures for the shaft a central position thereto, without which it would be difficult to produce such results. Two classes of end surface-pieces are illustrated in Figs. 21 and 24. The end surface-piece, 142[a], is illustrated in Fig. 1 in its position in the engine, and in Figs. 21, 22, and 23 is shown in detail detached. The surface-piece fits in respective grooves in the heads, and is made of one piece, 142[b] and 142[c], as shown in Fig. 1 in its connection with the engine, as illustrated in Figs. 24, 25, and 26 in detail detached, and is constructed of two parts, and is so arranged as to serve the same purpose as the surface-piece 142[a], (shown in Fig. 1.) To prevent displacement, these surface-pieces are secured to the respective heads by means of dowel-pins 5[b], connecting the same.

32 represents movable portions of the head extending radially from the outer surface to the abutment-bearings, as shown in Figs. 3 and 4, for the purpose of permitting the center journals of the abutment-rollers to be inserted, after which the pieces 32 32 are replaced in their position, and secured to the head by bolts 33 33, as shown in the respective Figs. 3 and 4. These pieces 32 may have tongues upon each side, which fit corresponding grooves in their respective seats in the heads; or they may each be grooved, receiving a separate tongue inserted therein, which secures them in their proper positions laterally. This head is also doweled, as the end heads are, to the respective cylinders and casings, thus securing a central lateral position to all the respective bearings therein, except the main shaft, relative to the cylinders. The heads are all provided with automatic followers for setting up the adjustable bearing of the abutment-rollers, thus securing steam-tight joints between the abutment-rollers and piston-wheels, which is more fully described in other applications of even date herewith.

Fourfold oscillating valves 10 10, 10[c], and 10[d], which belong to each cylinder, vary a little in construction, as illustrated in Fig. 1 and in detail in Figs. 1[a] to 1[h], inclusive, and may be used collectively, or either construction may be used, as desired. They are arranged in pairs in cylindrical seats 10[b], two opposite valves for each cylinder being at one time for induction

and the other two opposite valves at the same time for exhaust. The valve-journals 10^a within the center head are arranged in a bearing end to end, as shown in Fig. 19. Packing-rings 10^f, pressed outward in opposite directions by springs 10^g, form tight joints with the collars of the valve-shafts. In like manner the end journals turn in bearings in the end heads, as shown in Fig. 19^a, and are packed by rings 10^h and springs 10^i. The valve-seats, when too small, or when desired for dressing the ports accurately, are bored out larger for the purpose of receiving bushings therein for forming the valve-seats. These ports are cut through corresponding with the ports of the engine and valves, with bridges connecting the bushing together at opposite sides of the ports corresponding with those in the main casing, thus uniting the bushing completely. The bridges will assist the ring in sustaining it to the bed in which it fits, preventing leakage between it and the cylinder-casing proper. These bushings may be removed and replaced by new ones when required. They should be of sufficient thickness to sit firmly upon their seats. Encircling each port in the valve-seat and the outer surface of the valve casing should be creases or water-cuts, to assist in forming steam-tight joints. It would be well, also, to insert water-creases in the valve-seats, at least one or two, near the edge of each port.

For the purpose of reversing the motion of the engine, all the valves are first moved by a simultaneous motion of the reversing-gear. The outer ends of the valve-stems 10^a are tapered, and provided with segment-pinions 13, gearings, with cogged segments 14 on the arms 14^a, which are parts of a ring, 15. The ring is provided with an arm having a toothed segment, 16, which gears with a pinion-segment, 17, on the rock-shaft 18, operated by a hand-lever, described and claimed in another application for patent of even date herewith designated "Case A," so as to impart a simultaneous oscillating movement to the necessary extent of all the valves. The pair of valves which are for the time being induction are provided with an independent automatic movement, to cut off the steam at the required proportion of the revolution of the piston-wheel for which they may be constructed. This movement is imparted by a tappet-wheel, 24, secured to the under or in side of the main gear-wheel, having on each face tappets 25, which engage with arms 26 26^a as required, which are connected to their respective valves by automatic clutches 27, (illustrated in Figs. 5 and 6 and in detail in Figs. 8 to 18^a, inclusive,) so that the opposite pairs of valves, which are for the time being used for induction, may be connected with their cut-off arms—26 for example—while the intermediate valves, which are for the time being used for exhaust, are disconnected from their cut-off arms—26^a, for example.

The abutment-rollers 6 carry reversing-tappets 28, which at the proper moment engage with arms 29 to reopen the valves. In Fig. 6 the relative positions of tappets 25 are shown in full lines, and piston-teeth 3 shown in dotted lines in position in the cylinder, and stand at right angles to each other, while the tappets 28 upon the abutment-roller gearing are in line with the recess of the respective abutment-rollers, recesses being shown in dotted lines and tappets 28 in full lines. The arms 26 and 29 constitute rigid members of the same clutch-connection, 27. They are held in position by means of the main bolts of the engine, extending through recesses in the frame-work thereof at each end, and allowing just the play sufficient for the valve in cutting off and letting on steam, and a bushing is slipped upon the end of the bolt to prevent it from wearing.

Dogs are shown at 30 in Fig. 5, to assist the limiting of the cut-off movement of the induction-valves, there being one for each valve, which regulates the cutting off and letting on of steam. Those dogs belonging to the cut-off valves are in use only while those of the exhaust-valves are out of use for the time being, and when the valves are reversed for reversing the engine the dogs are also reversed by the rim or flange 15^a of the armed ring 15, which extends inward toward the head, and which is provided with recesses which engage with the arm of each respective dog, which extends in a nearly opposite direction from its hinge or fulcrum toward the center of the main shaft, the ends of the arms being in their respective positions in the recesses of the rim or flange of the ring, with the end striking either one or the other side of the rim. This moves the dog in or out, respectively, of the recesses of the valve-case gearing as they become induction or exhaust, as the case may be.

The motion of the valves either for cutting off or letting on steam, as shown herein, is twenty-two and one-half degrees, while the full motion of the valves for reversing the engine is forty-five degrees; or as the full motion of each respective valve-stem-gear casing for reversing the engine and throwing the valves in and out of gear (which is required for induction and exhaust valves) is ninety degrees, forty-five degrees are allowed for play in the cam-sleeve clutch, twenty-two and one-half degrees play of the valve in letting on and cutting off steam, and twenty-two and one-half for end motion of the clutch for throwing the previous exhaust-valves in gear for receiving, and vice versa—the former receive-valves becoming exhaust-valves.

The relative distance of motion of either valve or valve-gear may be varied, if required, being governed by the relative size and location of ports and size and make of valves and valve-gear.

The mechanism for throwing the clutches carrying the arms 26 and 29 in and out of gear with tappets 25 and 28 is shown in detail in Figs. 8 to 18^a, inclusive, one member, 27, of the clutch being secured by means of pins and cap-bolt to the stem 10^a of the valve, the valve-stem being tapered and the clutch

tapered to fit, by which means they are secured in position and removed with ease, while the other member, 27ª, constitutes a sleeve sliding longitudinally on the clutch 27, and to assist in holding it in gear therewith.

The coil-spring 351 between the two clutch-sleeves 27 27ª is employed to assist in holding it in position during the operation of cutting off and letting on steam, and yields for a longitudinal motion, throwing it out of gear when the valves are reversed. Each end of this spring rests between two rings, 13ᵇ and 13ᶜ, which oscillate with the valve, the upper one, 13ᵇ, Fig. 18ª, has two feathered keys in it for sliding in corresponding grooves on the outside of clutch-sleeve 27 to carry it with the clutch.

To permit the independent movement of the inlet steam-valve, and to impart a longitudinal movement to the clutch-sleeve in throwing the cut-off tappets in and out of gear, pins or studs 352 are employed, projecting inwardly through the outer clutch-sleeve, as illustrated in Figs. 5 and 6 in full and in detail in Figs. 8 to 18ª, inclusive, engaging with regular cam slots or openings 353 in the sliding clutch-sleeves, as illustrated in Figs. 8 to 15, inclusive. The said cam slots or openings are of such forms as to permit the oscillating movement imparted to the inlet-valves by the cut-off arms 26 and inlet-arms 29 without moving the sleeve longitudinally; but in the event of a rotary movement being imparted to the reversing-pinion segments 13, so as to carry the pins 352 beyond the straight portion which they for the time being occupy, the pressure of said pins against the oblique portion of the cam slot or opening imparts the required longitudinal movement to the clutch-sleeve 27ª to place it in or out of gear, as the case may be, with the valve-sleeve clutch 27.

The operation of this mechanism may be described as follows: Taking, for example, the position of the valve-connection when the cut-off apparatus is in gear, as illustrated in Figs. 9, 11, 13, 15, and at 26 and 29 in Fig. 6, it will be evident that the clutch-sleeve 27ª can oscillate freely under the action of the cut-off mechanism to a distance equal to one-sixteenth of a revolution, which is required to cut off and let on the steam at each passage of the respective tappets in connection with the valve-levers, and that this movement does not change longitudinally the relative positions of the two ports 27 27ª of the clutches; but if now the pinion-segments 13 be moved by the action of the reversing-gear so as to cause the clutch-sleeves to bear and ride up on the pins 352, the clutch-sleeve 27ª will be drawn down to the position shown in Figs. 8, 10, 12, and 14, the effect of which is to remove the arms 26 29ª out of the way of the tappets 25 28, thus throwing the cut-off mechanism out of gear with this pair of valves, which now constitute the exhaust, and remain constantly open for this purpose. Simultaneously the other pair of valves are turned into receiving-valves, and are then acted upon by the reverse movement of the opposite pair of automatic clutch-sleeves.

The above-described reversing-gear and cut-off-valve gear is placed in both outer heads of the engine, and reversed by the same rock-shaft. This mechanism for reversing is described in another application for patent filed by me of even date herewith, designated "Case A."

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

1. A double reversible cut-off trochilic or rotary engine having two piston-wheels provided with two teeth upon each and secured to a main shaft, two abutment-rollers to each having recesses for the passage of the piston-teeth in their revolutions by the abutment-rollers, forming steam-tight joints between the surface of the piston-wheels and abutment-rollers, and eight reversible cut-off valves with operating-gear, two main casings, three heads, and two outside covers for the end heads, all substantially as specified.

2. The combination, with the toothed piston-wheel and the cylinder-head, of the concentric annular surface-pieces 142ª 142ᵇ 142ᶜ, against which the ends of the piston-teeth work, said surface-pieces being renewable when worn, as described.

3. In a trochilic or rotary engine, a ring, 15, having a flange, 15ª, provided with recesses to engage with the dogs 30, to assist in limiting the motion or play of the cut-off valves, substantially as set forth.

4. In a trochilic or rotary engine, the oscillating valves having live-steam passages leading to opposite recesses, and also passages to opposite recesses for exhaust-steam, and provided with adjustable packing-pieces, substantially as specified.

5. In a trochilic or rotary engine, the tapered valve-stem 10ª, frame 13ª, ring 13ᶜ, clutch 27, bolt having lock-washer, and pins for securing the valve-stem to the reversing-connections, substantially as set forth.

6. The valve-stem 10ª, bolt and its lock-washer, pins for securing the stem in position, sleeve-clutch 27 and 27ª, rings 13ᶜ and 13ᵇ, spring 351, segmental gear 13, bolts 352, and valve-levers 26 29, substantially as specified.

7. The valve-stem 10ª and its connections, as described, with the valve-levers 26 29, in combination with the double-faced tappets 25, secured to the main shaft, and double-faced tappets 28, secured to the abutment-roller journals, substantially as and for the purpose set forth.

8. The combination, with the end head and the valve-stem passing through the same, of the packing-ring and spring, substantially as herein shown and described.

9. The combination, with the center head, of the valve-stems, meeting end to end, the bearings in which they work, and the packing-rings and springs, substantially as set forth.

10. In a trochilic or rotary engine, in combination with the ring and main shaft bearing in

end head of the two pinion-bolts, and gear connecting them together, said gear secured to the end of the bearing-case for operating said pinion-bolts simultaneously, and thereby adjusting the said ring and bearing, substantially as specified.

11. In a rotary engine, one or more toothed piston-wheels with concave end faces, in combination with heads having convex faces, between which the said wheels rotate, and adjustable bearings within said convex heads, the concavity of the piston-wheels giving greater length and consequent area to their piston-teeth, and the convexity of the heads affording greater length for the bearings, substantially as set forth.

I. N. FORBES.

In presence of—
ERNEST ABSHAGEN,
FRED. L. FOSTER.