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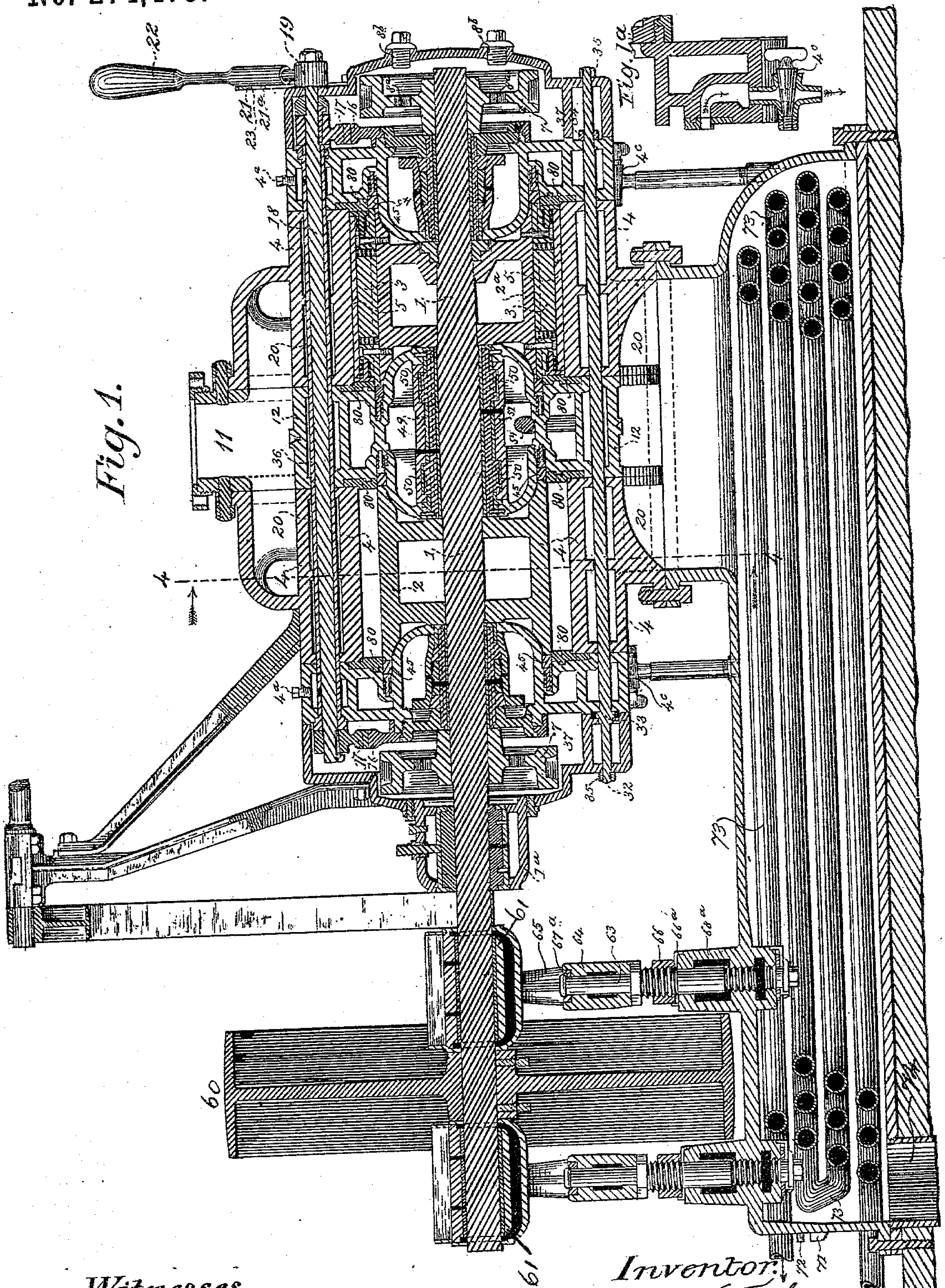
I. N. FORBES.

ROTARY ENGINE.

No. 274,475. Patented Mar. 27, 1883.



Witnesses.

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By his Attys Knight Bros.

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I. N. FORBES.

ROTARY ENGINE.

No. 274,475. Patented Mar. 27, 1883.

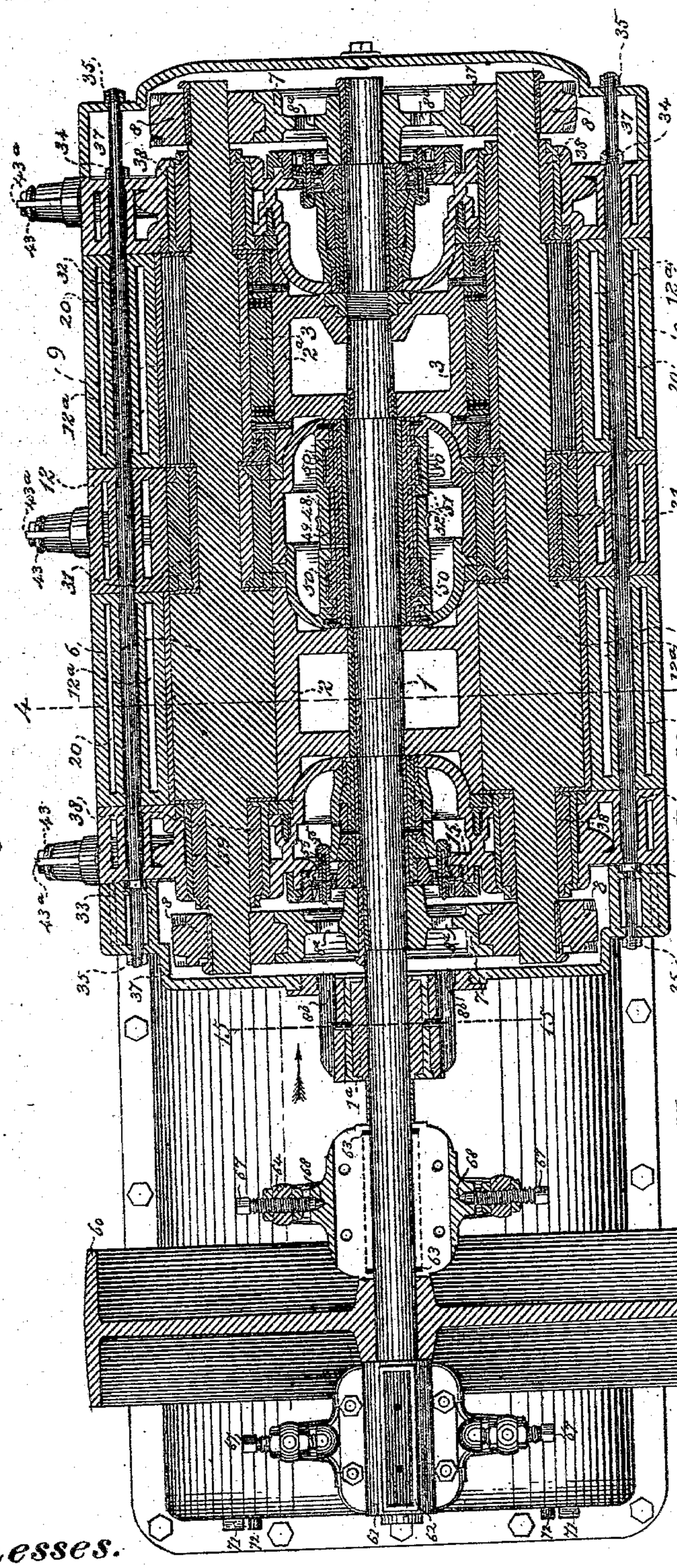
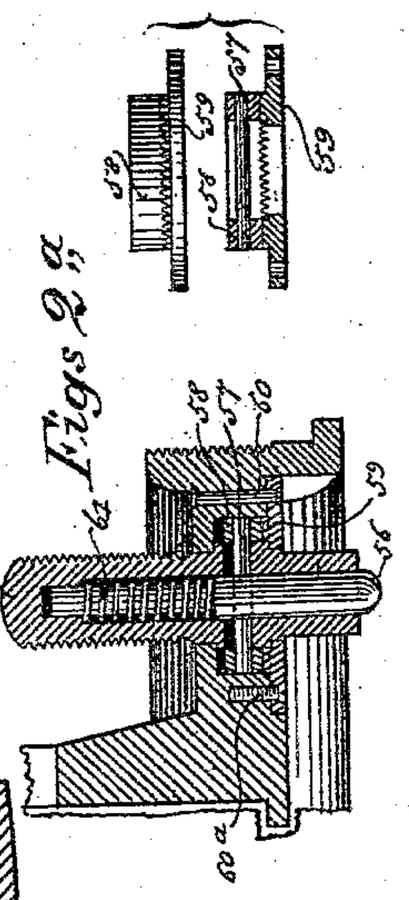


Fig. 2.



Figs 2a

Witnesses.

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I. N. FORBES.

ROTARY ENGINE.

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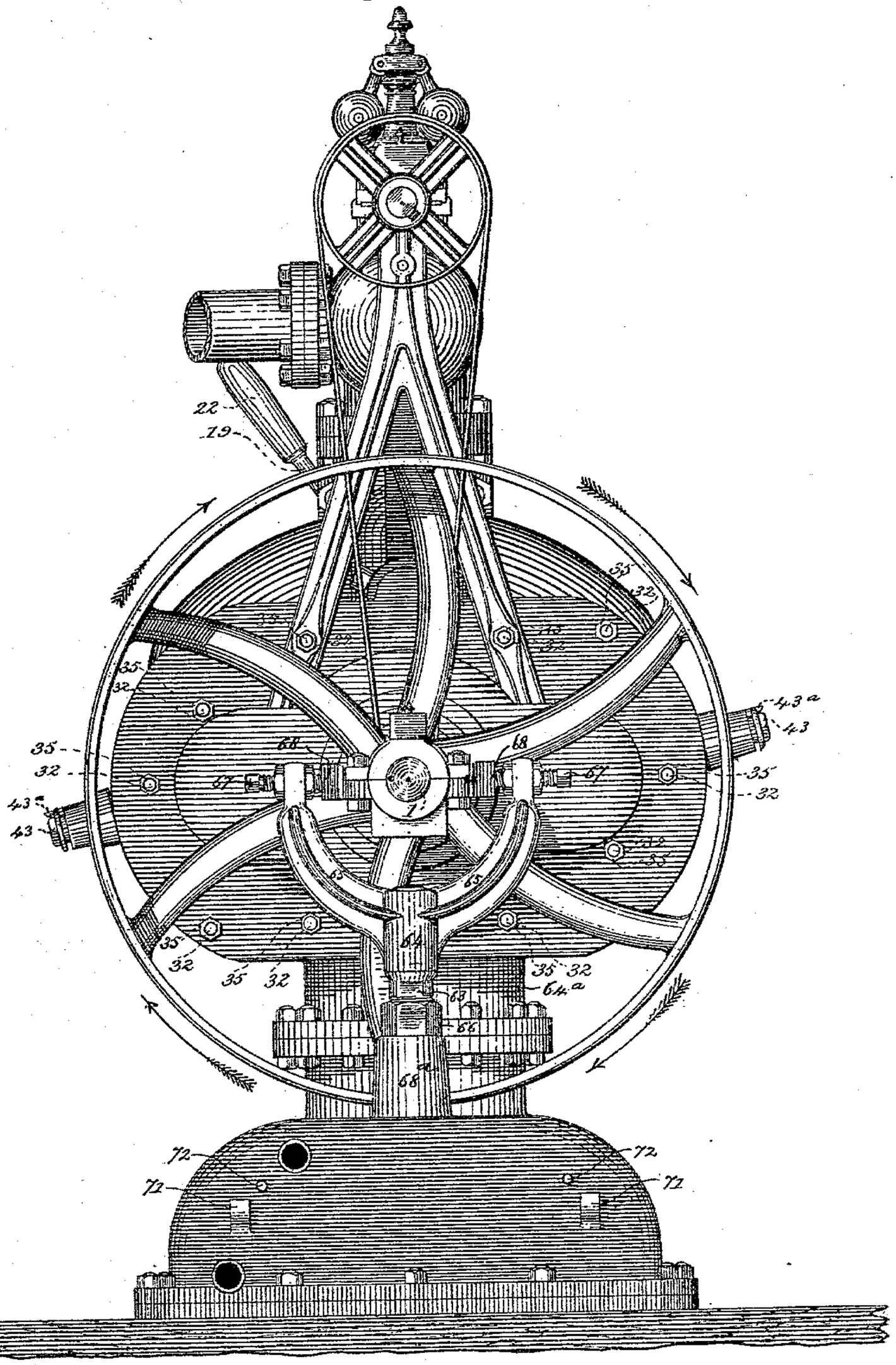
Fig. 3.



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(No Model.)

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I. N. FORBES.

ROTARY ENGINE.

No. 274,475. Patented Mar. 27, 1883.

Fig. 4.

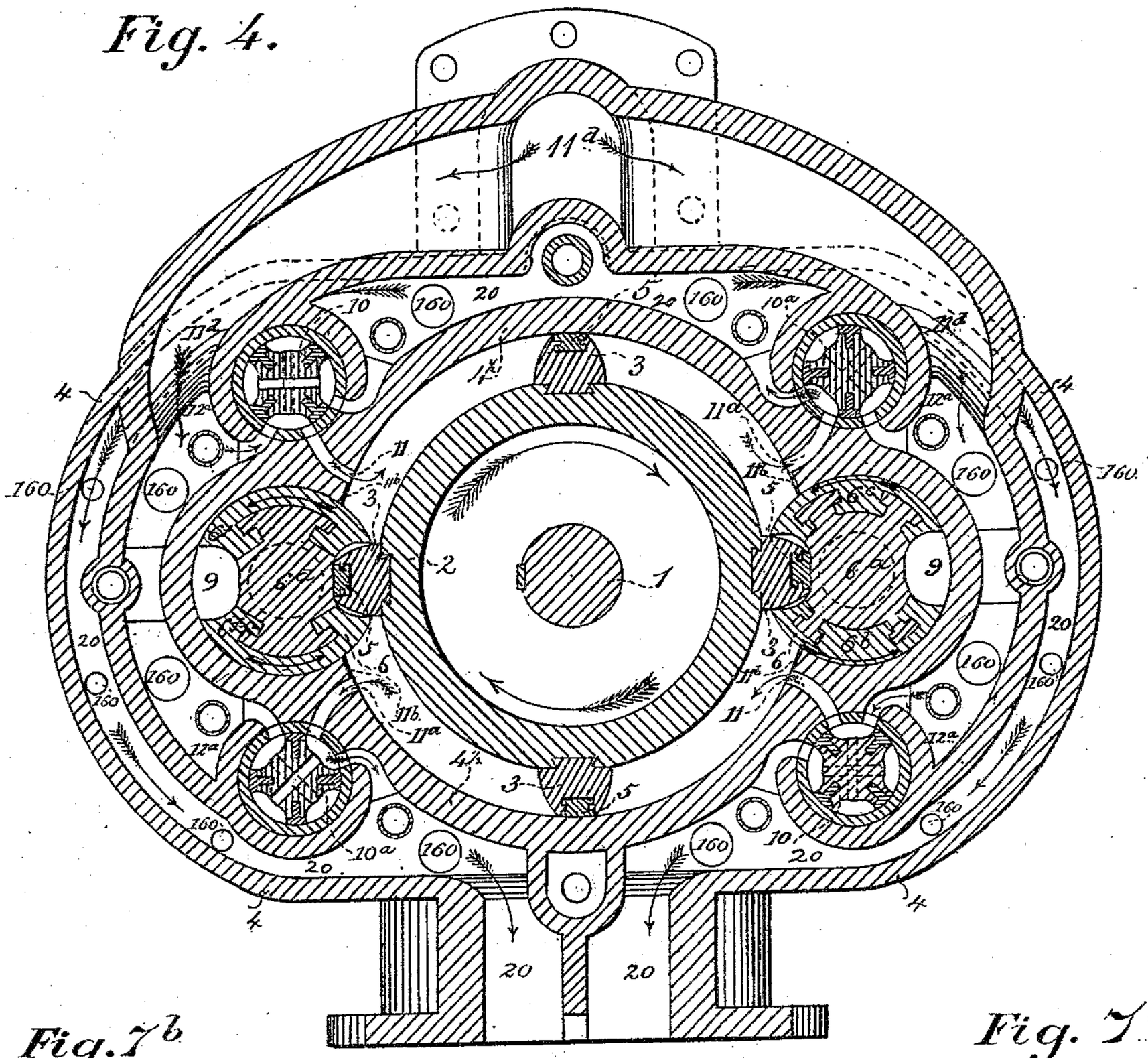


Fig. 7b

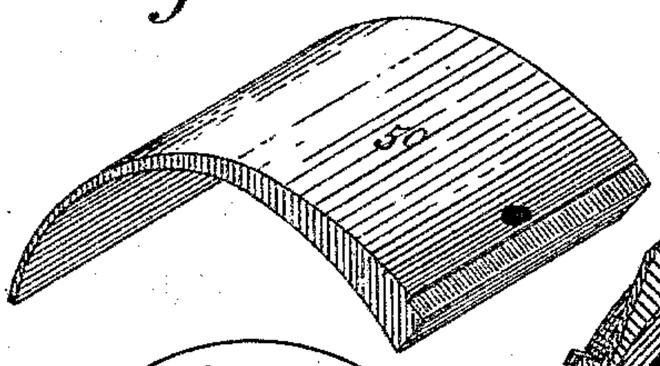


Fig. 7a

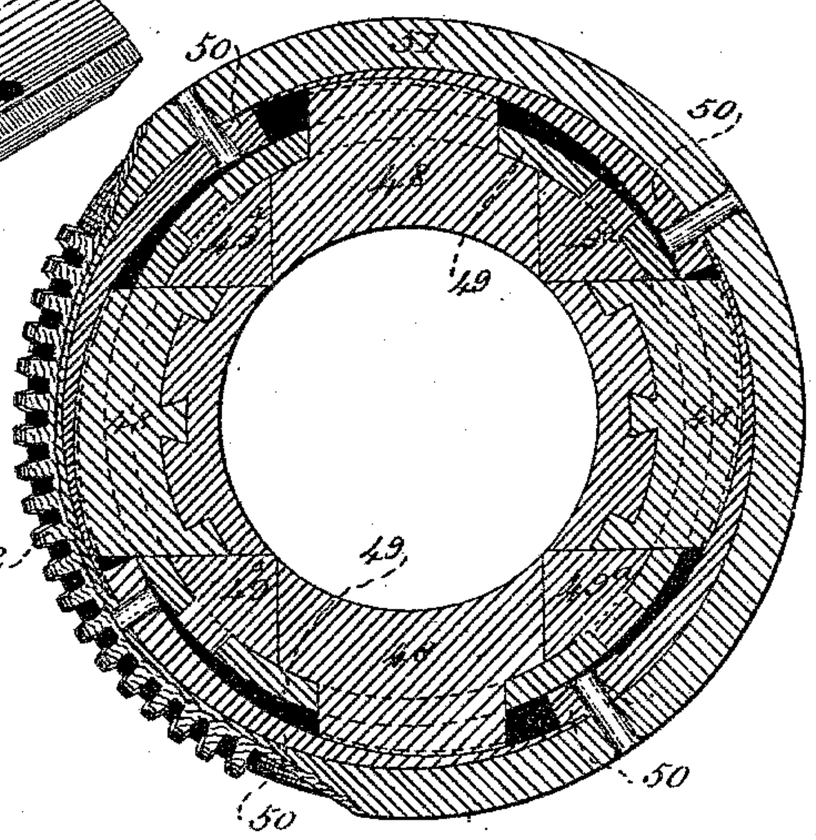


Fig. 7d

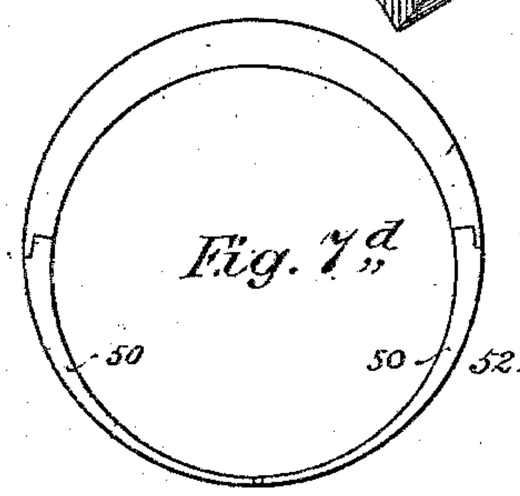
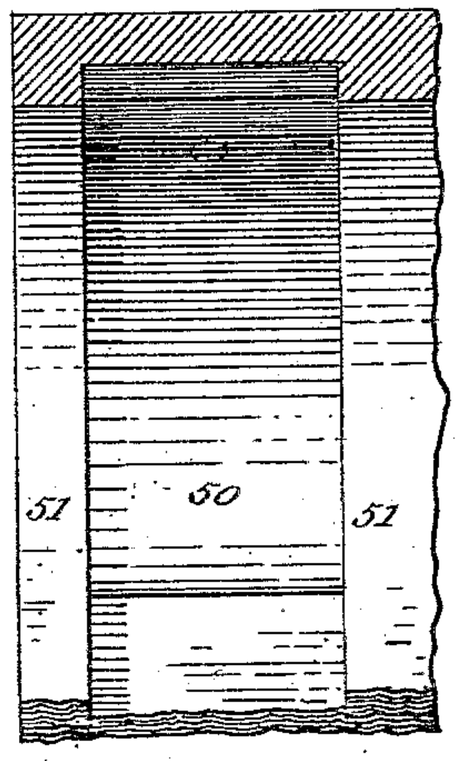


Fig. 7c



WITNESSES

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Fig. 5.

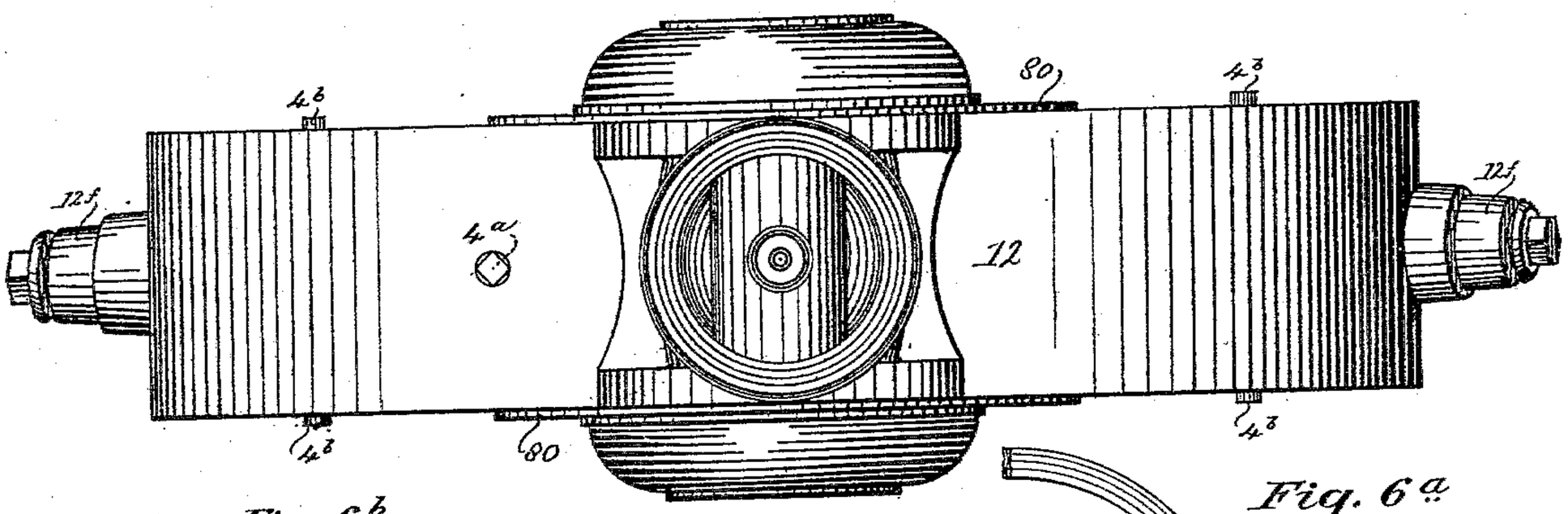

Fig 6b.

Fig. 6.

Fig. 6a

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Fig. 7.

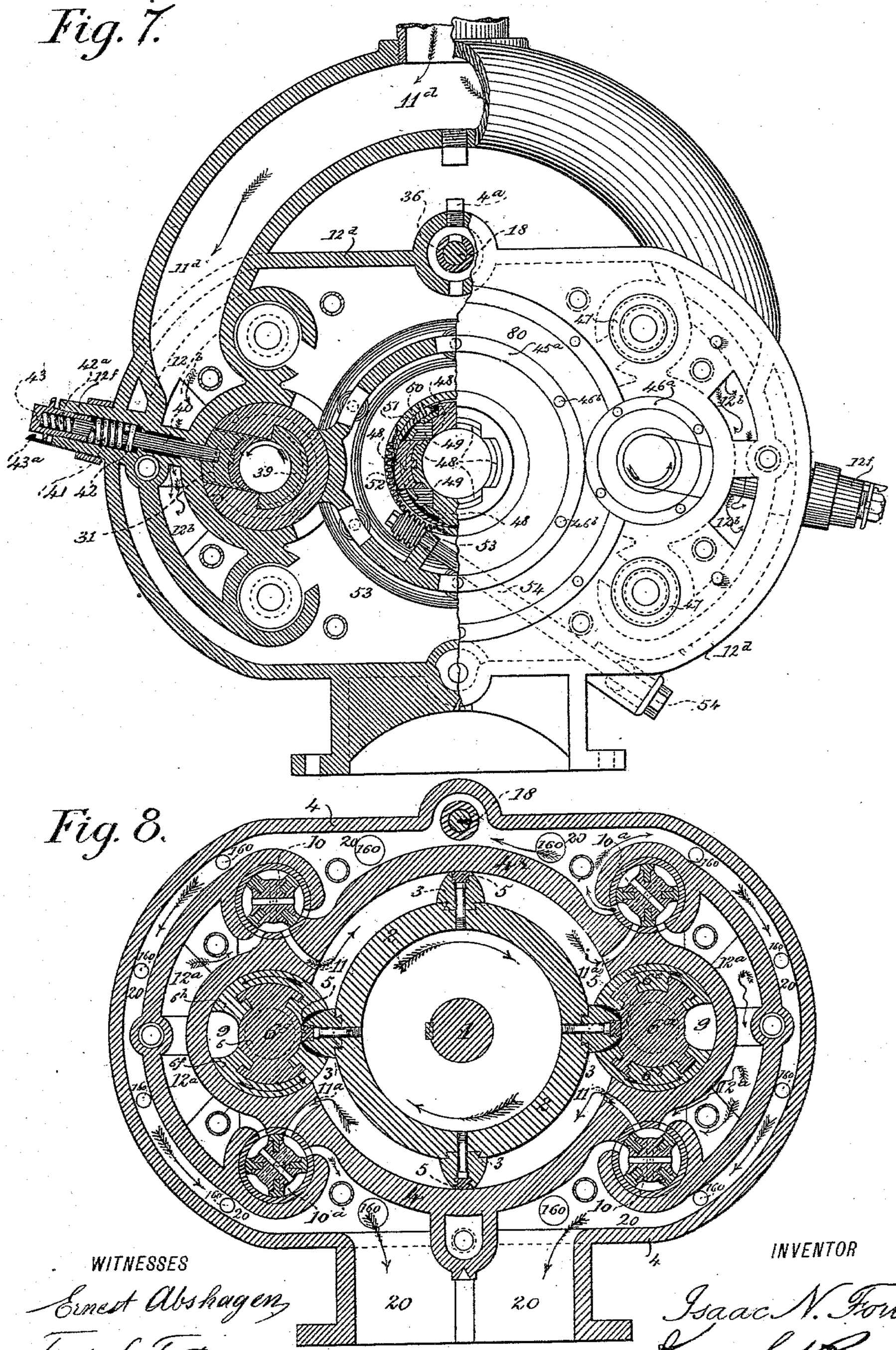

Fig. 8.

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No. 274,475. Patented Mar. 27, 1883.

Fig. 9.

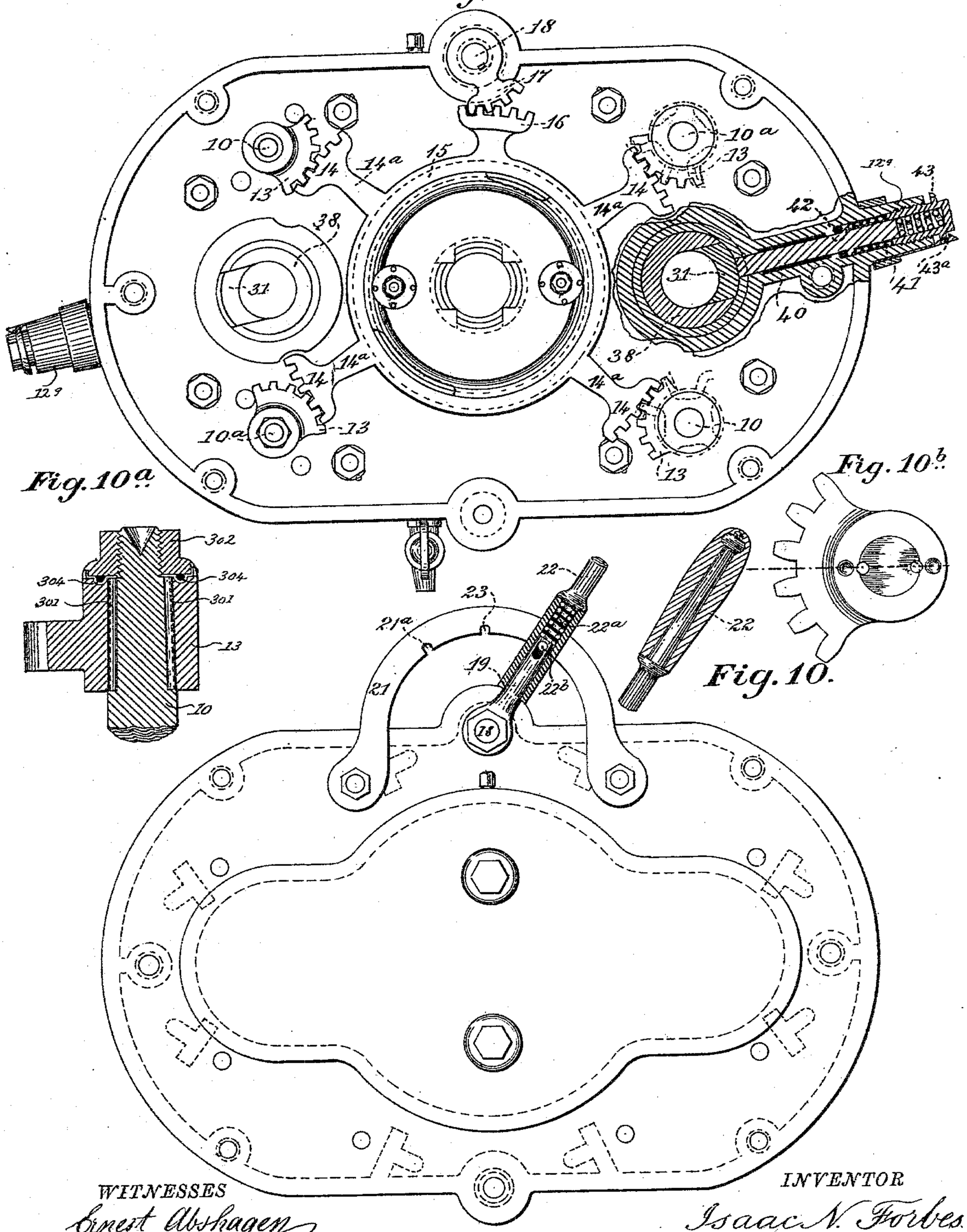

Fig. 10a.

Fig. 10b.

Fig. 10.

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ROTARY ENGINE.

No. 274,475. Patented Mar. 27, 1883.

Fig. 11.

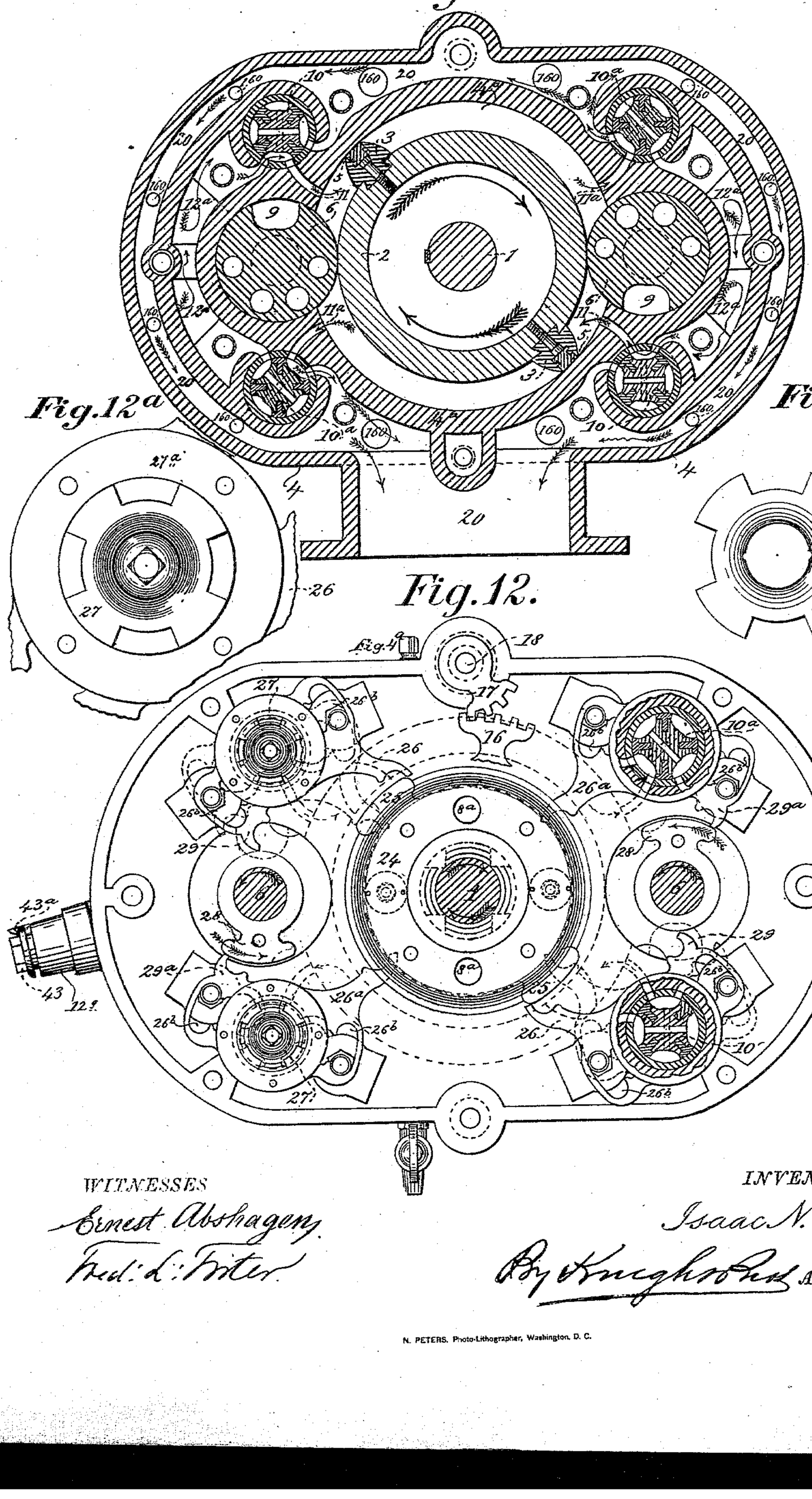

Fig. 12a

Fig. 12b

Fig. 12.

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ROTARY ENGINE.

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Fig. 13.

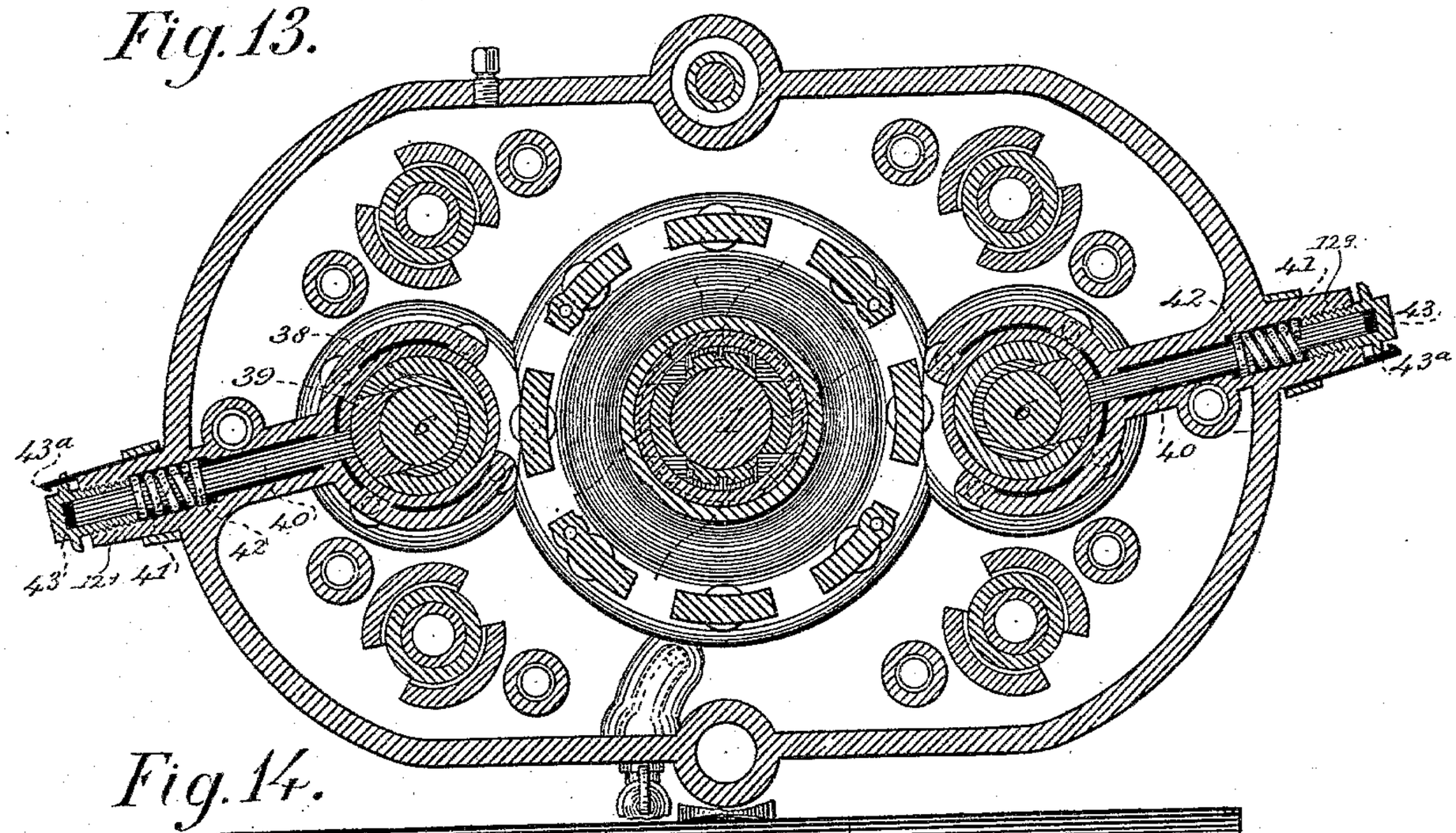
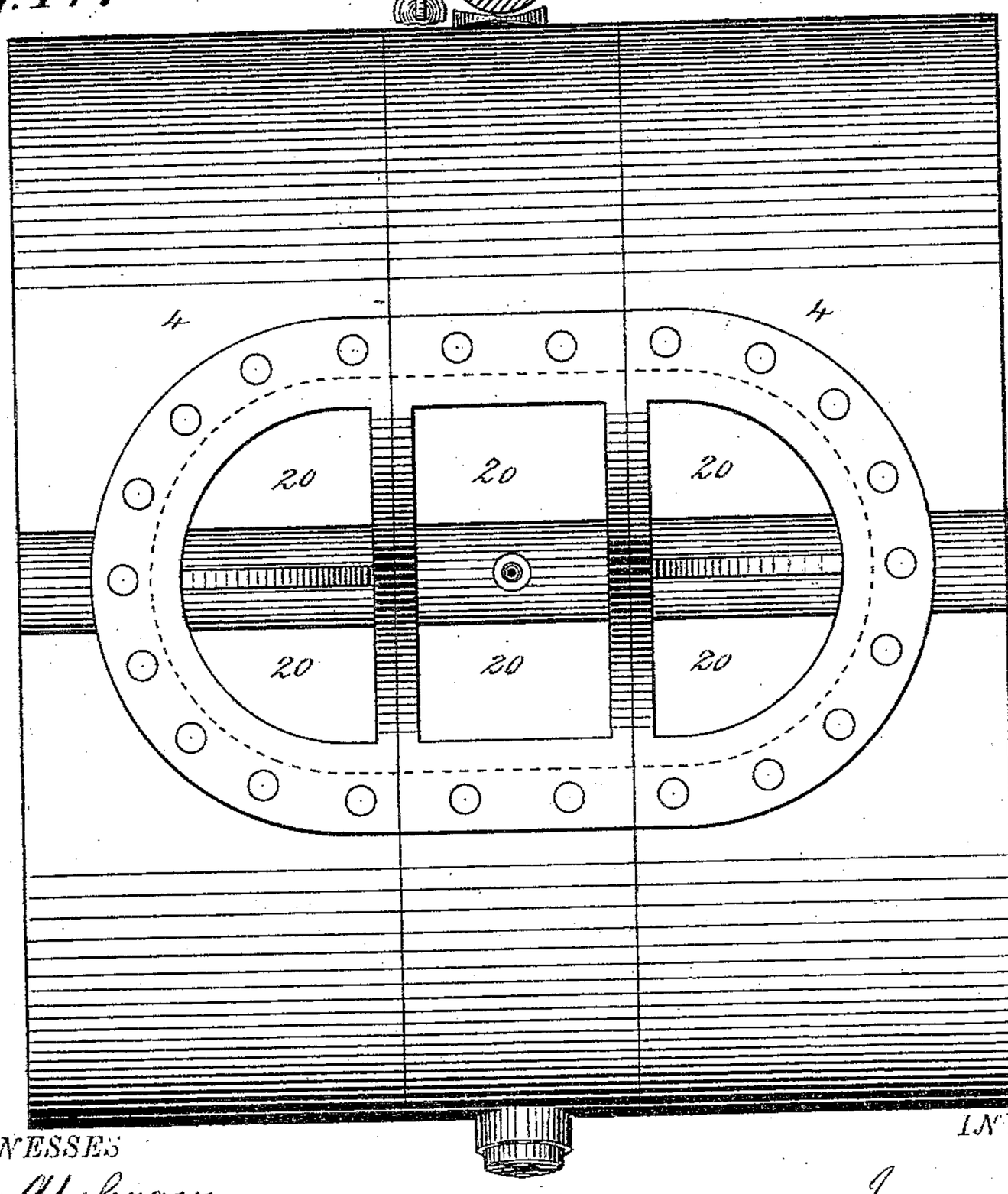


Fig. 14.



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ROTARY ENGINE.

No. 274,475. Patented Mar. 27, 1883.

Fig. 15.

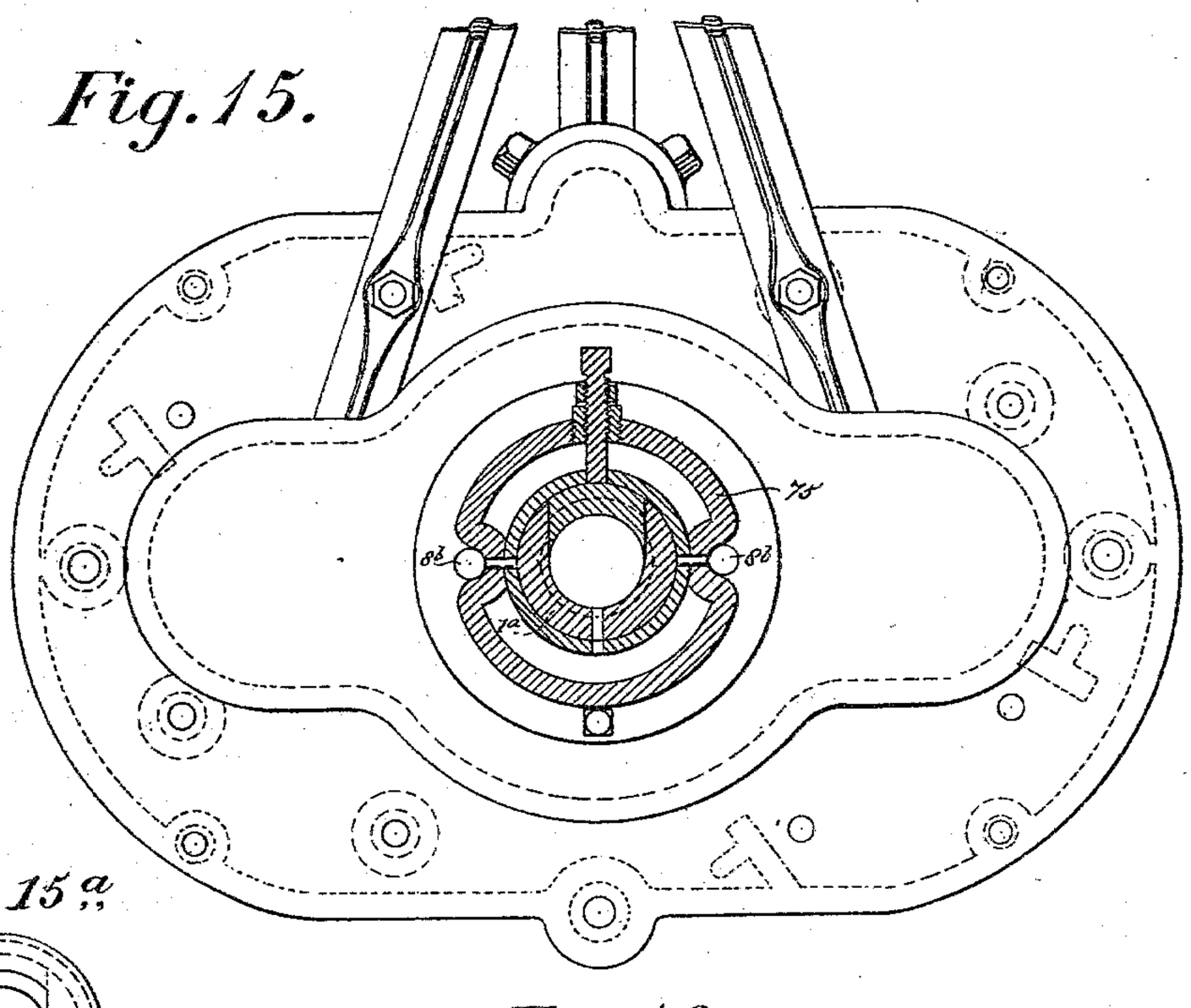


Fig. 15a.

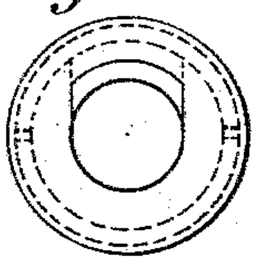
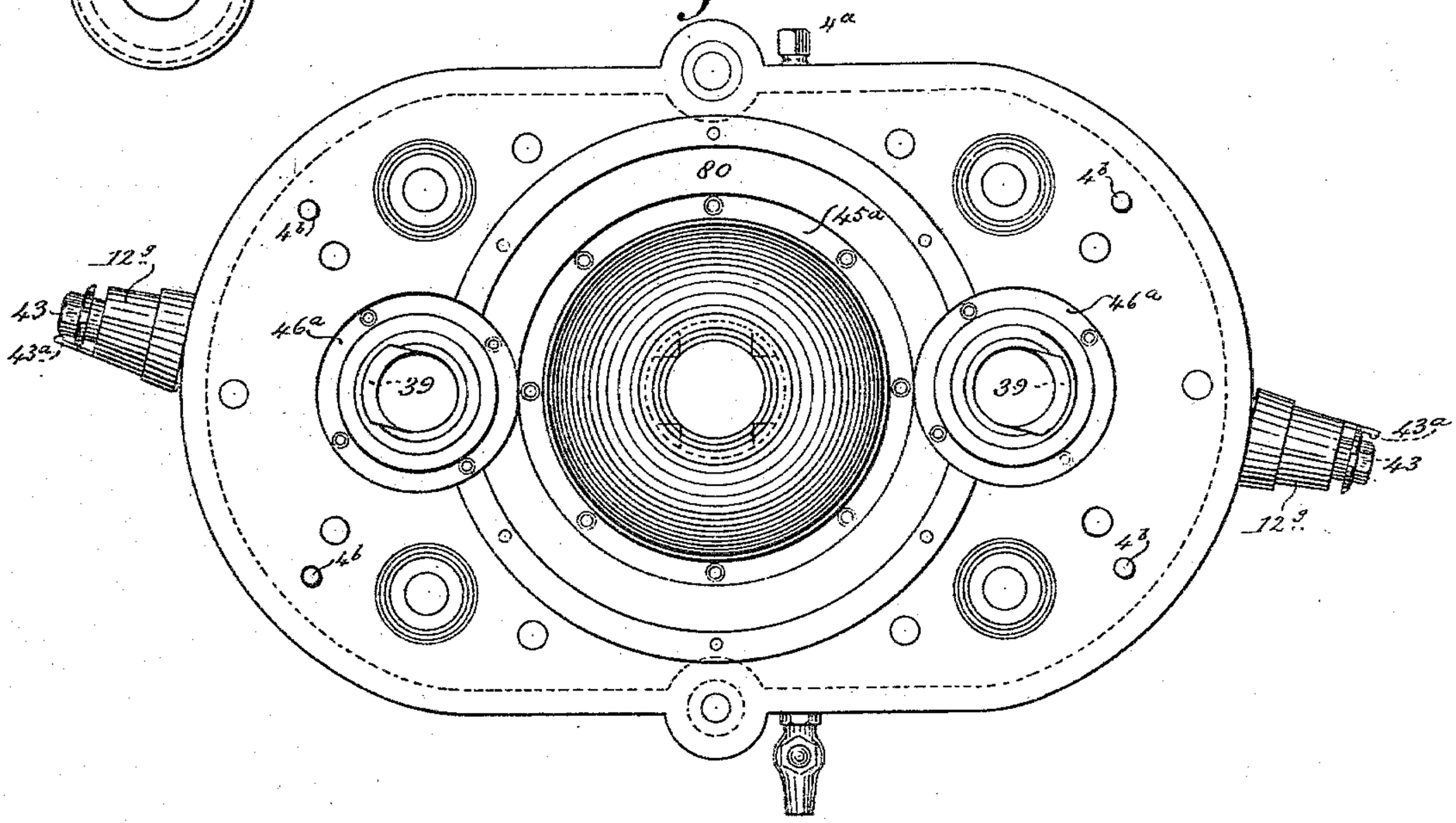


Fig. 16.



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UNITED STATES PATENT OFFICE.

ISAAC NEWTON FORBES, OF LAWRENCE COUNTY, DAKOTA TERRITORY.

ROTARY ENGINE.

SPECIFICATION forming part of Letters Patent No. 274,475, 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 trochilic or rotary engine constructed with two cylinders and three heads, with two or more rigid teeth or pistons on the piston-wheel in each cylinder, and with abutment-rollers recessed for the passage of the said teeth, said abutment-rollers being geared to the piston-wheels, so as to rotate in unison therewith without slip between their peripheries. The teeth or pistons are located at diametrically-opposite points on the peripheries of the piston-wheels, so that they perfectly counterbalance each other both as to weight and pressure. The abutment-rollers may be of the same diameter as the piston-wheels, or any desired multiple thereof, but are preferably of one-half the diameter, as in the present illustration. In any case they must be so geared together that the speed of motion of the peripheries of the piston-wheels and abutment-rollers will be the same. The abutment-rollers revolve in steam-tight casings consisting of seats and heads. The surfaces of the piston-wheels and abutment-rollers are provided with fine grooves or creases extending from end to end, for the same purpose as the circumferential water creases or cuts commonly used in pistons, pumps, plunges, and other joints to prevent leakage. The cuts or creases should be so close together that at least one such cut intervenes at all times between the surfaces to prevent leakage. It is preferred to use fine cuts or grooves, as shown in the drawings. In these engines every precaution is taken to economize power and use it to the best possible advantage. Hence the possibility of leakage in any of the working parts or other joints, or unnecessary friction by difference in expansion, or otherwise, is carefully guarded against. The journals of the main shaft and of the abutment-rollers run in bearings in the chambers of the heads, which chambers also contain oil or other lubricant for lubricating said journals. Bearings adjustable automatically or otherwise are provided to support the abutment-rollers against the steam-pressure, and to keep them up to their proper relative positions in contact with the piston-wheel to prevent leakage between them. The engine is provided with four fourfold valves to each cylinder, which have four automatically-adjustable surface-pieces, forming valve-faces at opposite points, and a steam cavity or recess between each piece divided in pairs, each pair being connected by steam-passages to admit of equal pressure on opposite sides, two being connected by live and two by exhaust steam, thus counterbalancing the pressure. The valves may be worked as cut-offs, or otherwise, as preferred, the piston-wheels of this engine having each two teeth where the steam is to be worked expansively, and four teeth when used without cut-off. For reversing the engine the valves are reversed by gearing operating on them all simultaneously from a common center, and actuated by means of a single lever from without. Whether two or four piston-teeth be used on each wheel, the teeth on the respective wheels are set at bisecting angles—that is to say, the teeth of one wheel are opposite the spaces between those of the other wheel. The valves of the entire system are operated for reversing by a lever common to all. In order to adjust and set up the main-shaft bearing in the center head, the said bearing is constructed in segments, which are pressed inward simultaneously by the revolving motion of an encircling ring carrying a series of curved wedges or eccentric segments pressing on the corresponding eccentric backs of the bearing-segments. The ring is provided on a part of its periphery with worm-teeth, so as to be actuated by an endless screw or worm-gear upon a shaft, which extends to the outer surface of the head, through a stuffing-box or otherwise, to prevent the leakage of oil from the reservoir in the head. The stuffing-box may be dispensed with, if desired, by a close fit of the worm-gear rod in the hole through which it passes out, and circumferential water cuts or creases turned in its surface to prevent the passage of oil, in which case a head with a spring-catch or other fastening is provided to prevent the shaft from turning around; and where the stuffing-box is used the gland thereof has the spring-catch or other device to prevent the shaft from turning. The main bearings in the end heads are also con-

structed in segments, with radial projections extending through the mortises in the casing of each, in which the bearing-segments are held, and having inclined backs to provide for the adjustment or setting of the segmental bearings by the longitudinal movement of the encircling ring formed on its inner periphery, with inclined faces corresponding and pressing against the inclined backs of the aforesaid projections of the bearing-segments. The required longitudinal movement of this adjusting-ring is imparted by screw-bolts fitted in a base flange or projection of the said ring, which bolts are turned by means of a key or wrench inserted through apertures in the main connecting gear-wheels and in the external end covers of the engine.

In order that the invention may be fully understood, I will proceed to describe it with reference to the accompanying drawings, in which—

Figure 1 is a vertical longitudinal section of a double engine illustrating the invention. Fig. 1ª is a detail section, upon a larger scale, through the water-cock, showing the mode of discharging water of condensation from the cylinder into the hollow base or partial condenser of the engine. Fig. 2 is a horizontal longitudinal section of the same. Fig. 2ª is an enlarged detail view of the bolt for adjusting the bearing. Fig. 3 is a rear end elevation of the engine. Fig. 4 is a vertical transverse section, on a larger scale, through the steam-passages on the line 4 4, Figs. 1 and 2. Fig. 5 is a top view of the center head. Fig. 6ª is a face view of an abutment-roller packing-ring and a part of a packing-ring for the rim of the piston-wheel. Fig. 6 is a face view of the center head, partly in section. Fig. 6ᵇ is a face view of a valve-packing ring. Fig. 7 is in part a vertical transverse section through the center head, and part an elevation of said center head, illustrating a modification under which steam is taken into the cylinder through the center head. Fig. 7ª is a transverse section on a larger scale of the bearing within the center head. Fig. 7ᵇ is a perspective view of one of the curved wedges or eccentric segments detached. Fig. 7ᶜ is an interior view, partly in section, showing part of the ring which carries the said curved or eccentric wedges, with one of the said wedges or eccentric segments fixed therein. Fig. 7ᵈ is an end view of an eccentric ring from which two eccentric pieces are made. Fig. 8 is a vertical transverse section of the engine through one of the cylinders of the same corresponding with Fig. 7. Fig. 9 is an elevation of the head, showing the reversing-gear and one of the abutment-roller bearings, with its setting-follower in section. Fig. 10 is an elevation of the front cover and reversing-lever and stops. Fig. 10ª is a longitudinal section of a segment-pinion, showing its attachment to the valve-stem, on line 10ª, Fig. 10ᵇ. Fig. 10ᵇ is an end view of Fig. 10ª with the cap-nut removed. Fig. 11 is a vertical transverse section of an engine, illustrating the invention adapted for working the steam expansively by means of a cut-off-valve gear. Fig. 12 is an elevation of the end head and part of the cylinder and valves beneath, showing the cut-off levers and trips and part of the reversing-gear, parts of the gear being omitted to expose the cut-off gear. The two right-hand valves, valve-seats, ports, and part of the cylinder-head, &c., being broken through down to the cylinder, valves, and seats to show their relative position to the valve-gear. Fig. 13 is a transverse section through one of the end heads, looking toward the center of the engine. Fig. 14 is a bottom view of the cylinders and center head. Fig. 15 is an elevation of the rear cover of the outer head. Fig. 15ª is an end view of the auxiliary bearing of main shaft in outer cover. Fig. 16 is a view of the inner face of one of the end heads.

1 is the main shaft of the engine, upon which two piston-wheels, 2 2ª, are secured, the wheel 2 being a fixture keyed solidly to the shaft, while the other slips upon a tapered portion of the same, and is held securely to its position by one or more stops on the shaft, projecting within the wheel-connection and preventing it from turning thereon. The wheel is held longitudinally, by a nut screwed upon the shaft, against the inner portion of the wheel, the nut being held by one or two hollow pins threaded inside to enable them to be withdrawn, which pins pass through the nut into the wheel. This wheel is reamed out to exactly fit the tapered part of the shaft, and may be easily removed for taking the engine apart, or for other purposes, and replaced. Bearings are turned upon the shaft in harmony with the construction and purposes of the engine. The main shaft may be extended through both ends of the engine, and the base also elongated, if desired, in which case new bearings would be added at the extended portion of the base. This would be done for the reception of cog or clutch gearings, pulleys, or other means of transmitting power. In the present example a heavy band-pulley is shown secured to one end of the shaft and supported by universally-jointed bearings. The piston-wheels 2 2ª are each provided with two or more piston-teeth, 3, revolving within the cylinder 4, and made steam-tight by suitable packings, 5 and 5ª.

6 6 represent abutment-rollers connected by gearing with the main shaft 1, so as to rotate in unison with the piston-wheels 2 2ª without any slip between their peripheries. For this purpose it is preferred to employ the helical gearing shown in Figs. 1 and 2, being helical cogged wheels keyed on the main shaft 1, and 8 8 pinions with corresponding helical teeth on the shafts of the abutment-rollers 6 6. These helical gears are of special advantage in rotary engines, in that when properly made and adjusted they avoid the possibility of backlash or lost motion, and act one upon the other with

accuracy and uniformity of pressure and movement in all parts of the revolution.

In the abutment-rollers 6 are recesses 9 to admit the passage of the piston-teeth 3 3 of the piston-wheels. The abutment-rollers should each be half the diameter of the piston-wheel, or they may be of equal diameters. Any other relative diameters will not effect the best results. They must be so geared together that their peripheries will move at the same speed, so as to have an equal surface movement without friction, as above stated. With a two-toothed piston-wheel and abutment-rollers of one-half the diameter of said wheel a single recess 9 in each roller will serve to pass the two teeth upon the piston-wheel; or two recesses in each abutment-roller will be used with a four-toothed piston-wheel. Where the piston-wheel and the abutment-rollers are of equal diameter the recesses in the latter must of course be equal in number to the teeth upon the former.

Figs. 1 and 2 show the embodiment of my invention in an engine with two piston-wheels, 2 2ª, on the shaft 1, the piston-teeth 3 of one wheel being arranged opposite the spaces between those of the other wheel, with recesses in the abutment-rollers in harmony therewith for the passage of the piston-teeth.

To each piston-wheel are four fourfold oscillating valves, 10, fitted in seats in the casing, adjacent to the abutment-rollers 6, the said valves being constructed with communicating cavities on diametrically-opposite sides of their surface connected by radial channels, a connected pair of these cavities in each of the induction-valves being in communication with the live steam, and a connected pair in each of the eduction-valves with the exhaust and the other two exhaust-valves, as will be hereinafter more particularly explained, so that the pressure on the opposite sides of the valve may be precisely balanced.

The engine may be made with four teeth to each piston-wheel, as illustrated in Figs. 4 and 8, or with two teeth on each piston-wheel, as shown in Fig. 11, for working the steam expansively, in which case the induction-valves are used as cut-offs, as hereinafter described, the exhaust-valves being always at rest.

The induction steam-passage is shown at 11ᵈ in Figs. 1 and 4, extending longitudinally in each direction to about the centers of the respective steam-cylinders. It may, if preferred, be introduced through separate pipes with proper steam-fittings, or through the center head itself, as illustrated in Fig. 7, instead of outside the top of the center head, as shown in Figs. 1, 3, 4, and 6. The course of the induction and the exhaust currents is indicated by arrows. The valves, whether inlet or exhaust, are constructed in the same manner, and by being moved on their axes are made to stop, start, or reverse the engine, those which were induction-valves becoming exhaust-valves when reversed, and vice versa. The valves are fourfold—that is, they have four adjustable bearing-faces which work against the valve-seats. All the valves are at rest when employed as above stated, or to cut off the steam at the desired proportion of revolution, as hereinafter described. The valves are moved by means of segment-pinions 13, secured to projecting ends of the valve-journals, gearing with the toothed segments 14, carried by arms 14ª, projecting from a ring, 15, which is fitted in a suitable bearing concentric to the main shaft, and is rotated to the necessary extent, through the medium of a toothed segment, 16, by a segment-pinion, 17, carried by a rock-shaft, 18, which is actuated by an arm, 19, fixed in any position to which it is set by a spring-catch engaging at the extremities of the permitted movement with notches 21ª in a curved rack, 21, and retracted by pressure upon the handle 22 of the arm 19. Said handle is fitted to the arm by a socket permitting a relative longitudinal movement, and is pressed outward by a spring, 22ª. The spring-catch before referred to consists of a pin, 22ᵇ, fastened through the handle-socket 22, and projecting from the side thereof, so as to engage with either of the notches 21ª or 23, as before stated, and thrown up by the action of the spring within the socket, as before described. The central notch, 23, is employed for holding it in an intermediate position, at which point the valves are closed, so as to stop the engine before reversing it.

The simple reversing-gear above described, by which a simultaneous movement of forty-five degrees is imparted to all the valves, is illustrated in Fig. 9.

Fig. 12 shows an automatic cut-off mechanism, by which the valves are closed when the piston-teeth reach the desired proportion of their revolution between the abutment-rollers, so as to work the steam expansively.

For working expansively the valves are opened for the induction of steam by a tappet-wheel, 24, on the inner side of the main gear-wheel, having on its periphery double-faced tappets 25, which engage with arms 26, one to each valve, connected to their respective valves by automatic clutches 27, (more particularly described in another application of even date herewith, marked C,) so that the opposite pair of valves, which are for the time being the induction-valves, are connected to their respective arms 26, for example, while the intermediate valves, which are for the exhaust, are disconnected from their arms 26ª, for example.

The abutment-rollers 6 carry reversing double-faced tappets 28, which at the proper moment engage with arms 29 or 29ª, as the case may be, to close the valves to cut off the steam at the required point.

The cut-off-valve levers 26 and 29, and 26ª and 29ª are provided with curved slots 26ᵇ, through which the bolts of the engine pass. The latter have sleeves on them as a protection against injury from the levers. These

slots allow the valves to play twenty-two and one-half degrees—the proper distance for cutting off and letting on steam.

The adjustable bearings of the abutment-rollers in the center head are shown at 31 in Figs. 6 and 7. The end heads are fitted with bearings 38 for said abutment-rollers, preferably of Babbitt or other suitable metal poured in the bearing-case around the journals, and secured to the case by screws or holes in the case for the Babbitt to pass through, or both, as may be preferred, leaving a space extending radially outward equal to the diameter of the shaft, which is occupied by an adjustable bearing-piece, 39, the case having been bored out and fitted and the adjustable bearing-piece dressed to suit and put in place before the Babbitt is poured in. Each of the bearing-pieces 31 and 39, is pressed in by a spring, 41, bearing inward against a collar, 42, on the follower 40, and outward against a screw-cap, 43, held by a spring-catch, 43ª. An additional spring, 42ª, may be placed within the screw-cap, as illustrated in Figs. 6 and 7.

The spring-followers 40 afford automatic adjustment to maintain tight joints between the abutment-rollers and the piston-wheel.

The cylinder-heads are all provided with central projections, in which the main shaft-bearings are, which projections, being convex, extend within the concave ends of the piston-wheels upon the main shaft, thus affording greater length of bearing and greater length and area of piston-teeth than could otherwise be had with a given length or size of engine. The heads are also provided with removable hard surface-pieces 80 for the ends of the piston-teeth to work against, to be replaced when worn too much. They are preferably made of steel, which may be hardened, or they may be made of hard brass or other suitable material. They also project outwardly into the cylinder a short distance, thus securing the main-shaft bearing in an exact central position to the cylinders. The surface-pieces are also secured by dowel-pins to keep them from turning. They are fitted in recesses in the heads, and upon tongues or grooves, as the case may be, respectively, as shown in the different figures.

The respective cylinder-heads 12 are all provided with recesses containing packing-rings 45 45ª for the rims of the piston-wheels, and for the abutment-rollers 6 at each end, and are provided with bosses within the heads, in which holes are bored for the reception of coil-springs, either with or without plugs in connection therewith. If plugs are used, the spring for each coils around the plug and rests upon the bottom of the hole or shoulder above it. When the end of the plug passes into the smaller part of the hole beneath (thus preventing the spring from getting beneath the plug) the spring then rests beneath the head of the plug, which fits the bore in which the spring is located. The top of the head being pressed out by the spring against the packing-ring, the latter is brought into close contact either with the rim of the piston-wheel or the plate covering the recess upon the end of the abutment-roller, as the case may be, thus forming steam-tight joints therewith.

When the spring is used without plugs, unless of good size, the end of the spring is liable to get under the packing-ring and prevent it from adjusting itself to correspond with the contraction and expansion of the metal. The packing-rings must have play beneath the recesses in which they fit.

Plugs with their inner ends extending part of the way through the spring, and tapered so that they cannot rest upon the spring, with the heads performing the same office as at first described, may be used.

Steam may be used, in combination with the coiled spring, to press the rings out, if necessary; or, if preferred, steam may be used, and springs dispensed with, for doing the same thing, and the area of pressure made in accordance with the amount of power required to produce tight joints. Where steam is used the peripheries of the rings should be recessed or grooved for water-cuts, and it would be well, if convenient, to water-groove the peripheries of the recesses also, and thus secure steam-tight joints. These packing-rings may be of some non-corrosive metal, hard brass or other suitable material.

The packing-rings may be made solid, or grooved upon their inner or outer surfaces or bottom, or all, if necessary, the object being to insure strength and stiffness. The springs should be a proper distance apart, and just a sufficient number for the purposes designed. The packing-rings are secured from turning by stops in the recesses, pins, or other devices. Similar recesses for similar packing-rings are also employed for packing the ends of the valves and providing for end motion. These recesses may be in the heads, or in the valve-case bearings, or partly in each, if necessary, for receiving the packing-rings, and if in the heads, bosses may be used in which holes are inserted for the reception of coil-springs, if they are used, similar to those above described for the abutment-rollers and piston-wheel springs, or steam may be used, if necessary, to perform the same office.

All working-joints, where steam is applied, are provided with water-cuts or fine grooves to assist in maintaining steam-tight joints.

The adjustable bearing-pieces 48 of the main shaft in the center head are in segment form, fitted in radial mortises in their casing 49, to permit their concentric adjustment upon the shaft, which is effected by a series of curved wedges or eccentric segments, 50, carried by a ring, 51, encircling the bearing-case 49, and each projection of the bearing-pieces upon their backs is made eccentric to fit the eccentric pieces 50 in the outer ring, upon which they rest, and by which they are adjusted upon the

shaft by the revolving movement of the outer ring, given by the worm-gear on the shaft, extending to the surface of the head for that purpose. This ring has on its outer periphery worm-teeth 52, acted on by an endless screw, 53, carried by shaft 54, extending to the exterior of the head, where it is made oil-tight by passing through a suitable stuffing-box and gland, and is operated by a wrench for adjusting the bearing.

Triangular pieces 49ª, which may be made of Babbitt metal poured through openings in the bearing-case, or other metal, may be fitted in the casing and secured thereto, which form guides for the bearing-segments 48. The bearing-cases for the main shaft in each head, and for the abutment-rollers, are all bored out and dressed to the proper shapes and the adjustable bearings fitted and put in position before the Babbitt is poured in or other guides secured, thus insuring true and accurate adjustable bearings, which is indispensable. The main-shaft bearings in the end heads are likewise formed of radially-adjustable segments fitted in their cases, similarly to those first described. These segments have one or more inclined projections extending through mortises in a guiding or casing frame, and receive outward pressure from a ring having inclined faces, to suit the inclined radial segments, which ring is drawn endwise by screw-bolts bearing against the outer face of the bearing-case which forms part of the cylinder-head, and screwed into the flanged base of the said ring at opposite points. Fig. 2ª is a detached view, upon a large scale, of one of these bolts, with its appendages, shown in position in a portion of the bearing-case. 55 is the bolt proper. 56 is the adjustable pin which fits in the bolt. 57 is the rivet which passes through it and through the slot in the bolt, and through the ratchet-toothed ring 58, which is riveted thereon. 59 is the cap-ratchet ring, which is riveted or otherwise secured in the recess in the bearing-case, the said cap-ratchet being a fixture to the casing which forms part of the end head of the engine. The bolt 55 has a slot for the rivet 57 to play in longitudinally, and a coil-spring, 61, in the hollow of the bolt around the pin, for keeping the ratchet-ring 58 and the cap-ratchet ring or plate 59 in engagement. By a pressure of the wrench upon the end of the pin the ratchet-ring 58 is thrown out of engagement with the cap-ratchet ring or plate 59 and the bolt left free to turn with the ratchet-ring 58, in order to adjust the main-shaft bearing-segments, as above stated and described.

Apertures, which are indicated at 8ª in Fig. 12, passing through the main gear-wheel and tappet-wheel 24, to admit a wrench or key for turning the bolts, and corresponding holes, 8ᵇ, are made in the covers of the outer heads to admit the wrench. The smaller holes (indicated in Fig. 12) are for bolts or rivets for securing the tappet-wheel to the gear-wheel.

All the heads are made hollow for the reception of oil, which is supplied through oil-holes in the upper portion of the heads, fitted with plugs 4ª, and suitable ducts lead to all the bearings of the piston-wheel, abutment-rollers, valves, &c. The oil-chambers of the various heads are preferably fitted with cotton waste or other capillary material, to retain the oil and supply it gradually and uniformly to the various bearings, if required.

The engine is fastened together by longitudinal bolts 32, extending completely through from end to end, preferably formed with heads, as shown at 33 in Fig. 2, and with screw-threads to receive nuts 34, bearing on the cylinder-heads, and nuts 35 35 at both extremities for securing the outer cover, through which the bolts extend. The inner surfaces of these covers form oil-tight joints with the outer surfaces of the cylinder-heads, which have raised bearing-surfaces, each being dressed off for that purpose. The extremities of the bolt-heads 33, projecting from the surface of the cylinder-head, constitute dowels for locating the cover at the end next to the pulley, through which the main shaft passes. Thus the concentric position of the bearing 1ª of the main shaft may be better secured.

A hollow bolt is shown at 36, on the upper side of the engine, said hollow bolt performing the same office as the solid bolts 32, except for fastening the outer cases. It also receives within it the rock-shaft 18, for operating the valve-gear at the opposite end of the engine simultaneously with the one next to the reversing-lever.

The end chamber, 37, of the engine, in which the gear-wheels 7 8 work, is an oil-receptacle to keep said gear-wheels constantly clean and lubricated and free from injury or dust.

Where the bolts 32 are exposed to the steam, they may be protected with casings of copper or other non-corrosive material.

The outer end of the main shaft contains a heavy driving-pulley, 60, which assists in producing a steady motion, and upon each side thereof is an adjustable bearing, 61, supported on universal joints, which permit adjustment of the bearings both vertically and horizontally. The bearings have receptacles for oil at the top and bottom, and are mounted by horizontal pivot-screws 67 and swiveled by the pivot-screws at 68, sustained by bracket-arms 65, which arms are united at their base by a sleeve, 64, which is bored out, fitted to and sustained by a vertical standard, 63, the upper end of which passes through the sleeve 64 and collar 67ª, which fits in the recess in the upper end of the sleeve, and through which the upper end of the standard passes and is riveted on. The standard may extend upwardly and receive nuts, instead of being riveted, to hold the sleeve in position vertically. Both these methods leave the bracket-sleeve free to turn on the standard horizontally, in order to adjust itself and the bearing to the line of the main shaft of the engine.

The lower end of the bracket-sleeve rests upon the collar of the standard 63, upon which a wrench may be applied to screw the standard up or down for the vertical adjustment of the bearing. The nut 66 is secured to its position by a lock-washer, 66ª, upon the stand 68ª, which projects up from the base of the engine. This stand is cast solid to the base, but may be made of a separate piece and secured thereto, if desired. The stand 68ª and bracket-sleeve 64 have chambers, as shown, which may be used for oil-receptacles to lubricate the vertical standard 63, which latter is provided with a screw-thread at its lower end, which fits another thread cut in the lower end of the stand 68ª, or in the engine-base, by means of which the vertical movement of the standard is made. For convenience of construction the threaded hole passes entirely through the upper part of the base of the engine, and a boss is formed around the lower end, in which a screw-plug is fitted with an elastic ring and washer to form steam-tight joints; or the joints may be dressed and made steam-tight to prevent the leakage of steam and the consequent corrosion of the screw-threads upon the standard 63. If the screw-thread can be cut as conveniently, the hole need not be made entirely through the top of the base of the engine. The lateral adjustment of the bearing in line with the engine-shaft is made by the pivot-screws 67.

By the use of a suitable proof-templet resting on the seats 71, Figs. 1 and 3, and held in position by pins 72, the bearings may be set accurately in line with the cylinders and main shaft with the utmost facility and expedition. The attachments described also relieve the engine-bearings proper from lateral strain and sustain the draft of the driving-belt, and may be proved and readjusted at any time.

A supplemental box containing another bearing for the main shaft is fitted and bolted to the outer face of the end cover to sustain the draft of the governor or other belts, if desired. This bearing-box is formed so as to combine an oil-chamber and bearing-case. The adjustable part is put in and Babbitt or other suitable metal is poured around the journal, thereby forming a guide for the adjustable bearing-piece. This forms a fine guide internally for the sides of the bearing to work against. This bearing-piece is properly adjusted by a set-screw which is held by a locked jam-nut.

In constructing the auxiliary bearing 1ª, (shown in Figs. 1, 2, 15, and 15ª, the bearing-case is first bored out and the ends properly dressed. The adjustable bearing-piece is then finished and slipped in position in the case, which is fitted with screws or pins to hold the Babbitt. The shaft or templet is then put in position in the bearing and the Babbitt poured in.

The movable bearing-piece is adjusted by a set-screw to sustain the draft of the governor-belt, thus preventing the deflection of the main shaft from its central position with the cylinder. The movable cap and set-screw are placed in any required position radially to the shaft to sustain the draft of the governor-belt, or the combined draft of the main driving-belt and the governor-belt.

The governor-shaft is indicated running in a bearing on a standard which is supported by a brace. On this shaft is a pulley, through which the governor is driven by a belt from the main shaft 1, all of which is more fully described and claimed in another application of even date herewith.

The hollow base upon which the engine is mounted forms a receptacle for a series of connected pipes, through which cold water passes. This arrangement serves the purpose of creating a partial vacuum by the condensation of the steam on the cool pipes, and this assists the steam in working the engine to the extent of the vacuum.

A double purpose may be served by using the water for making steam in the boiler or other purposes, if desired, and thus save the heat imparted in the act of condensation. The illustration of these pipes is shown in Fig. 1 by 73, and the exhaust-pipe leading to the open air by 74.

The water of condensation is taken from the steam-cylinder by ducts through the surface-bearing of the heads, and thence into the hollow base by water-cocks, as shown in Figs. 1, 1ª, 13, &c. These water-cocks are fixed to the end heads, at the under side thereof, and may be opened and closed by hand. A channel is formed to each water-cock through the end heads of the annular chamber in which the piston-teeth revolve. An exhaust-pipe, 74, is screwed or otherwise fastened to the bottom of the base, and passes from thence through the foundation to the open air.

The handle 22 of the reversing-lever 19 is formed with a socket at its lower end fitting loosely over a portion of the lever 19. The latter has a slot near its upper end, in which a pin, 22ᵇ, plays. This pin passes through the socket of the handle 22, and is riveted thereto. A coil-spring, 22ª, is placed in that part of the socket of the handle between the end thereof and the end of the lever 19, which serves to press up the handle 22 and keep the projecting portion of the pin 22ᵇ in engagement with the notches 21ª and 23 in the rack or bail 21, and thus prevent the movement of the lever. A downward pressure on the handle disengages the pin from the notches 21ª, 23, &c., and thus sets the lever free to move either way.

By referring to Figs. 4 and 8 it will be seen that the main portion of the abutment-rollers are each made up of three different pieces of metal—a frame and two surface-pieces. The former is preferably of one piece with the journals and of the shapes shown by the sections in Figs. 4 and 8. The surface-pieces may be composed of Babbitt or other suitable metal

cast on the frames, or of steel, hard brass, or other metal formed to fit the frames.

In Fig. 4, 6^a and 6^d show different forms of frames, and 6^b, 6^c, and 6^f differently-shaped surface-pieces fitting thereto.

In Fig. 8, 6^g shows a frame differently shaped from those just mentioned, and 6^h and 6^j surface-pieces fitting thereto. These surface-pieces can be readily replaced when worn, this being the object in having them renewable. The segment-pinions 13 are fixed on the tapered stems of the valves 10 10 10^a 10^a by pins 301 and a cap-nut, 302, locked by a flexible disk or washer, 303. (See Figs. 10^a and 10^b.) Before the nut is applied the washer 303 is punched down into holes 304, formed in the hub of the pinion, and after the nut is screwed home one or more portions of said washer are turned up against the recess in said nut, as shown in Fig. 10^a.

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

1. A reversible trochilic or rotary engine with two piston-wheels secured to the main shaft, containing two or more piston-teeth placed at opposite sides and at equal distances apart, and secured firmly thereto by bolts, or otherwise, and with two abutment-rollers to each piston-wheel, recessed for the passage of the piston-teeth by the abutment-rollers in their revolutions, the piston-wheels and abutment-rollers being geared together, so that their peripheries shall form steam-tight joints and move at the same speed without slip between their peripheries, in combination with the respective piston-wheel cylinders, abutment-roller cylinders or casings, containing steam and exhaust passages, arranged, as shown, opposite ports 11 11 and 11^a 11^a, and reversible valves, substantially as and for the purpose set forth.

2. A double reversible trochilic or rotary engine with two piston-wheel cylinders, two abutment-rollers, and four reversing-valves to each cylinder, with one center head and two end heads, substantially as and for the purpose set forth.

3. In combination with the toothed piston-wheel and opposite abutment-rollers, the cylinder or casing having inlet steam-passages 11^d and 12^a, opposite induction and exhaust ports 11 11 and 11^a 11^a, paired valves 10 10 and 10^a 10^a, and exhaust-passages 20, substantially as and for the purposes set forth.

4. The abutment-roller provided with renewable surface-pieces 6^b, 6^c, 6^f, and 6^h, and the respective abutment-roller frame-work upon which they are fitted, substantially as and for the purpose set forth.

5. A center head cast hollow, consisting of an oil or other lubricant reservoir therein for a continuous lubrication through ducts of the engine casing and bearings therein located, and a supply-duct and plug, 4^a, in the upper surface of the head for supplying lubricant to the reservoir therein, as described.

6. The hollow heads of the engine, containing closed chambers for oil or other lubricant, from which the engine-bearings therein are constantly lubricated by means of ducts through the respective bearing casings and bearings, with inlet-ducts and plugs to suit in the upper surfaces of the heads, through which lubricant is supplied to the reservoirs of the heads, substantially as and for the purpose described.

7. An adjustable center bearing for the main shaft in the center head, composed of adjustable segment-bearings, for the purpose of securing a continuous central position of the main shaft at its central bearing, and the piston-wheels thereon to their respective cylinders, as and for the purpose set forth.

8. The combination of the bearing-segments 48 and housing 49 and 49^a, through which the said bearings project radially, as set forth, the circular wedges or eccentric segments 50, and the toothed ring 51, said wedges or eccentric segments 50 for adjusting or setting up the bearings, substantially as set forth.

9. The combination of the adjustable main-shaft bearing in the center head and rotary mechanism for adjusting said bearings, with the adjustable main-shaft bearings in the end heads, and the main shaft of a trochilic or rotary engine, substantially as and for the purpose set forth.

10. The combination, with the cylinders, of heads having central projections, 80, upon which the respective cylinders are secured in a position concentric with the main shaft, and piston-wheels in the respective cylinders, as and for the purposes set forth.

11. A reversing valve-gear ring, 15, concentric with the main shaft or valves, with its bearing secured to the surface of the outer head, or bearing-case therein, and arms 14^a, and toothed segments 14, geared with segment-pinions 13, which pinions are secured to the valve-stems, and toothed arms 16, toothed lever 17, rock-shaft 18, and suitable operating mechanism.

12. A reversing valve-gear ring, 15, concentric with the main shaft or valves, with its bearing secured to the surface of the outer head or bearing-case therein, and arms 14^a, and toothed segments 14, geared with segment-pinions 13, which pinions are secured to the valve-stems, and toothed arms 16, toothed lever 17, rock-shaft 18, and lever 19, and reversing socket-lever 22, with a non-conductor handle, coil-spring 22^a, catch 22^b, and semicircular rack with recesses 21^a 21^a 23, in which spring-catch 22^b may be thrown out of gear by pressure of the hand upon the handle and moving the lever to either one of the recesses for placing the valve-gear, valves, and engine in any desired position required, substantially as and for the purpose set forth.

13. In combination with the abutment-roller

bearings, a reversing valve-gear ring concentric with the main shaft or valves, with bearing secured to the surface of the outer head or cover, or both, provided with arms connected by suitable mechanism for operating the valves.

14. In combination with a rotary engine, substantially as described, a lever, 19, socket-handle 22, non-conductor handle, coil-spring 22^a, spring-catch 22^b, and semicircular rack 21, with recesses 21^a 23, substantially as set forth.

15. The combination, with the segmental bearings 48, of eccentric backs, ring or housing 49, and guides 49^a, secured therein, substantially as specified.

16. The combination of a ring, 51, having one or more recesses, with corresponding eccentric segments, 50, secured to said ring by means of rivets or equivalents, as shown, at one end, while the other end is held in recesses formed in the preceding eccentric segment, and the ring 51, substantially as specified.

17. The combination of the segmental bearings 48, having eccentric backs, ring or housing 49, and guides 49^a, eccentric segments 50, and worm-toothed ring 51, with the worm 53, and shaft 54, all substantially as set forth.

18. The combination, with one or more piston-wheels, 2, the main shaft 1, on which said wheel or wheels are mounted and bearings for said shaft in the cylinder-heads, of one or more bearings external to the cylinder, adjustable vertically and horizontally to set or adjust the piston wheel or wheels within the casing and prevent unequal lateral stress thereon, substantially as set forth.

19. In combination with the piston wheel or wheels 2, shaft 1, casing 4, bearings in the heads 12 thereof, and external bearings, 1^a, the pulley-bearings 21, mounted on universal joints, consisting of stands 68^a, standards 63, sleeves 64, bracket-arms 65, and adjustable bearing and pivot screws 67, substantially as and for the purposes set forth.

20. In combination with the main-shaft bearing in the head, a bearing-housing secured to the outside of the cover and having bearing-case and bearing 1^a, provided with an adjustable bearing-piece at its upper side, substantially as and for the purpose set forth.

21. In a rotary engine, the combination of an inclined ring for setting up the adjustable bearing-segments of the main bearing in the end head, with a hollow bolt, 55, spring-bolt, rivet 57, and plate 59, and ring 58, serrated on their faces, as and for the purpose set forth.

22. In rotary engines, the method of adjusting the main shaft by means of a proof-templet supported on lugs 71 on the end of the base, and dowel-pins 72 for securing its position, substantially as and for the purpose described.

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