No. 652,044. Patented June 19, 1900.

G. C. ROHDE.

ROTARY ENGINE.

(Application filed Oct. 20, 1899.)

(No Model.) 5 Sheets—Sheet 1.

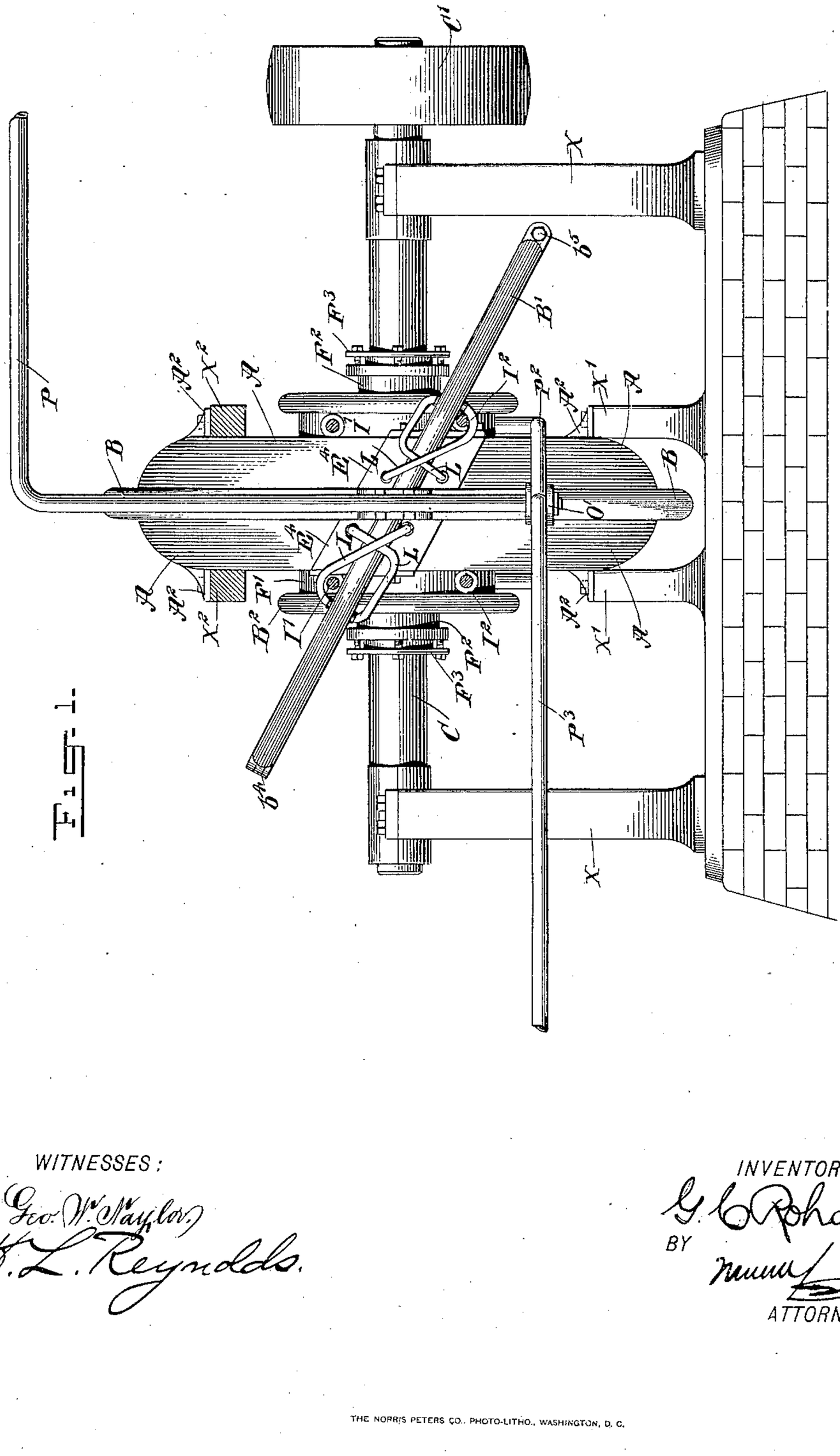

FIG. 1.

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FIG. 2.

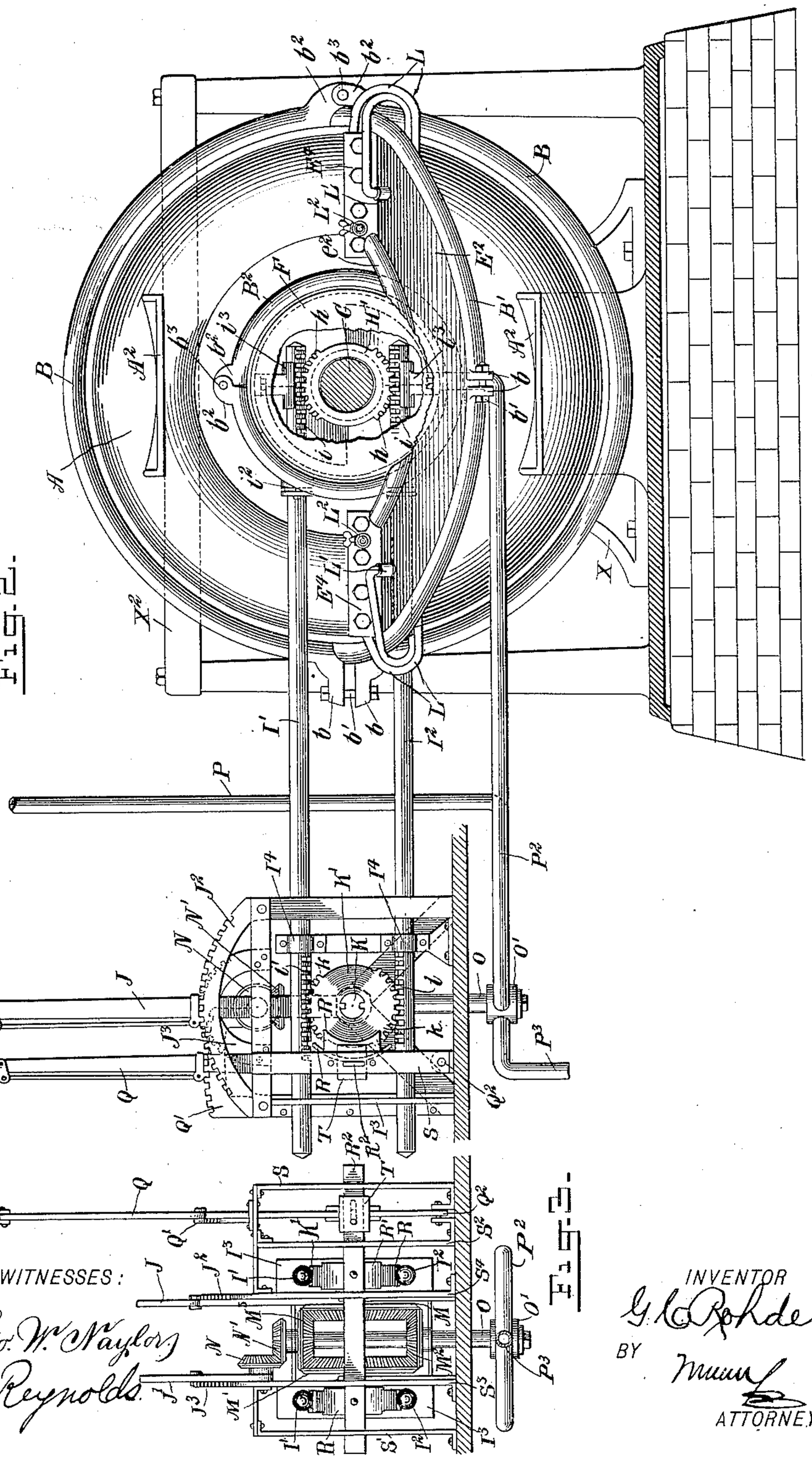

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Fig. 16.

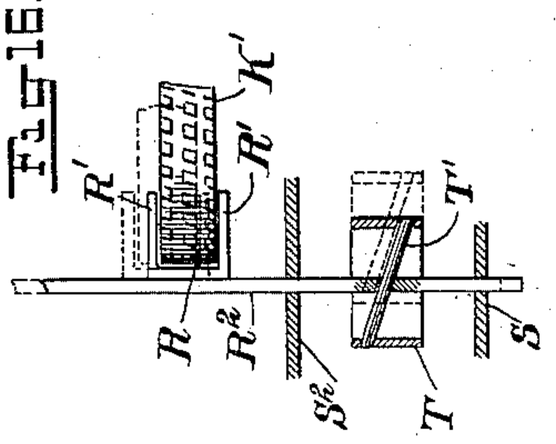

Fig. 15.

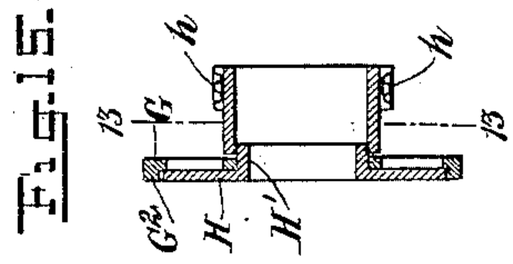

Fig. 17.

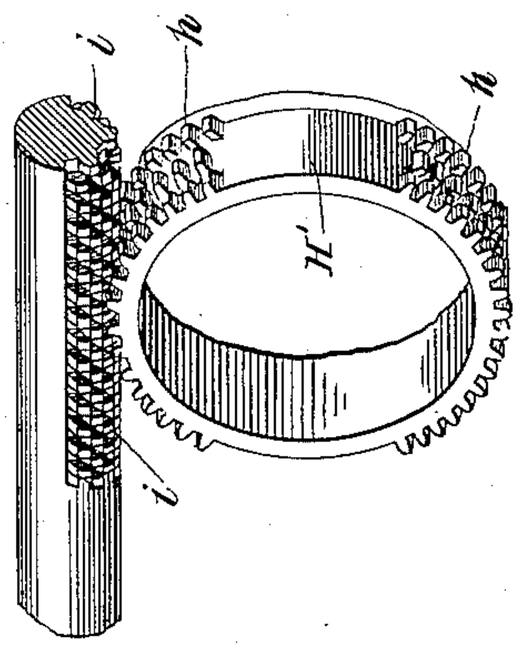

Fig. 18.

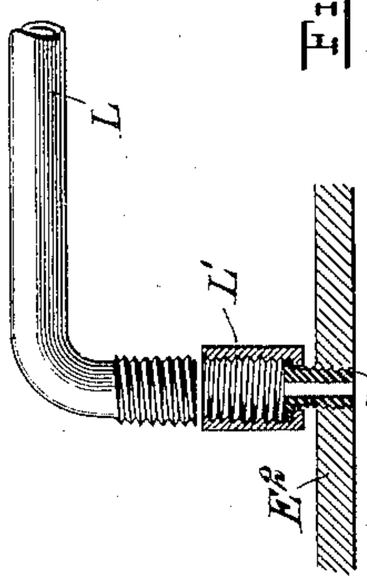

Fig. 14.

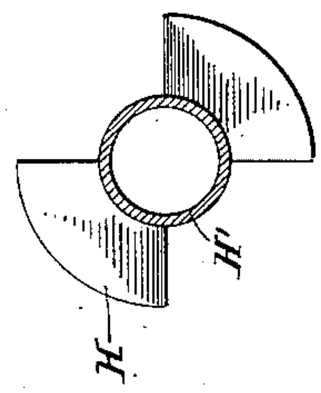

Fig. 4.

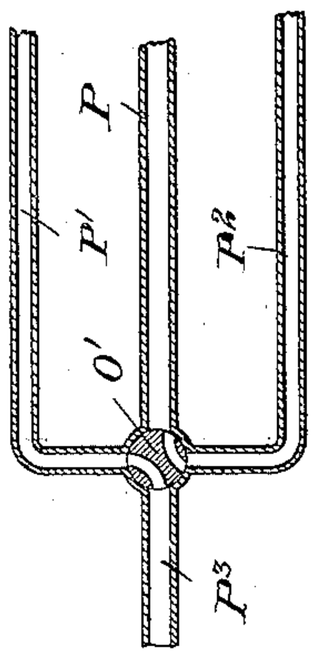

Fig. 13.

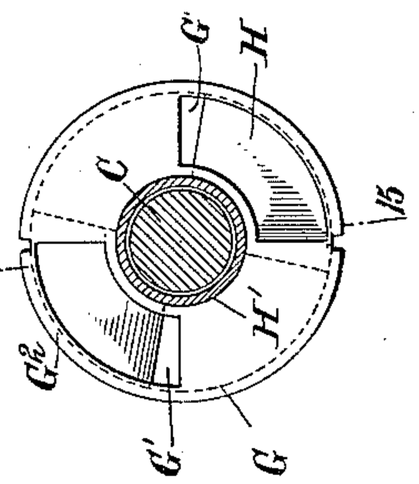

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Fig. 10.

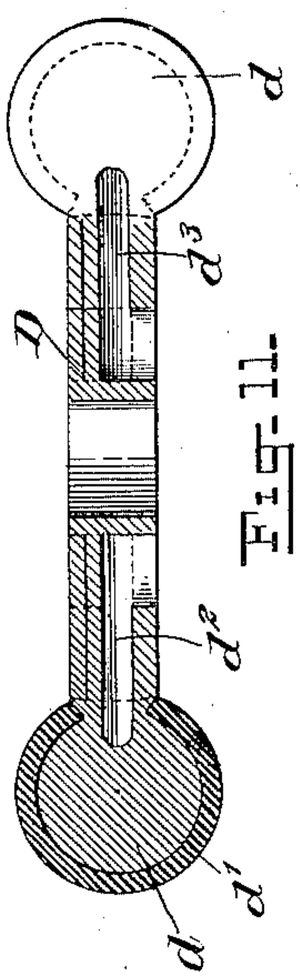


Fig. 11.

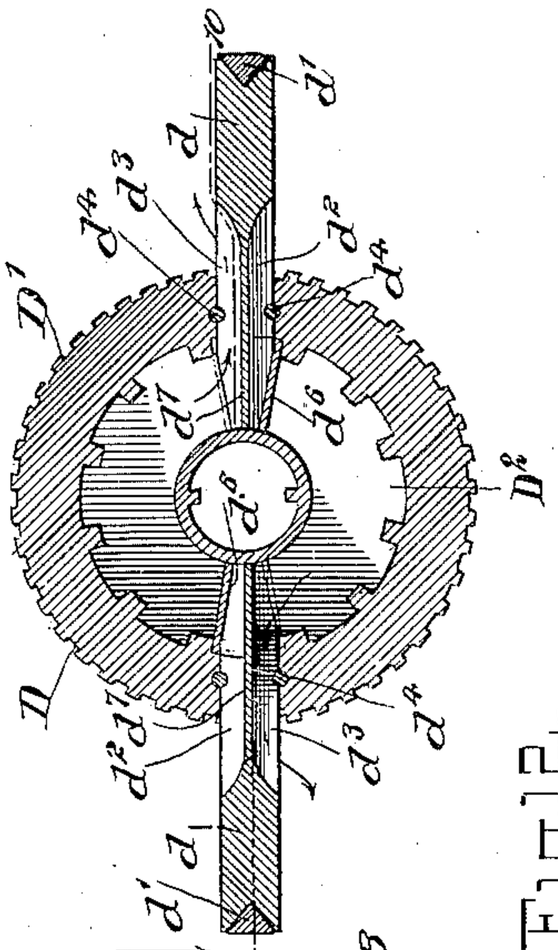


Fig. 12.

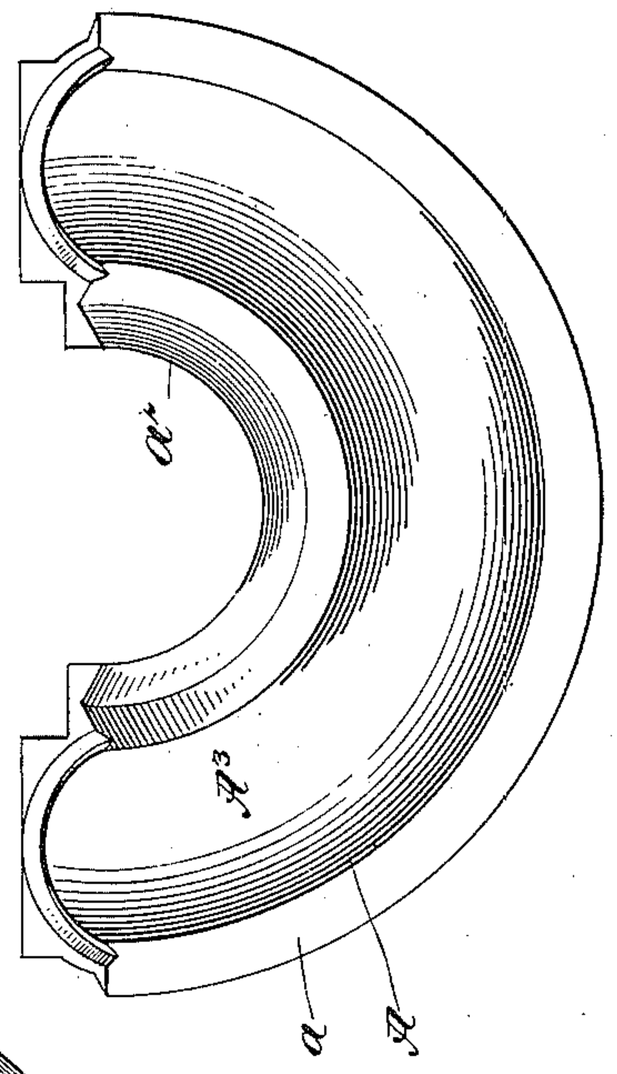
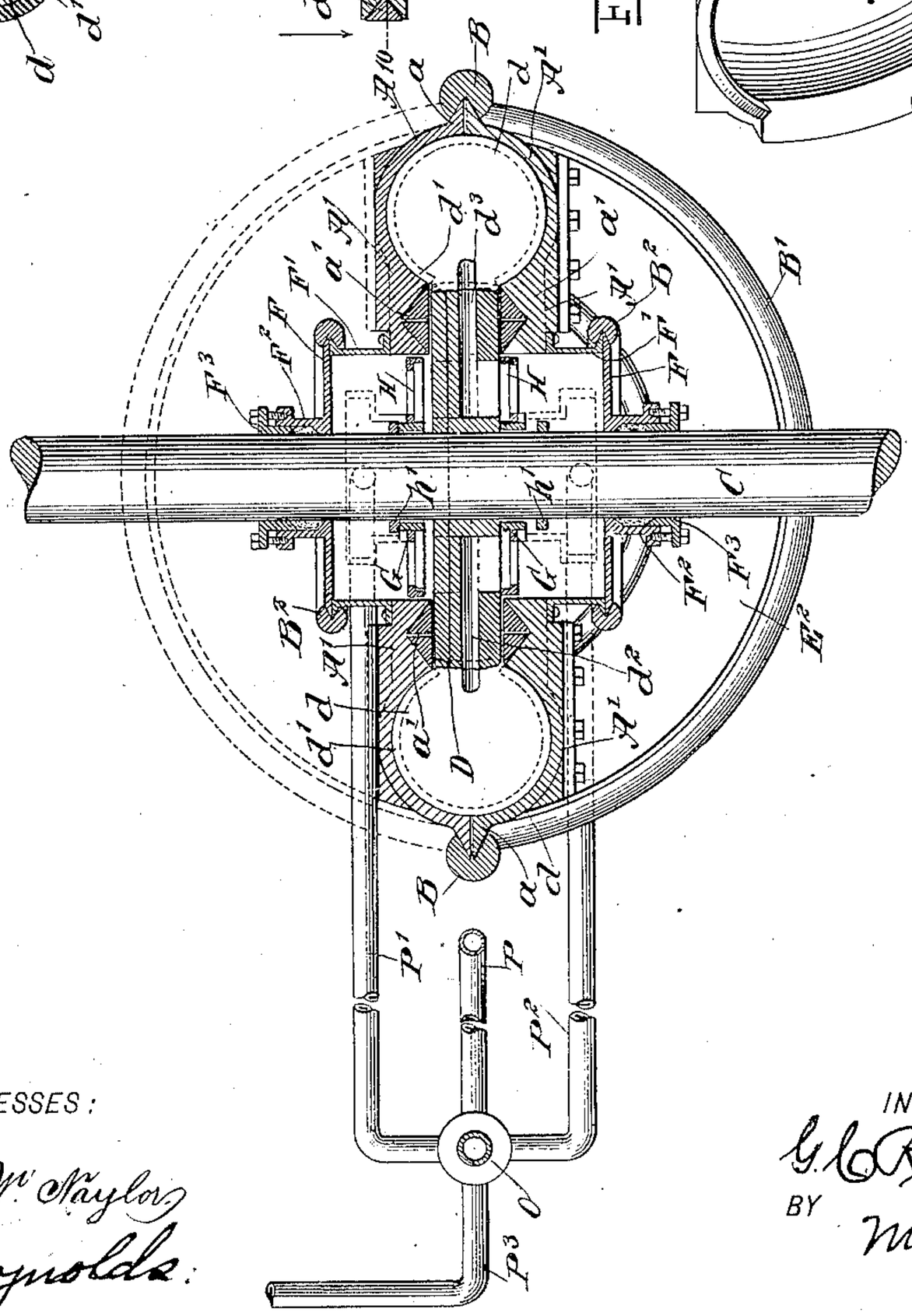


Fig. 5.



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(Application filed Oct. 20, 1899.)

(No Model.) 5 Sheets—Sheet 5.

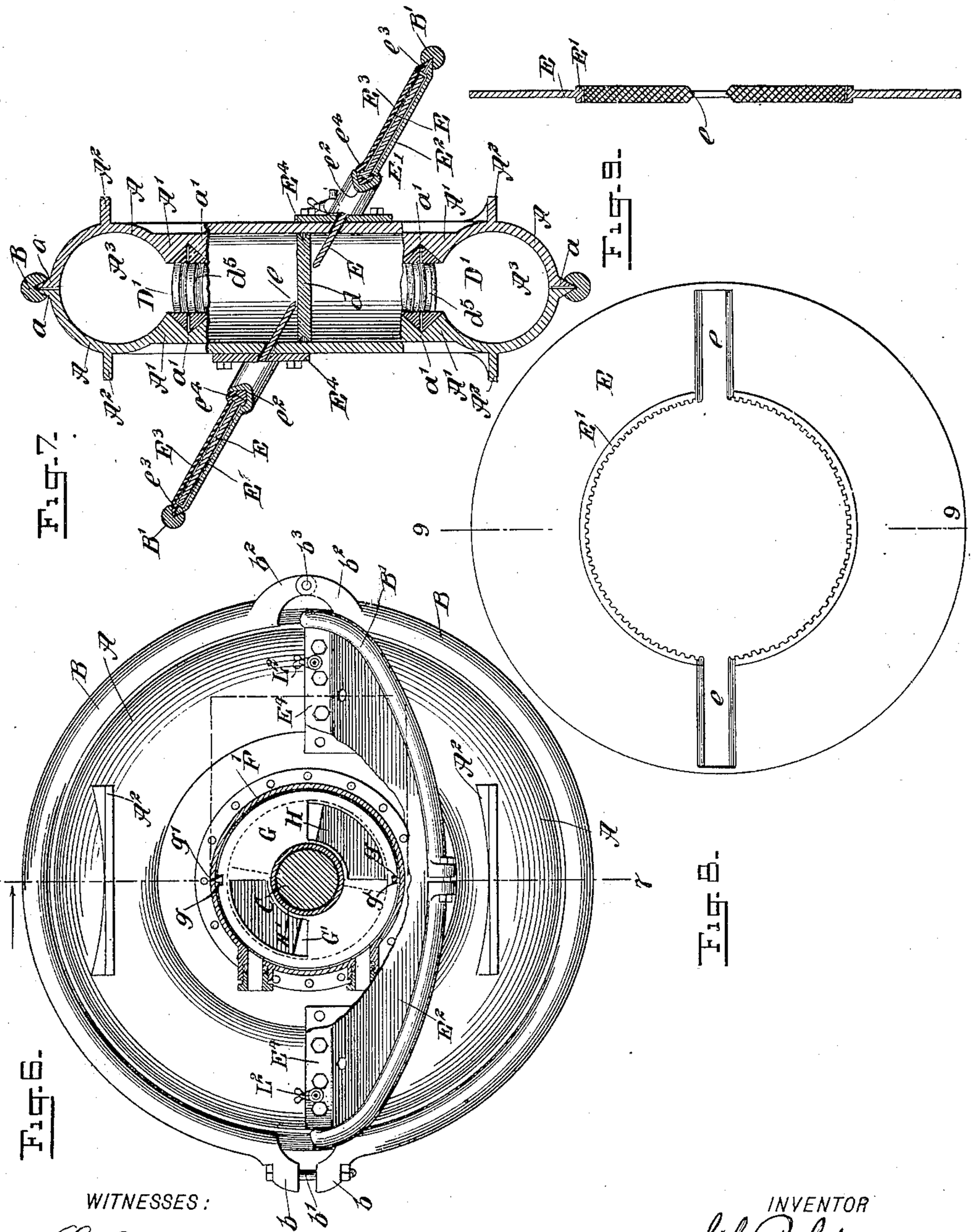

FIG. 7.

FIG. 8.

FIG. 9.

FIG. 6.

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UNITED STATES PATENT OFFICE.

GEORGE C. ROHDE, OF GUNNISON, COLORADO.

ROTARY ENGINE.

SPECIFICATION forming part of Letters Patent No. 652,044, dated June 19, 1900.

Application filed October 20, 1899. Serial No. 734,201. (No model.)

To all whom it may concern:

Be it known that I, GEORGE C. ROHDE, of Gunnison, in the county of Gunnison and State of Colorado, have invented a new and Improved Rotary Engine, of which the following is a full, clear, and exact description.

My invention relates to an improvement in rotary engines, and comprises the novel features hereinafter described and claimed.

Reference is to be had to the accompanying drawings, forming a part of this specification, in which similar characters of reference indicate corresponding parts in all the figures.

Figure 1 is an end elevation of my device. Fig. 2 is a side elevation with a portion of the cover broken away to show the manner of connecting with the valve. Fig. 3 is an elevation taken at right angles to Fig. 2, showing the mechanism for controlling the position of the valve. Fig. 4 is a sectional plan through the steam-pipes and the reversing-valve. Fig. 5 is a sectional plan through the cylinder and valves. Fig. 6 is an end elevation of the cylinder with one valve-chest in section. Fig. 7 is a sectional elevation on the line 7 7 of Fig. 6. Fig. 8 is a plan view of the ring or annular plate which forms the cylinder-heads. Fig. 9 is a section of the same on the line 9 9 of Fig. 8. Fig. 10 is a section through the piston-disk on the line 10 10 in Fig. 11. Fig. 11 is a section through the piston disk and heads, taken at right angles to Fig. 10. Fig. 12 is a perspective view of one section of the casing forming the cylinder. Fig. 13 is an elevation and partial section of the valves. Fig. 14 is an elevation and partial section of the cut-off valve. Fig. 15 is a section through the valves, taken on the line 15 15 of Fig. 13. Fig. 16 is a detail showing in sectional plan the manner of operating the valve-shifting mechanism. Fig. 17 shows in perspective the manner of connecting the valve-rod and valve, and Fig. 18 shows the manner of connecting the ends of the pressure-counterbalancing pipes with the cylinder and steam-chest.

The cylinder of my engine is composed of sections A, which are joined together in such manner as to form an annular steam-space which is circular in cross-section. Four of these sections A are used, each section forming one-half of one side of the cylinder. These sections upon their outer peripheries and on the edge which joins with the sections upon the opposite sides of the cylinder are provided with outwardly-extending triangular flanges *a*. About these flanges passes a binder-ring B, which is formed in two or more sections hinged together by two ears b^2, which are provided with a pivot-pin b^3 and fit over the triangular flanges *a*. The inner periphery of the binder-ring is provided with a triangular groove adapted to receive the two flanges *a*. The opposite ends of these two sections of the binder-ring are provided with ears *b*, through which passes a clamping-bolt *b'*. This ring, fitting tightly over the flanges upon the cylinder-sections and being bound down thereon, will hold them together without the direct use of bolts between the cylinder-sections. These cylinder-sections have a thickened centrally-projecting portion A', which lies upon the side of the piston-disk D.

The sections A' upon opposite sides of the cylinder are separated from each other a sufficient distance to accommodate the outer portion of the piston-disk D. This disk is secured to the shaft C and rotates therewith, said disk having the piston-heads *d* secured thereto and moving within the annular steam-space formed in the outer portions A' of the cylinder-sections. The inner faces of the portions A' of the cylinder-sections are provided with triangular grooves adapted to receive triangular packing-rings *a'*, which bear against the outer side surface of the piston-disk and prevent leakage of steam past the same. The piston-disk is shown in sections taken at right angles in Figs. 10 and 11, and each circular disk is provided with an elastic packing *d'*, placed in a peripheral groove thereof. At two opposite points upon this disk it is provided with recesses or slots adapted to receive the stems of the piston-heads *d*. These piston-heads are then secured in place by means of pins or set-screws d^4, which pass through holes formed partially in the piston-disk and partially in the stems of the heads, thus binding the heads securely in place. The stems of the piston-heads are provided with passages d^2 and d^3, forming steam-ports, by which the steam is admitted to and exhausted from the cylinder. These ports are separated by a central wall d^7 and open at

the inner end of the disk at opposite sides of the piston-disk. The ports d^2 are separated from the chamber D^2 at the center of the disk by plates or partitions D^6. The object of this chamber is to counterbalance the pressure of steam upon the outer surfaces of the valves. The steam-ports d^2 discharge at the side of the piston-disk into the steam-chests formed upon each side of the cylinder. These steam-chests are formed by the annular rings or sleeves F', which are secured at one end to the sides of the cylinder and have their outer ends closed by means of like plates F. These two parts F' F at each side of the disk D are secured together by means of a two-part binder-ring B^2, said parts being hinged together, as at b^4 in Fig. 2, and at opposite ends are clamped by a bolt, the same as b' in the same figure. A triangular groove is formed upon the inner periphery of the binder-ring, which engages triangular flanges formed upon the outer edges of the plate F and the sleeve F', similar to the manner described for securing the sections of the cylinder together. The plate F has an outwardly-projecting flange F^2, which, in connection with the collar F^3, forms a packing device by which a tight joint may be obtained about the engine-shaft C. Within each of these steam-chests is a combined cut-off valve, which is shown in detail in Figs. 13, 14, and 15. This valve consists of two parts, one part consisting of a plate G, which is provided with two opposite segmental holes G'. This plate is also provided with a flange G^2, which projects inwardly or toward the center of the cylinder a short distance from the outer periphery of the plate. Within the recess formed by said flange lies the cut-off plate H, which is shown in detail in Fig. 14. This plate has a sleeve H' attached by thread and key, which passes through the central opening in the plate G. The valve portion of this plate consists of the two segmental wings H, which are of such size as to cover the segmental holes G' when placed in proper position. The other end of the sleeve has teeth h projecting from its periphery and forming opposite toothed segments, each of which extends over about one-third of its circumference. The teeth of these segments are arranged in plural rows and staggered or with the teeth of one row opposite the spaces of the next row, or otherwise, so that the teeth i, which are formed upon the ends of the valve stems or rods I' and I^2, may both turn and slide the valve upon the shaft C as the result, respectively, of a reciprocating and a turning movement given to said rods by means of suitable mechanisms, which will be hereinafter described.

The turning movement of the valve serves to alternately admit and cut off steam from the cylinder, while the sliding movement permits it to rise from its seat when the steam is escaping or to be held from its seat permanently, if desired. The valve which is at the time acting as the exhaust-valve should be held off of its seat, so that the exhaust-ports may be open all the time, while the valve which is acting as the admission-valve would not be held off of its seat unless it is desired to admit steam for the full stroke or so that no expansion is secured. To steady the ends of the rods I' and I^2, brackets i^3 are provided within the steam-chest and engaging the ends of the rods. Stuffing-boxes i^2 surround said rods where they enter the steam-chests.

Upon the shaft C and at a little distance outside of the valves just described are secured two collars or rings h'. These rings are so placed that the valves may be forced outward or away from the center of the cylinder a slight distance before they come in contact with the ring, as is clearly shown in Fig. 5, in which one of the valves is shown in contact with the side face of the piston-disk and the other is shown as being moved away from the piston-disk, so as to contact with one of the rings h'.

The cylinder-heads are in form of an annular plate or ring E, which is shown separated from the other mechanisms in Figs. 8 and 9. This consists of a thin annular plate which has a flange E' upon its inner periphery extending to each side of the plate and forming a slightly-greater surface for engaging with the outer periphery of the piston-disk. This plate is also provided with two slots e, which are made at an angle of about thirty degrees with the plate and are adapted to accommodate the piston-heads d. The edges of these slots are beveled from each side toward the center, making a V-shaped edge. This plate is placed so as to cut through the steam-space of the cylinder and lies at an angle of about thirty degrees with the plane of rotation of the piston-disk, as shown in Figs. 1 and 7. The cylinder is suitably slotted to receive this plate and allow of its passage. The inner periphery of the flange E' upon this plate and the outer periphery of the piston-disk are toothed, the teeth intermeshing, so that the revolution of the piston-disk will cause the plate E to turn about said disk. The teeth d^5 upon the periphery of the piston-disk extend squarely across the same, while the teeth upon the inner periphery of the flange E' extend at an angle of about thirty degrees with the side faces thereof, whereby the teeth upon the disk and plate will intermesh. The teeth upon the plate are in double sets, which cross each other, one set coacting with the teeth upon one side of the piston-disk and the other set with the teeth upon the other side of the disk.

The plate E is constrained to move in its proper plane by means of a casing which is formed of the two plates E^2 and E^3 and which closely fit and inclose the plate. The plate E^2 is secured to the outer surfaces of the cylinder by means of flanges E^4, which are bolted to said cylinder. The plate E^2 has a triangu-

lar trough e^2 extending about its inner periphery and adapted to receive the inner portion of the plate E^3. The two plates E^2 and E^3 are secured to each other by means of a grooved binder-ring B', which engages with the triangular outer edges e^3 of the plates E^2 and E^3. It will thus be seen that, although the plate E passes through slots in the sides of the cylinder, it is inclosed in such manner that the escape of steam through these slots is prevented. The slots *e* in the plate E and the teeth upon said plate and piston-disk are so proportioned and located that the plate E will be rotated synchronously with the piston-disk at double the speed, so that the slot *e* will be presented at the proper time to receive and pass the piston-heads *d*.

The engine is suitably supported by means of flanges or lugs A^2, which project laterally from the sides of the cylinder and engage the standards X' and X^2. The outer ends of the shaft C are supported upon standards X. The shaft C is provided at one end with a pulley or fly-wheel C', by means of which power is communicated from the engine to any desired machinery.

Upon a suitable stand located at one side of the cylinder is mounted the mechanism by which the valves G and H are controlled. The two rods I' and I^2, which are directly connected with the valve H, pass through guides I^4, by which they are constrained to move in a straight line. The outer ends of these rods are provided with plural rows of teeth *i'*, similar to the teeth *i* upon the opposite ends, which engage with the toothed segments of the valves. The ends of these rods are each respectively guided in holes formed in a plate I^3, which is secured to the frame. Loosely keyed upon a shaft K is a disk K', which has toothed segments *k*, similar in construction to the toothed segments upon the valves, and said teeth mesh with the teeth *i'*. By sliding the disk K' the rods I' and I^2 may be turned and the valves moved away from their seats.

The valve-controlling mechanism is in duplicate, each set controlling the valves upon one side of the engine. A curved plate R is placed back of each disk K' and has flanges R' extending from each edge and embracing the disk, so that if the plate is moved sidewise the disk is moved with it. The two plates R are connected by a bar R^2, so that they will be moved together. The bar R^2 is guided in suitable holes in the parts S, S', S^2, S^3, and S^4 of the frame which supports the valve-controlling mechanism.

A lever Q is pivoted at Q^2 upon the frame and is provided with the usual hand-controlled detent, which engages the segment bar or rack Q'. At a point where it will embrace the bar R^2 this lever Q is provided with a box-like section T, which surrounds the bar R^2 and has a pin T' passing diagonally across the box portion of the lever and through the bar R^2. As a result of this construction when the lever is swung upon its pivot it will move the bar R^2 lengthwise in its guides, carrying with it the plates R and the toothed disks K', which, through the mechanism previously described, shifts the position of the valves, throwing the valve upon one side close against its seat and moving the one upon the other side away from its seat. In this way the valves are adjusted for a reversal in motion of the engine.

The turning of the valves is accomplished by means of a lever J, which is secured to one section of the bisected shaft K, upon which the disks K' are slidably held. The two-part shaft K extends across the frame, and upon each portion is secured one of the toothed disks K'. On each part of the bisected shaft K, at their inner ends, the bevel-gears M and M' are secured. These gears mesh with bevel-gears M^2 and M^3, which are loosely mounted upon the shaft O. The shaft O has the reversing-valve O' secured to its lower end, as shown in Fig. 4, by which the course of the steam-supply is controlled. The pipe P is the one connecting with the boiler and through which steam is supplied to the engine. The pipes P' and P^2 connect with opposite sides of the engine, and the pipe P^3 is the exhaust-pipe. The ports in the valve O' are so placed that by a slight turning of the valve the pipes P' and P^2 may be used at option either as supply or exhaust pipes. This valve is controlled in position by means of a lever J', which is pivoted to the upper part of the frame and is provided with the usual hand-operated locking device or detent, which engages the toothed segment bar or rack J^3, a like device on the lever J engaging the toothed bar J^2. A bevel-gear N is secured to the lever-pivot and is turned thereby to operate the bevel-gear N', which is secured to the upper end of the shaft O, which carries the valve O'.

The space between the plates E^2 and E^3, in which the plate E turns, is connected with the cylinder by means of the pressure-counterbalancing pipes L L, which connect the steam-chambers and exhaust-chambers in the cylinder A in the case of each pipe with shallow chambers in the casing E^2 E^3 on opposite sides of the casing from where the other end connects with the cylinder, as shown in Fig. 1. These shallow chambers in the casing E^2, E^3 are as near the cylinder A on either side as may be, and each chamber has an area equal to one-half that of the cylinder. To counterbalance the pressure upon the plate within the cylinder, the pipes L are used, which admit steam to the said casing. These pipes are secured in place by means of a nipple or sleeve L', which is mounted to turn upon a plug L^3, which screws into the plate of the casing or the cylinder, the sleeve being threaded to screw upon the threaded end of the pipe L, as shown in detail in Fig. 18.

When the lever J' stands perpendicular, all steam is shut off by the valve O'. By throwing the lever forward steam passes into the

pipe P^2, whence it passes into the right-hand steam-chest. When the lever J is standing perpendicular, the segmental opening G′ will be half closed by the segmental wings of the valve H. If the lever J be pushed forward, the opening may be closed entirely; if drawn backward, it will be opened full. When opened "full," steam will pass into the side ports in the piston-disk during a "half-stroke," or from the time the piston-head *d* leaves the point of intersection with the cylinder-head E on either side of the cylinder A until it is directly above or below the shafting C, thus making the cut-off at half the stroke. As the lever is pushed forward the cut-off is brought nearer the beginning of the stroke until the steam-port in the valve is entirely closed. The valve G is fixed in opposite steam-chests in a reverse position—that is, in one the segmental openings are as shown in Fig. 13, and in the other the upper opening is to the right of the center and the lower one to the left, and the valve H in opening and closing rotates in an opposite direction to the one on the other side. This combination-valve being open more or less, if the side ports on the piston-disks are in front of the valve-openings G′ the steam will pass into these ports d^2 d^3 and thence into the cylinder A behind the piston-heads *d d*, and between these piston-heads and the cylinder-head plate E the piston-heads will be forced forward until they reach and pass through the notch *e* in the cylinder-head plate E in front of them. When the piston-head *d* reaches the position shown in Fig. 7, half-way through the cylinder-head, the steam from the upper section of the cylinder A exhausts back through the steam-port opening in front of the piston-head *d*. The lower chamber exhausts at the same instant back through the front port of the piston on the other side, which is exactly opposite *d*. When the piston has moved ahead its own thickness, the port on the back of the piston passes the cylinder-head E, and the side ports in the piston-disk D being exactly opposite the piston-heads *d* steam is admitted and the pistons are forced on again *ad infinitum*. Now, to go back, if the side steam-ports d^2 d^3 in the piston-disk D do not chance to be in front of the segmental openings in the valves G H steam will still pass through into the cylinder if the valve G H be not up tight against the face of the piston-disk, because the opening between the valve and the side face of the piston-disk will connect the two ports wherever they may be. If, however, this valve on the side where the steam seeks to enter is in close contact with the face of the piston-disk D, then it must be slightly opened by use of the lever Q. A forward motion will press the valve up to the side face of the piston-disk and a backward movement will withdraw it. If the valve G H be kept slightly withdrawn from the face of the piston-disk on the side which the steam is entering by use of the lever Q, it will serve to feed steam to the engine during the entire stroke if the valves G H be open to any extent whatever. For economy in the use of steam the connected valves G H on the side where the steam enters will always be kept in close contact with the side face of the piston-disk D, except when it may be necessary to open them to start the engine or when the engine may be used to the extreme limit of its power. It will be observed that the two-part valve G H on the opposite or exhaust side of the cylinder A must always be kept removed to a greater or less extent from the side face of the piston-disk D in order that the exhaust may be open all the time. This exhaust-valve should always be kept removed a greater distance from the side face of the piston-disk than the inlet-valve on the opposite side, though to do otherwise would only waste power. The engine would still run. The opposite valve G H is operated to slide it toward and from the piston-disk simultaneously by the lever Q, so that when one is closed the other is wide open. In their turning action they open and close together. When one is closed, the other is also. Their simultaneous sliding action is brought about by the lever Q through the guide-shields R′. In this combination-valve the outer half is prevented from rotating by two grooves *g* in its opposite edges, which engage the lugs *g′*, which project from the inner surface of the steam-chests F′. These lugs need not extend a great distance from the side face of the piston-disk D.

It will be observed that the turning motion of the valves G H is caused by the lever J, which being thrown backward or forward forces the rods I′ I^2 into and out of the steam-chests, the toothed ends of the rods intermeshing with the toothed segments of the valve H, causing the same to turn. The lever Q induces the longitudinal action of the valve G H by means of a rolling motion given thereby to the rods I′ I^2, which are doubly meshed at right angles with the teeth *h* and at the other ends with the teeth *k*, which last are given side motion by means of the guide-shield R′ and the mechanism of the lever Q, acting upon the bar R^2, which is attached to the guide-shield R′.

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

1. A rotary engine having ports in the piston-disk opening at the side thereof, a steam-chest inclosing said ports, a valve controlling the port-opening and comprising two parts, one consisting of a disk having segmental openings therein, and means for holding it against turning, and the other consisting of a member having segment-arms adapted to close the openings in said disk and to turn to vary the opening, and means for turning said latter member, substantially as described.

2. A rotary engine having ports in the pis-

ton-disk opening at the side thereof, a steam-chest inclosing said ports, a valve controlling the port-opening and comprising two parts, one consisting of a disk having segmental openings or ports therein, and means for holding it against turning, and the other consisting of a member having segment-arms adapted to close the openings or ports in said disk and to turn to vary the port-opening, a sleeve secured to said adjustable or turning member of the valve and having teeth upon its periphery arranged in lines substantially at right angles, a rod entering the steam-chest and having teeth thereon extending in rows lengthwise and circumferentially thereof and engaging the teeth carried by the adjustable valve member, whereby the valve may be moved bodily toward or away from its ports and turned about its axis, substantially as described.

3. A valve mechanism for rotary engines, comprising a disk surrounding the engine-shaft and having segmental holes or ports therein, means for preventing said disk or plate from turning about the shaft but permitting it to slide lengthwise thereof, a cut-off member mounted to slide upon said disk and having segmental arms or plates adapted to close the ports in said disk, a sleeve secured to said cut-off member and having teeth upon its periphery arranged in circumferential and axial lines, and a rod entering the steam-chest and having its end toothed in circumferential and longitudinal lines and engaging the teeth upon the cut-off member, whereby the latter may be slid back and forth upon the shaft, substantially as described.

4. A valve mechanism, comprising a valve member mounted to turn and slide upon its axis, a sleeve thereon having teeth upon its periphery arranged in circumferential and axial lines, a valve-operating disk having similar teeth, and a rod having teeth upon its ends adapted to engage both disk and sleeve, and means for both turning and sliding said disk, substantially as described.

5. A valve mechanism, comprising a valve member mounted to turn and slide upon its axis, a sleeve thereon having teeth upon its periphery arranged in circumferential and axial lines, a valve-operating disk having similar teeth and having a sliding keyed connection with its shaft, a rod having teeth upon its ends adapted to engage both disk and sleeve, a lever secured to the axis of said disk to turn it, a slide engaging the disk to slide it upon its shaft, and a lever for operating the slide, substantially as described.

6. The combination in a rotary engine, of a rotary piston-disk and head, and an annular cylinder or casing with cylinder heads or abutments consisting of an annular plate or ring placed at an acute angle with the plane of the piston's revolution and cutting the path of said piston and cylinder on opposite sides, the cylinder having slots accommodating said ring, means for synchronously turning the ring and pistons, and slots in the ring adapted to pass the pistons through them, substantially as described.

7. The combination in a rotary engine of a rotary piston-disk and heads, and an annular cylinder or casing with cylinder heads or abutments consisting of an annular plate or ring placed at an acute angle with the plane of the piston's revolution and cutting the path of said piston and the cylinder on opposite sides, the cylinder having slots accommodating said ring, the ring having upon its inner periphery and the piston-disk upon its outer periphery, intermeshing teeth whereby the two are turned synchronously, and slots in the ring adapted to pass the pistons through them, substantially as described.

8. The combination in a rotary engine, of a rotary piston-disk and heads, and an annular cylinder or casing with cylinder heads or abutments consisting of an annular plate or ring placed at an acute angle with the plane of the piston's revolution and cutting the path of said piston and the cylinder on opposite sides, the cylinder having slots accommodating said ring, toothed connection between ring and piston disk whereby the two are turned synchronously, and slots in the ring adapted to pass the pistons through them, substantially as described.

9. A rotary-engine cylinder composed of sections divided on a radial plane, said sections having projecting triangular or bevel flanges at their contact edges, and a binding-ring having an internal groove fitting over said flanges and holding the sections together, substantially as described.

10. A rotary engine, having a piston-disk mounted to turn and having slots or piston-receiving sockets in its edge, and piston-heads having stems secured in said slots or sockets, said stems being provided with steam-ports, substantially as described.

11. A rotary engine having a piston-disk mounted to turn, and having slots or piston-receiving sockets in its edge, and piston-heads provided with stems secured in said slots or sockets and having passages on opposite sides forming steam-ports, substantially as described.

12. A rotary engine, having a cylinder provided with an annular steam-chamber, a rotating piston-disk and heads thereon fitting said steam-chamber, in combination with cylinder heads or abutments consisting of an annular plate or ring lying at an acute angle with the cylinder and cutting through the steam-chamber, the walls of said steam-chamber having slots accommodating said ring and the ring having slots permitting the passage of the piston-heads therethrough, a casing fitting closely about the projecting parts of said ring and secured to the cylinder, and means for turning the ring in unison with the piston-disk, substantially as described.

13. A rotary engine having a cylinder provided with an annular steam-chamber, a ro-

tating piston-disk and heads thereon fitting said steam-chamber, in combination with cylinder heads or abutments consisting of an annular plate or ring lying at an acute angle with the cylinder and cutting through the steam-chamber, the walls of said steam-chamber having slots accommodating said ring, and the ring having slots permitting the passage of the piston-heads therethrough, a casing fitting closely about the projecting parts of said ring and secured to the cylinder, and intermeshing teeth upon piston-disk and ring whereby the two are turned synchronously, substantially as described.

14. A rotary engine, having a cylinder provided with an annular steam-chamber, a rotating piston-disk and heads thereon fitting said steam-chamber, in combination with cylinder heads or abutments consisting of an annular plate or ring lying at an acute angle with the cylinder and cutting through the steam-chamber, the walls of said steam-chamber having slots accommodating said ring and the ring having slots permitting the passage of the piston-heads therethrough, a casing fitting closely about the projecting parts of said ring and secured to the cylinder, means for turning the ring in unison with the piston-disk, and pressure-counterbalancing pipes connecting the sides of said ring-casing with the cylinder upon the opposite sides of the ring, substantially as specified.

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