No. 715,221. Patented Dec. 2, 1902.

E. C. WARREN.

ROTARY ENGINE.

(Application filed Feb. 5, 1902.)

(No Model.) 3 Sheets—Sheet I.

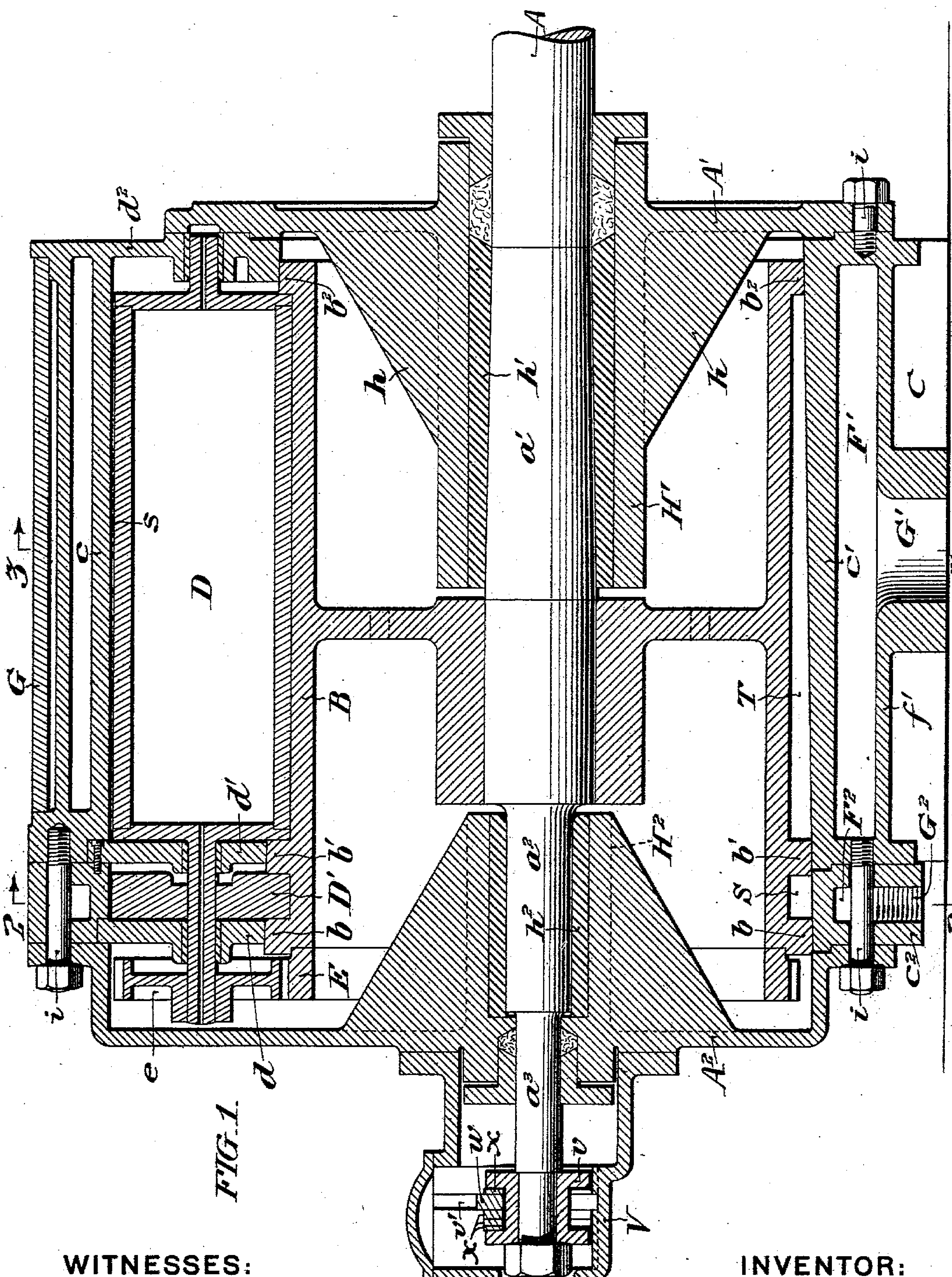

FIG. 1.

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INVENTOR:

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THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

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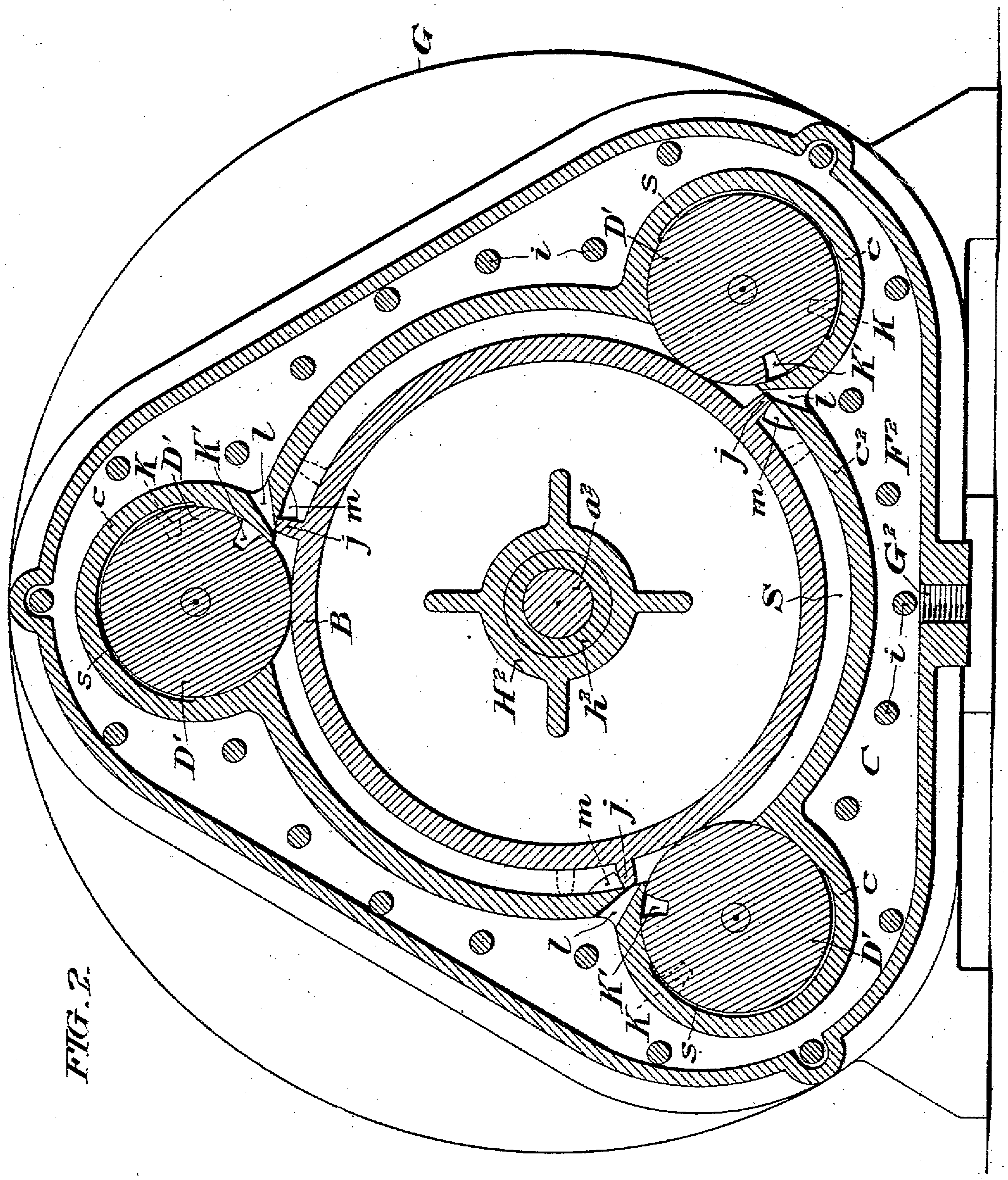

FIG. 2.

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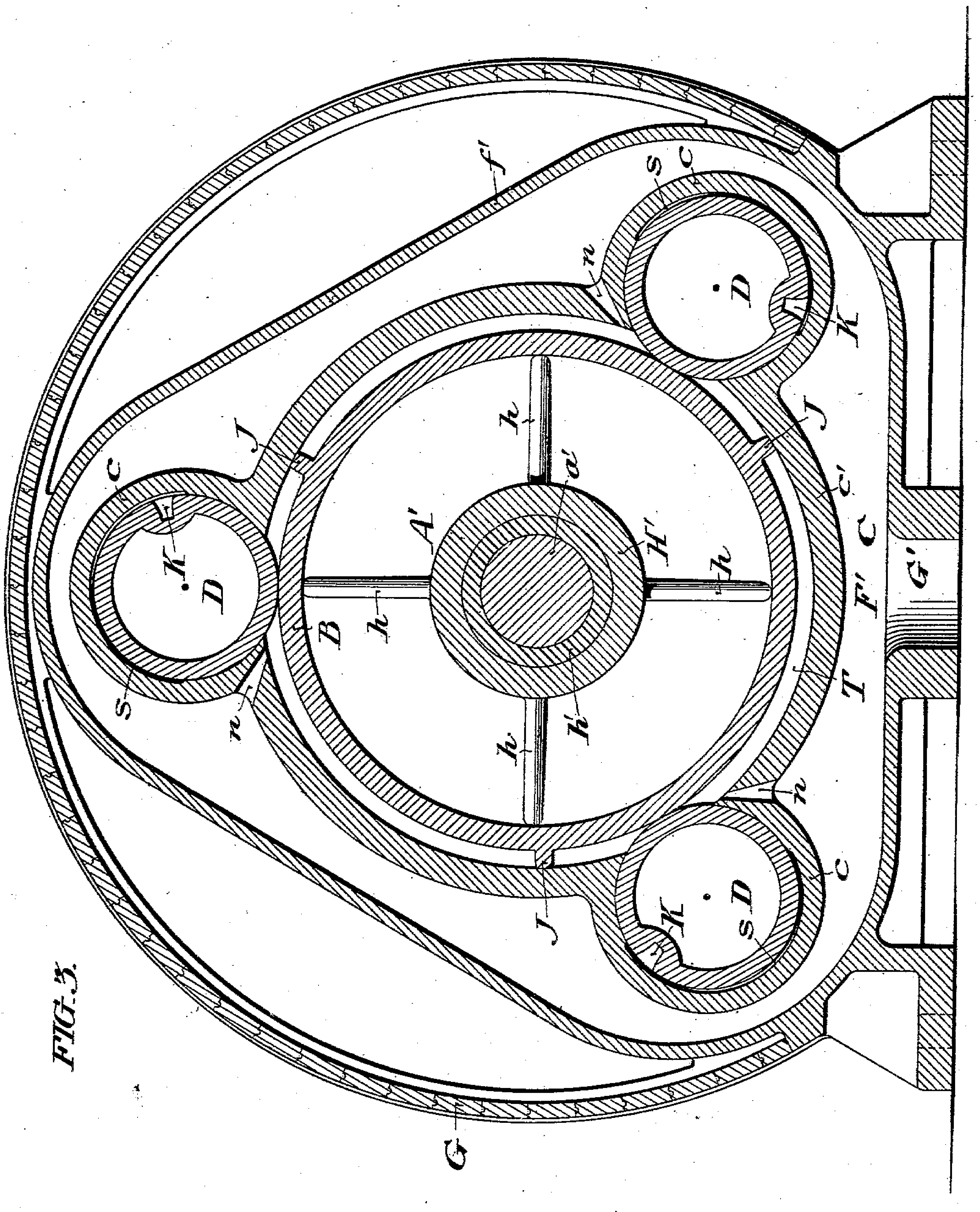

FIG. 3.

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UNITED STATES PATENT OFFICE.

EDWARD C. WARREN, OF PROVIDENCE, RHODE ISLAND, ASSIGNOR TO THE ROTARY ENGINE COMPANY, A CORPORATION OF DELAWARE.

ROTARY ENGINE.

SPECIFICATION forming part of Letters Patent No. 715,221, dated December 2, 1902.

Application filed February 5, 1902. Serial No. 92,602. (No model.)

To all whom it may concern:

Be it known that I, EDWARD C. WARREN, a citizen of the United States, residing in the city and county of Providence and State of Rhode Island, have invented certain new and useful Improvements in Rotary Engines, of which the following is a specification, reference being had to the accompanying drawings.

My invention relates to an engine of the annular-expansion-chamber rotary-abutment type, and has for its object to improve the efficiency of such an engine.

In the accompanying drawings, Figure 1 is a vertical longitudinal central section through an engine embodying my present improvements. Fig. 2 is a vertical cross-section through 2 2, Fig. 1. Fig. 3 is a similar section through 3 3, Fig. 1.

A is the main shaft of the engine. Made fast to the shaft is a rotary cylinder B. This cylinder is hollow, open at both ends, and united to the shaft by a central web, which is preferably integral with the cylinder. The periphery of the rotary cylinder has formed upon it terminal flanges b b^2 and an intermediate flange b', placed much nearer to flange b than flange b^2. The space S between flanges b b' forms the annular high-pressure expansion-chamber of the engine, while the larger space T between flanges b' b^2 forms the annular low-pressure expansion-chamber. The rotary cylinder, with its flanges, fits snugly within a cylindrical casing C. This casing is formed with cylindrical enlargements c c c at three equidistant points around its periphery. The casing is preferably made up of large peripheral castings c', corresponding approximately in position to the low-pressure chamber, a smaller peripheral casting c^2, similarly corresponding in position to the high-pressure chamber, and the two end plates A' A^2, all bolted together by the bolts i i. Within the front end plate A' is formed centrally the large journaling-sleeve H'. This journaling-sleeve projects inwardly almost to the union between the rotary cylinder and the shaft, its inward extension being supported by triangular webs h h, bracing the sleeve to the inner wall of the end plate. A similar journaling-sleeve H^2, similarly braced, is formed in the center of the rear end plate A^2 and also projects inwardly almost to the union between the rotary cylinder and the shaft. Within the journaling-sleeve H' is fitted a bushing h', and within the journaling-sleeve H^2 is fitted a bushing h^2. These two bushings form the main journals for the engine-shaft A. Each of the cylindrical extensions c c c of the casing has mounted upon a common axis within it a large rotary abutment D and a small rotary abutment D'. The large abutment D is preferably made in the form of a hollow cylinder with peripheral and end pieces. The length and position of the abutment D correspond accurately to the low-pressure space T between flanges b' and b^2. The abutment-trunnions are preferably formed integral with the end pieces of the abutment D. Of these the front trunnion is the shorter and is journaled in a bushing supported in the front wall d^2 of this part of the casing. The rear trunnion is larger and is journaled in bushings supported in two abutment-plates d d', which span the cylindrical extension of the casing, the abutment-plate d being situated in the plane of the flange b and the abutment-plate d' in the plane of the flange b'. To this longer trunnion is made fast the smaller rotary abutment D', which may be made solid and which in length and position corresponds accurately to the high-pressure space S between flanges b and b'.

To the rear end of the rotary cylinder B, alongside of the terminal flange b, is fastened a toothed ring E, and in the same plane with this ring there is made fast to the end of the rear trunnion of the abutment (which for this purpose projects through the abutment-plate d) a pinion e, which intermeshes with the toothed ring E.

The large peripheral casting c' of the cylindrical casing C is a hollow shell, of which the exterior wall f' has a triangular shape. The space F' within the walls of this casting has a large aperture G', by which it is in communication with the exhaust, and thus forms a large exhaust-chamber. Likewise the smaller peripheral casting c^2 is a hollow shell of similar cross-section. The space F^2 within the walls of this casting (separated from space F' by the solid ends of the castings) is in free communication with steam or other fluid pressures by means of aperture G^2, and thus forms an annular pressure-chamber. The two peripheral castings may be inclosed by a rounded exterior case G.

The annular high-pressure expansion-chamber S is subdivided into three equal compartments by three transverse wing-pistons *j j j*, uniting flange *b* of the rotary cylinder with flange *b'*. Similarly the low-pressure expansion-chamber is subdivided into three equal compartments by three transverse wing-pistons J J J, uniting flange *b'* with flange b^2.

The peripheries of the rotary abutments and the cylinder are in direct contact, and as the lengths of the abutments are respectively equal to the chambers S and T the contact-lines form fixed barriers against the passage of pressure from the compartments of the chambers on one side to those on the other side. This contact is a direct metallic contact without interposition of packing. In order to permit at the proper times the passage of the wing-pistons by the abutments, the large abutments D are formed each with a longitudinal groove K, cut from end to end, the ratio of the gearing between the abutment-pinion and the toothed ring of the rotary cylinder being such as to cause this recess to accurately intermesh with one of the wing-pistons J at each rotation. Similarly the smaller abutments D' are formed each with a longitudinal groove K', which intermeshes with one of the wing-pistons *j* at each rotation. For insuring closeness and accuracy of this intermeshing with a minimum leakage of pressure the contacting surfaces of the wing-pistons and of the grooves have both a convex curvature, the curves being calculated according to the rules of a true toothed gearing. To maintain the lines of contact between the abutments and the rotary cylinder, pressure-spaces *s s* are formed by slightly recessing the inner walls of the extensions *c c c*, which receive the abutments on the sides opposite to the lines of contact of both large and small abutments. Pressure from the high-pressure expansion-chamber is allowed to leak into the interior of the casing C at its rear end. Hence it finds its way through the journals of the abutment-trunnions (or, if desired, by specially-designed passages) into these pressure-spaces, constantly forcing the abutments down on the cylinder. It will be noticed that the trunnions of abutment D are pierced axially by a passage which transmits this pressure from the rear to the front bearing, thus equalizing the pressure upon the ends of the trunnions. There is also a constant passage of pressure from the expansion-chamber of the cylinder to these pressure-spaces by transference by the grooves K K' as they rotate from one to the other. To equalize this contact, I prefer to provide a moving or slipping contact between these contiguous surfaces. This is attained by giving to the abutments a slightly-greater diameter than the circle formed by the pitch-line of the pinions *e*. In this way without disturbance of the intermeshing there is a constant slippage between the abutments and the rotating cylinder.

Pressure is constantly admitted from the pressure-chamber F^2 into the compartments of the high-pressure expansion-chamber S by three ports *l l l*, which, as seen in Fig. 2, are cut angularly, so as to open in immediate juxtaposition to each of the rotary abutments on the side away from which the rotation of the cylinder B takes place. From the high-pressure expansion-chamber constant communication is had with the compartments of the low-pressure expansion-chamber by three ports *m*, cut through the flange *b'*, the triangular shape of which is shown in Fig. 2. Although the ports are shown as reaching to the periphery of the flange, it is not necessary that they should do so. They may instead of forming notches, as shown, be true apertures, of which the outer edge is parallel to the periphery of the flanges. Each of these ports *m* is immediately in advance (considering the direction of rotation) of one of the wing-pistons *j*. The wing-pistons *j* of the low-pressure expansion-chamber are situated relatively a short distance in advance of the wing-pistons *j* of the high-pressure expansion-chamber. Consequently each port *m*, although it opens from the high-pressure expansion-chamber immediately in advance of one of the wing-pistons of that chamber, enters the low-pressure expansion-chamber immediately behind the wing-piston of that chamber. The low-pressure expansion-chamber T is in constant communication with the exhaust-chamber F' by three ports *n n n*, which, as seen in Fig. 3, are cut so as to open in immediate juxtaposition to each of the rotary abutments on the side toward which rotation of cylinder B takes place.

The operation of the parts thus described is as follows: The three wing-pistons *j j j* simultaneously clear the abutments, and high pressure is admitted between each wing-plate and the abutment. The pressure in front of the abutment is free to exhaust through ports *m* into one of the larger low-pressure compartments, the difference in pressure thus being exerted to effect rotation. At the same time in the low-pressure compartments each wing-piston J J J as it clears an abutment receives pressure through port *m*, exhausted only to the extent of the difference in size between the high and low pressure compartments. The pressure in advance of these wing-pistons is constantly free to exhaust through ports *n*, and consequently the difference is exerted to effect rotation. There is no dead-center, because during the short interval required for the wing-pistons *j* of the high-pressure chamber to pass from the lines of contact with the abutment until they cross the ports *l* (which is the only interval during which the high-pressure chamber is dead) the ports *m* are admitting high pressure directly into each low-pressure compartment behind the wing-piston J.

I will now describe those parts of my invention which are designed to maintain closeness of fit between the casing C and the edges of the flanges *b* *b'* and b^2 of the cylinder B. To this end the interior of the casing C is formed with a forwardly-reducing taper, as will be noticed by observing the upper edge of the casting *c'* as it appears in Fig. 1. As the diameter of cylinder B is constant, this reduction is taken up by the successively-diminished height of the flanges *b* *b'* b^2. In like manner the bushing *h'* and the portion *a'* of the main shaft, which rests within it, are reduced by a taper at a corresponding angle. The portion a^2 of the main shaft, which rests within the rear bushing h^2, is of considerably smaller diameter than the portion immediately in front of it, to which the rotary cylinder B is attached. The shoulder thus formed is exposed to the pressure which constantly exists within the casing C by reason of the leakage which has been spoken of. There is thus exerted a constant thrust tending to force the main shaft A, and with it the cylinder B, forward into the casing. A further thrust in the same direction will be exerted by the difference in pressure between the rear and front ends of the cylinder. Usually, however, this excess is not required, and in this case the pressure on both ends may be equalized by piercing the central web, on which the rotary cylinder is mounted. This forward movement takes place as rapidly as the adjustable thrust-bearing, which will hereinafter be described, will permit. By carefully regulating this thrust-bearing the proper contact between the flanges and wing-pistons of the cylinder and the interior of the casing will be maintained. To allow for this forward motion of the cylinder, it will be observed that spaces are provided at all points where it is necessary for this motion to be taken up, including the forward ends of the abutments and of the abutment-trunnions, which by reason of their engagement with the flanges of the cylinder must advance simultaneously with it, as in all engines the wear upon the rotating parts occurs chiefly at the bottom, where the weight rests, entailing a slight downward movement of the axis of the shaft. By a proper calculation this downward motion, in combination with the advance of the shaft, which has been provided for, will yield a resultant angle, and for the highest efficiency the angle of the taper of the parts which have been described should be made to correspond to the resultant angle. For the more perfect regulation of the advance of the shaft I have provided it at its rear end with an adjustable thrust-bearing, which is shown in Fig. 1. Behind the smaller portion a^2 of the main shaft a still smaller rearward extension thereof, a^3, passes through a stuffing-box in the end plate A^2 of the casing into a bearing-box V, supported on the outside of this end plate. Within this bearing-box the extension of the shaft carries a flanged collar *v*. The sides of the bearing-box have vertical grooves *v'* cut in them, in which a bearing-plate *w* rests. This plate is in the form of a partial annulus approximating a horseshoe, slid down over the flanged collar *v*. A series of movable washers *x* *x*, of similar shape, but smaller in size, so as not to engage the grooves *v'*, fill up the spaces on either side of *w* and the flanges of collar *v*. As the shaft travels forward these washers *x* are renewed, transposed in position, or changed in thickness, so as to properly bear the thrust of the shaft, and restrained in axial travel to whatever extent is necessary to carry out the regulation of the contact of the rotary cylinder with the casing, as has been explained.

Having thus described my invention, I claim—

1. In a compound rotary engine, the combination of the casing; a rotary cylinder within the casing, with an intermediate flange forming high and low pressure expansion-chambers; wing-pistons on either side of the intermediate flange; recessed rotary abutments revolving coincidently with the rotary cylinder; and ports formed in the intermediate flange, whereby the high and low pressure expansion-chambers communicate with each other, substantially as described.

2. In a rotary engine, the combination of the casing; a rotary cylinder within the casing, with terminal and intermediate flanges forming two expansion-chambers; wing-pistons between the flanges; recessed rotary abutments revolving coincidently with the rotary cylinder; and ports formed in the intermediate flange, whereby the two expansion-chambers communicate with each other, substantially as described.

3. In a compound rotary engine, the combination of the casing; a rotary cylinder within the casing with an intermediate flange forming high and low pressure expansion-chambers; wing-pistons on either side of this flange, those of the low-pressure chamber being somewhat in advance of those of the high-pressure chamber; recessed rotary abutments revolving coincidently with the rotary cylinder; and ports formed in the flange between the high and low pressure expansion-chambers, said ports opening into the high-pressure chamber immediately in advance of its wing-piston, and into the low-pressure chamber immediately behind its wing-piston, substantially as described.

4. In a compound rotary engine, the combination of the casing; a rotary cylinder within the casing, with an intermediate flange forming high and low pressure expansion-chambers; wing-pistons on either side of the flange; recessed cylindrical abutments in contact with the periphery of the rotary cylinder and revolving coincidently therewith;

ports formed in the flange; the advancing edge of the port having a curvature parallel to that of the periphery of the rotary abutment as it passes it, substantially as described.

5. In a compound rotary engine, the combination of the casing; a rotary cylinder within the casing, with terminal and intermediate flanges forming high and low pressure expansion-chambers; a plurality of wing-pistons between the flanges forming high and low pressure chambers; a similar plurality of wing-pistons between the flanges forming the low-pressure chamber; the wing-pistons of one chamber being somewhat in advance of those of the other; a plurality of rotary abutments revolving coincidently with the cylinder; said abutments having each a single groove intermeshing with each of the wing-pistons of the high-pressure chamber, and a single groove intermeshing with each of the wing-pistons of the low-pressure chamber, substantially as described.

6. In a rotary engine, the combination of the casing; a rotary cylinder within the casing carrying one or more wing-pistons; a rotary abutment in contact with the rotary cylinder and formed with a longitudinal recess; toothed gears fast to both cylinder and abutment whereby the wing-piston of the cylinder is caused to intermesh with the recess of the abutment, the pitch-line of these gears being in a different cylindrical plane from the contacting peripheries of the abutments and cylinders, whereby there is obtained a constant slippage along their line of contact, substantially as described.

7. In a rotary engine, a tapered cylindrical casing; a flanged rotary cylinder with wing-pistons fitting therein; recessed rotary abutments revolving coincidently therewith; and means whereby the wear between the cylinder and its casing is taken up by axial advancement of the cylinder within the casing toward its reduced end, substantially as described.

8. In a rotary engine, the combination of a tapered cylindrical casing; a flanged rotary cylinder with wing-pistons fitting therein and mounted upon a shaft, a portion of which is tapered to correspond to the taper of the casing; and a tapered bushing in which the taper of the shaft fits, substantially as described.

9. In a rotary engine, the combination of a tapered cylindrical casing; a true cylinder mounted rotatably therein, with flanges and wing-pistons the edges of which are tapered to fit the casing; rotary abutments which are true cylinders mounted on axes parallel to the axis of the central cylinder; and means whereby the wear upon the edges of the flanges and wing-pistons is taken up by the axial advancement toward the reduced end of the casing of both the central cylinder and the rotary abutment, substantially as described.

10. In a rotary engine, the combination of a tapered cylindrical casing; a flanged rotary cylinder with wing-pistons fitting therein and mounted upon a shaft having a shoulder formed thereon opposite to the reduced end of the tapered casing; and means for admitting pressure in the region of this shoulder, whereby the wear of the parts is taken up by axial advancement of the rotary cylinder toward the reduced end of the casing, substantially as described.

11. In a rotary engine, the combination of a tapered cylindrical casing; a flanged rotary cylinder with wing-pistons fitting therein and mounted upon a shaft having a shoulder formed thereon opposite to the reduced end of the tapered casing; means for admitting pressure in the region of this shoulder, whereby the wear of the parts is taken up by axial advancement of the rotary cylinder toward the reduced end of the casing; and a thrust-bearing upon the extremity of the shaft consisting of a flanged collar mounted thereon, a fixed bearing-washer surrounding the collar, and movable washers fitting between the bearing-washer and the flanges of the collar, substantially as described.

12. In a rotary engine, the combination of a cylindrical casing formed of end pieces and two hollow peripheral castings, the annular spaces of which respectively form high-pressure and exhaust chambers; a rotary cylinder having terminal and intermediate flanges situated respectively in the planes of the edges of these castings, whereby high and low pressure expansion-chambers are formed between the flanges; wing-pistons uniting the flanges; rotary abutments; and ports connecting the high-pressure and exhaust chambers respectively with the high and low pressure expansion-chambers, substantially as described.

13. In a rotary engine, the combination of a cylindrical casing; a flanged rotary cylinder mounted thereon; wing-pistons uniting the flanges of the cylinders; cylindrical rotary abutments mounted within the casing, the peripheries of which are in contact with the periphery of the central cylinder; longitudinal recesses cut in the peripheries of the abutments; means whereby coincident rotation of the central cylinder and abutments is obtained, both of the contiguous surfaces of the recesses of the abutments and sides of the wing-pistons being formed of a convex curvature after the fashion of intermeshing gear-teeth, substantially as described.

14. In a rotary engine, the combination of a cylindrical casing; a central rotary cylinder with terminal and intermediate flanges forming high and low pressure expansion-chambers; wing-pistons subdividing each of the expansion-chambers into compartments; a plurality of rotary abutments situated around the central cylinder and with their peripheries in contact therewith; means for maintaining coincident rotation of the central cylinder

and the rotary abutment; pressure-ports opening into the high-pressure expansion-chamber immediately in advance of each abutment; and exhaust-ports opening into the low-pressure expansion-chamber immediately behind each of the abutments, substantially as described.

15. In a rotary engine, the combination of a cylindrical casing; a central rotary cylinder with terminal and intermediate flanges forming high and low pressure expansion-chambers; wing-pistons subdividing each of the expansion-chambers into compartments; a plurality of rotary abutments situated around the central cylinder and with their peripheries in contact therewith; means for maintaining coincident rotation of the central cylinder and the rotary abutments; pressure-ports opening into the high-pressure expansion-chamber immediately in advance of each abutment; exhaust-ports opening into the low-pressure expansion-chamber immediately behind each of the abutments; and connecting-ports between the high and low pressure expansion-chambers formed in the intermediate flange of the cylinder, substantially as described.

16. In a compound rotary engine, the combination of a cylindrical casing; a central flanged rotary cylinder within the casing fitted with both terminal and intermediate flanges forming high and low pressure expansion-chambers; three equidistant wing-pistons between the flanges in both the high and low pressure chambers; three equidistant recessed abutments surrounding the rotary cylinder and rotating coincidently therewith, substantially as described.

In witness whereof I, the said EDWARD C. WARREN, have hereunto signed my name, in the presence of two subscribing witnesses, this 30th day of January, A. D. 1902.

EDWARD C. WARREN.

Witnesses:

JAMES H. BELL,

ELIZABETH C. MAHON.