(No Model.)

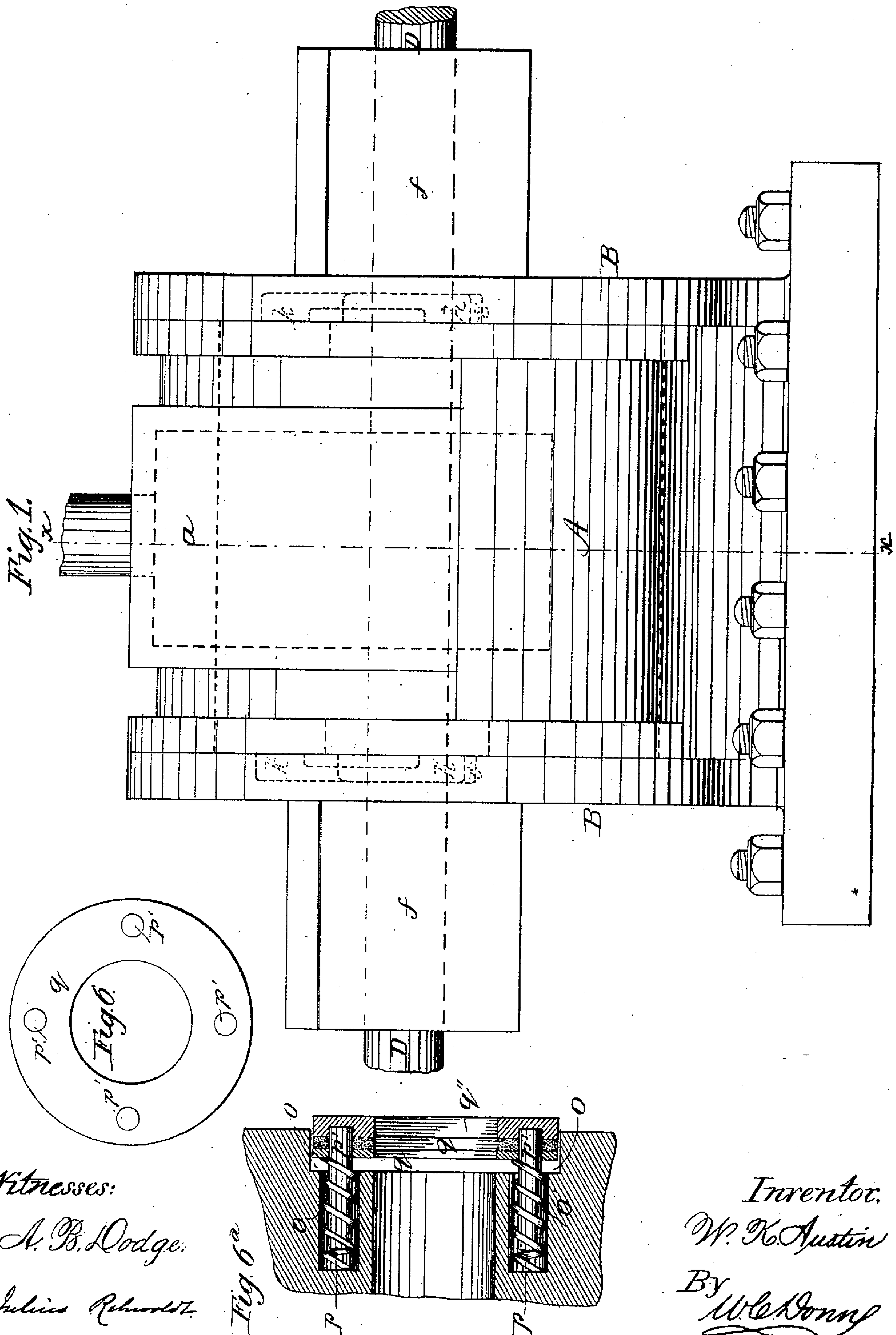
6 Sheets—Sheet 1.

W. K. AUSTIN.

ROTARY STEAM ENGINE.

No. 348,879.

Patented Sept. 7, 1886.



Witnesses:

A. B. Dodge.

Julius Rehwoldt.

Inventor.

W. K. Austin

By W. E. Donny

Attorney.

N. PETERS. Photo-Lithographer, Washington, D. C.

(No Model.)

6 Sheets—Sheet 2.

W. K. AUSTIN.

ROTARY STEAM ENGINE.

No. 348,879. Patented Sept. 7, 1886.

Fig. 2.

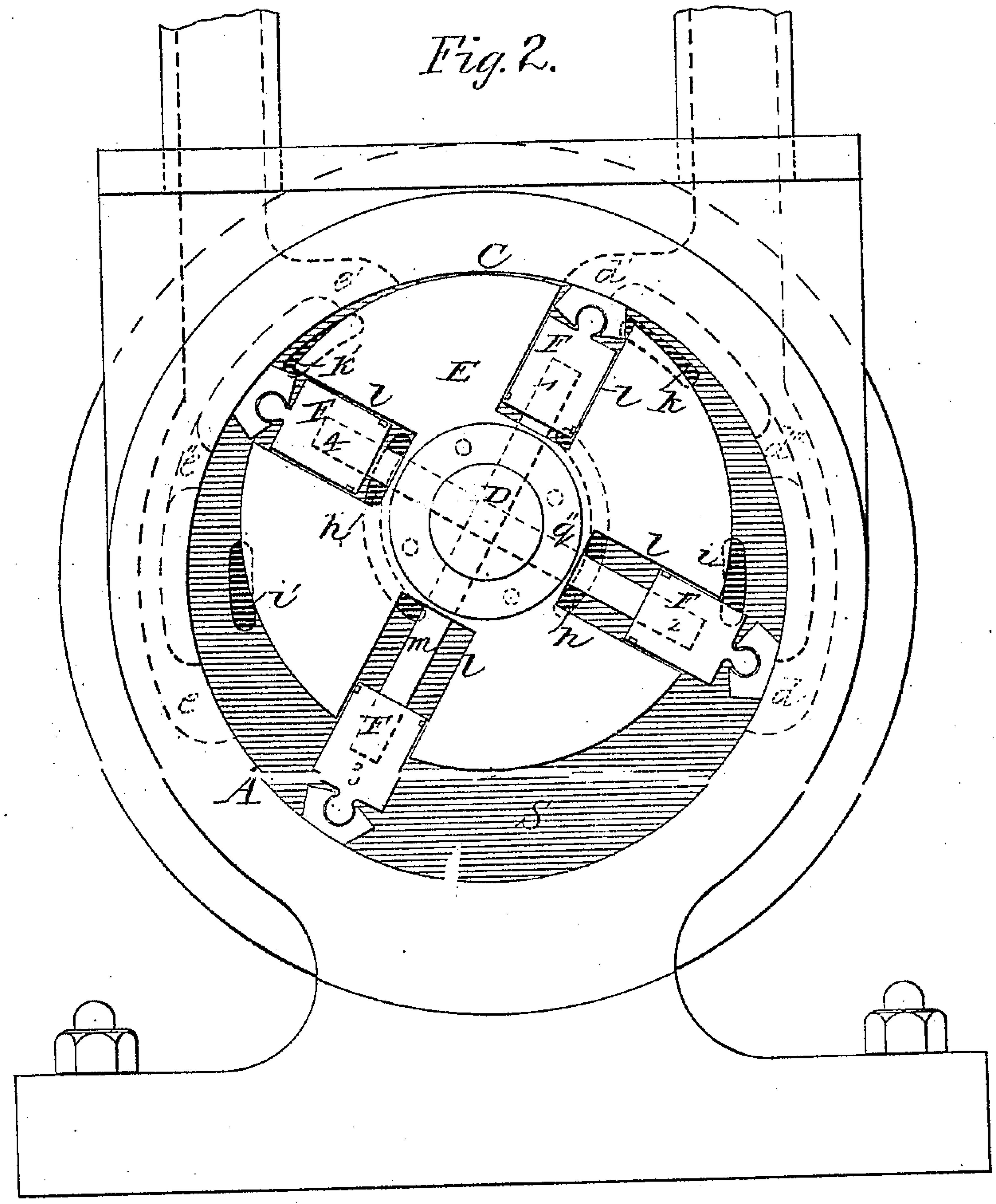


Fig. 7.

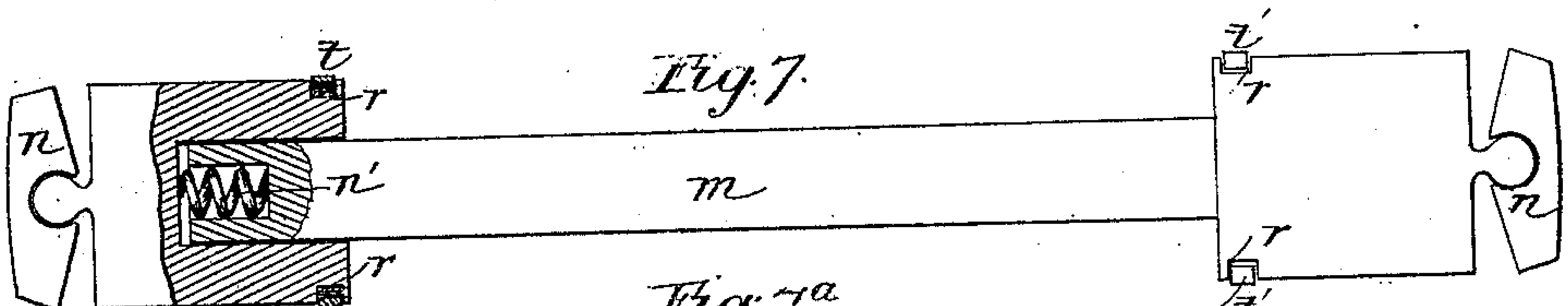
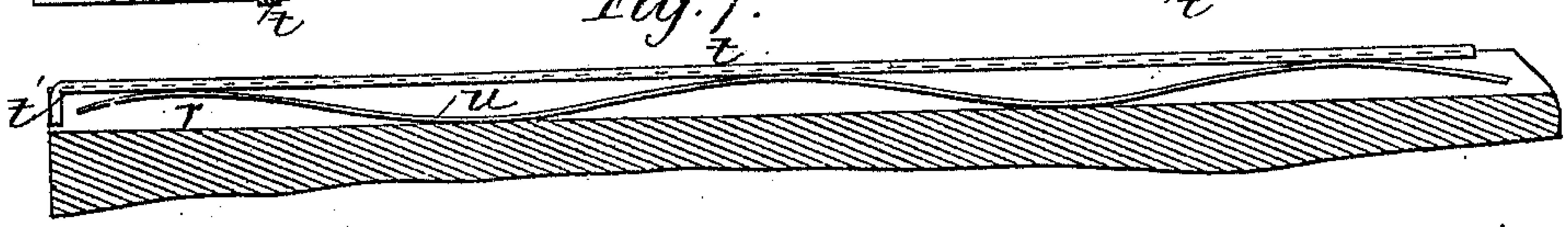


Fig. 7ª.



s.
odge.

Inventor.
W K Austin

By W. C. Dodge
Attorney.

N. PETERS, Photo-Lithographer, Washington, D. C.

(No Model.)

6 Sheets—Sheet 3.

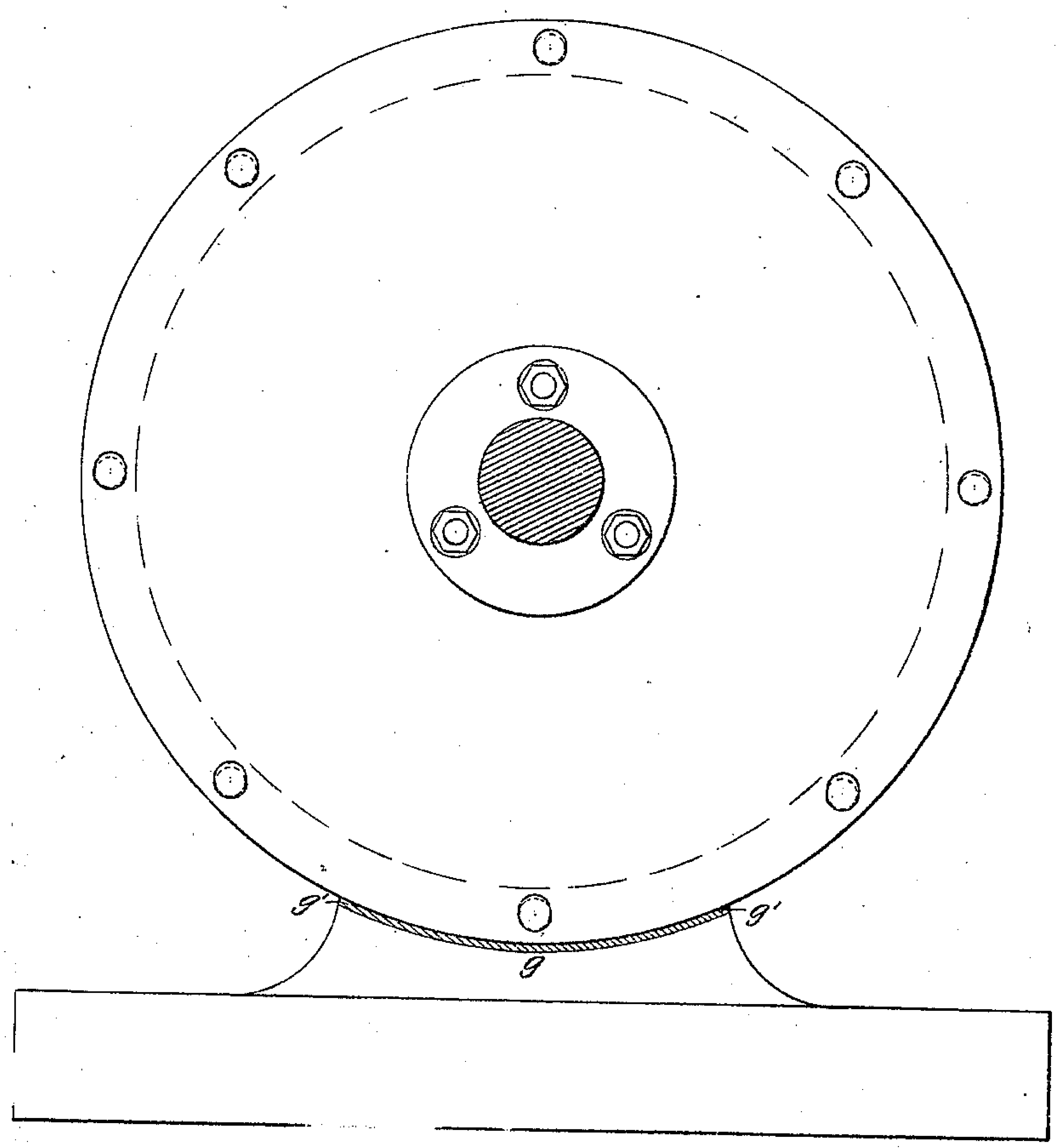
W. K. AUSTIN.

ROTARY STEAM ENGINE.

No. 348,879.

Patented Sept. 7, 1886.

Fig. 2a.



Witnesses:

A. B. Dodge

Julius Rehwoldt

Inventor.

Wm. K. Austin

By W. C. Dodge

Attorney.

(No Model.)

W. K. AUSTIN.

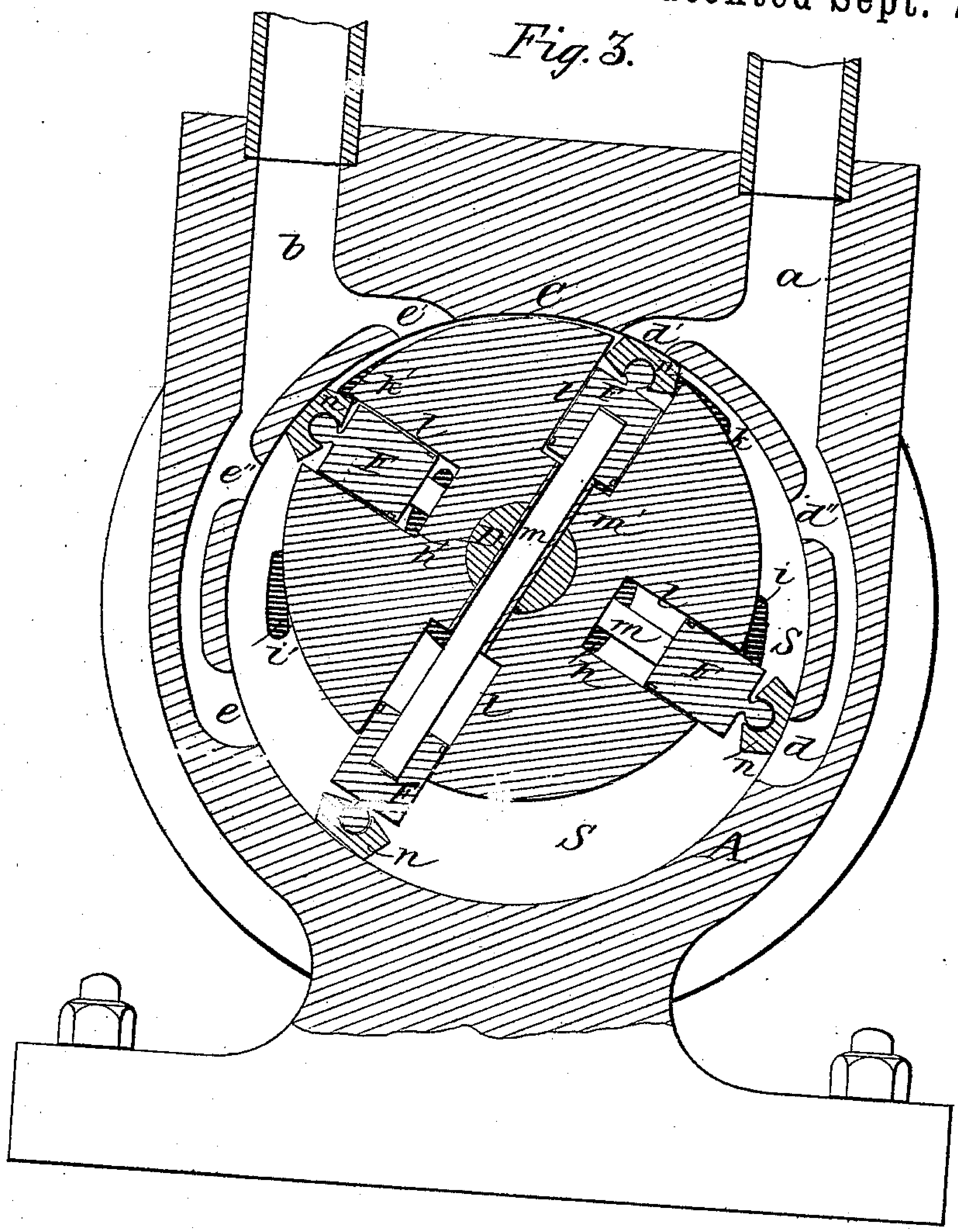
ROTARY STEAM ENGINE.

6 Sheets—Sheet 4.

No. 348,879.

Patented Sept. 7, 1886.

Fig. 3.



Witnesses:
A. B. Dodge.
Julius Rehwoldt

Inventor,
W. K. Austin

By W. C. Dodge
Attorney.

N. PETERS, Photo-Lithographer, Washington, D. C.

(No Model.) 6 Sheets—Sheet 5.

W. K. AUSTIN.

ROTARY STEAM ENGINE.

No. 348,879. Patented Sept. 7, 1886.

Fig. 4.

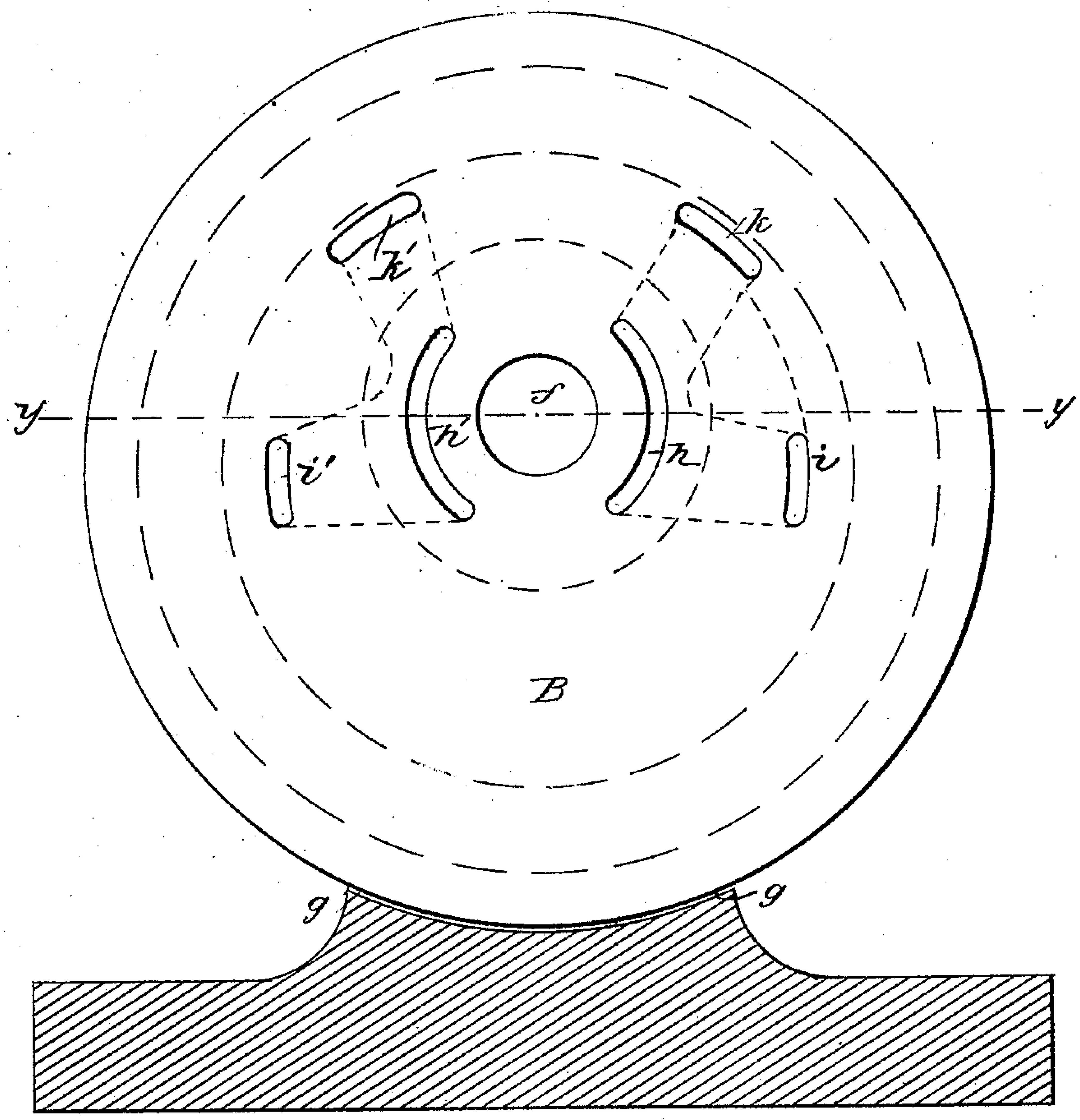
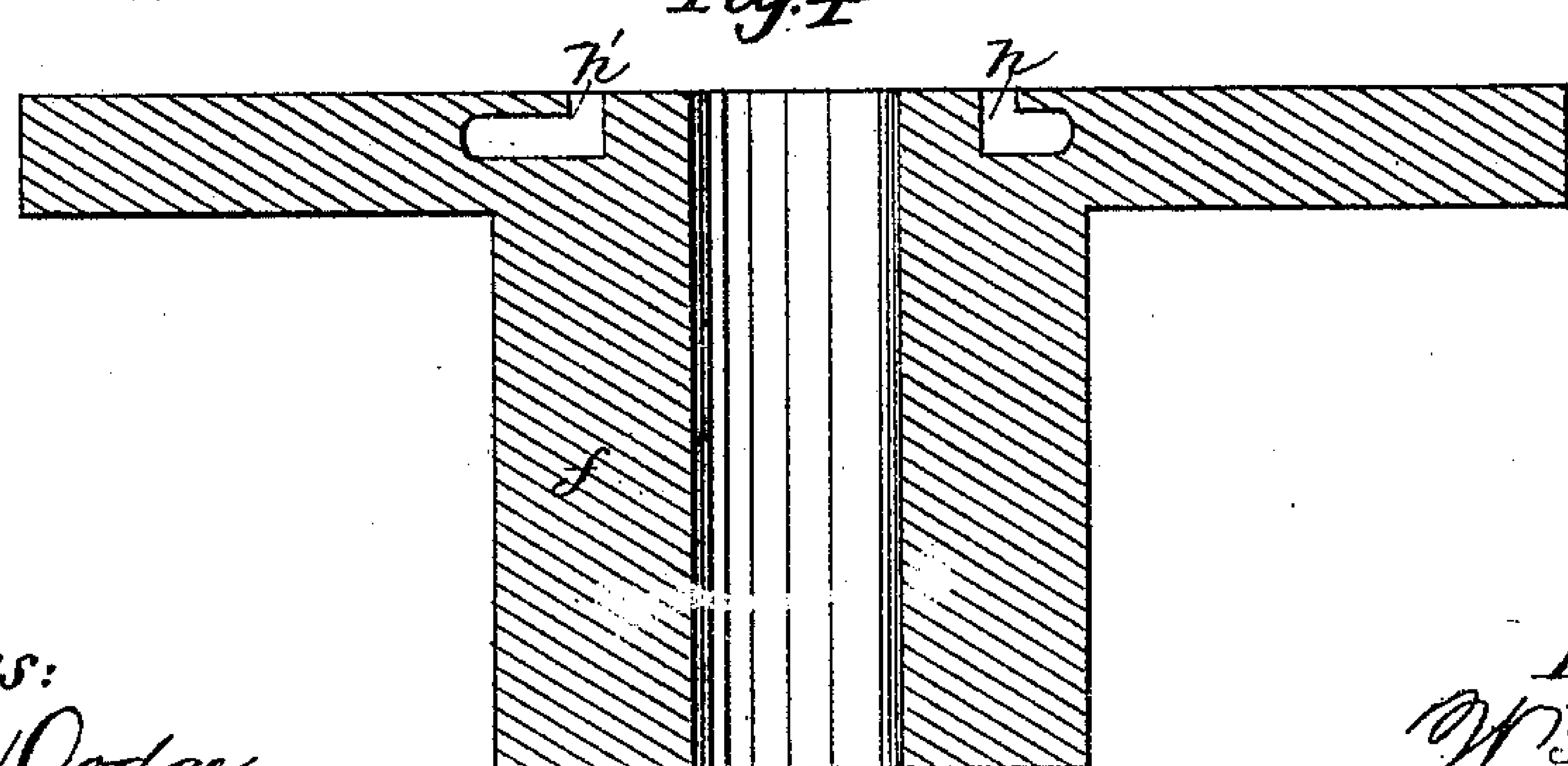


Fig. 4a



Witnesses:
A. B. Dodge.
Julius Rehwoldt.

Inventor,
W. K. Austin
By W. C. Dunn
Attorney.

(No Model.)

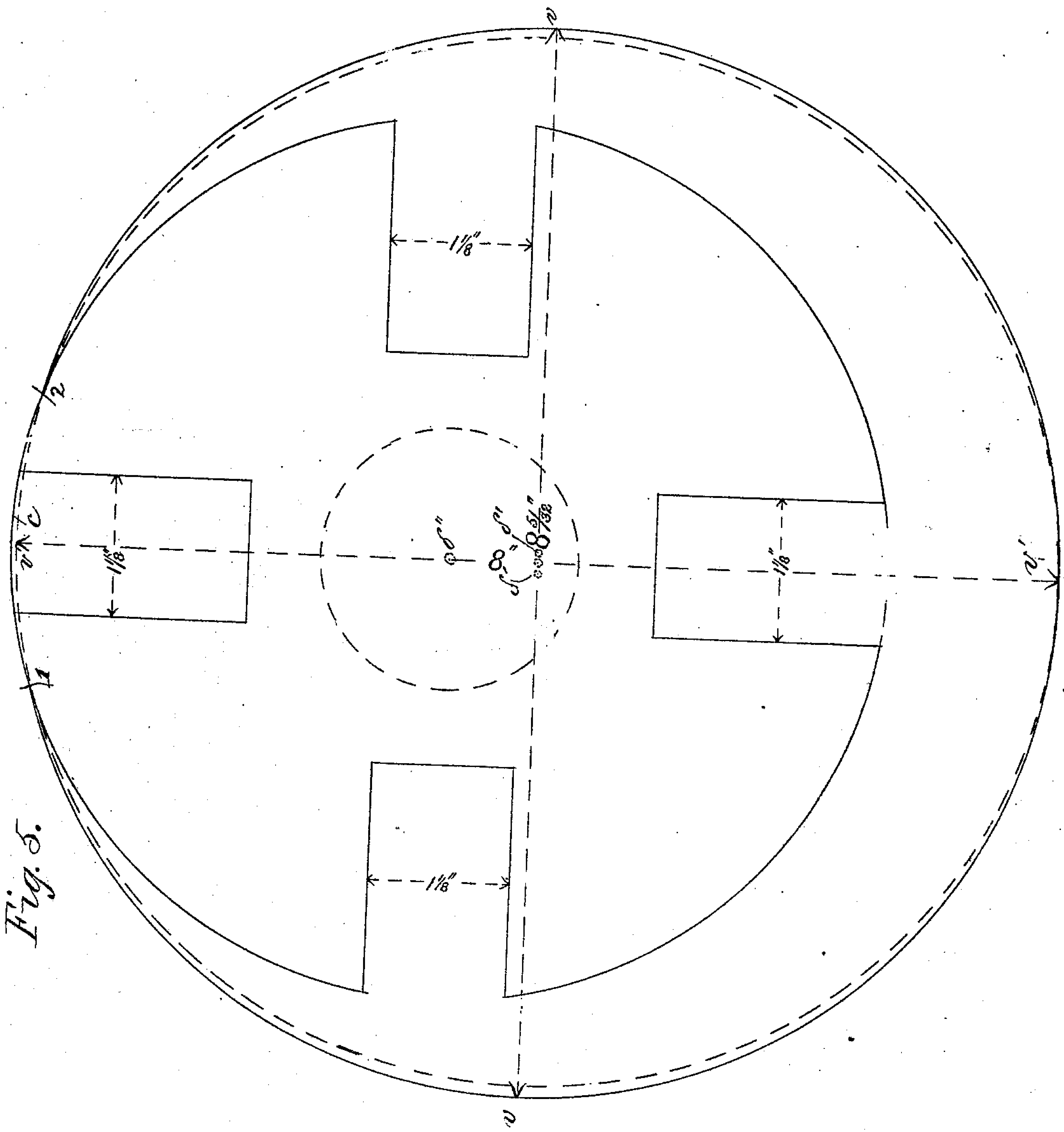
6 Sheets—Sheet 6.

W. K. AUSTIN.

ROTARY STEAM ENGINE.

No. 348,879.

Patented Sept. 7, 1886.



Witnesses:
A. B. Dodge
Julius Rehwoldt

Inventor:
W. K. Austin
By W. C. Dodge
Attorney.

N. PETERS, Photo-Lithographer, Washington, D. C.

UNITED STATES PATENT OFFICE.

WILLIAM K. AUSTIN, OF BROOKLYN, NEW YORK.

ROTARY STEAM-ENGINE.

SPECIFICATION forming part of Letters Patent No. 348,879, dated September 7, 1886.

Application filed December 27, 1884. Serial No. 151,368. (No model.)

To all whom it may concern:

Be it known that I, WILLIAM K. AUSTIN, a citizen of the United States, residing at Brooklyn, in the county of Kings and State of New York, have invented a new and useful Rotary Steam-Engine, of which the following is a specification.

My invention relates to rotary steam-engines, and the object of the invention is to reduce the internal resistance of the engine, and to balance the moving parts thereof as perfectly as possible; also, to remedy defects in the construction of rotary engines which have heretofore interfered with their practical utility—such as rapid wear of the moving parts, unequal resistance in the cylinder, and difficulties in the way of adjusting the engine and taking up wear.

In the accompanying drawings, Figure 1 represents a front elevation of my improved rotary engine with the fly-wheel and other outside connections detached; Fig. 2, an end elevation of the same with the head of the cylinder removed; Fig. 2ª, an end elevation with head in place; Fig. 3, a vertical transverse section of the engine taken on line *x x* of Fig. 1. Fig. 4 represents an inside view of one of the cylinder-heads. Fig. 4ª is a horizontal section of the cylinder-head, taken on line *y y* of Fig. 4. Fig. 5 is a diagram of the face of the cylinder and the spider, showing the proportions of the several parts. Figs. 6 6ª, Sheet I, are respectively a plan and a sectional detailed view of the packing of the spider and the heads of the cylinder. Fig. 7 represents an end view on an enlarged scale and partly in section of one of the pistons. Fig. 7ª is a section of the same.

Referring to the drawings, A represents the cylinder of the engine. B B are the heads. *a* is the steam-chest, and *b* the exhaust-chamber.

Suitable steam-supply, exhaust, and valve connections and attachments are to be placed on the engine in the usual manner.

The bore of the cylinder is formed of arcs or segments of three circles or cylinders, two of which, forming the steam-cylinder proper, have the same radius, but are eccentric to each other, while the third, which forms the head of the steam-cylinder, or in conjunction with the spider or hub and the pistons, the abutment dividing the steam from the exhaust side of the cylinder, has a shorter radius than the other two segments and is concentric with the pistons and spider. The cylinder proper is of a slightly oval form, its greater diameter (that taken on line *v v*, Fig. 5,) being about five thirty-seconds of an inch longer than its shorter diameter taken on line *v' v'*. The diagram of the bore of the cylinder (illustrated by Fig. 5) is drawn to scale, the proportions being eight inches by eight and five thirty-seconds inches. In reckoning the proportions the arc of the abutment is not included, as this is a part of a circle of less radius than the arcs of the cylinder, and is formed in the upper intrados of the cylinder. The proportions of eight inches by eight and five thirty-seconds inches are adhered to in the construction of other cylinders, whatever the size of the engine, as thereby abrupt changes of curvature are avoided and resistance to the pistons is almost wholly overcome.

The centers from which the periphery of the cylinder is described are indicated by S' S'. The regular periphery of the oval bore is varied at the top or upper intrados by describing an arc, *c*, from a center, S'', which coincides with the axis of the spider or hub which carries the pistons. The part of the case included in this arc constitutes the abutment C, by which the cylinder is divided into two equal parts, in one of which—viz., that part to the right of the vertical axis—are situated the induction-ports, and in the opposite part the exhaust-ports. The abutment C extends from 1 to 2, which are the points or lines of intersection of the steam-cylinder and abutment on the exhaust and steam sides, respectively, and they are also the points at which the walls of the steam-cylinder approach nearest to the center of the spider or hub and the axes of the pistons.

In the cylinder on one side are formed the steam-induction ports, of which there are three, *d d' d''*, and on the opposite side are the exhaust-ports *e e' e''*. The upper induction-port, *d'*, opens into the cylinder just below the terminus of the abutment at 2, and the lower or main port below the horizontal axis of the cylinder. The port *d''* opens into the cylinder at a point intermediate of the other two. The exhaust-ports open from the cylinder in similar positions on the opposite side.

The object in making the cylinder in the peculiar manner described is to reduce the resistance to the movement of the piston to the lowest possible point. It will be observed that the periphery of the cylinder beyond the abutment is perfectly regular, there being no abrupt changes of the curvature, but only a gradual enlargement on the steam side, forming an incline, down which the pistons move with less resistance than if they moved in a perfect circle, owing to a peculiarity in their construction, which will be hereinafter described. This construction avoids also all abrupt changes in the position of the pistons and the resistance consequent thereupon. The only points where the pistons meet with a change of curvature are at the intersections of the abutment and the cylinder. The point or line of intersection 1 on the exhaust side is where the pistons meet with the greatest resistance, as it is at this point that they leave the surface, which, by its shortening curvature with respect to the spider or hub, causes them to retire gradually within the spider, and at this point, by reason of the change of curvature, the pistons are forced back into the slots until their outer ends are flush with the surface of the spider. It is at 1, therefore, if the engine is running to the right, or 2, if running to the left, that the greatest resistance is encountered; but this resistance is almost destroyed by an arrangement whereby the pistons are prevented from bearing with any retarding force against the walls of the cylinder on the exhaust side. This will be described presently.

Another object in making the bore of the cylinder of a slightly oval form is to prevent the pistons from binding when passing through certain parts of the cylinder where a binding effect would occur if the cylinder were circular, owing to the eccentric position of the spider or hub and pistons. This will be more fully referred to hereinafter.

I am aware that cylinders for rotary steam-engines have been constructed with the bore formed of curves struck from three points in a line coincident with the longer axis of the cylinder, forming thereby an oval bore, the surface of which in line with the shorter axis is tangential to the spider, and the tangential contact of the spider with the surface of the bore forms the abutment. That construction I do not claim. The advantage of the construction I have adopted over that described is that a considerable segment of the cylinder is parallel to the periphery of the spider, and the contact of the two parallel surfaces forms a segmental abutment, which, in addition to effectually dividing the steam from the exhaust side of the cylinder by its long bearing, supports the spider and pistons and thereby insures steadiness in the running of the engine.

The heads of the cylinder.—These are disks having sleeves or pillow-blocks *f f* projecting from their outsides at a point above their centers. The said sleeves or pillow-blocks form the bearings for the main shaft D, which is passed through them and carries the spider or hub inside the cylinder. Suitable boxes are placed in the said sleeves or pillow-blocks. The heads B B rest on the curved bearings *g* in the bed-plate on either side of the cylinder, and they are connected with the cylinder by bolts passing through the rim into flanges formed on the cylinder and into the bed-plate below or under the cylinder. The arrangement of the bolts is such that the heads can be moved vertically to a slight extent. This is for the purpose of adjusting the spider and pistons, the spider being fastened to the shaft D, which in turn rests in the sleeves *f f*, so that when the heads are raised the shaft and spider are raised with it. This facility of adjusting the heads is obtained by slightly elongating the bolt-holes in the heads or leaving a slight play therein, as shown in Fig. 2[a], and to prevent strain on the bolts after the heads are raised, a packing-strip of paper or other suitable material equal in thickness to the space formed between the periphery of the head and the curved bearings *g*, is inserted between the heads and the said bearings. The heads are provided with certain steam ports for induction and eduction, those on the right in the present case being for induction and those on the left for eduction ports. The ports *h h'* are close to the sleeves *f* and are curved. They are intended to be covered by the disk when rotating, except at certain intervals, which will be stated further on. The ports *i i'* are mainly in the steam-space S, and just above the induction and exhaust ports *d e*. The ports *k k'* also lie beyond or partly beyond the periphery of the spider and just below the ports *d' e'*. The ports *h i k* communicate with each other by an interior passage within the heads, which is indicated by dotted lines in Fig. 4. The ports *h' i' k'* likewise communicate with each other in the same manner. Both heads are provided with these ports, so that steam is inducted and educted by these ports at both ends of the cylinder equally.

The pistons.—These are connected with a cylindrical spider or hub, E, which is fixed to the shaft D, and therefore occupies a position eccentric to the longer axis of the cylinder. The diameter of the said spider or hub and the position of the axis are such that a segment of its periphery enters and fills the arc *c* of the abutment, and thus forms a steam-tight joint at the abutment and divides the cylinder into two equal parts. The periphery of the spider is provided with radial slots *l*, parallel to the axis and of a little more than half the radius of the spider. The depth of the slots should be such that when the spider rotates the slots will uncover the ports *h h'* in the heads when they pass over them, as shown in Fig. 2.

F designates the pistons, of which there are four, coupled together in pairs, or two double pistons. They are placed in the radial slots *l*, into which they fit closely. The pistons on opposite sides of the spider are coupled together by two or more spindles, *m*, which are passed diametrically through the spider and the shaft, a bushing, *m'*, being inserted in the hole in the spider and shaft as a bearing for each of said spindles, the said bushing being secured or fastened in place by pins or other devices. In the bushing the piston-spindles slide freely. The pistons are thus directly coupled in pairs and work together from opposite sides of the spider and cylinder. By this arrangement the pistons are made to adjust themselves positively as they revolve, so that the piston on the induction side is forced out against the receding walls of the cylinder below the induction-ports by the opposite piston, which is forced in toward the axis of the disk by the gradually-decreasing curvature of the walls of the cylinder relatively to the disk, and the direct positive movement thus obtained forces the piston on the opposite side outward against the receding walls of the cylinder. The pistons carry on their cylinder ends vibrating or rocking plates *n*, being connected therewith by a hinge or rolling joint, which permits the plates to vibrate or rock freely, but does not allow them to become disconnected otherwise than by drawing off endwise. The faces of the plates are curved to the same radius as the cylinder, so that they will bear with their whole surface against the walls of the cylinder continuously when rotating. As the pistons revolve, they are continually changing the angle of their sides and ends to the walls of the cylinder, owing to their eccentric movement. This, if the ends of the pistons were rigid, would cause resistance to their motion, uneven wear, and a steam-tight connection between the pistons and the walls of the cylinder would be impossible; but by providing the ends of the pistons with the vibrating plates the position or angle of the pistons relatively to the walls or face of the cylinder is immaterial, as the said plates always maintain the same position of parallelism to the walls or face of the cylinder whatever the position of the pistons, and bear with their entire surface against the cylinder. In Figs. 2 and 3 this feature of the invention is clearly shown, where it will be observed the rocking plates are turned in different directions with respect to the connected pistons, one of which has passed the exhaust-port and the opposite one is just about to pass the induction-port. In both instances it will be observed the pistons are at a sharp tangent to the walls of the cylinder, while the plates maintain their parallelism. This arrangement makes impossible any resistance from the changing angles to the cylinder which the pistons assume while rotating. The spindles *m* are socketed in the pistons, and preferably springs *n'* are placed in the ends of the spindles and bear against the pistons, forming thus spring-cushions. By this device the pistons are made more elastic, their movements are produced with greater ease, and the wear is taken up. By passing the connecting-spindles *m* diametrically through the disk and shaft, in addition to the advantages above enumerated, the spindles and bushing serve as keys for fastening the disk and shaft together.

The packing.—The spider is packed on the sides adjacent to the heads to prevent escape of steam through the bearings. This packing is arranged in the following manner: Around the shaft on each side of the spider are annular grooves *o*, and in the bottom of the said grooves are sockets *o'*, parallel to the axis of the spider, which sockets form spring-seats. Into the sockets are placed spiral springs *p*, coiled around studs *p'*, which project out of the springs and are passed through the packing-rings *q q'*, and are fastened to the outer ring, *q'*. These rings are placed in the annular groove, and the first, *q*, which is at the bottom of the groove and bears against the springs, is preferably made of iron. The next, *q'*, is made of rubber or other suitable material, and the last or outer ring, *q''*, which bears against the head of the engine, may be made of steel. The spiral springs keep the steel ring pressed closely against the heads, and thus form a steam-tight joint around the bearings, while the pressure expands the elastic ring *q'*, which is between the iron and steel rings, and thereby causes it to fill the annular groove and stop the passage of steam into the groove and around the packing. The pistons are packed to prevent the steam from the steam-space around the spider from passing between the pistons and the sides of the slots *l*, in which the pistons move, and also to prevent the steam under the pistons from passing out. For this purpose the pistons are provided with longitudinal groove *r*, close enough to their inner ends to avoid being uncovered when the pistons are out to their farthest point. In the said slots are placed the flat steel packing-plates *t*, one of which is shown in detail and on an enlarged scale in Fig. 7ᵃ, Sheet II. It consists of a plate of steel of the width of the grooves *r*, so as to fit closely therein, and having projections *t'* at the ends as wide as the grooves are deep, or nearly so. Between the projections *t'* springs *u* are placed. These strips or plates of steel are placed in the grooves *r* with the ends or projections *t'* and the springs *u* against the bottom of the grooves. The smooth exterior surfaces of the plates are pressed by the springs *u* against the sides of the slots and pack the space on either side between the pistons and the sides of the slots and prevent the passage of steam either way.

The following is a general description of the operation of the engine and the several parts which co-operate to produce the operation: Let it be supposed that the pistons are in the several positions indicated in Fig. 2, and it is desired to start the engine. For convenience, the pistons are numbered 1, 2, 3, 4. It must be understood that the principle of action which underlies most rotary engines is availed of in this engine—viz., the production of motion by the pressure of steam on unequal areas. Thus piston 3 presents more surface to the steam in the space behind it than does piston 2 to the steam in the same space. Consequently piston 3 moves and piston 2 must follow. In the same way there is more pressure against the back of piston 2 than against the face of piston 1, &c. The main steam-induction port *d* is partly open, and port *d'* is also partly open, piston 1 being just past the upper side. The valve being opened, steam flows to the ports and into the cylinder. From the upper port, *d'*, the steam passes behind the rocking plate *n*, and presses upon the top of the disk and also against the rear edge of the plate, exerting thereby some power against the upper piston. At the lower port, *d*, the steam flows into the steam-space between pistons 2 and 3, and acting on piston 3 turns the engine. Steam also flows from port *d''* between pistons 1 and 2, and presses against piston 2, thereby tending to give impetus to piston 2 before it is acted upon by the steam from the main port *d*, which pressure and impetus are sufficient to carry the piston past the said port and also to balance the pressure against the front of the piston. Thus a continuous pressure of live steam is exerted against the pistons on the steam side of the cylinder from the abutment around to the piston which is about to exhaust, this continuous pressure being produced by admitting steam behind piston 1 from port *d'*, behind piston 2 from port *d''*, and behind piston 3 from port *d*, and at the same time a balancing of the back-pressure is obtained, which is finally borne by the abutment.

The balancing of the pistons 1 and 2 is effected, approximately, in the following manner: Steam entering from port *d* presses against so much of the face of piston 2 as is exposed, and this pressure lessens the force exerted on piston 3. The back-pressure thus produced is almost neutralized by the steam which enters by port *d'* into the space between pistons 1 and 2, which presses against the back of piston 2 with nearly as much force as the pressure of the steam on its face. The back-pressure of steam in the space between pistons 1 and 2 is practically without effect, as for most of the space traversed by piston 2 the steam presses against the head of the cylinder—*i. e.*, the abutment—and when piston 1 passes the abutment but a very small part of its surface compared to that of piston 2 is exposed to the pressure of the steam. Furthermore, when piston 1 passes the end of the abutment at 2 the steam is admitted behind it through port *d'*, and the pressure tends to balance the pressure against its face. Thus it will be seen that the back-pressure between the pistons is opposed by pressure in the direction of rotation, and back of piston 1 it is borne by the head of the cylinder.

The induction of steam under the pistons is effected in the following manner: When the pistons are in the position indicated in Fig. 2, the ports *i k* at both ends of the cylinder are open, and the steam from the space between pistons 1 and 2 passes through the said ports to *h*, and thence into slots *l* under the pistons; but when the ends of piston 1 pass over ports *k* these ports are partially closed by the ends of the piston, and ports *i* being open the steam passes thence to the ports *h*. So, too, when piston 2 is passing ports *i* these are closed, or partly so, and then the steam flows through *k* to *h*, and thence under the pistons.

The effect of directing the steam in the manner described is as follows: As before stated, the pistons are adjusted positively—that is, when opposite connected pistons are approaching, respectively, the shorter and longer radii of the cylinder, the piston approaching the shorter radii is forced in or retired toward the axis of the spider and the other or opposite piston is forced out. If this positive motion were alone relied on, there might be more or less resistance from friction, steam-pressure, and other causes, especially when the pistons on the exhaust side pass from the steam-cylinder to the abutment at 1, where it is moved or retired into the slot in the spider, as explained heretofore. To prevent this and reduce the resistance to a minimum, steam is admitted under the pistons at the moment they commence to move out after passing the upper port, and the steam pressing against the pistons on the steam side forces them out of their slots, and thus aids their movement and relieves the opposite piston to a great extent, whereby the pressure of the opposite piston against the walls of the cylinder on the exhaust side is reduced to zero. The pressure of the steam against the under side of the piston continues until the piston has reached and passed the point where it has moved out to the greatest extent possible and presented the whole effective surface to the pressure of the steam, after which it commences to retire into the slot, and at the instant it does so the slot reaches the exhaust-port *h'*, on the opposite side, and the steam is exhausted from under the piston through the said port, and thence by internal connecting passages and ports, *i' k'*, to the main exhaust-ports *e e'*. At the moment, therefore, that the steam begins to flow from the port *h* under the piston 1, after it has passed the upper port the steam is exhausted from under its opposite piston, 3. Thus a perfect balancing of the pistons is obtained, and resistance from friction against the face of the cylinder is almost destroyed. Furthermore, this pressure of the steam under the piston on the steam side continues until the piston on the exhaust side passes from the cylinder to the abutment, and thereby at the moment when the piston meets with its greatest resistance—*i. e.*, when passing the point 1—the pressure of steam under and against the opposite piston serves to draw the piston away from the walls of the cylinder on the exhaust side, so that while contact is not broken there is practically no friction between the ends of the piston and the walls of the cylinder, and the end of the piston passes easily over the point of intersection 1.

Another effect produced by admitting steam under the piston is that it aids the pistons in their rotary motion. At the moment the steam is admitted under the piston the latter reaches a part of the cylinder where the radius is constantly lengthening, and the surface against which the piston presses is similar to an inclined plane. The pressure of the steam is perpendicular to this plane, and as the rocking plate maintains its parallelism with the surface, the two forces are at an angle to each other, and by a well-known law there is a resultant motion, which in this instance coincides with the motion of the piston.

Another result flowing from the admission of steam into the ports *h i k* is that a part of the steam flows out of the port *i* in the steam-space behind the piston 2 before the latter is acted upon by the steam from the main port, and pressing against the piston aids in supplying steam behind piston 2 and balancing the same; also, in imparting power to the engine.

It is proper to add in connection with the description of the power exerted by the steam under the pistons that as the pressure of the steam is on one side only—that is, as it is directed against but one of the connected pistons—the steam having been exhausted from under the other previous to its admission to the opposite one, there is no counterbalancing effect whatever.

The admission of steam from the upper port, *d'*, against the spider is an important feature of this engine. The point of greatest resistance is at the abutment, for the reason that here the spider and pistons must press against the abutment with sufficient force to be steam-tight, in order to prevent back action. In addition to this the greatest pressure of steam is against the spider directly opposite the abutment, as it is here the full force of the steam is exerted. This pressure is borne partly by the bearings and partly by the abutment. Now, by admitting steam from the upper port against the top of the spider, a counter-pressure is obtained, which in a measure counterbalances the friction of the spider against the abutment and the pressure of the steam against the under side of the spider, and the consequence is that the resistance at the abutment is to a great extent overcome.

The oval form given to the cylinder has this further object. The spider being eccentric to the axis of the cylinder, the radius of the cylinder relatively to the center of the spider varies. Consequently, if the cylinder were formed in a true circle, when one piston reached, say, the horizontal or longer diameter of the cylinder, the opposite connected piston would be at a point considerably above the said diameter. Consequently the pistons which have no independent movement and must touch the faces of the cylinder on opposite sides would bind as soon as they passed the vertical axis of the cylinder, and produce such resistance that the engine would probably be brought to a stop. To avoid this the cylinder is made oval, and in that manner the eccentricity of the spider and pistons is compensated for.

The invention has been described and referred to throughout as a "rotary engine," but I do not limit the application of the principles of the invention to steam-engines alone, as they may be applied to pumps, water-meters, and other similar mechanical contrivances. Furthermore, the engine may be run in either direction by adapting suitable reversing mechanism, valves, &c., to it.

I claim—

1. In a rotary steam-engine, a cylinder having a bore formed of the arcs of three circles, two of which, forming the steam-cylinder proper, have the same radius, but are struck from different centers, so as to intersect and form an oval cavity, and the third, forming the abutment, is of less radius than the other two and is concentric with the spider or hub and pistons, substantially as specified.

2. A cylinder having the bore formed of the arcs of three circles, two of which, forming the steam-cylinder proper, have the same radius, but are struck from different centers, so as to intersect and form an oval cavity, and the third, forming the abutment, is of less radius than the other two and is concentric with the spider or hub and the pistons, in combination with a cylindrical spider or hub carrying the pistons hung eccentrically in the cylinder, with a segment of its periphery set in the cavity of the abutment, substantially as specified.

3. The combination of the cylinder provided with the ports *d d' d''*, arranged as described, and suitable exhaust-ports, the abutment C, formed of the segment of a cylinder of the same radius as the spider, the spider hung eccentrically in the cylinder with a segment of its periphery set in the segmental cavity of the abutment, and the pistons connected with the spider, substantially as specified.

4. The combination of the oval cylinder, the abutment formed on the arc of a circle of the same radius as the spider, the intersecting point of the steam-cylinder and abutment on the exhaust side, the spider, the pistons held in radial slots in the spider and coupled together through the same, said pistons having less depth than the slots, so that a steam-space is left under the pistons when retired within the slots, and the steam and exhaust ports in the heads of the cylinder communicating at intervals with the space under the pistons, substantially as specified.

5. The combination of the oval cylinder, the spider having radial slots, the pistons placed in the slots and having less depth than the slots, so that a steam-space is left under the pistons, which communicates with steam-ports at in-

tervals and from which the steam cannot escape when the pistons are on the steam side of the cylinder and the rocking face-plates on the ends of the pistons, substantially as specified.

6. The combination of the cylinder, the spider provided with radial slots, the pistons placed in the said slots and having less depth than the slots, and steam induction and eduction ports h h', so arranged that when steam is let into the space under one of the pistons it is exhausted from the space under the opposite piston, substantially as specified.

7. The combination of the oval cylinder, the spider, the coupled pistons placed in slots in the spider and having less depth than the slots, so that a steam-space is left under them when retired, rocking face-plates on the cylinder ends of the piston, steam-induction ports communicating with the space under the pistons for a portion of their movement, and the oval cylinder provided with steam-ports opening directly into the space behind the pistons, substantially as specified.

8. In combination with the cylinder provided with induction-ports opening directly into the steam-space of the cylinder, the spider carrying the pistons in radial slots, and the heads of the cylinder provided with steam-ports which communicate with each other and with the steam-space of the cylinder and the slots in the spider under the pistons, substantially as specified.

9. The combination of the cylinder provided with steam induction and exhaust ports opening directly into the cylinder, the spider hung eccentrically in the cylinder, pistons placed in slots in the spider and coupled together through the spider, said pistons being of less depth than the slots in which they are held, so that when retired a space is left between the pistons and the bottoms of the slots, and induction and exhaust ports communicating with the said space under the pistons and with the steam-space of the cylinder, substantially as specified.

10. The combination of the steam-cylinder having induction-ports d d' d'' and suitable exhaust-ports, the heads of the cylinder provided with steam-ports i k h, communicating with the steam-space of the cylinder, and suitable exhaust-ports, the spider E, provided with the longitudinal radial slots l, which communicate alternately with the steam-port h and the exhaust-port h', and pistons placed in the said slots and connected together in couples, said pistons having less depth than the slots l, whereby, when they are retired, a space is left between the pistons and the bottom of the slots for the entrance of steam when the pistons are on the steam side, and from which the steam is exhausted when the pistons reach the exhaust side, substantially as specified.

11. In combination with the spider provided with the annular groove around the main shaft and the heads of the cylinder, an annular packing composed of the rings q q' q'', spiral springs p, and studs p', substantially as specified.

12. In a rotary engine wherein the cylinder is connected with the bed-plate, the adjustable heads or ends, in combination with the hub or spider and shaft, substantially as and for the purpose specified.

WILLIAM K. AUSTIN.

Witnesses:

A. B. DODGE,

CHAS. KELLOGG.