No. 858,778. PATENTED JULY 2, 1907.

W. K. AUSTIN.

ROTARY ENGINE.

APPLICATION FILED DEC. 9, 1905.

4 SHEETS—SHEET 1.

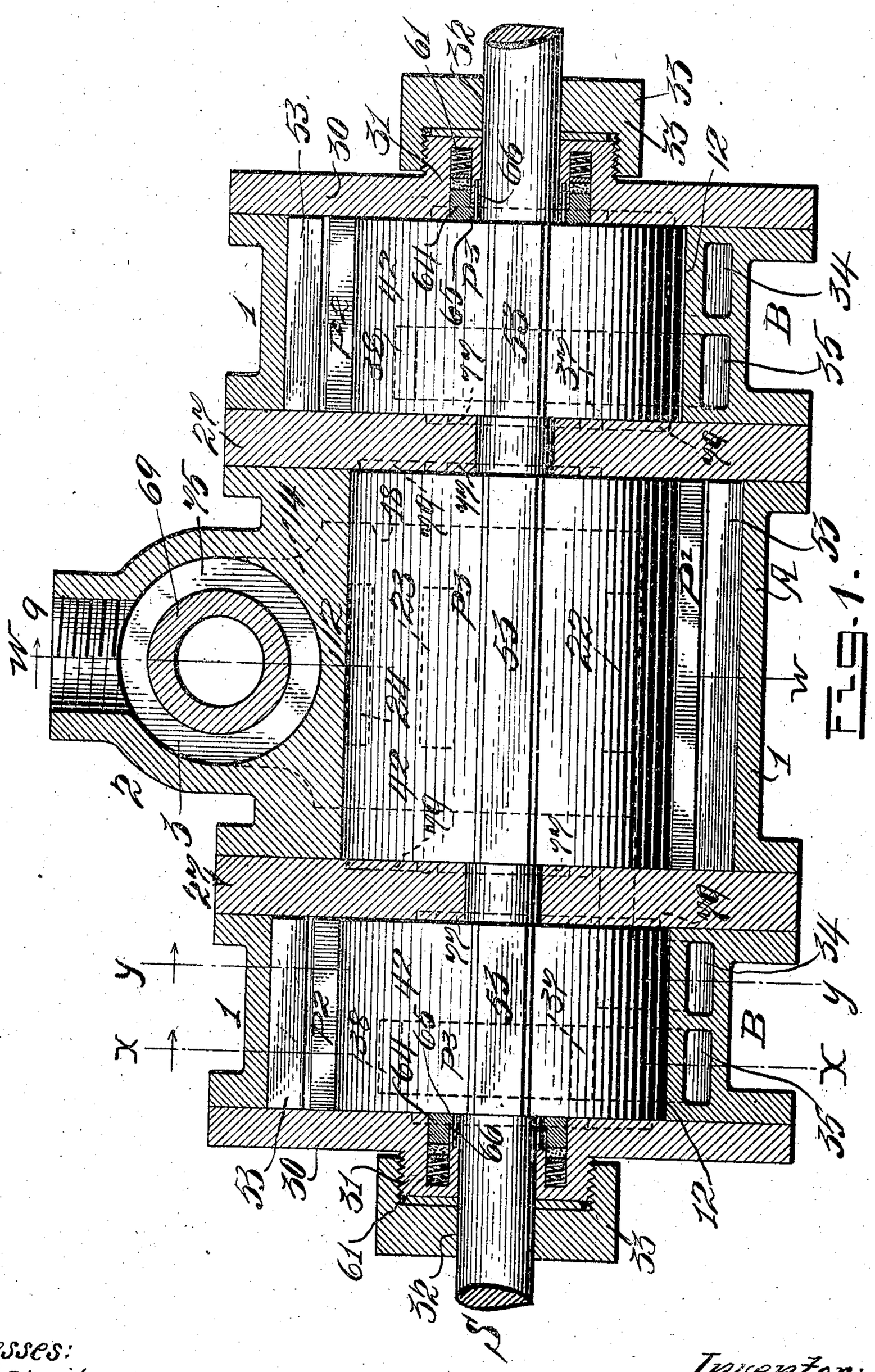


FIG. 1.

Witnesses:
C. A. Jarvis
Hans Amrhein

Inventor:
William Kerr Austin
By Whittemore Donn
Attorney.

No. 858,778. PATENTED JULY 2, 1907.

W. K. AUSTIN.

ROTARY ENGINE.

APPLICATION FILED DEC. 9, 1905.

4 SHEETS—SHEET 2.

Fig. 2.

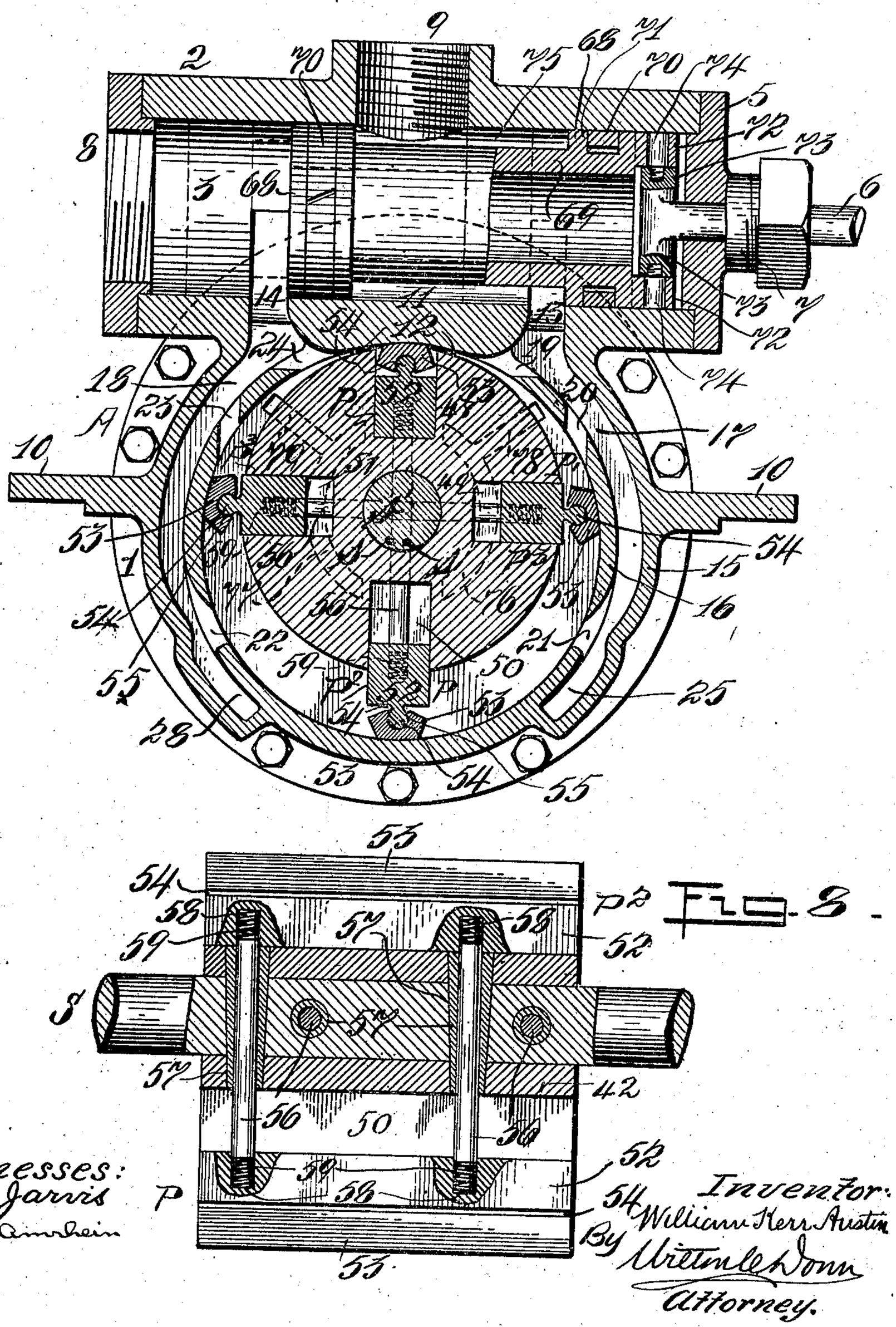


Fig. 3.

Witnesses:
C. A. Jarvis
Hans Amrhein

Inventor:
William Kerr Austin
By Whittemore Donn
Attorney.

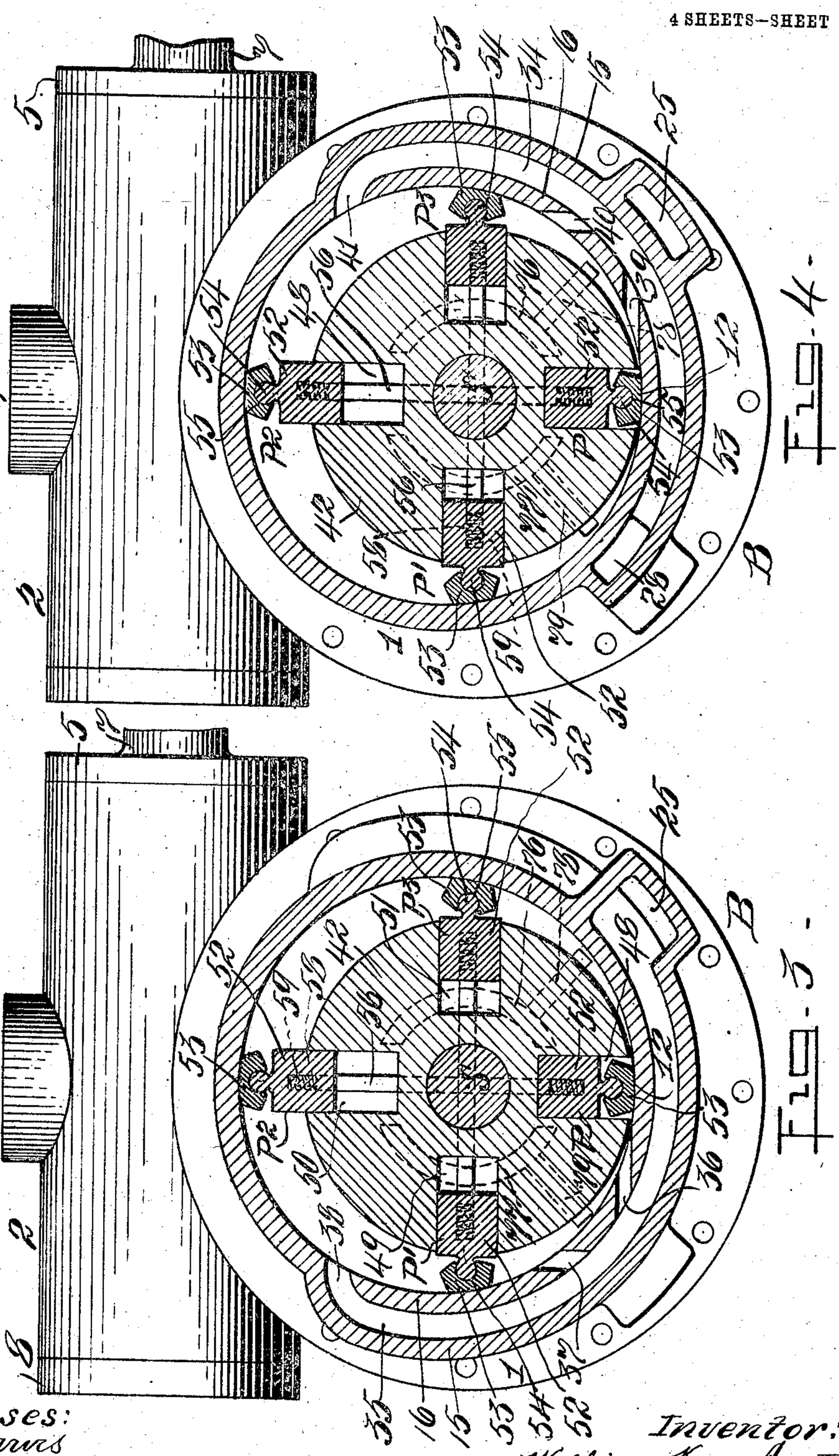
No. 858,778. PATENTED JULY 2, 1907.

W. K. AUSTIN.

ROTARY ENGINE.

APPLICATION FILED DEC. 9, 1905.

4 SHEETS—SHEET 3.



Witnesses:
C. A. Jarvis
Hans Amrhein

Inventor:
By William Kerr Austin
Whittemore Donn
Attorney.

No. 858,778.

PATENTED JULY 2, 1907.

W. K. AUSTIN.

ROTARY ENGINE.

APPLICATION FILED DEC. 9, 1905.

4 SHEETS—SHEET 4.

Fig. 5.

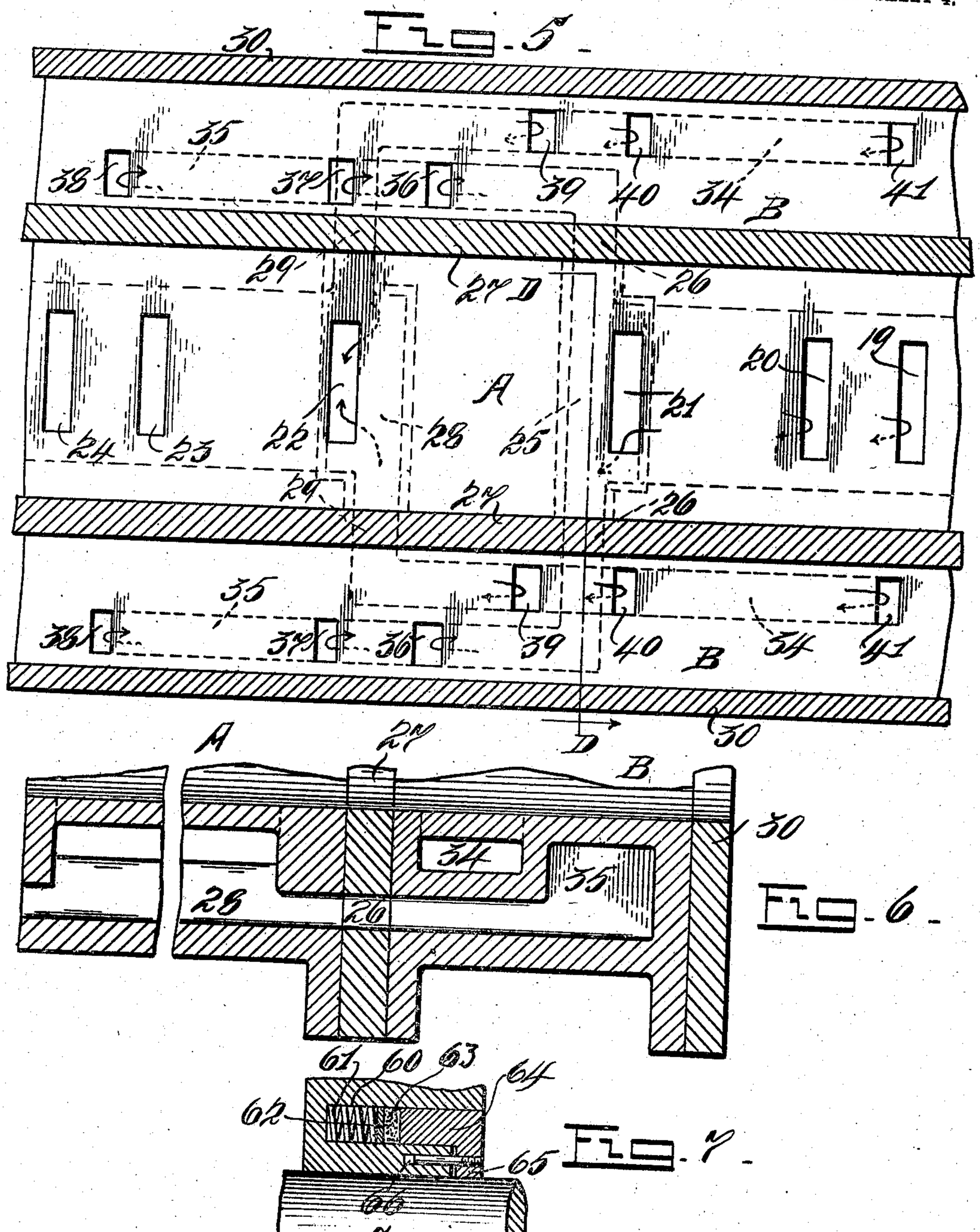


Fig. 6.

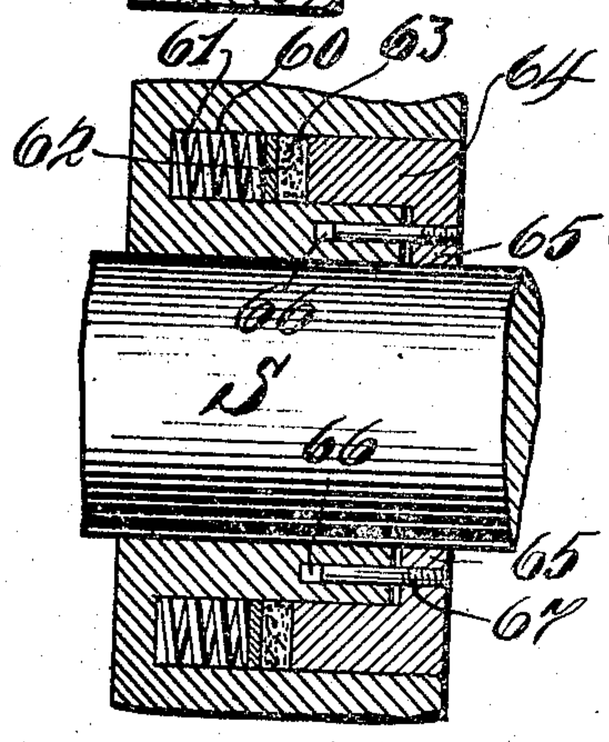


Fig. 7.

Witnesses:
C. A. Jarvis.
Hans Amrhein

Inventor:
William Kerr Austin
By Uretus & Donn
Attorney.

UNITED STATES PATENT OFFICE.

WILLIAM KERR AUSTIN, OF NEW YORK, N. Y., ASSIGNOR, BY MESNE ASSIGNMENTS, TO AUSTIN ENGINE COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

ROTARY ENGINE.

No. 858,778. Specification of Letters Patent. Patented July 2, 1907.

Application filed December 9, 1905. Serial No. 291,041.

To all whom it may concern:

Be it known that I, WILLIAM KERR AUSTIN, a citizen of the United States, residing at New York, borough of Brooklyn, in the county of Kings and State of New York, have invented certain new and useful Improvements in Reversible Balanced Rotary Engines, of which the following is a specification.

This invention relates to that class of rotary engines in which are combined a plurality of cylinders arranged in reverse position to one another with respect to the abutments and the points where the steam enters and leaves the cylinder, so that the pressure in one cylinder is counter-balanced by the pressure in another cylinder, and the force exerted to rotate the driving shaft is applied on opposite sides of the shaft; a smooth, even running and substantially noiseless engine being produced by this construction and arrangement of the cylinders.

The object of the invention described in the following specification is, first, to produce a rotary engine which shall be balanced absolutely both diametrically and longitudinally; and this part of the invention consists in a rotary engine composed of a primary cylinder and secondary cylinders located at the ends of the primary cylinder and in a reverse position with respect thereto, whereby the steam pressures are equalized throughout all the cylinders and the pressure on the pistons in the primary cylinder is counter balanced by the pressures on the pistons in the secondary cylinders and the driving shaft, pistons and hubs "float" between the counterbalancing pressures and the friction is thereby reduced to a minimum.

A further object of the invention is to produce a multiple-cylinder balanced rotary engine in which the admission of steam to all the cylinders shall be controlled by a single valve; and this part of the invention consists in an engine of the class described in which the steam spaces of the several cylinders are connected together and with an induction port in the primary cylinder, so that steam is admitted into all the cylinders simultaneously and at constant boiler pressure.

A further object of the invention is to produce a multiple-cylinder balanced rotary engine in which the exhaust steam from all the cylinders is passed from the engine through a single port; and this part of the invention consists in an engine of the class described in which the exhaust sides of the several cylinders are connected together and with an eduction port in the primary cylinder, so that the exhaust steam from the secondary cylinders is led back into the primary cylinder and with the exhaust steam from the latter leaves the engine by a single eduction port in the primary cylinder.

A further object of the invention is to produce a multiple-cylinder, reversible balanced rotary engine in which the reversing of the engine shall be effected by means of a single valve; and this part of the invention consists in an engine of the class described in which are combined a primary cylinder and secondary cylinders which are connected with the primary cylinder by steam passages that communicate with induction and eduction ports in the primary cylinder which are opened by a single valve, so that by adjusting the valve in the valve chamber the steam is admitted to either side of the primary cylinder and is led therefrom to the opposite sides of the secondary cylinders, and by shifting the valve the admission of steam can be changed from one side to the other of the cylinders and the engine thereby reversed.

The invention has for its objects, finally, to provide an efficient packing for the driving shaft and hubs of the engine, and means for facilitating the adjustment of the pistons as they pass around the cylinder; these objects being accomplished by means which will be fully described in connection with the drawings.

To facilitate understanding the construction of the cylinders of this engine and the action of the pistons, reference is made to Letters Patent of the United States, No. 348,879, dated September 7th, 1886, granted to the present applicant, the form of the cylinders in the present application being precisely the same as the cylinders described and illustrated in said patent.

In the accompanying drawings:—Figure 1 represents a longitudinal sectional elevation of my improved balanced reversible rotary engine. Fig. 2 is a cross-section of the same taken on line *w—w* of Fig. 1. Fig. 3 is a cross-section taken on line *x—x* of Fig. 1. Fig. 4 is a cross-section taken on line *y—y* of Fig. 1. Fig. 5 is a diagrammatic representation of the cylinders showing the various steam spaces and steam passages. Fig. 6 is a cross-section of the same taken on line *z—z* of Fig. 5. Fig. 7 represents a part of one of the exterior cylinder-heads in section and showing the packing for the same around the shaft. Fig. 8 is a sectional side elevation of the hub, pistons and shaft showing the pistons and the means of connecting them together through the hub and shaft.

The engine which will now be described in connection with the drawings comprises three cylinders, viz:—a central or primary cylinder —A— and secondary cylinders —B—B— which are placed at each end of the primary cylinder. The interior construction of these cylinders is substantially the same, but in describing them certain parts will be designated by different reference characters in order that the movements of the steam when passing into and through the cylinders may be more easily understood.

The exterior casings —1—1—1— of the cylinders are

of a general cylindrical form and their ends are flanged and the flanges provided with bolt holes. On the top or upper side of the casing there is a cylindrical casting —2— that forms the casing of a valve chamber —3—, this casting being preferably an integral part of the cylinder, the center being bored out longitudinally to form the valve chamber. One end of the valve chamber is closed by a head —5—, which is perforated at the center for a valve rod —6—, and has a stuffing box —7— for the valve rod packing. The other end of the casing is fitted with a screw-threaded flange —8— to receive the end of the eduction pipe. The upper side of the casing has a socket —9— which is screw-threaded to receive the end of the steam pipe. The cylinder has also projecting from opposite sides about in line with the axis of the hub which carries the pistons, hereafter described, arms —10—10— which are rabbeted on their under sides to adapt them to rest upon and be fastened to a bed plate or other foundation and support the engine and prevent lateral movement.

Primary cylinder:—The cylinder —A— is elliptical in form, the ratio of its longer diameter to its shorter being preferably 8″ to 8 5/32″, but these proportions may be varied, more or less if found desirable or expedient. The central part —11— of the top of the cylinder casing is hollowed out on its underside to form an abutment —12— the shape of which is that of the segment of a cylinder of less radius than the segments of the cylinders that form the primary steam cylinder. The centers from which the inner periphery of the steam cylinder are struck are indicated by —*s*—*s*— and it will be seen that they are on a line coincident with the horizontal axis of the cylinder and equally distant from a line drawn through the shorter or vertical axis thereof. The center —*s*′— from which the segment of the abutment is struck is above the centers —*s*—*s*— and on a line that coincides with the vertical axis between them. In the top of the casing and at the ends of the abutment there are ports —13—14— which are extended into the walls of the valve chamber on either side to a point in line with the axis of the chamber. These ports are for the passage of the steam into and out of the central or primary cylinder, one being an induction and the other an exhaust port; but, as the engine is reversible the two ports are exactly alike and are used interchangeably for induction and eduction. The side walls of the cylinder are double, consisting of an outer wall —15— and an inside wall —16—, these double walls in the primary cylinder extending from the abutment to points below the horizontal axis of the cylinder. Between these double walls on the respective sides of the cylinder there are steam spaces —17—18—, on the right and left-hand side of the cylinder. The space —17— communicates with the cylinder through openings —19—20—21— in the inside wall —16— and the space —18— on the opposite side communicates with the cylinder through openings —22—23—24—. The openings —19—24— are located at opposite ends of the abutment and under the ports —13—14—. The steam space —17— at its lower end is continued into a passage —25— on the right-hand side of the cylinder that extends from end to end thereof and leads to openings —26—26— in the cylinder heads —27—27—, and the space —18— is continued into a similar lateral passage —28— on the left-hand side of the cylinder which also extends from end to end thereof and communicates with openings —29—29— in the heads —27—27—.

Secondary cylinders:—The secondary cylinders are also of a generally cylindrical form and have flanges on their ends provided with bolt holes. The heads —27—27— of the primary cylinder also form heads of the adjoining ends of the secondary cylinders, the rim of the cylinder heads and the flanges of the cylinder casings being bolted together. The secondary cylinders are closed at their outer ends by heads —30—30— bolted to the flanges thereon. The heads —27—27—30—30— have holes at their centers for the driving shaft —S—, and the heads —30—30— are also provided with outwardly projecting collars —31— around the shaft holes by means of which the bearings —32— for the shaft in the heads are lengthened sufficiently to give a firm support. The collars are screw-threaded exteriorly and fitted with caps —33—33— for auxiliary packing around the shaft at the ends of the bearings. The secondary cylinders have the same horizontal and vertical dimensions as the primary cylinder, but they are only half as long and, like the primary cylinder, they are provided with abutments —12—, but these are formed in the inside walls —16— of the casing. Between the inside and outside walls —15—16— of each of the secondary cylinders and on the right and left-hand sides respectively there are steam spaces —34—35— similar to the steam spaces —17—18— in the primary cylinder. Fig. 3 shows the steam space —35— on the left-hand side of the cylinder, and Fig. 4 the steam space —34— on the right-hand side. The steam space —35— communicates with the cylinder through openings —36—37—38—, and the steam space —34— through openings —39—40—41—. The steam spaces —35—35— of the secondary cylinders extend from the left-hand side of the cylinder under the abutments —12— (see Fig. 3, 5) to the opposite side thereof and to points below the horizontal axes of the cylinders and midway between the same and the vertical axes where they bend at right angles and are extended to the openings —26—26— in the cylinder heads —27—27— thus forming continuations of the passage —25— in the primary cylinder and supplying a passage for the steam from the primary cylinder to the secondary cylinders. The steam spaces —34— extend under the abutments —12— around to a like position to the left of the abutments where they make a right-angled bend and are extended laterally parallel to the axis of the cylinder to the openings —29—29— in the heads —27—, and thus form continuations of the passage —28—, in the walls of the primary cylinder on the left-hand, and supply a passage for the steam from the secondary cylinders back into the primary cylinders on the exhaust side. By inspecting the figure it will be seen that there are continuous internal steam passages from the right-hand side of the primary cylinder through the interior heads and thence to the left-hand side of the secondary cylinders, and similar passages from the left-hand side of the primary cylinder through the interior heads and thence to the right-hand sides of the secondary cylinders. Each of these separate systems of internal passages are adapted to be used to convey the steam from the primary cylinder into the secondary cylinders and also to lead the exhaust steam from the secondary cyl-

inders into the primary cylinder, their use for induction or exhaust purposes being governed by the direction the engine is running.

The primary and secondary cylinders are constructed interiorly precisely alike, that is to say both cylinders have double walls with steam spaces between them which communicate with the cylinder through openings in the inner walls and connect with other steam passages that form continuations of steam passages in the walls of the primary cylinder. Both of the secondary cylinders are arranged in a reverse position with respect to the primary cylinder; that is to say, their abutments are diametrically opposite the abutment of the primary cylinder. Furthermore, the steam spaces —35— of the secondary cylinders are in line with the steam space —17— in the primary cylinder, but they are in communication through openings —26—26— in the heads —27—27— with the steam passage —25— and the steam space —16— of the primary cylinder; and the steam space —34— is in line with the steam space —16— of the primary cylinder, but in communication with the steam passage —28— through the openings —29—29— in the heads. The steam spaces —34—35— are reversed with respect to the heads of the secondary cylinders, that is, in the left-hand cylinder the space —34— is adjacent to the outer head and in the right-hand cylinder it is next to the inner head, but this arrangement is optional, and they may be in like positions if desired.

The pistons:—These are connected with a cylindrical hub —42— mounted on the shaft —S—, thereby occupying a position above the horizontal diameter of the cylinder and concentric to the arc of the abutment. The diameter of the hub and its position are such that a segment of its periphery enters, fills and rotates in the abutment arch and fits against the surface thereof accurately, thereby forming a steam-tight joint and dividing the cylinder into two equal parts.

The periphery of the hub is provided with radial slots —48—49—50—51 the depth of which is a little greater than half the radius of the hub.

The pistons —P—P′—P^2—P^3— are coupled together in pairs diametrically of the hub. They are composed of two parts, viz:—a rectangular part —52—, which is inserted in the radial slot and an oscillating face plate —53—, which is hinged to the rectangular part —52—. The shape of the oscillating face-plate is that of the frustum of a wedge, in cross-section, but its face, that bears against the walls of the cylinder, is curved convexly to about the same radius as the arcs of the cylinder. The under-side is also chamfered off or cut away at more or less of an angle to a line drawn through its axis, so that it can oscillate freely to a limited extent. The face-plate is connected with the rectangular part by means of a rolling joint formed by a cylindrical rib or tongue —54— on the inner part of the piston which is inserted in a corresponding groove —55— in the face-plate, so that it cannot become disconnected while oscillating, but can be removed by slipping it off endwise when a head of the cylinder is taken off. By making the face-plate convex and of the same curvature as the arcs of the cylinder, its entire surface bears evenly against the walls of the cylinder when rotating. As the hub rotates the angular positions of the pistons to the walls of the cylinder change constantly owing to the eccentricity of the path of the pistons to the cylinder. If the contact faces were rigid more or less friction would be produced which would cause rapid and uneven wear, and, after the engine had been running for a short time, the surface of the faces would be worn down transversely to such an extent that they would no longer form a close enough contact with the walls of the cylinder to stop the steam; but by curving the bearing faces so that their entire surface bears against the walls of the cylinder and adapting them to oscillate and thus maintain a uniform position with relation thereto in every part of the cylinder, they afford a perfect obstruction to the steam and remain at all times parallel to the walls, whereby freedom of movement and even wear are insured.

The pistons are connected together through the hub and shaft diametrically by means of two or more connecting bars —56— which are passed through tapered bushings —57— inserted in perforations in the hub and the shaft. The ends of these bars are inserted in sockets —58— in the inner sides of opposite pistons. Between the ends of the bars and the bottom of the sockets spiral springs —59— are inserted to supply an elastic bearing for the pistons. The bushings —57— extend from the bottom of a slot on one side to the bottom of its opposite slot, and by tapering them they can be wedged securely in the perforations in the hub and shaft. The opposite pistons being thus coupled together they adjust themselves as they revolve so that the piston on the steam side is forced out against the receding walls of the cylinder as it moves down the same by the retirement of the opposite piston into its slot which is brought about positively by the wall of the cylinder on the opposite side, which forces the piston on that side into its slot. The direct and positive movement of the pistons thus produced by coupling them together, forces the one which the steam is driving against the walls of the cylinder as they recede from the hub and thus maintain a steam tight connection therewith.

The shaft packing:—The shaft is packed in the following manner; In each of the heads —30—30— on the inside there is an annular groove —60— which is concentric to the shaft, but extends into the shaft only at its inner end. This groove forms the box for the packing which is arranged in the following manner:—At the bottom of the groove there are springs —61— which may be spiral as shown, or of other form; against these springs a wrought-iron ring —62— is laid, and, next to the wrought-iron ring, a ring —63— of soft or fibrous packing is inserted, and on top of this, a cast-iron ring —64— is placed. The latter ring is right angular in cross-section, a flange —65—, projecting inward and forming a broad face that extends down to the shaft. The ring is inserted in the groove which it fits closely, against the soft packing ring —63—. In the partition between the groove and the shaft, holes —66— are drilled parallel to the shaft to receive the pins —67— which are screwed into the flange of the steel ring —64—. These pins hold the steel ring and prevent it from being rotated by frictional contact with the sides of the hub. The face of the packing ring —64— is pressed against the end of the hub by the springs in the groove and steam tight joints thus formed around the

shaft between the hubs and the heads of the cylinder, and the soft packing —63—, which is expanded against the side of the annular groove by the pressure, packs the groove and prevents the escape of the steam through the same. By constructing the packing ring —64— with the flange as described it can be easily got at and removed when the cylinder head is taken off by inserting a tool under the flange and driving it out of the groove.

The admission of steam to the cylinder is controlled by means of a valve inclosed in the valve chamber —3—. This valve consists of heads —68—68— connected by a hollow cylindrical stem —69— of a smaller diameter than the chest. These heads are packed by means of expansible steel packing rings —70— inserted in grooves —71— in the periphery of the heads. At one end of the valve there are projections —72— between which the ends of the cross-arms —73—73— on the end of the valve rod —6—, are inserted and fastened by means of screw studs —74— driven down into them through the projections —72—72—. Between the heads of the valve a space —75— surrounding the valve, forms a passage to the induction port for the steam that enters the valve chamber from the steam pipe. The exhaust steam passes out of the chamber at its open end. When the engine is running to the right the valve is moved back to the right-hand end of the valve chamber and the steam passes through the space —75— to the port —13— and enters the cylinder through said port; but when running to the left the valve is moved to the opposite end of the chamber, as indicated by the dotted lines in which positions the heads are to the left of the ports —13—14—, and the steam enters the cylinder through the port —14—, exhausts through the port —13—, and enters the open end of the hollow valve stem between the arms —73—73—, passes through the same and escapes into the exhaust pipe at the open end of the valve chamber. Hence the ports —13—14— are respectively the induction and exhaust ports when the engine is running in one direction and, when the direction is changed, port —13— becomes the exhaust port and —14— the induction port. By this construction therefore the engine is reversible by means of a single valve. To stop the engine the valve is moved to a central position so as to cover both ports —13—14—.

The heads of the cylinders are provided with segmental grooves or channels —76—77— on opposite sides of the driving shaft and these grooves are connected respectively with radial grooves —78—79— which extend out beyond the periphery of the hub above the horizontal axis of the cylinder and midway between it and the vertical axis. The ends of the hub cover these grooves except at their extreme ends which open into the steam spaces on opposite sides of the cylinder. The segmental grooves extend beyond the circle described by the bottoms of the piston-slots when the hub rotates so that they open into the said slots when the latter are moving over them. The space between the ends of these grooves is somewhat greater than the width of the piston slots so that when a piston is being driven by the pressure of the steam behind it its slot passes the end of the segmental groove —76— on the steam side before it reaches the grooves on the exhaust side, so that the live steam let into the slots under the pistons when they are moving out, will be exhausted from under them just before they begin to move into the slots. Referring to Fig. 2 which shows the primary cylinder, and supposing the engine to be running to the right, the steam entering the steam space by the port —13— and the cylinder through the opening —19— also enters the groove —78— and segmental grooves —76— and, when a piston slot passes the upper end of the segmental groove, which occurs when the piston begins to move out of the slot, the steam enters the slot and exerts a pressure against the bottom of the piston that tends to force the face of the oscillating plate against the wall of the cylinder on the steam side and, at the same time, reduces the pressure of the opposite piston against the wall of the cylinder on the exhaust side. This pressure on the piston continues while it is moving down to the bottom of the cylinder until it reaches its extreme outward position when the rear side of the piston slot passes the lower end of the segmental slot on the steam side and thus cuts off the steam from entering the slot, and the forward side of the slot passes the lower end of the segmental groove —77— on the exhaust side and thus opens up a passage from the piston slot to the exhaust steam space of the cylinder into which the steam flows and thence passes out to the exhaust and relieves the pressure under the piston at the time it begins to be retired into the slot by the approaching walls of the cylinder on the exhaust side. 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 its slot or retired towards the axis of the hubs and the opposite piston is forced out against the walls of the cylinder on that side. If this positive motion were alone relied on, there might be more or less resistance from friction, steam pressure and other causes, particularly when the pistons on the exhaust side pass from the cylinder to the abutment where the change of position is most abrupt. To prevent this and reduce the resistance to a minimum, steam is admitted under the pistons on the steam side through the grooves —76—78— when they begin to move out after passing the abutment and this steam bears against the pistons on the steam side and forces them out of their slots and against the walls of the cylinder, thus aiding their movement and relieving the pressure of the pistons against the walls of the cylinder on the exhaust side to a considerable extent. The pressure of the steam against the underside of the pistons continues until they have reached and passed the point where they are moved out to their full extent and presented their whole effective surface to the pressure of the steam and until they have commenced to retire into their slots. When they do so the piston slots reach the segmental groove —77— on the exhaust side and the steam passes from under the piston through said groove and the radial groove —79— and escapes through the exhaust passage of the cylinder.

While particular reference has been made to the primary cylinder in the foregoing description of the grooves for admitting the steam under the pistons and exhausting it therefrom, it is to be understood that these grooves are also in the heads of the secondary cylinders and that the steam is admitted under the pistons and exhausted therefrom in the same manner precisely as in the primary cylinder, but the position

of the pistons at the time the steam is admitted under them and exhausted from them, is reversed in these cylinders from the position they occupy in the primary cylinder.

The operation of this engine is as follows:—When the engine is running to the right the valve is moved to the right-hand end of the valve chamber, so that its right-hand head will uncover the port —13— which becomes the induction port and its left-hand heads uncovers the port —14— which becomes the exhaust port. Steam entering the valve chamber passes through the space between the stem of the valve and the walls of the chamber and enters the space —17— through the port —13—. From the space —17— it passes through the openings —19—20—21— into the cylinder when the pistons are in the position shown by Fig. 2. The steam between the pistons —P—P′— has no effect in moving the pistons because the pressure on both sides of the piston —P′— is about equal, but the steam entering the port —21— is opposed practically by the entire area of the piston —P^2—. The pressure causes the piston —P^2— to move and rotate the hub and shaft. When piston —P— reaches the opening —19—, —P′— passes the opening —21—, so that the steam entering through the opening —20— acts upon piston —P′—, and when the latter passes opening —21— the piston —P— reaches opening —20— and the rotation of the hub is produced by the pressure of the steam behind the piston —P′—. At this stage piston —P^2— is moving up the exhaust side of the cylinder and when it passes opening —22— in the wall of this side the steam behind it passes into the exhaust space —18—, and thence to the exhaust port —14—. Substantially the whole work in the primary cylinder is done by the steam that enters through opening —21— behind the piston which has passed said opening. The live steam continues to flow through the induction port —13— and it passes from the steam space —17— to the steam passage —25— and divides, part of it going to the right, and part to the left, passing through the openings —26—26— in the heads —27—27— and then enters the steam spaces —35—35— of the secondary cylinder, whence it passes into these cylinders through the openings —36—37—38— and drives the pistons in these cylinders. When the pistons in the secondary cylinders reach the exhaust side of the cylinders the steam behind the pistons passes into the exhaust spaces —34—34—, as indicated by the arrows, Fig. 5, thence flows through the openings —29—29— in the heads —27—27— and enters the exhaust passage —28— of the primary cylinder from which it passes into the space —18— and through the openings —22—23—24— to the exhaust port —14—. By reference to Fig. 5 the movement of the live steam from the primary cylinder into the secondary cylinders and its return from the secondary cylinders to the primary cylinder, are clearly indicated by the arrows

As the live steam enters and fills the steam space —17— of the primary cylinder on the right-hand side, and also enters and fills the steam spaces —35—35— on the left-hand side of the secondary cylinders, the pressure exerted by the steam on the pistons, hub and driving shaft in the primary cylinder is perfectly balanced by the pressure on the pistons, hub and driving shaft on the left-hand side of the secondary cylinders, and furthermore, as the pressure on the hub and shaft in the primary cylinder is counterbalanced by the opposing pressure on the hubs and the parts of the shaft that pass through the secondary cylinders it follows that there is no possible flexure of the shaft by excess of pressure on one end of the shaft.

As heretofore stated the greater pressure is exerted on the pistons after they have passed the lower opening —21— in the primary cylinder and after they have passed the upper openings —38—38— in the secondary cylinders, and as the opening —21— is diametrically opposite the openings —38—38—, it follows that the greatest pressure on the pistons, hubs and driving shafts is exerted in the space between the pistons —P′—P^2— as these are shown by Figs. 2, 3, 4, and, hence, it will be clearly seen that the balancing of pressures is absolute. It will be seen by reference to Fig. 5 that the openings —19—20—21— and —22—23—24— of the primary cylinder are much larger than the openings —33—34—35— and —36—37—38— of the secondary cylinders. This is necessary because of the greater area of the pistons and hub in the central cylinder, and, for the further reason, that when the openings on one side of the primary cylinder are used as the exhaust openings, and the exhaust from both secondary cylinders and also from the primary cylinder has to pass through the exhaust openings in the primary cylinder, it is necessary that these should be larger to give a perfectly free exhaust to avoid back pressures on the pistons when they move through the exhaust side of the central cylinder.

When the engine is to be run to the left the valve is moved over to the left-hand end of the valve chamber so that its heads will uncover the ports —13—14—. The steam entering the valve chamber passes from the steam space —75— through the port —14—, which now becomes the induction port, and the exhaust steam passes out through the port —13— around the right-hand head of the cylinder and thence through the hollow stem of the valve to the eduction pipe at the opposite end of the valve chamber. When the valve is thus adjusted the live steam enters the left-hand side of the central cylinder and fills the space —18— and flows into the steam passage —28— and passes thence through the opening —29—29— in the cylinder heads —27—27— to the steam spaces —34—34— and thence through the openings to the left-hand sides of the secondary cylinders; while the exhaust steam passes through the openings —36—37—38— into the steam spaces —35—35— and thence through the openings —26—26— into the cylinder heads to the steam passage —25— in the primary cylinders and from there into the steam space —16— and out through the exhaust port —13—. From the above it will be seen that by merely shifting the valve the engine is reversed.

It is not intended to restrict the secondary cylinders to the dimensions given in the specification, as in some instances it may be desirable or expedient to vary these dimensions more or less from that stated. Furthermore the invention is not limited to the exact mode of connecting the steam spaces of the secondary cylinders with the steam spaces of the primary cylinder, as other means of making these connections may be em-

ployed if desired or when circumstances may make it necessary.

I claim:—

1. In balanced rotary engines, the combination of a primary cylinder provided with pistons induction and exhaust ports, a valve for controlling the admission and escape of the steam therefrom, secondary cylinders connected with the ends of the primary cylinder and steam passages that connect the live steam sides and the exhaust steam sides of the secondary cylinders, with the live steam side and the exhaust steam side of the primary cylinder, substantially as specified.

2. In balanced rotary engines, the combination of a primary cylinder provided with pistons induction and exhaust ports, a valve for controlling the admission and escape of the steam therefrom, secondary cylinders connected with the ends of the primary cylinder arranged in a reversed relation to the primary cylinder, steam passages that connect the steam space on one side of the primary cylinder with the steam space on the opposite sides of the secondary cylinders, and an exhaust steam space on one side of the primary cylinder that connects with the exhaust steam spaces on the opposite sides of the secondary cylinders, substantially as specified.

3. In rotary engines, the combination of a primary cylinder provided with pistons, induction and exhaust ports, a valve for controlling the admission of the steam into the cylinder, a secondary cylinder at each end of the primary cylinder and steam passages leading from the primary cylinder into the secondary cylinders, to convey the live steam at boiler pressure into the secondary cylinders, substantially as specified.

4. In rotary engines, the combination of a primary cylinder provided with pistons, induction and exhaust ports, and a valve for controlling the admission of the steam into said cylinder, secondary cylinders provided with pistons at each end of the primary cylinder the longitudinal area of which is one half that of the primary cylinder, and steam passages leading from the primary cylinder into the secondary cylinders to convey the live steam at boiler pressure into the steam spaces of the secondary cylinders, substantially as specified.

5. In balanced rotary engines, the combination of a primary cylinder provided with pistons induction and exhaust ports, a valve for controlling the admission of the steam into the cylinder, a secondary cylinder provided with pistons at each end of the primary cylinder and steam passages leading from the primary cylinder into the secondary cylinders, to convey the live steam at boiler pressure into the secondary cylinders, substantially as specified.

6. In rotary engines, the combination of a primary cylinder provided with pistons, steam spaces on opposite sides of the cylinder, openings through the walls of the cylinder from the said steam spaces into the cylinder, induction and exhaust ports that communicate with the respective steam spaces, a valve that controls the admission of steam into said cylinder, secondary cylinders provided with pistons and steam spaces on opposite sides thereof and steam passages leading from the steam spaces in the primary cylinder to the steam spaces in the secondary cylinders and which connect the steam spaces on one side of the primary cylinder with the steam spaces on the opposite side of the secondary cylinders, substantially as specified.

7. In rotary engines, the combination of a primary cylinder provided with pistons and steam spaces on opposite sides thereof, openings in the walls of the cylinder between the steam spaces and the cylinder, exhaust ports leading into the steam spaces on opposite sides of the cylinder, a single valve for controlling the admission of steam to the cylinder which is adapted to be shifted and thus open either one of the ports for the admission of steam to either side of the cylinder, secondary cylinders at each end of the primary cylinder provided with steam spaces on opposite sides and openings in the cylinder walls between the steam spaces and the cylinder, steam passages that connect the steam spaces of the primary cylinder with the steam spaces of the secondary cylinders on both sides of each, the steam space on one side of the primary cylinder being connected by means of the steam passages with the steam spaces on the opposite sides of the secondary cylinders, substantially as specified.

8. In rotary engines, the combination of a primary cylinder provided with rotatable pistons and an abutment that divides the cylinder longitudinally into two equal parts, steam spaces in the walls of the cylinder on opposite sides thereof, openings in the walls between the cylinder and the steam spaces, ports that open from the valve chamber into the steam spaces on opposite sides of the cylinder, a secondary cylinder at each end of the primary cylinder, abutments in the secondary cylinders that divide them into two parts longitudinally and which are diametrically opposite the abutment of the primary cylinder, steam spaces on opposite sides of the secondary cylinders, a steam passage on one side of the primary cylinder that leads into the steam spaces on opposite sides of the secondary cylinders, and a single valve for controlling the admission of live steam to the primary cylinder and the secondary cylinders, so that it enters the primary and secondary cylinders simultaneously, substantially as specified.

9. In rotary engines, the combination of a primary cylinder having steam spaces in opposite walls, openings in the wall of the cylinder for the admission of steam on one side of the cylinder and its exhaust on the opposite side, an abutment at the top of the cylinder, a valve chamber, ports at each end of the abutment leading from the valve chamber to the spaces on opposite sides of the cylinder, secondary cylinders at the ends of the primary cylinder, heads between the primary cylinder and the secondary cylinders, heads at the outer ends of the secondary cylinders, a driving shaft passed through the heads and supported in bearings therein, hubs in the primary and secondary cylinders mounted on the said shaft, said hubs provided with radial slots, self-adjusting pistons in the slots of the hubs those on opposite sides connected together through the hubs and driving shaft so as to move together in either direction, steam spaces on opposite sides of the primary cylinder, steam spaces in the walls of the secondary cylinders which are oppositely placed with respect to the steam spaces in the primary cylinder, openings in the heads between the primary cylinder and secondary cylinders, steam passages leading from the steam spaces in the primary cylinder to the openings in the heads between the cylinder and communicating with the steam spaces of the secondary cylinders, a valve for controlling the admission of steam to the primary cylinder, substantially as specified.

10. A reversible balanced rotary engine, comprising a primary cylinder and secondary cylinders which are connected with the ends of the primary cylinder, abutments in said cylinders, a shaft passing through the cylinders, a hub mounted on the same in the respective cylinders provided with self-adjusting pistons the respective cylinders being of the same diameter and shape, but the secondary cylinders being in a reversed position with respect to the primary cylinder, a valve chamber connected with the primary cylinder, steam spaces in the opposite walls of the primary cylinder and secondary cylinders, openings leading therefrom into the cylinder, steam ports leading from the valve chamber into the steam spaces of the primary cylinder, steam passages leading from the steam spaces on each side of the primary cylinder to the steam spaces on the opposite sides of the secondary cylinders and a single valve for controlling the admission of steam into the primary cylinder through the same and the connecting steam passages into the steam spaces of the secondary cylinders, substantially as specified.

11. In reversible balanced rotary engines, the combination of a primary cylinder, two secondary cylinders having the same diameter and shape as the primary cylinder, but each of them being but half the length of the primary cylinder, a driving shaft passed through the said cylinders, hubs mounted on said shaft in the respective cylinders each of which is provided with self-adjusting pistons, abutments in the respective cylinders, those in the secondary cylinders being diametrically opposite the abutment of the primary cylinder, steam spaces in the

opposite walls of the primary and secondary cylinders, openings in the walls of the cylinders leading from the steam spaces into the cylinder, a valve chamber on the primary cylinder over the abutment, ports leading from the valve chamber into the steam spaces in the walls of the primary cylinder, a valve which is adapted to be adjusted to open either of the ports to admit steam to the steam space on either side of the primary cylinder, steam passages leading from the steam spaces of the primary cylinder into the steam spaces of the secondary cylinders, whereby when the valve is adjusted to admit steam through one of the ports to one side of the primary cylinder, it is led through the steam passages to the steam spaces on the opposite sides of the secondary cylinders, substantially as specified.

12. In reversible balanced rotary engines, the combination of elliptical primary and secondary cylinders provided with abutments in line with the vertical axes of the cylinders, the abutment in the primary cylinder being diametrically opposite the abutments of the secondary cylinders, steam spaces in the walls on opposite sides of the said cylinders, openings in the wall leading from the steam spaces into the cylinders, the steam spaces in the secondary cylinders extending from points above the horizontal axes of the cylinders around and under the abutments to the opposite sides thereof, steam passages leading from the spaces in the wall of the primary cylinder to the opposite spaces in the walls of the secondary cylinders, a valve chamber on the primary cylinder over the abutment, and steam ports leading from the valve chamber into the steam spaces in the walls of the primary cylinder, substantially as specified.

13. In reversible balanced rotary engines, a cylinder, a shaft passed through the said cylinder, a hub mounted on the said shaft provided with radial slots, self-adjusting pistons in the said slots, opposite pistons being connected together diametrically of the hub and shaft, whereby when the hub rotates the pistons on the steam side are moved out and those on the exhaust side are moved in the slots and grooves or channels in the heads of the cylinder consisting of segmental grooves concentric to the hub and having radial grooves extending out beyond the periphery of the hub, the segmental grooves communicating with the slots in which the pistons move, whereby when steam is admitted to the cylinder it passes through the radial grooves on one side into the segmental groove on the same side and thence into the slot under the piston, and when said piston reaches the segmental slot on the opposite side the steam therein is exhausted from under the piston, substantially as specified.

In testimony that I claim the invention above set forth, I have affixed my signature in presence of two witnesses.

WILLIAM KERR AUSTIN.

Witnesses:

HANS AMRHEIN,

FREDK. CORMACK.