(No Model.)

4 Sheets—Sheet 1.

S. G. BROSIUS.

ROTARY STEAM ENGINE.

No. 445,039. Patented Jan. 20, 1891.

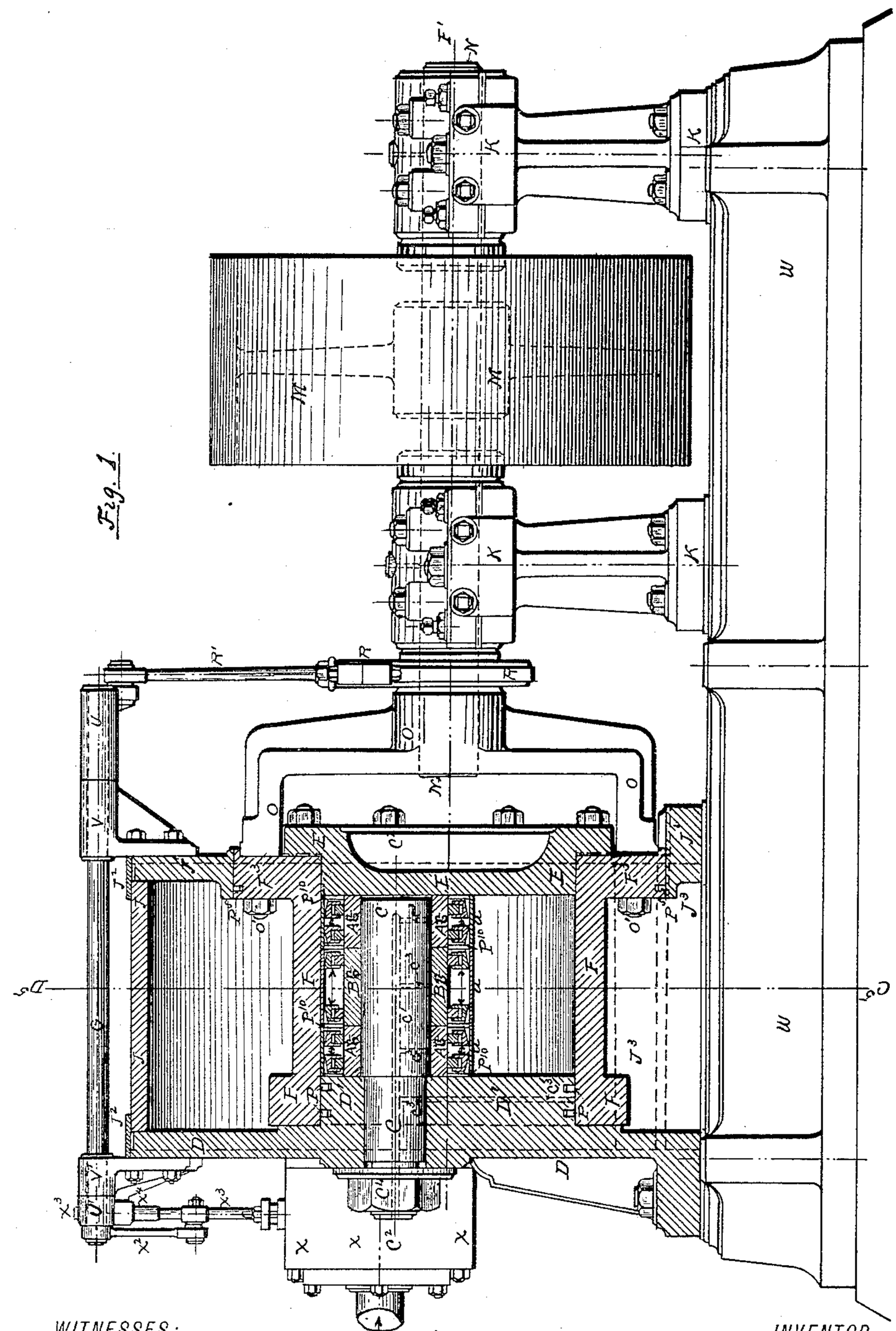

Fig. 1.

WITNESSES:

J. Henry Kaiser.

Benj. Munroe

INVENTOR

S. G. Brosius.

BY

J. L. Rusk

ATTORNEY.

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S. G. BROSIUS.

ROTARY STEAM ENGINE.

No. 445,039. Patented Jan. 20, 1891.

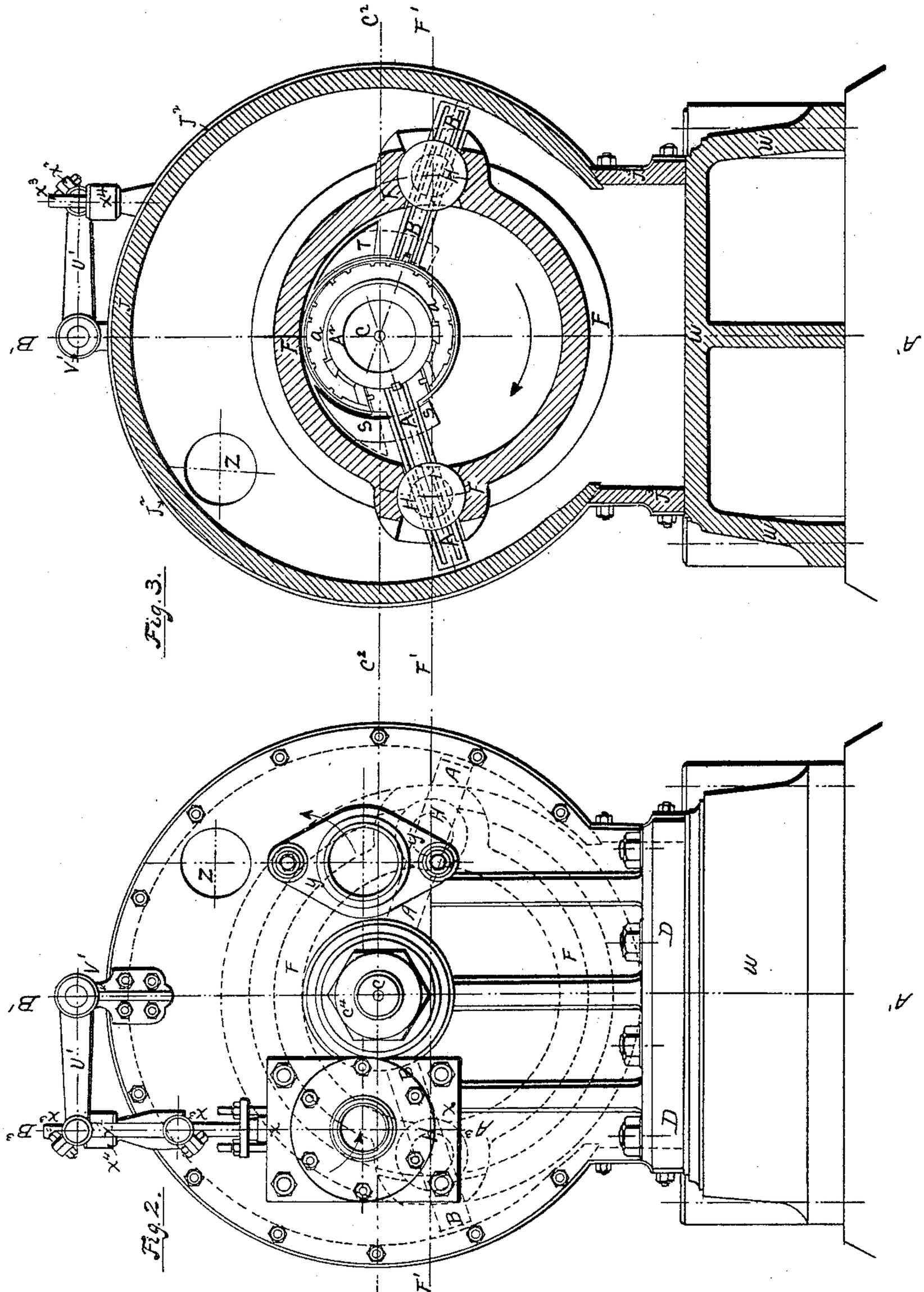

Fig. 3.

Fig. 2.

WITNESSES:

J. Henry Kaiser.

Benj. Munson

INVENTOR

S. G. Brosius.

BY

J. S. Ruck

ATTORNEY.

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S. G. BROSIUS.

ROTARY STEAM ENGINE.

No. 445,039. Patented Jan. 20, 1891.

Fig. 14.

Fig. 15.

Fig. 16.

Fig. 17.

Fig. 18.

Fig. 20.

Fig. 19.

Fig. 21.

Fig. 22.

Fig. 25.

Fig. 26

Fig. 23.

Fig. 24.

Fig. 11.

Fig. 13.

Fig. 5.

Fig. 6.

Fig. 7.

Fig. 8.

Fig. 9.

Fig. 12.

Fig. 4.

Fig. 10.

WITNESSES:

J. Henry Kaiser.

Benj. Munroe.

INVENTOR

S. G. Brosius.

BY

J. L. Rueck

ATTORNEY.

(No Model.)

4 Sheets—Sheet 4.

S. G. BROSIUS.

ROTARY STEAM ENGINE.

No. 445,039. Patented Jan. 20, 1891.

Fig. 34.

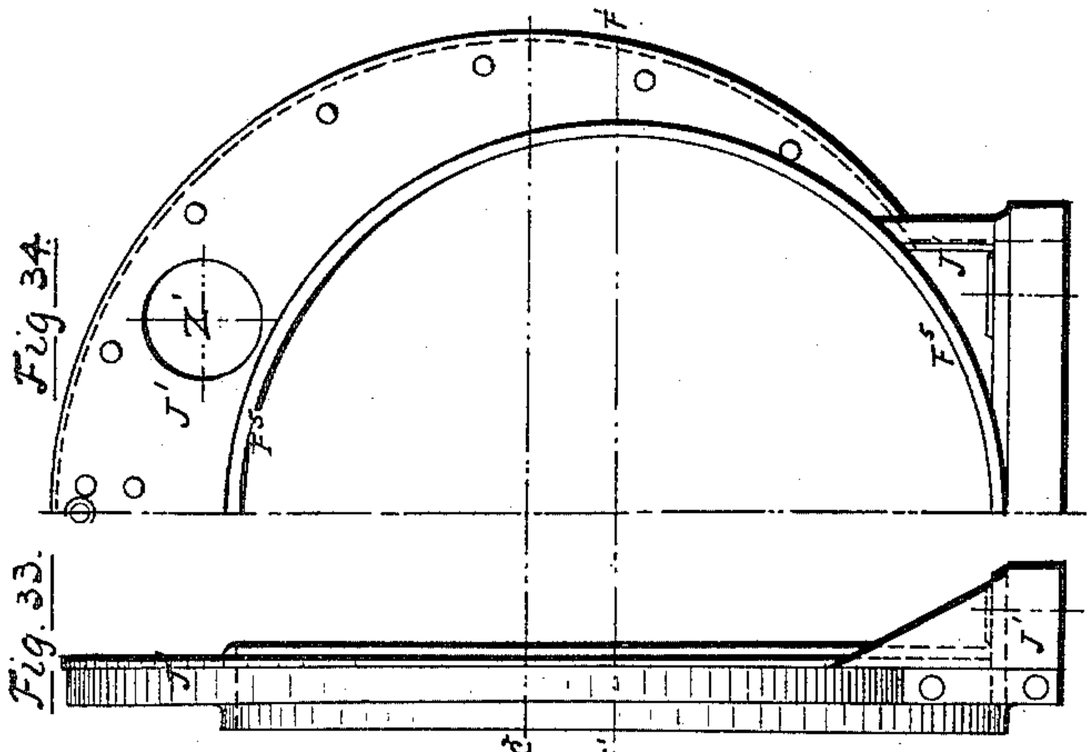


Fig. 33.

Fig. 37.

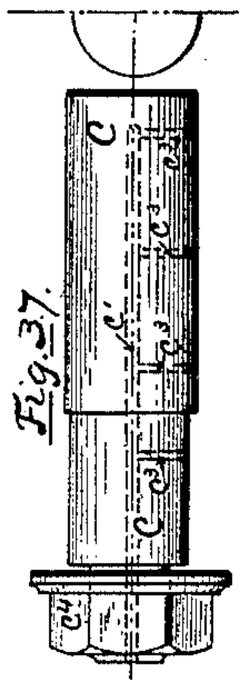


Fig. 32.

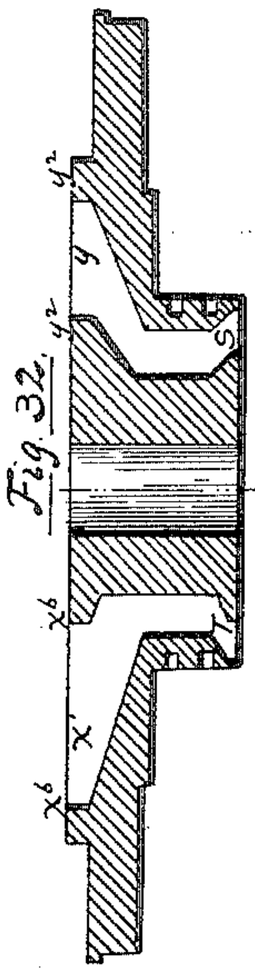


Fig. 31.

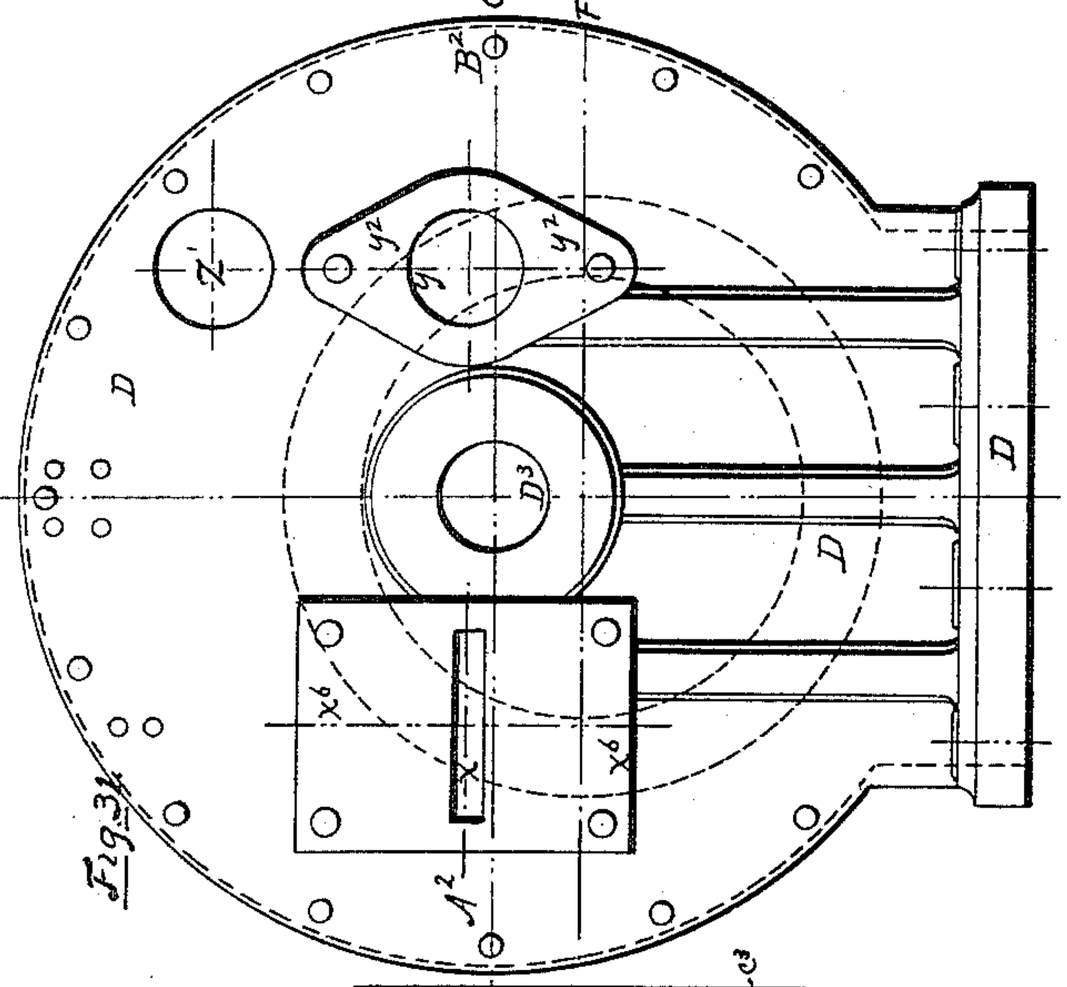


Fig. 36.

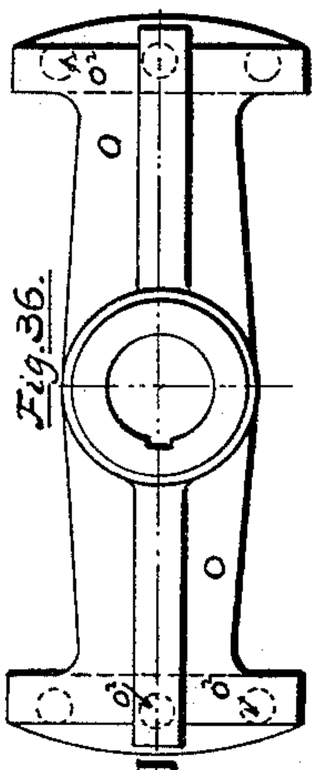


Fig. 30.

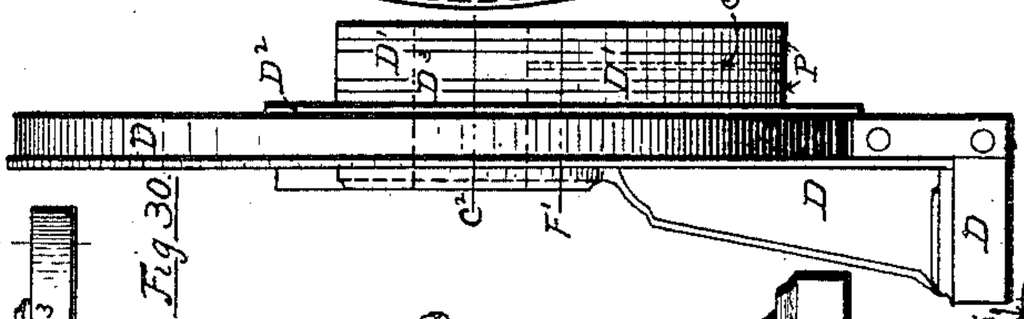


Fig. 35.

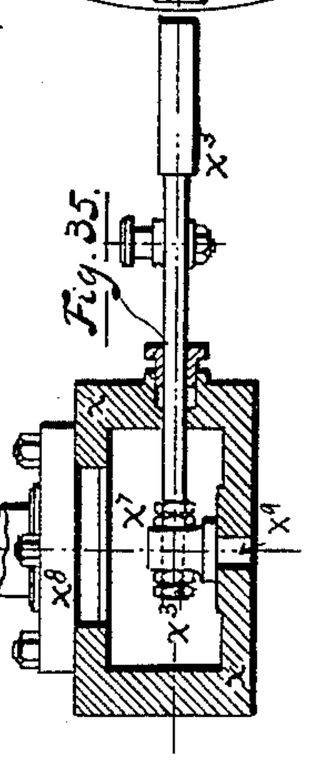


Fig. 28.

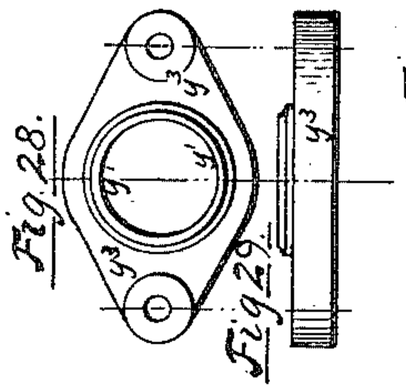
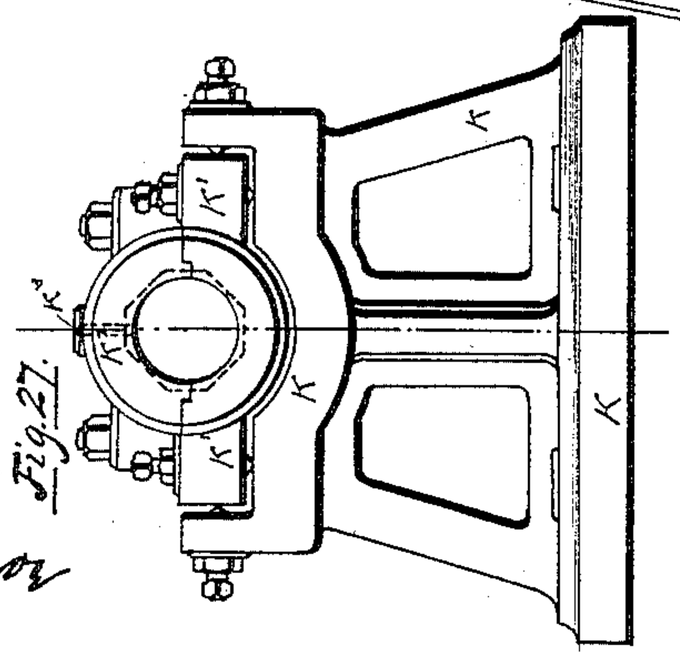


Fig. 29.

Fig. 27.



WITNESSES:

J. Henry Kaiser.

Benj. Munson

INVENTOR

S. G. Brosius.

BY J. L. Rusk

ATTORNEY.

UNITED STATES PATENT OFFICE.

SAMUEL GLENVILLE BROSIUS, OF SAVANNAH, GEORGIA.

ROTARY STEAM-ENGINE.

SPECIFICATION forming part of Letters Patent No. 445,039, dated January 20, 1891.

Application filed October 24, 1890. Serial No. 369,153. (No model.)

To all whom it may concern:

Be it known that I, SAMUEL GLENVILLE BROSIUS, of the city of Savannah, county of Chatham, State of Georgia, have invented a new and useful Improvement in Rotary Steam-Engines, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings, forming part of this specification, in explaining its nature and construction.

This invention relates to a novel construction of a rotary engine, being an improvement upon the construction of a rotary steam-engine shown in my application, Serial No. 340,828, filed February 17, 1890, allowed September 9, 1890.

In the engine set forth in this application the cylinder rotates on its axis and the pistons (two being used in this construction) pass through the circumference of the cylinder, being held in position by cylindrical guides, which are journaled in the sides of the said cylinder. The pistons revolve on a shaft whose center is eccentric to the axis of said cylinder. The distance between the axes of the pistons and the rotating cylinder is such as to allow the hubs of the pistons to be packed steam-tight against the inner periphery of the cylinder by the automatic packing held out against the inner periphery of the said cylinder. This packing is composed of a packing and an expansion ring in each end of said packing-ring. The packing-ring is held in position by separating or drawing together, as the case may be, of the expansion-rings. Said expansion-ring is so constructed as to allow the packing-ring to adjust itself to any inequality of the inner periphery of said cylinder, due to wear in said cylinder or any of the journals of the said engine, whereby the axis of the rotating cylinder may be thrown out of line with the axis of the pistons. In engines of this class as heretofore constructed, excepting the engine described in my application above referred to, the steam is admitted between the outer casing and the periphery of the inner rotating cylinder. This cylinder performs, ordinarily, the function of packing or abutment. Such a construction brings about great loss of steam, due to the condensation caused by the action of cold air upon the greater external surface of the outer casing and also the greater area contained between the rotating cylinder and the outer casing as compared with the area of the rotating cylinder itself, and also necessitating packing the pistons against the inner periphery of the outer casing, thereby causing great friction, due to centrifugal force of the packing against said outer casing. Among the several objects of my invention is to overcome this condensation and the greater steam area between the outer casing and rotating cylinder and the consequent loss of efficiency. This is overcome by introducing the steam within the rotating cylinder only and using the outer casing as a shield to prevent contact of cold air with the rotating cylinder.

A second object is to overcome the great friction between the packing of the pistons and the inner periphery of outer casing, as is the usual construction.

A third object is to obtain a steam-tight packing between the hubs, sides, and face of pistons, against the inner periphery, the heads, and in the cylindrical guides, respectively, of said rotating cylinder with the least possible friction.

A fourth object is to so admit and cut off the steam that the surface of back-pressure on the following piston is nearly or just equal to the surface of the steam-pressure on the leading piston at the moment the exhaust-port is opened, thereby balancing the following piston during the first quarter of the stroke under steam-pressure, as the piston travel during this time through the cylindrical guide is about two-thirds of the whole travel through said guide. It is therefore evident that the friction due to the travel of the piston through said guide is reduced to about two-thirds less than a piston not so balanced. It will be seen that the pistons are alternately leading and following.

These and other objects I accomplish by the constructions shown in the drawings and hereinafter described, and pointed out in the claims.

Figure 1 is a side elevation of the rotary engine, the section being taken through the cylinder and outer casing on line A′ B′ of Fig. 2. Fig. 2 is an end view of the rotary engine in elevation, showing location of steam-chest and exhaust-pipe. The cylinder-

pistons and cylindrical guides are also shown in broken lines. Fig. 3 is a view in cross-section on the line C^5 D^5 of Fig. 1. Fig. 4 is a cross-section of the rotating cylinder, taken on line *e e*, Fig. 5, the sections below and above *e' e'* looking toward the small flange and large flange, respectively, of said rotating cylinder. Fig. 5 is a side view of the rotating cylinder, partly in elevation and partly in section. Fig. 6 is a side view of the cylindrical guides. Fig. 7 is a view of large end of said cylindrical guides. Fig. 8 is a cross-section of the cylindrical guides on line *i i*, Fig. 6. Fig. 9 is a view of the small end of the cylindrical guides. Figs. 10 and 11 are elevations of the pistons. Figs. 12 and 13 are side views of the pistons. Fig. 14 shows an end view of the automatic packing in position around the hub of a piston. Fig. 15 shows a cross-section of the automatic packing and expansion rings. Fig. 16 shows a cross-section of the automatic packing-ring on line *z z*, Fig. 14. Fig. 17 is an end view of the wedge of the automatic packing-ring. Fig. 18 is a cross-section of the outer expansion-ring on line *z' z'*, Fig. 14. Fig. 19 is an end view of the wedge of the outer expansion-ring in position in said ring. Fig. 20 is a cross-section of the inner ring on line *z' z'*, Fig. 14. Fig. 21 is a cross-section of the automatic packing on line *z' z'*, Fig. 14. Fig. 22 is a side view of the automatic packing shown in Fig. 21. Fig. 23 shows the wedges of the packing-ring so constructed as to expand the packing-ring by drawing together the expansion-rings. Fig. 24 is a side view of the automatic packing shown in Fig. 23. Fig. 25 is a front view of the wedge used in packing-ring, as shown in Fig. 24. Fig. 26 is an end view of the wedge as shown in Fig. 25. Fig. 27 is an end view of the adjustable pillow-block, an elevation of the same being shown in Fig. 1. Fig. 28 is the plan of the exhaust-port cap; Fig. 29, side view of the cap as shown in Fig. 28; Fig. 30, an elevation of the front cylinder and casing heads on line A' B' of Fig. 2. Fig. 31 is a front elevation of front cylinder and casing heads as shown in Fig. 30. Fig. 32 is a cross-section of front heads on line A^2 B^2, Fig. 31, showing the steam and exhaust ports. Fig. 33 is an elevation of the rear casing-head. Fig. 34 is a half-elevation of the rear head as shown in Fig. 33. Fig. 35 is a cross-section through the steam-chest on line A^3 B^3 of Fig. 2, the elevations being shown in Figs. 1 and 2. Fig. 36 is a plan view of the double crank, the elevation of the same being shown in Fig. 1. Fig. 37 is a view of the stationary shaft on which the pistons revolve.

Like letters of reference indicate like parts in all the figures.

All the figures of the drawings are on the same scale, except those from 14 to 26, inclusive, which are double the scale.

The cylinder-head D' is attached to the casing-head D and is held stationary by it and forms one of the journals for cylinder F.

F is the cylinder, which revolves on or is journaled at one end on head D' and packed steam-tight on said head by packings P P, and the other end is firmly attached to double crank O by flange F^3 and has bolted to said flange the cylinder-head E, which revolves with the said rotating cylinder F.

N is the driving-shaft and is journaled in pillow-blocks K K (one or more pillow-blocks may be used) and is firmly fastened in hub of double crank O.

Cylinder F, double crank O, and shaft N are firmly attached to each other and revolve, being held in position by head D and pillow-blocks K K, so the cylinder F may be said to be journaled by shaft N in pillow-blocks K K and in or on head D', all as shown in Fig. 1. The cylinder F contains in its circumference openings *h h h h* and the journal-boxes *h'* and h^3, to receive the guides H and its journals H' and H^3, as shown in Figs. 4 to 9, inclusive. Blocks F^4 F^4 are held in position in the flange F^3 of cylinder F by bolts F^5 F^5. This construction is to facilitate the placing of the cylindrical guides and pistons in position. The flange F^3 has a groove for ring-packing P^5, which packs said flange against the inner periphery of the rear casing-head J^3.

The shaft C is fixed stationary in heads D and D', and is the axis on which the pistons revolve, as shown in Figs. 1 and 3. This shaft has oil-channels *c* and c^3 c^3 c^3 c^3, so that the hubs of the pistons and journal of cylinder F at the head D' may be lubricated, as shown in Figs. 1 and 37.

A and B are the overlapping or hinging pistons, which are journaled on shaft C and are held in position by cylindrical guides H and H. The guides are journaled in the circumference of cylinder F, so that the pistons may move freely through them during the revolution of the rotating cylinder, as shown in Fig. 3. In Figs. 10 to 13, inclusive, the pistons are shown as extended on the center line A' B'. The hubs of the piston extend over that portion of the shaft C which protrudes into the cylinder F. In this construction piston A has two hubs and piston B one and of such length as to give them about equal wearing-surfaces to each piston. The pistons are attached or firmly fixed to the hubs by bolts passing through the flanges b^3 b^3 and screwing into the hubs b^2 b^2 by bolts b^4. These pistons and hubs may be made in one piece, in which case flanges b^3 will be done away with and the packing-strips be placed in the face of the pistons and the automatic packing-rings correspondingly increased in length, so that they may be packed by the packing-strips b^6, as shown in Fig. 14 in dotted lines. The hubs of the pistons are provided with the guide-pieces *m'* and *m'*, which fit into the grooves *m* and *m* of the automatic packing, and so hold the packing firmly in position. These guide-pieces may be dovetailed into the hubs of said pistons, as shown in Figs. 12 and 13 by broken lines.

The expansion-rings are free to move lengthwise of these guides. The cross-sections of these guides are dovetail in shape, so that the packing cannot get out of place, as shown in Figs. 10 to 14, inclusive. The pistons are flat and made to fit the slot *b b* in the guides H H, through which they pass. The pistons are packed steam-tight in said guides by packing-strips P^4 and P^8, and packed against the cylinder-heads by packing-strips P^2 p^2, and against the inner periphery of the rotary cylinder by the automatic packing. Packing-strips P^6 and P′, respectively, are also placed along the flanges of each piston to pack against the flange or lugs of the automatic packing and in the overlapping portion of the piston to pack against the periphery of the automatic packing. These pistons, hubs, and flanges may be made of one piece or of several pieces, as shown in Figs. 3, 6 to 9, and 10 to 13, inclusive.

The cylindrical guides H H are journaled in the circumference of the cylinder F. These guides may be made in one or more pieces, and provision should be made to take up the wear both in the guide H and the cylinder F in any of the common ways of adjustment for wear, and is reduced at the end next to the head D′, so as to avoid cutting into said head, thereby allowing the guides to be brought as near to the center of said cylinder F as may be, thereby doing away with the pressure on the face of the pistons that would otherwise exist between said face of pistons and the interior edges of cylinder F, as shown in Fig. 3.

In this engine the guide is constructed of two blocks H^3 and H^4 and circular arcs H^2, so placed and held by taper riveted pins H^6 as to leave the slot *b b*, through which the pistons pass. The guide is provided with grooves for the packing-strips P^4, P^8, P^9, *p*, and p^2 and grooves for the rings P^{12} and P^7. These packing-rings and packing-strips pack the guides steam-tight in cylinder F and against the sides and face of the pistons. These guides are free to oscillate on their axes and adjust themselves to the position of the pistons during the revolutions of the engine.

One set of automatic packing is provided for each hub of the pistons, the packing-rings being the exact length of the respective hubs. These packing-rings are set out against the inner periphery of the rotating cylinder by the expansion-rings, one at each side of the packing-ring. The packing-ring is provided with wedges a^5 a^5, which correspond to the bevel on the expansion-rings. These expansion-rings expand the packing-ring by being separated or drawn together, as the case may be, as shown in Figs. 21 to 24, inclusive. Each end of the packing-ring is firmly attached to the wedges *f f*. These wedges form the flanges or lugs of the packing-ring, against which the flanges b^3 b^3 of the pistons are packed by the packing-strips P′ P′. This expansion-ring consists of an outer ring a^2 and an inner ring a'. The inner ring fits in an annular cavity d^3 in ring a^2, leaving a space d' between ring a' and a^2 of sufficient size to admit the springs *d d*. The ring a^2 is held to ring a' by bolts a^4 a^4. These bolts are countersunk into the ring a^2 sufficiently deep to allow the rings a' and a^2 to come together without the head or bolt a^4 protruding. The distance between rings a' and a^2 may be diminished, but cannot be increased, as bolts a^4 a^4 prevent it. It will be seen that the expansion-ring is composed of the ring a', placed in a cavity d^3 of ring a^2 and held in position by bolts a^4 a^4 and springs *d*. The packing-ring a^3 is held in position by the expansion-rings, which fit against the wedges a^5 of the packing-ring, so as to allow the packing-ring a^3 to be pressed against the inner periphery of cylinder F by means of said expansion-rings being pushed apart or drawn together, as the case may be, by springs or any suitable means, the direction of the movement of the expansion-rings being indicated by arrow-heads. The flanges *f f* of packing-ring a^3 extend over the ends of the expansion-rings. The ends of said expansion-rings are beveled to fit the bevels on the flanges *f f* of the packing-ring a^3 and prevent the packing-ring from going out too far and binding against the inner periphery of the rotating cylinder. The bevel a^6 of the said expansion-ring fits the wedges a^5 a^5 of the packing-ring a^3. The bevels a^6 on the periphery of the expansion-rings are in the same proportion to the sum of the bevels f^3 at their two ends as the diameter of circle is to its circumference. The same is necessarily true of the wedges a^5 a^5 and f^2 of the packing-ring a^3. The tendency of the said expansion-rings to spread by reason of the pressure exerted upon them by packing-ring a^3 is overcome by the guides m' and m' on hubs b^2 of the piston, being fitted into slots *m* and *m* of the said expansion-ring, but are allowed to slide along the hub, so as to expand packing-ring a^3 by the method just described. Each packing-ring a^3 is packed against the other and against its respective cylinder-head by packing-rings P^{10}. The packing-seats P^{11} are provided in packing-ring a^3, all as shown in Figs. 1, 14, and 16, inclusive. It will be noted that the ends of expansion-rings and said packing-ring, and also that side of the guide next to the pistons, are so beveled that the circumference of the packing-ring cannot be increased, except by the action of the said expansion-rings, as just described, and that the said expansion-rings are so constructed that it will allow the packing-ring a^3 to adjust itself to any inequalities on the inner periphery of the rotating cylinder, whether due to wear on the inner periphery of said cylinder or to the axis of shaft C being out of line with axis of rotating cylinder F to wear on shaft C or any of the journals; but provision to keep the axis of shaft C and rotating cylinder in line is made in the adjustable pillow-blocks K K. The double crank O is bolted to flange F^3 of

rotating cylinder F and securely attached by its hub to shaft N, and is so constructed that the head E of cylinder F may be removed without disturbing any other portion of the engine, which facilitates any repairs in the rotating cylinder F. As shown in the drawings, these packing-rings a^3 serve as an abutment between the steam inlet and exhaust ports.

T is the steam-port, and S is the exhaust-port. The exhaust-port should be so located that the steam may escape at the moment that the surface of the back-pressure on the following piston is nearly or just equal to the surface of the steam-pressure on the leading piston, so as to balance the following piston, as hereinafter set forth. The steam enters at port T and drives the piston in direction as indicated by arrow and escapes at port S. The pistons cause the cylinder F to revolve, thereby driving shaft N, and shaft N is firmly attached to cylinder F by double crank O.

N is the driving-shaft on which pulley M is securely fastened.

J and J^3, with that portion of the surface of the bed-plate W which is below the rotating cylinder F and between the casing-heads D and J′, with said casing-heads, form the outer casing. It may be used as a chamber in which to exhaust the steam and thereby superheat the live steam in cylinder F. The exhaust-steam may be admitted at opening Z in the head D and taken from the opening Z′ in head J′, as shown in Figs. 2, 3, 33, and 34. Where the exhaust-steam is not admitted within this casing, the casing is used to protect the cylinder from cold air, preventing rapid radiation and condensation of steam within the rotating cylinder, the air in the space between the cylinder and casing acting as a non-conductor of heat. It is also used for the purpose of holding the journal-boxes V and V′ of the rocker-shaft G. This casing may be dispensed with entirely, if desired.

R is the eccentric which operates the cut-off by means of the rocker-shaft G and its connections.

X is the steam-chest.

x' is the outer steam-port in head D.

x^3 is the valve-stem.

x^7 is the valve.

x^9 is the steam-port in the steam-chest.

x^2 is the connecting-link.

x^4 is the valve-stem guide.

x^5 is the steam-pipe.

x^8 is the steam-chest head, and x^6 is the steam-chest seat on head D.

Y is the exhaust-port in head D.

Y^2 is the seat for the exhaust-cap on head D.

Y′ is the opening in the exhaust-cap, and Y^3 is the exhaust-cap.

V and V′ are the journal-boxes for the shaft G and are attached to the heads J′ and D, respectively.

U is the eccentric-crank, and U′ the valve-crank.

R and R′ are the eccentric and eccentric-rod.

K is the adjustable pillow-block. K′ is the journal-box of said pillow-block. K^3 is the cap of said journal-box.

K^3 is the oil-hole to lubricate the shaft.

M is the pulley and balance-wheel, which is firmly keyed or attached to shaft N and is driven by it.

W is the bed-plate, to which are securely fastened heads D and J′ and pillow-blocks K K in proper positions, as shown in Fig. 1.

It is not necessary to use a cut-off, except to gain advantage of the expansion of the steam. Any kind of cut-off may be used at the steam-port.

It is not necessary to use a cut-off at the exhaust-port.

While I have shown the steam as entering at T and exhausting at S, yet it is obvious that S may be constructed as the inlet-steam port, and T as the exhaust-port, as indicated in broken lines, Fig. 3.

It is not necessary to have the center of the revolving cylinder F directly under shaft C, as shown in Fig. 3—that is to say, the center line A B may be inclined at any angle to the perpendicular.

I do not confine myself to this identical construction, as it is obvious that slight changes may be made in the details without departing from the spirit of my invention.

I am aware that overlapping pistons and revolving cylinders have been used prior to my invention. I therefore do not claim them, but use them in combination, as described.

What I do claim as my invention, and desire to secure by Letters Patent, is—

1. The combination, in a rotary steam-engine, of a rotating cylinder and a double crank attached to the driving-shaft and connected to the said rotating cylinder, substantially as and for the purpose set forth.

2. The combination, in a rotary steam-engine, of a rotating cylinder having flanges extending outwardly and a double crank attached to the driving-shaft and connected to the flanges on said cylinder, substantially as and for the purpose set forth.

3. The combination, in a rotary steam-engine, of a rotating cylinder having flanges extending outwardly with a double crank attached to a driving-shaft and connected to the flanges on said cylinder beyond the periphery of the removable rotating cylinder-head, substantially as and for the purpose set forth.

4. In a rotary steam engine, the combination of a rotating cylinder having a flange to which the double crank is attached with removable caps attached to the flange to facilitate the placing of the pistons, substantially as described.

5. In a rotary steam-engine, the combination of a rotary cylinder and its pistons with a fixed head on which it is journaled at one end, said head being provided with inlet

and exhaust ports, and a second fixed head at the other end provided with an annular opening in which said cylinder revolves, substantially as described.

6. In a rotary steam-engine, the combination of a rotating cylinder and its pistons with a fixed head on which it is journaled at one end, said head being provided with inlet and exhaust ports, a second head at the other end provided with an annular opening in which said cylinder revolves, and an outer casing secured between the two heads and attached to the base-plate, substantially as described.

7. In a rotary steam-engine, a steam-chest with a single port controlled by a valve which makes two cut-offs to each revolution of the cylinder by passing and repassing entirely over said port, substantially as described.

8. In a rotary steam-engine, a steam-chest with a single port controlled by a sliding valve which makes two cut-offs to each revolution of the cylinder by passing and repassing entirely over said port, substantially as described.

9. In a rotary steam-engine, a rotating cylinder, in combination with pistons mounted upon a shaft eccentric to said cylinder and automatic split packing-rings surrounding the hubs of said pistons and being fixed to said hubs by guides fitting in dovetail cavities in said packing rings, substantially as described.

10. In a rotary steam-engine, a rotating cylinder, in combination with pistons mounted upon a shaft eccentric to said cylinder and automatic split packing-rings surrounding the hubs of said pistons and being fixed to said hubs by guides fitting in dovetail cavities in said packing-rings, said packing ring or rings serving as an abutment between the inlet and exhaust ports, substantially as described.

11. In a rotary steam-engine, a rotating cylinder, in combination with pistons mounted upon a shaft eccentric to said cylinder and automatic split packing-rings surrounding the hubs of said pistons and consisting of a split packing-ring and two outer and two inner expansion-rings, substantially as described.

12. In a rotary steam-engine, a rotating cylinder, in combination with pistons mounted upon a shaft eccentric to said cylinder and a packing surrounding the hubs of said pistons, consisting of a split packing-ring and two outer expansion-rings having annular cavities for the reception of inner expansion-rings, whereby the split packing-ring is packed steam-tight against the inner periphery of the rotating cylinder, substantially as described.

13. In a rotary steam-engine, a rotating cylinder, in combination with pistons mounted upon a shaft eccentric to said cylinder and a packing surrounding the hubs of said pistons, consisting of a split packing-ring and two outer expansion-rings having annular cavities for the reception of inner expansion rings, said packing-ring having wedges on its inner periphery bearing against the outer beveled periphery of the two outer expansion-rings, whereby said packing-ring is expanded by the movement of the expansion-rings along and against the said wedges of the packing-ring, substantially as described.

14. In a rotary steam-engine, the combination of a rotating cylinder with the hubs of the eccentric-pistons, said hubs being provided with dovetail guides and inner and outer expansion-rings, said rings provided with cavities into which said guides fit, whereby said inner expansion-rings are held in contact with and around the said hubs, but permitting lateral movement, substantially as described.

15. In a rotary steam-engine, a rotating cylinder, in combination with pistons mounted upon a shaft eccentric to said cylinder and packing-rings surrounding the hubs of said pistons and consisting of a split packing-ring and two outer expansion-rings having annular cavities into which fit the inner expansion-rings, said outer expansion-rings being held to said inner expansion-rings by bolts firmly fixed thereto and whose heads are countersunk in the outer ring sufficiently deep to prevent protrusion when the rings are compressed together, and springs in said cavities to hold said rings apart, whereby the outer ring can decrease but not increase its distance from the inner ring, so as to hold the packing-ring against the inner periphery of the rotating cylinder and to allow it to adjust itself to any inequalities in said periphery, whether due to wear or disalignment of the engine in any of its parts, substantially as described.

16. In a rotary steam-engine, a rotating cylinder, in combination with pistons mounted upon a shaft eccentric to said cylinder and packing-rings surrounding the hubs of said pistons and consisting of a split packing-ring and two outer expansion-rings having annular cavities into which fit inner expansion-rings, said outer expansion-rings having flanges or lugs at each end turned inwardly and abutting against the ends of the inner expansion-rings, substantially as described.

17. In a rotary steam-engine, a rotating cylinder, in combination with pistons mounted upon a shaft eccentric to said cylinder and packing-rings surrounding the hubs of said pistons and consisting of a split packing-ring and two outer expansion-rings having annular cavities into which fit inner expansion-rings, said packing-rings having flanges or lugs turned inwardly at each end and abutting against the ends of said outer expansion-rings, substantially as described.

18. In a rotary steam-engine, a rotating cylinder, in combination with pistons mounted upon a shaft eccentric to said cylinder and packing-rings surrounding the hubs of said pistons, consisting of a split packing-ring with flanges on the ends turned inwardly and wedges on the inner periphery thereof and two outer expansion-rings on their outer periphery beveled to correspond to the wedges

of the packing-ring, with flanges or lugs turned inwardly and abutting against the ends of the inner expansion-ring, which is held in the annular cavity in the outer expansion-ring, the said flanges of the packing-ring and the outer expansion-ring correspondingly beveled to each other, so that the sum of the bevels of the flanges on the outer expansion-rings and the packing-ring shall be to the bevel on the periphery of the outer expansion-rings, which correspond to the wedges of the packing-ring, as the circumference of a circle is to its diameter, thereby allowing for the expansion of the packing-ring to be adjusted on said flanges, substantially as described.

19. In a rotary steam-engine, a rotating cylinder, in combination with pistons mounted upon a shaft eccentric to said cylinder and packing-rings surrounding the hubs of said pistons and consisting of a split packing-ring and two outer expansion-rings having cavities into which fit the inner expansion-rings, said packing-rings having in their sides cavities to receive the cut rings for the purpose of packing the split packing-rings against each other and against the heads of the rotating cylinder, substantially as described.

20. In a rotary steam-engine, a rotating cylinder, in combination with two pistons mounted upon a shaft eccentric to said cylinder, one piston having two hubs and the other piston one hub which fits in and against the two outer hubs, thereby avoiding any tendency of the piston to twist, each hub being provided with one set of automatic packing secured by guides projecting therefrom, substantially as described.

21. In a rotary steam-engine, a rotating cylinder, in combination with pistons mounted upon a shaft eccentric to said cylinder, said pistons consisting of a flanged ring and a hub or hubs to which it is firmly secured by a key and by bolts passing through said flanges and fastened in said hub or hubs, said flanges having packing-strips in their face next to the ends of the split packing-rings, substantially as described.

22. In a rotary steam-engine, a rotating cylinder and pistons mounted upon a shaft eccentric to said cylinder and passing through the circumference of the cylinder, in combination with guides through which the pistons pass, having at one end a reduced portion and journaled in said rotating cylinder, so as to facilitate placing said guides in position, substantially as described.

23. In a rotary steam-engine, a rotating cylinder and pistons mounted upon a shaft eccentric to said cylinder and having the inlet and exhaust steam ports so located as to exhaust the steam when the area of back-pressure on the following piston is nearly or just equal to the area of steam-pressure on the leading piston, thereby balancing or nearly balancing the following piston through that portion of the stroke in which the travel and consequent friction through the guides of the following piston is greatest, thereby reducing the friction, substantially as set forth.

24. In a rotary steam-engine, a rotating cylinder and pistons mounted upon a shaft eccentric to the cylinder and having a packing around the hub of said pistons, which acts as an abutment between the inlet and exhaust steam ports, which ports are so located as to exhaust the steam when the area of back-pressure on the following piston is nearly or just equal to the area of steam-pressure on the leading piston, thereby balancing or nearly balancing the following piston through that portion of the stroke in which the travel and consequent friction through the guides of the following piston is greatest, thereby reducing the friction, substantially as set forth.

25. In a rotary steam-engine, a rotating cylinder and a fixed outer casing, in combination with pistons mounted eccentric to said cylinder, said pistons provided with packing within said rotating cylinder and so constructed as to be out of contact with said outer casing, thereby preventing the use of steam under pressure in said outer casing, substantially as described.

26. In a rotary steam-engine, a rotating cylinder having one head fixed and the other revolving with it and an outer casing with both heads fixed in combination with pistons mounted eccentric to and passing through cylindrical guides journaled in the sides of said rotating cylinder and being packed against the inner periphery, the heads, and in the cylindrical guides of said rotating cylinder, said pistons provided with packing within said rotating cylinder and so constructed as to be out of contact with said outer casing, thereby preventing the use of steam under pressure in said outer casing, substantially as described.

SAMUEL GLENVILLE BROSIUS.

Witnesses:

J. HENRY KAISER,

BENJ. MUNROE.