June 26, 1928. 1,675,129

W. F. PAUL

ENGINE

Filed Jan. 16, 1922 6 Sheets-Sheet 1

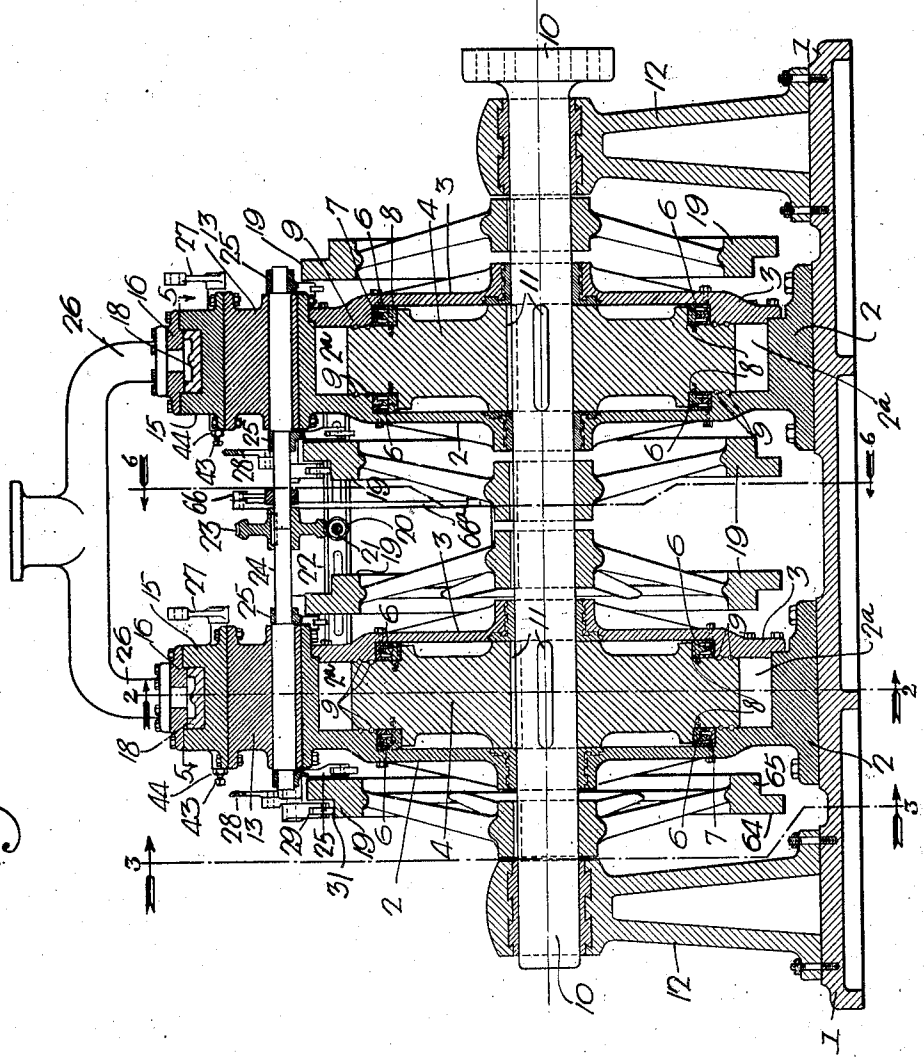


Fig. 1.

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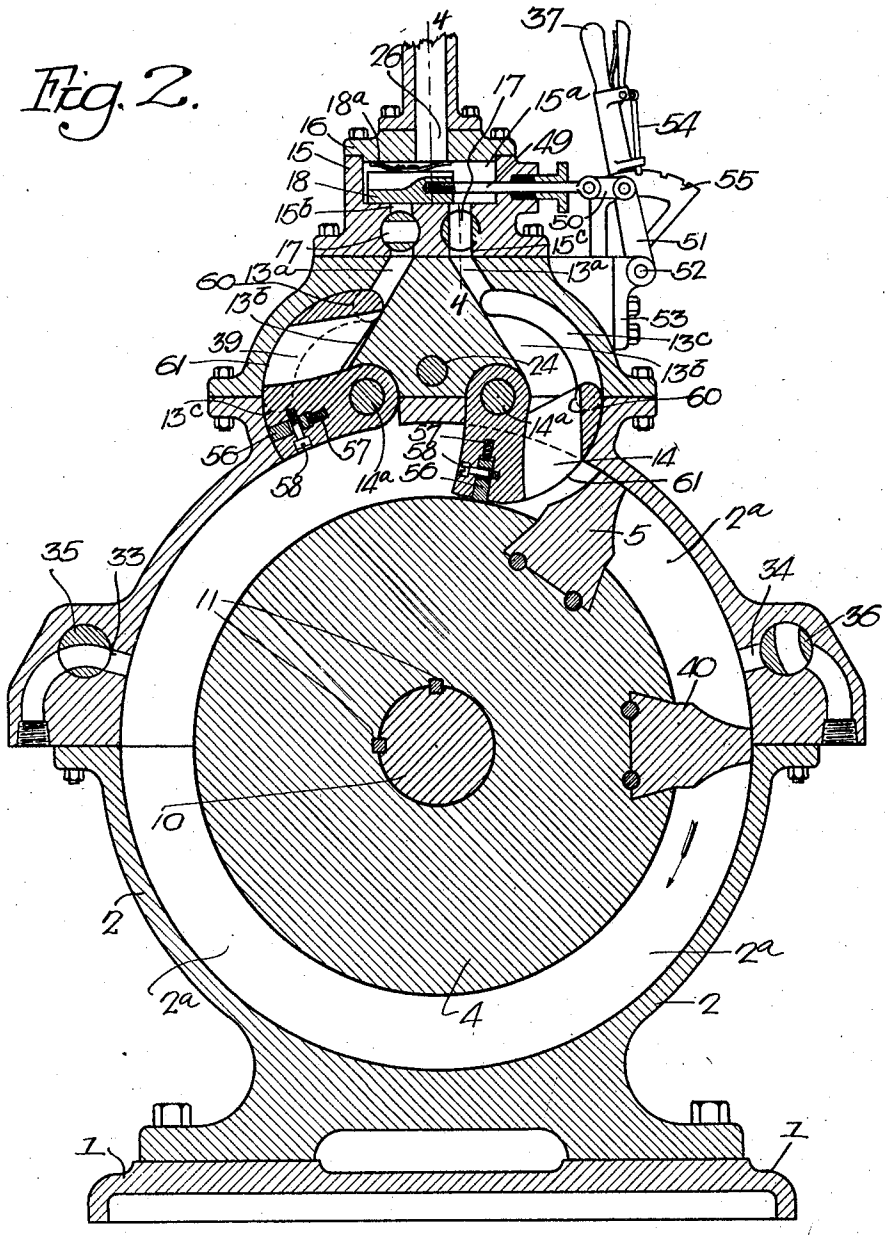
June 26, 1928. 1,675,129

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Filed Jan. 16, 1922 6 Sheets-Sheet 2

Fig. 2.



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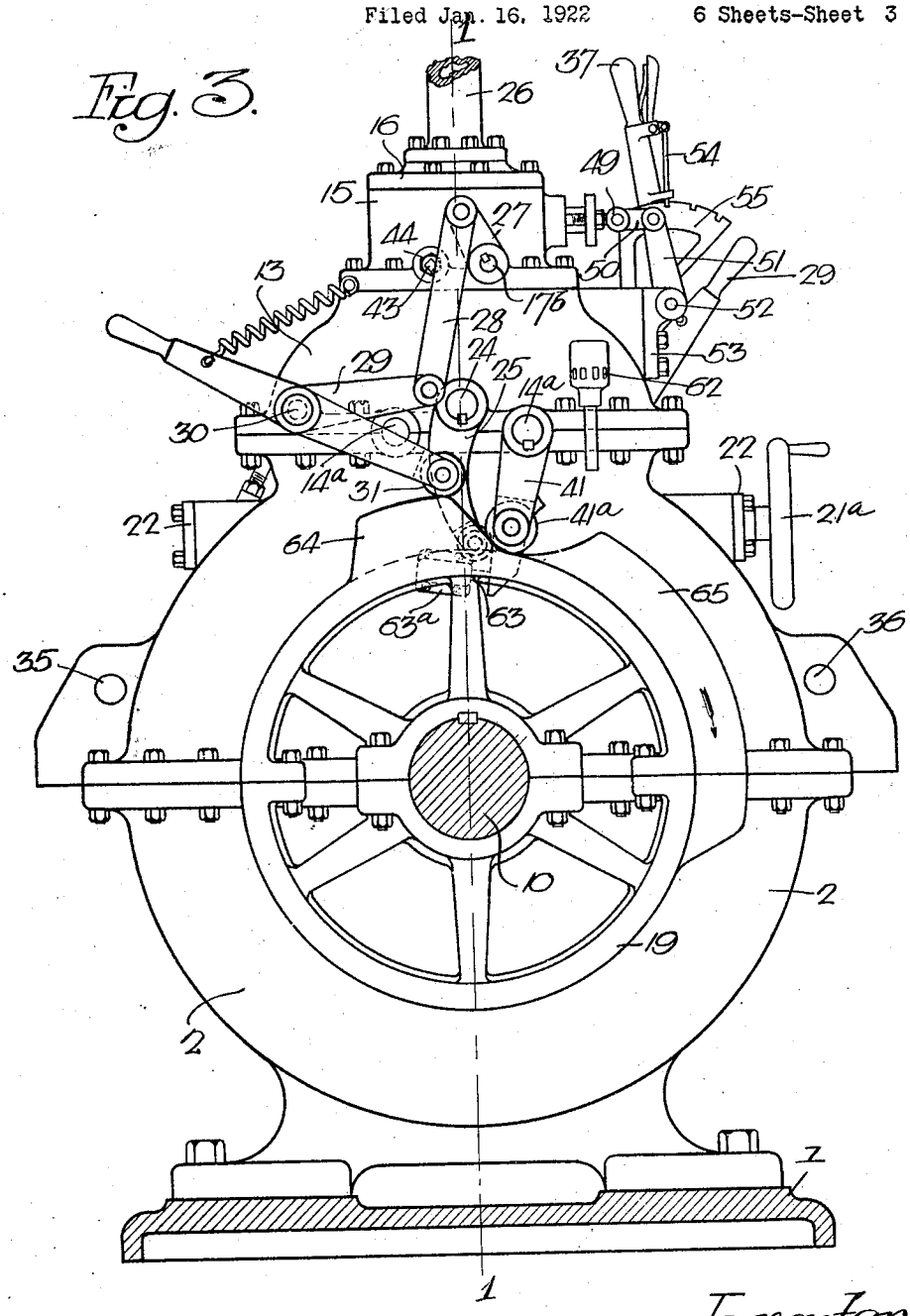
June 26, 1928. 1,675,129

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Filed Jan. 16, 1922 6 Sheets-Sheet 3

Fig. 3.



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June 26, 1928. 1,675,129

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Filed Jan. 16, 1922 6 Sheets-Sheet 4

Fig. 4.

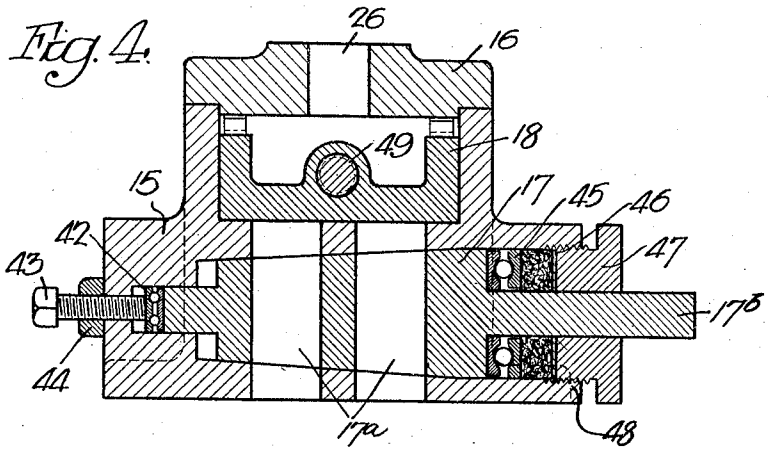
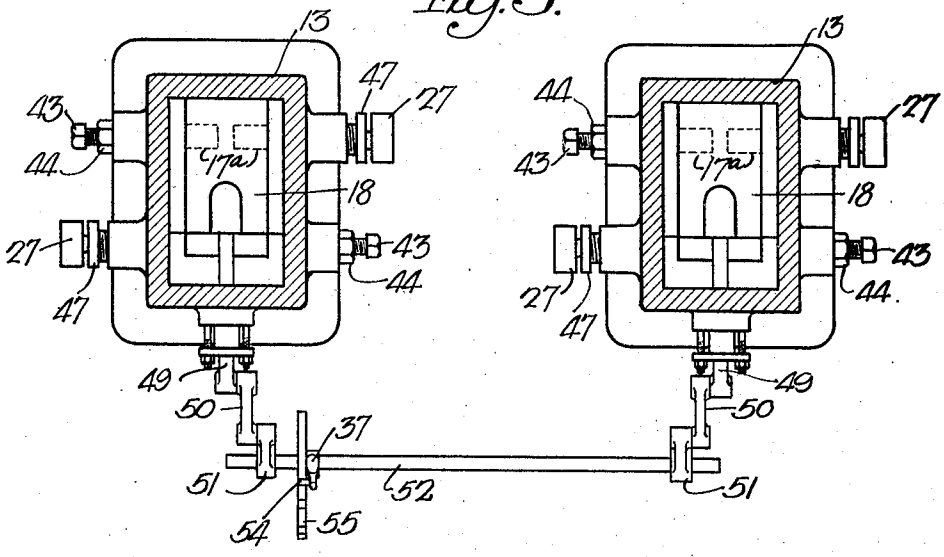


Fig. 5.



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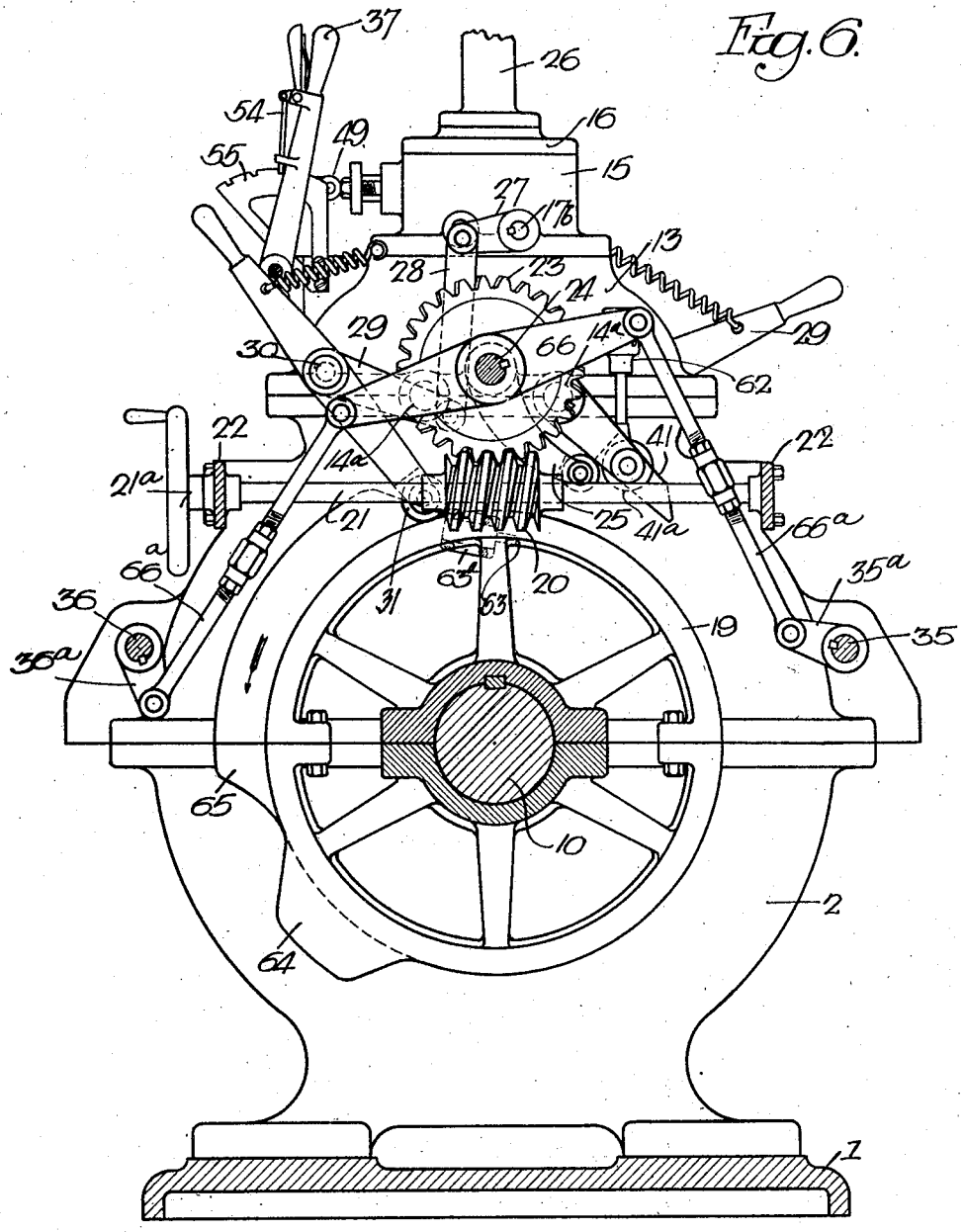
June 26, 1928. 1,675,129

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Filed Jan. 16, 1922 6 Sheets-Sheet 5

Fig. 6.



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June 26, 1928. 1,675,129

W. F. PAUL

ENGINE

Filed Jan. 16, 1922 6 Sheets-Sheet 6

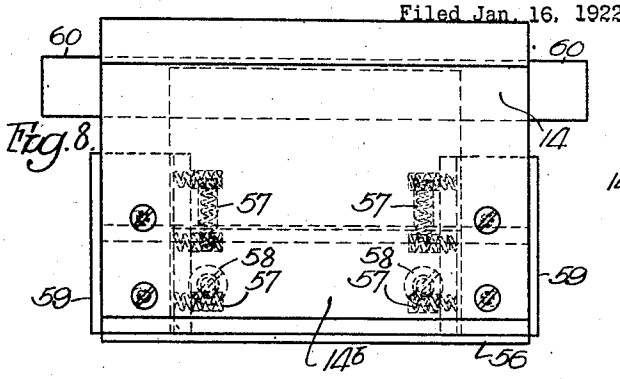


Fig. 8.

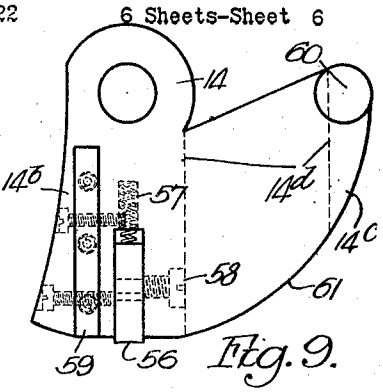


Fig. 9.

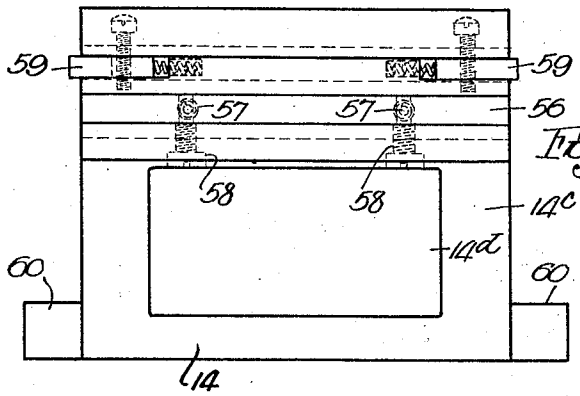


Fig. 7.

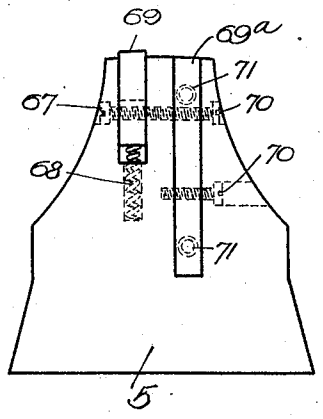


Fig. 10.

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Patented June 26, 1928. 1,675,129

UNITED STATES PATENT OFFICE.

WILLIAM F. PAUL, OF PHILADELPHIA, PENNSYLVANIA.

ENGINE.

Application filed January 16, 1922. Serial No. 529,416.

My invention relates to improvements in engines of the rotary, expansion type, and has for its object the provision of an engine having certain novel and improved features of construction hereinafter fully set forth and illustrated in the attached drawings, in which:

Figure 1, is a longitudinal sectional view on the line 1—1, Fig. 3 of a bi-unit engine made in accordance with my invention;

Fig. 2, is a transverse section through one of the units on the line 2—2, Fig. 1;

Fig. 3, is a transverse section on the line 3—3, Fig. 1, showing in side elevation one of the power units and illustrating the valve gear mechanism;

Fig. 4, is a sectional view on the line 4—4, Fig. 2, of a head chest of the machine illustrating the details of the reversing throttle and steam cut-off valves;

Fig. 5, is a horizontal section on the line 5—5, Fig. 1, illustrating the details of the reversing mechanism;

Fig. 6, is a transverse section on the line 6—6, Fig. 1, showing in elevation the opposite side of the power unit illustrated in Fig. 3;

Figs. 7, 8 and 9, are, respectively, rear, front and end views of one of the steam heads illustrating details of construction thereof, and

Fig. 10, is an end view of one of the rotor pistons illustrating the method of application of the wearing plate.

With reference to the drawings, my machine comprises a bed-plate 1, upon which the engine is mounted, said engine comprising further a casing 2 constituting a housing for a rotor 4. As clearly illustrated, the rotor 4 is of such dimension and is so mounted in the casing as to provide an annular space or chamber 2^a around the periphery of the rotor for the application of steam, said rotor being provided with pistons 5 and 40 projecting from the periphery, which pistons travel and operate in the said annular chamber.

As best shown in Fig. 1, the casing 2, the head 3, and the rotor are so formed as to provide for the insertion of ring, steam packing 6, one at each side of the rotor, said packings being fastened in rings 7 attached respectively to the casing and the casing head and sliding in rings 8 attached to the rotor. Concentric grooves 9, 9, are also provided in the opposite faces of the rotor to form a condensate seal between the rotor and the casing.

As best shown in Fig. 1, the rotors 4 are mounted upon a shaft 10, to which they are secured by keys 11, the shaft 10 being supported by pedestal bearings 12, 12, and in the casing 2 and the removable head 3 of each power unit.

At the top of the casing 2 is a head chest 13 which is formed in the interior with a pair of passages 13^a which extend inwardly from the upper end of said head and which communicate with recesses or chambers 13^b in the lower portion of the chest and which are respectively adapted to receive portions of a pair of pivotally mounted and swinging abutments 14, 14, the construction of which is clearly illustrated in Figs. 7, 8 and 9. The abutments 14 are carried by shafts 14^a, 14^a, which are mounted in the top of the casing 2, and between the said casing and the chest 13, said abutments being provided with a solid main portion 14^b and a rearward extension 14^c, which extensions are adapted to occuppy the respective chambers 13^b of the head chest and which are provided at each side with a stop pin or lug 60 adapted to move in arcuate slots 13^c formed in the sides of the respective chambers 13^b, said slots and stops 60 limiting the travel in both directions of the abutments 14, as well as taking the total working load.

As best shown in Fig. 2, provision is made in the upper part of the casing 2 for the reception of the main portions 14^b of the abutments 14, and as shown the sides of the portion 14^b are formed on the arc of a circle corresponding in diameter to the outside diameter of the annular steam space 2^a within the casing, so that when the abutment is swung up into inoperative position, the lower face thereof conforms accurately with that surface of the casing forming the outer wall of the said chamber 2^a.

It will further be noted by reference to Fig. 2, that the abutments 14 are adapted to swing downwardly into a position in which the main portion 14^b extends across and effectually blocks the chamber 2^a, and the abutments are provided with an aperture 14^d which extends through the rearward extension 14^c in such manner as to provide a clear passage from the chambers 13^b into the chamber 2^a of the casing.

As clearly illustrated in Figs. 7, 8 and 9, the abutments 14 are provided with packing

or seal plates 56 and 59 respectively in the outer face and the side faces of the portion 14^b, the plate 56 providing for a seal between the periphery of the rotor and the adjacent face of the abutment, and the plates 59, 59, forming a seal between the sides of the abutment and the sides of the casing.

Mounted at the top of the head chest 13 is a valve chest 15 having a cover 16, said cover having therein an aperture 26 through which steam is admitted to the interior of the valve chest, as will be described hereinafter.

In the top of the valve chest 15 is a chamber 15^a from the base of which extend passages 15^b and 15^c communicating respectively with the channels 13^a, 13^a, of the head chest 13. Within the chamber 15^a is slidably mounted a reversing valve 18, which is adapted in different positions to cover either one or both of the passages 15^b and 15^c, said valve being operated in a manner hereinafter described to open one or other and close either one or both of the said passages. A spring 18^a is provided on the top of the valve 18, which spring is adapted to bear against the inner face of the cover 16 to retain the valve firmly to the floor of the chamber 15^a.

Mounted in suitable chambers or recesses in the valve chest 15 below the chamber 15^a are a pair of cut-off valves 17, 17, said valves being adapted to control respectively the opening and closing of the passages 15^b and 15^c.

As best shown in Fig. 4, the valves 17 and the chambers which they occupy are substantially conical in shape, the valves being provided with through passages 17^a which, as the valves are turned, are alternately brought into and out of registration with the passages which the valves control, thereby opening and closing the passages.

As best shown in Fig. 4, the valves 17 have at their smaller ends a projection which abuts a ball thrust bearing 42, which latter can be adjusted by means of a set screw 43, and locked in position by means of a nut 44, the large ends of the valves having grooved ball end thrust bearings 45 backed by steam packing 46 compressible by means of a screw-tight gland 47 and a metal friction washer 48.

Each of the valves 17 has extending through the gland 47 a stem 17^b, the stem of one valve extending at one side and the stem of the other valve at the opposite side of the engine, and each of said stems having keyed thereto a lever arm 27 which is connected by means of a link 28 with a bell crank lever 29 mounted upon a shaft or spindle 30 carried by the head chest 13, the free end of the bellcrank lever 29 having mounted therein a cam roller 31 which rides upon one of the cam faces 64 of a cam wheel 19 mounted upon and fixed to the shaft 10, the cam surface 64 being such that the valves are oscillated to open and cut off the respective passages 15^b and 15^c at the proper points in the revolution of the rotor.

The cam wheels 19, 19, are also employed to operate the swinging abutments 14. The shafts 14^a upon which these abutments are mounted extend through the casing 2, and each has fixed thereto and at opposite sides of the casing an arm or lever 41 which carries a cam roller 41^a adapted respectively to engage the cam surfaces 65 of their respective cam wheels 19, these cam surfaces as the wheels revolve alternately elevating the abutment to permit the passage thereby of the pistons 5 and 40 of the rotor, and thereafter allowing the abutment to move downwardly to the operative position closing the chamber 2^a. The lower ends of the levers 41 are adapted when the abutments are moved downwardly into operative position to engage a spring-engaged plunger 63, which is mounted in a suitable casing 63^a on the sides of the casing, this plunger taking up the shock of the impact as the abutment reaches the end of its downward travel.

Mounted in the head chest 13 and extending therethrough is a shaft 24, which shaft has fixed thereto, one at each side of the casing 2, an arm 25, which are adapted to engage respectively the levers 41, 41. As will be clearly seen from reference to Figs. 3 to 6, these arms 24 are adapted, when the shaft is rotated, to elevate one or other of the said arms 41, depending on the direction of rotation of the said shaft, this having the effect of elevating into an inoperative position one or other of the abutments 14. The shaft 24 has thereon a worm wheel 23, and a lateral shaft 21 is provided mounted in the present instance on cross beams 22, 22, extending between the casings 2 of two power units, which shaft carries a worm 20 meshing with the worm wheel 23 and having at one end a hand wheel 21^a for manually rotating the shaft. By means of this arrangement, one or other of the said abutments 14 can be rendered inoperative, depending on the direction of rotation desired for the rotor.

It will be noted that each of the chambers 13^b in the head chest 13 is provided with a relief valve 62, which relief valve is ordinarily closed, but which, when the respective heads are raised into an inoperative position, are adapted to be engaged and opened by the respective associated levers 41.

The casing 2 is provided at each side with an exhaust port 33 and 34 respectively, said ports being controlled by rotary valves 35 and 36 respectively, suitably mounted in the casing 2, said valves each having a stem extending through the casing, which stems have secured thereto at the outside of the casing a lever arm 35^a and 36^a respectively. An arm 66 is fixed to the shaft 24 and has

attached at each end thereof a connecting rod 66ª, which respectively are attached to the arms 35ª and 36ª of the exhaust valves 35 and 36. The arrangement is such that as the shaft 24 is oscillated to bring one of the abutments 14 into action and render the other inoperative, the valves of the exhaust ports are simultaneously operated to close one exhaust and to open the other.

The valve 18 has attached thereto a rod 49 which extends through the side of the valve chest 15 and which is connected by means of a link 50 to an arm 51 upon a spindle 52, which spindle is mounted in suitable bearings in a bracket 53 secured to the side of the head chest 13. The spindle 52 has fixed thereto an operating lever 37, which lever has a spring-actuated pawl adapted to engage a toothed segment 55 to retain the lever in any one of three desired positions. By means of the lever 37, the spindle 52 may be oscillated to shift the valve 18 to any desired position, the detent 54 and the slotted segment 55 being adapted to hold the lever 37 in three different positions in which the passages 15ᵇ and 15ᶜ are both closed, or one closed and the other opened, as previously explained.

As best shown in Fig. 10, the rotary pistons 5 and 40 are provided with seal plates 69 and 69ª extending respectively from the outer end of the pistons and from the side faces, said seal plates functioning to seal the joints between the outer end and the sides of the piston and the casing.

The operation of the device is as follows: Steam is admitted to the valve chest through the opening 26 and is directed by means of the valve 18 to one or other of the cut-off valves 17, and thence through the passage 13ª and the chamber 13ᵇ, and through the opening 14ᵈ of the swinging abutment 14 into the annular chamber 2ª. Power is thus applied to the rotor piston 5. When the rotor has advanced through a given part of its revolution, the roller 31 on the bell crank lever 29 passes off the elevation on the cam surface 64, thereby closing the cut-off valve 17 and allowing expansion of the steam to continue the power stroke until the rotor piston reaches the port 33, which remains open to the condenser. Exhaust of the steam through this port and where a condenser is employed condensation of the steam creates vacuum assisting in the power stroke. As previously stated, while the valve 35 remains open, the valve 36 remains closed.

As the piston 40 approaches the abutment 14, the cam surface 65 acting upon the roller 41ª of the lever 41 acts to elevate the abutment into inoperative position and to retain it thus during the time that the pistons 40 and 5 are passing the abutment position, after which the abutment is again permitted to drop to the operative position, steam again admitted to the chamber 2ª and the cycle repeated.

In the present instance, the reversing mechanism is operated through the hand wheel 21ª by means of which the shaft 21 is rotated to oscillate through the worm 20 and the worm wheel 23, the shaft 24, which latter shaft operates the control lever 25 to raise one or other of the heads 14 and to hold it securely in the inoperative position through the levers 41, the latter levers effecting the opening of the relief valve 62. Simultaneously with the raising of one of the abutments, the other abutment by reason of the oscillation of the shaft 24, is brought into operation, after which the lever 37 is shifted to move the valve 18 to a position closing one of the steam passages 15ᵇ or 15ᶜ and opening the other.

Supposing that the direction of rotation of the rotor 4 is shifted from that indicated by the arrow in Fig 2 to the opposite. In this instance, the shaft 24 is rotated to raise the abutment 14 and to lower the abutment 39, this oscillation of the shaft 24 resulting also in the opening of the exhaust 34 and the closing of the exhaust 33. Thereafter the valve 18 is shifted to the opposite position, in which the passage 15ᶜ is closed and the passage 15ᵇ is opened to admit steam to the chamber 2ª, the steam acting against the face of the piston 40.

It will be noted that the faces 61 of the swinging abutments 14 and 39 are shaped to accord with the contour of the faces of the pistons 5 and 40, as best shown in Fig. 2, whereby in case the rotor is moved by external means in a direction the reverse of that for which the controls are set, the shock of the engagement between the pistons and the abutments is brought to bear on the swinging abutment shaft 14ª, thus eliminating possible damage to the abutments themselves.

As illustrated in Fig. 1, the machine in the present instance is shown to comprise two power units, each comprising a casing 2, a rotor 4 and a cam wheel at each side of the casing to operate the various valves and abutments. The units are identical, and it will be understood that where in the description one alone is described, the description applies equally to the other.

As clearly shown in Fig. 1, the shaft 24 extends through both the units and therebetween, this being also true of the shaft 52 which is operatively associated, as heretofore described, with the slide valves 18, this latter shaft and its connections with the valves of the two units being best shown in Fig. 5.

It will be understood that the number of units in any one machine may be varied to suit the conditions, and that the number of

units may range from one to any required number.

It will also be understood that although the units are shown in the present instance reversible, they may be formed without the reversible feature, in which case one of the swinging abutments and its associated valves and exhaust port may be eliminated.

The construction and the distribution of the various essential elements of the machine as herein described will result in a considerable economy in operation and in manufacture, and a substantial simplification over other forms of engines of this type.

I claim:

1. In a rotary engine of the type specified, the combination of a rotor, a casing forming an annular chamber at the periphery of the rotor and having separate recesses therein communicating with the chamber, abutments pivotally mounted in the respective recesses and adapted to oscillate into and out of the said chamber, projections on the rotor constituting pistons adapted to operate in said chamber to actuate the rotor in opposite directions, levers connected with the respective abutments for oscillating them, cams rotatable with the rotor and adapted to engage the respective levers to oscillate the abutments in timed relation with the rotation of the rotor, a rock shaft, and arms carried by the rock shaft and adapted to engage the respective levers to move them and the corresponding abutments respectively out of operative positions when the rock shaft is turned in one direction or the other and manually operable means for turning said rock shaft.

2. In a rotary engine of the type specified, the combination of a rotor, a casing forming an annular chamber at the periphery of the rotor and having separate recesses therein communicating with the chamber, abutments pivotally mounted in the respective recesses and adapted to oscillate into and out of the said chamber, projections on the rotor constituting pistons adapted to operate in said chamber to actuate the rotor in opposite directions, levers connected with the respective abutments for oscillating them and located at opposite sides of the rotor, cams rotatable with the rotor and adapted to engage the respective levers to oscillate the abutments in timed relation with the rotation of the rotor, a rock shaft parallel with the axis of the rotor, and arms carried by the rock shaft at opposite sides of the rotor and adapted to engage the respective levers to move them and the corresponding abutments respectively out of operative positions when the rock shaft is turned in one direction or the other and manually operable means for turning said rock shaft.

3. In a rotary engine of the type specified, the combination of a rotor, a casing forming an annular chamber at the periphery of the rotor and having separate recesses therein communicating with the chamber, abutments pivotally mounted in the respective recesses and adapted to oscillate into and out of the said chamber, projections on the rotor constituting pistons adapted to operate in said chamber to actuate the rotor in opposite directions, levers connected with the respective abutments for oscillating them, cams rotatable with the rotor and adapted to engage the respective levers to oscillate the abutments in timed relation with the rotation of the rotor, a rock shaft, arms carried by the rock shaft and adapted to engage the respective levers to move them and the corresponding abutments respectively out of operative positions when the rock shaft is turned in one direction or the other, a worm wheel carried by the rock shaft, a worm meshing with the worm wheel, and manually operable means for rotating the worm.

4. In a rotary engine of the type specified, the combination of a rotor, a casing forming an annular chamber at the periphery of the rotor and having separate recesses therein communicating with the chamber, abutments pivotally mounted in the respective recesses and adapted to oscillate into and out of the said chamber, projections on the rotor constituting pistons adapted to operate in said chamber to actuate the rotor in opposite directions, levers connected with the respective abutments for oscillating them, cams rotatable with the rotor and adapted to engage the respective levers to oscillate the abutments in timed relation with the rotation of the rotor, means including a rock shaft for moving the levers and the corresponding abutments respectively out of operative positions when the rock shaft is turned in one direction or the other, two separate exhaust valves communicating with the chamber, and means operated by the rock shaft for respectively opening and closing the exhaust valves in accordance with the movements of the abutments by the rock shaft.

5. In a rotary engine of the type specified, the combination of a rotor, a casing forming an annular chamber at the periphery of the rotor and having separate recesses therein communicating with the chamber, abutments pivotally mounted in the respective recesses and adapted to oscillate into and out of the said chamber, projections on the rotor constituting pistons adapted to operate in said chamber to actuate the rotor in opposite directions, levers connected with the respective abutments for oscillating them, cams rotatable with the rotor and adapted to engage the respective levers to oscillate the abutments in timed relation with the rotation of the rotor, a rock shaft, arms carried by the

rock shaft and adapted to engage the respective levers to move them and the corresponding abutments respectively out of operative positions when the rock shaft is turned in one direction or the other, two separate exhaust valves communicating with the chamber, means operated by the rock shaft for respectively opening and closing the exhaust valves in accordance with the movements of the abutments by the rock shaft, a worm wheel carried by the rock shaft, a worm meshing with the worm wheel, and manually operable means for rotating the worm.

6. In a rotary engine of the type specified, the combination of a rotor, a casing forming an annular chamber at the periphery of the rotor and having separate recesses therein communicating with the chamber and having steam passages connected with the recesses, abutments pivotally mounted in the respective recesses and adapted to oscillate into and out of the said chamber, projections on the rotor constituting pistons adapted to operate in said chamber to actuate the rotor in opposite directions, levers connected with the respective abutments for oscillating them, cams rotatable with the rotor and adapted to engage the respective levers to oscillate the abutments in timed relation with the rotation of the rotor, cut-off valves in the respective steam passages, operating levers for the said valves, cams rotatable with the rotor and additional to the aforesaid cams for operating the last said levers, and means for moving the first said levers and the corresponding abutments respectively out of operative positions.

7. In a rotary engine of the type specified, the combination of a rotor, a casing forming an annular chamber at the periphery of the rotor and having separate recesses therein communicating with the chamber and having steam passages connected with the recesses, abutments pivotally mounted in the respective recesses and adapted to oscillate into and out of the said chamber, projections on the rotor constituting pistons adapted to operate in said chamber to actuate the rotor in opposite directions, levers connected with the respective abutments for oscillating them, cams rotatable with the rotor and adapted to engage the respective levers to oscillate the abutments in timed relation with the rotation of the rotor, cut-off valves in the respective steam passages, operating levers for the said valves, cams rotatable with the rotor and additional to the aforesaid cams for operating the said levers, two separate exhaust valves communicating with the chamber, and means operated by the rock shaft for respectively opening and closing the exhaust valves in accordance with the movements of the abutments by the rock shaft.

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