No. 625,950. Patented May 30, 1899.

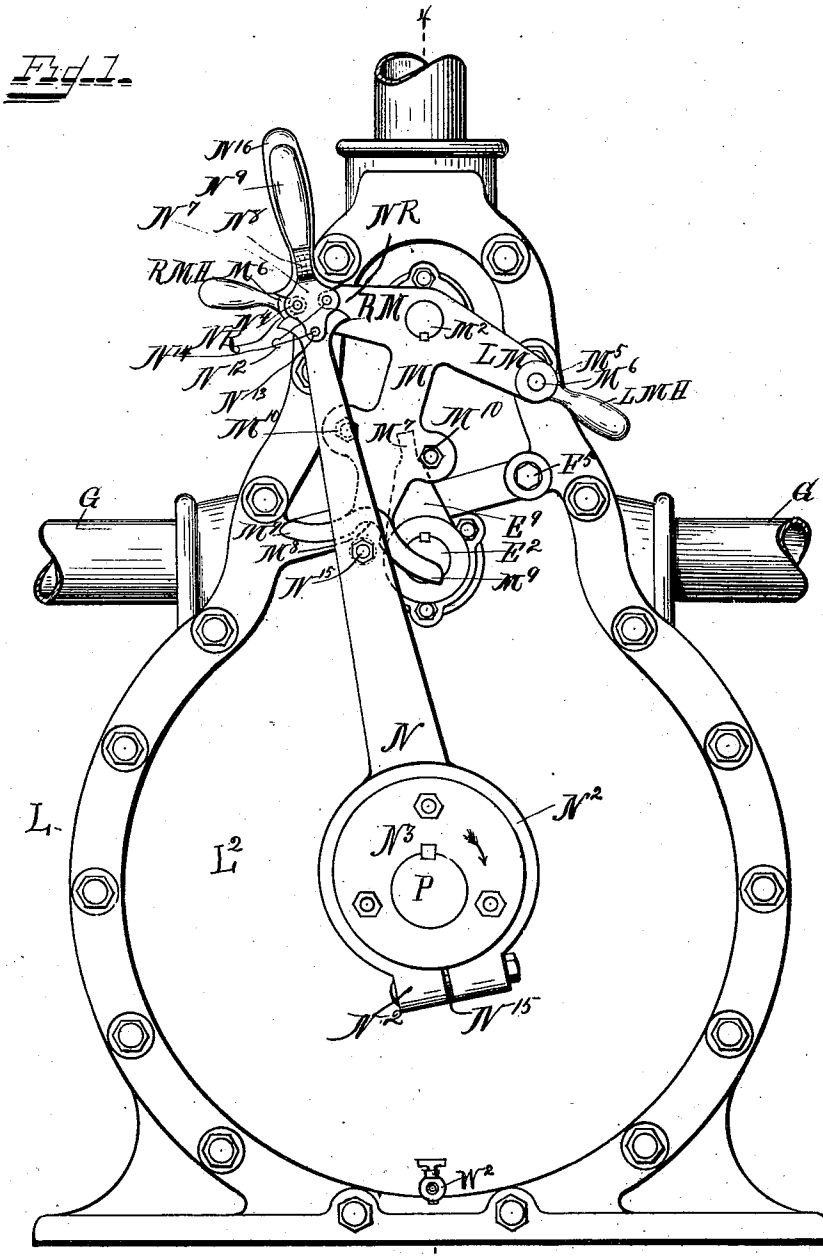
W. HADDOCK.

ROTARY ENGINE.

(Application filed June 1, 1898.)

(No Model.) 5 Sheets—Sheet 1.

Fig. 1.



WITNESS

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No. 625,950. Patented May 30, 1899.

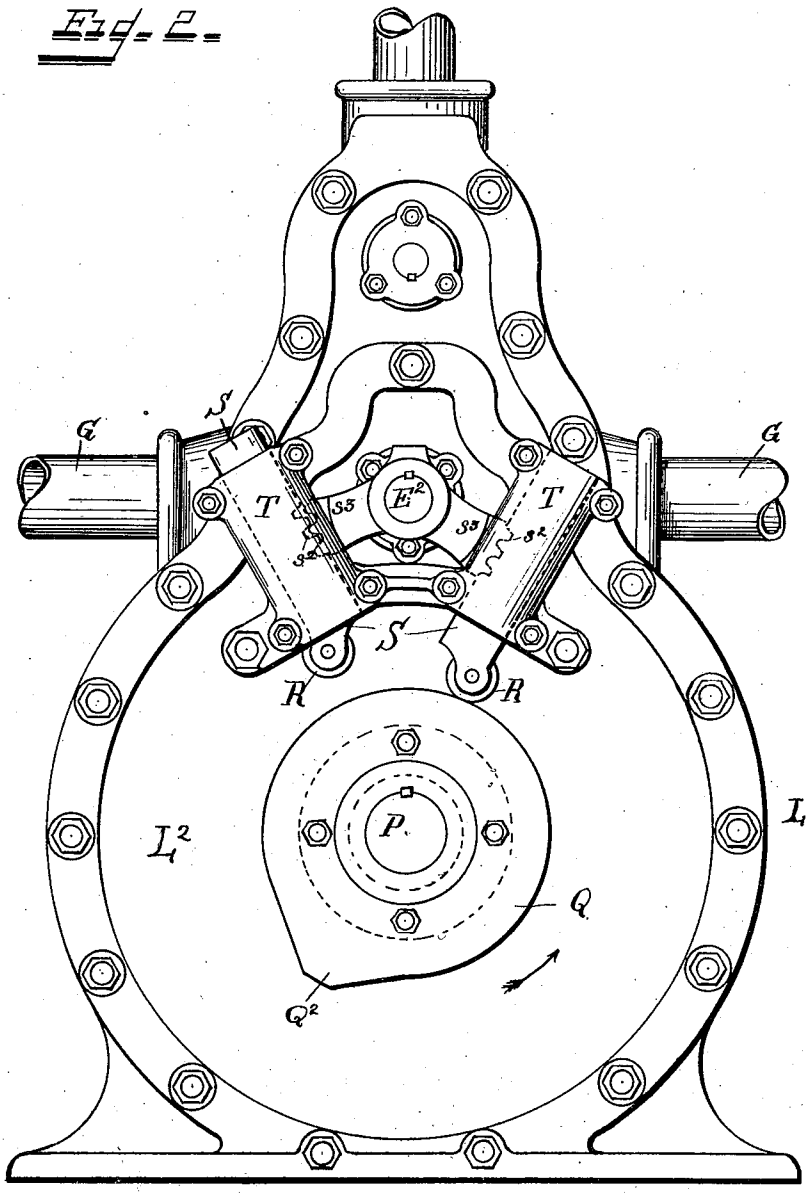
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Fig. 2.



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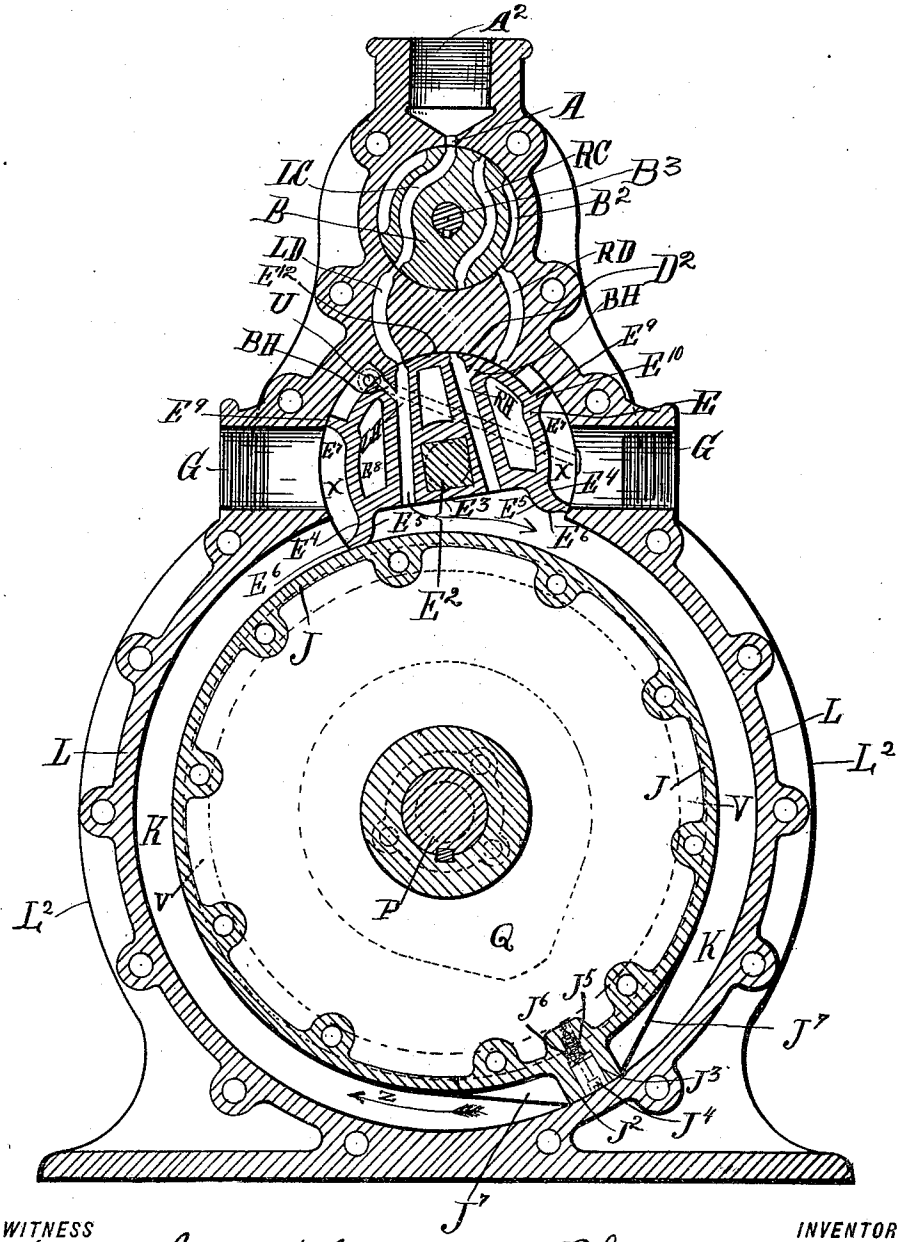
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Fig. 3.



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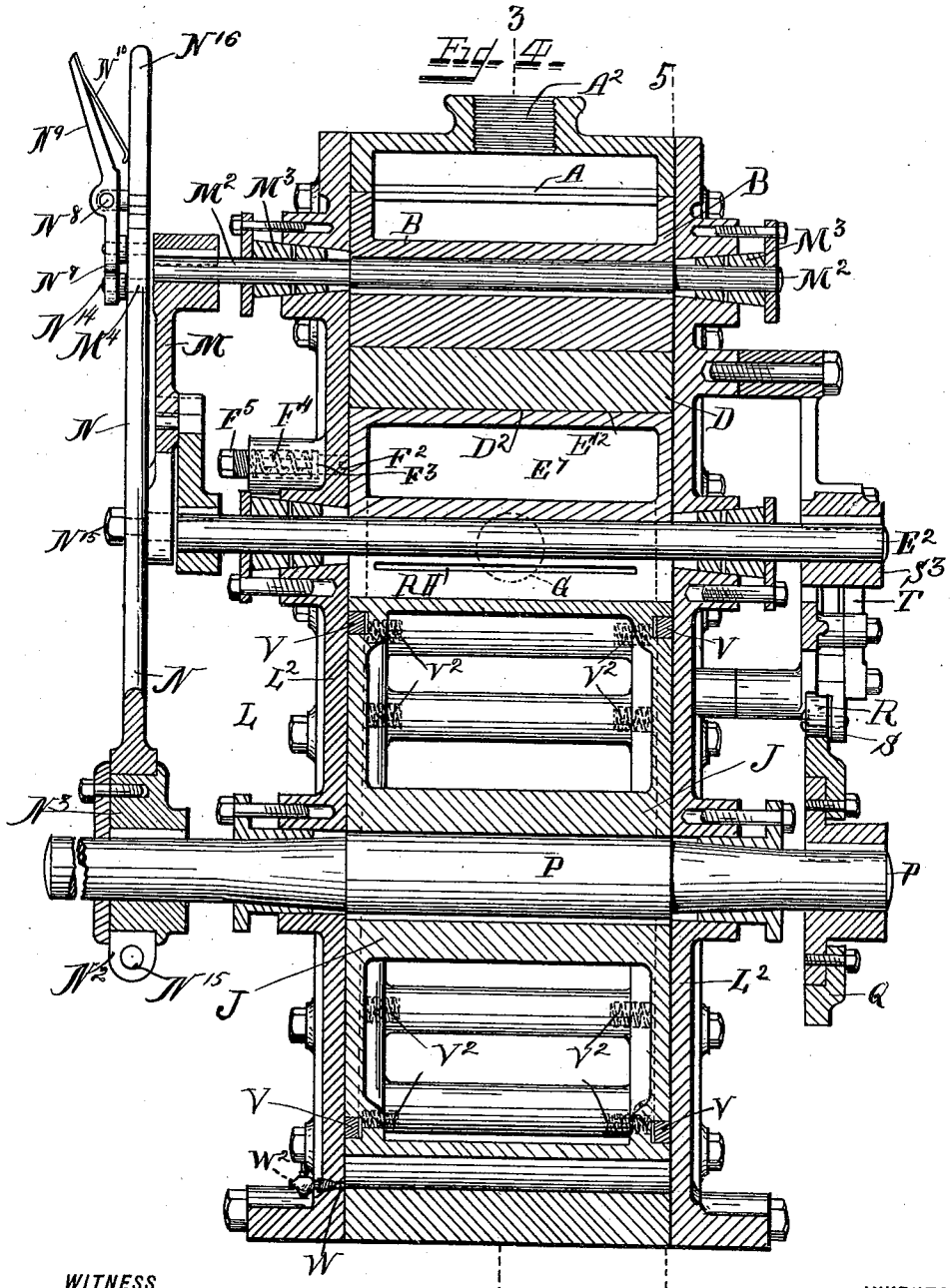
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ROTARY ENGINE.

(Application filed June 1, 1898.)

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W. HADDOCK.

ROTARY ENGINE.

(Application filed June 1, 1898.)

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Fig. 5.

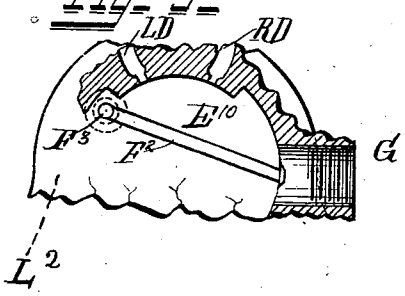


Fig. 6.

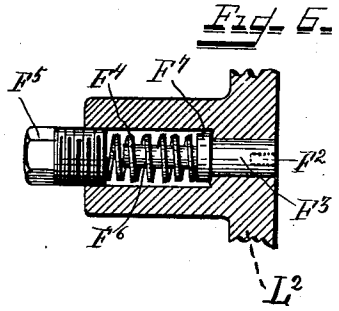


Fig. 10.

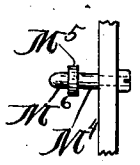


Fig. 7.

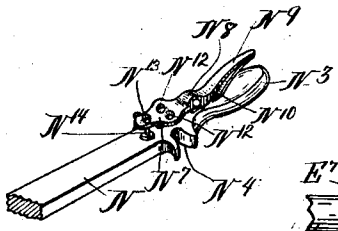


Fig. 9.

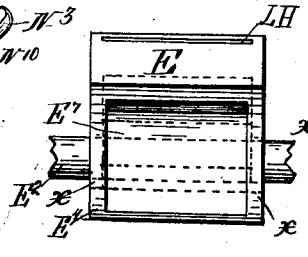
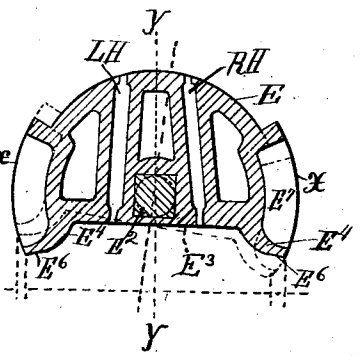


Fig. 8.



WITNESS

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UNITED STATES PATENT OFFICE.

WORCESTER HADDOCK, OF CINCINNATI, OHIO, ASSIGNOR OF THREE-FIFTHS TO HERMAN E. BLAIR, OF SAME PLACE

ROTARY ENGINE.

SPECIFICATION forming part of Letters Patent No. 625,950, dated May 30, 1899.

Application filed June 1, 1898. Serial No. 682,293. (No model.)

To all whom it may concern:

Be it known that I, WORCESTER HADDOCK, a citizen of the United States, and a resident of the city of Cincinnati, in the county of Hamilton and State of Ohio, have invented certain new and useful Improvements in Rotary Engines, of which the following is a specification.

The several features of my invention and the various advantages resulting from their use conjointly or otherwise will be apparent from the following description and claims.

In the accompanying drawings, making a part of this specification, Figure 1, Sheet 1, is an elevation of the front of the engine and showing the cam for operating the valve B and also showing mechanism for reversing the valve and thus reversing the engine. Fig. 2, Sheet 2, represents an elevation of the rear of the engine and the mechanism for operating the valve E. Fig. 3, Sheet 3, is an elevation of a vertical central cross-section taken in the plane of the dotted line 3 3 of Fig. 4, that face of the section being seen which faces toward the front. Fig. 4, Sheet 4, shows a vertical central section taken in the plane of the dotted line 4 4 of Fig. 1, that face of the section being seen which faces toward the right in Fig. 1. Fig. 5 is a view on a scale less than that upon which Figs. 1 to 4 are made. Fig. 5 is a view of a portion of the inner side of that part of the engine which lies to the left of the plane of the dotted line 5 5 of Fig. 4. Fig. 6 is a view of the means for rendering the valve or stopple which elastically closes the exit for steam from the steam-cushion more or less yielding, as desired. This figure is on an enlarged scale. Fig. 7 is a view in perspective of the upper end of the cam-rod and of the latch combined therewith for hooking (locking) together the rocking device and the cam-rod. Fig. 8 is a sectional view of the abutment-valve on a scale somewhat larger than that of Figs. 1 to 4. Fig. 9, Sheet 5, represents a side elevation of the valve E. Fig. 10 is a detailed view of one of the sets of wrist, collar, and stud for enabling the adjacent arm of the rocking device to be securely fastened to the cam-rod.

I will now proceed to specify my invention in detail.

I will first describe the interior parts of my engine. In connection with the inlet steam-pipe for delivering steam to the engine there is (in the cylinder or casing of the engine) the inlet-port A, preferably preceded by a chamber A^2, whose bottom parts converge downward to the port A. Next the port A is the receiving, cut-off, and reversing valve B, rotatable in its closely-fitting chamber B^2 in the cylinder or casing of the engine. This valve B is fixed on its rotatable shaft B^3. This valve is not moved more than a short portion of the arc of a revolution, as will be soon hereinafter apparent. This valve has two ports passing through it—viz., RC and LC. The cylinder or casing below has two stationary ports RD and LD, and the ports of the valve B are arranged substantially as shown, so that when the upper end of the inlet-port LC connects with the inlet-port A the lower end of the port LC will be in connection with the upper end of the port LD, and when the upper end of the inlet-port RC connects with the inlet-port A the lower end of this port RC will be in connection with the upper end of the port RD. Below the ports LD and RD is the abutment receiving valve E, adapted to oscillate with and by its shaft E^2. In the working portion of this abutment-valve E the upper part has a convexly-curved face E^{12}, which bears against the concavely-curved face D^2 of the cylinder or casing. The bottom portion of this valve has a long recess E^3, bounded at each end by a wing E^4 of the valve. Each of these wings is preferably formed, as shown, between flanges X at ends of the valve and consists of a downward portion E^5 and a horizontal portion E^6, the latter turning outward from the vertical line of the valve. The outer ends of each of these wings are curved to accommodate themselves to the adjacent curved surface of the valve-chamber U, wherein this valve works. There are in this valve spaces E^7 E^7, respectively located on opposite sides of the valve E and arranged above their respective adjacent valve-wings E^4, so as to aid in the conveyance of exhaust-steam to the exhaust. Outlets G of the exhaust are duly shown, respectively located on opposite sides of the engine and of the abutment-valve E. This valve is provided with two receiving-ports

RH and LH, running through it from bottom to top. This valve may be solid except at its ports or be lightened by three chambers E^8, cast or otherwise formed therein.

The engine has a cylinder L. Within the latter is a rotary piston J, having a piston-abutment J^2. The piston is concentric with the cylinder except at the abutment J^2. Between the cylinder and the piston is the steam-space K. The piston-abutment is provided with suitable packing. A preferred description of such packing and its mode of combination with the cylinder is as follows: The abutment J^2 has a recess J^3, in which lies a metallic packing J^4, fitted to reciprocate in said recess. This packing J^4 is held up against the inner peripheral face of the cylinder—viz., the outer surface of the steam-space K—by a spring or springs J^5, located in a recess J^6 below the recess J^3, but extending up into the latter recess and pressing against the inner edge of the packing J^4. A suitable adjustable stop or stops prevent the spring from pushing the packing out beyond the point required for its impingement on the surface of the cylinder. The ports RH and LH of the abutment-valve E are arranged substantially as shown, so that when the upper end of the port LH is in connection with the lower end of port RD the foot E^6 of the left-hand wing E^4 rests upon the periphery of the rotary piston J and the left-hand passage E^7 of valve E is in connection with the steam-space K around the piston J and within the cylinder L and in front of the piston-abutment J^2, and, on the other hand, when the upper end of the port RH is in connection with the lower end of the port RD the foot E^6 of the right-hand wing E^4 rests upon the periphery of the rotary piston J and the right-hand passage-space E^7 of the valve E is in connection with the steam-space K and in rear of the piston-abutment J^2. A device for moving or tripping the valve E is present within the cylinder L and attached to the piston. It consists of the inclines J^7 J^7, located, respectively, on each side of the piston-abutment J^2 and beginning at the surface of the piston J and leading up to the outer or free end of the abutment J^2. The number of pairs of these inclines J^7 may be increased or diminished, as needed.

In order to prevent the valve E, after being thrown over and when moving toward its resting-point, from seating hard on the periphery of the piston, and thus wearing the parts faster than they would otherwise be worn, I provide cushioning devices, and the preferred description thereof, also of my invention, is as follows: I provide the valve E on each side with a wing or flange E^9, forming on each side in connection with the valve-box a chamber E^{10}, varying in size as the valve E moves. At the upper end of the chamber E^{10} on the left hand is located an escape-opening for the compressed steam when the pressure of the latter becomes too great. This escape is through an opening F in the inner face of the cylinder-head L^2, communicating with an oblique passage F^2 of the latter, in turn connecting with the exhaust G, substantially as indicated. This passage F^4 is preferably present as a groove in the inner side of the cylinder-heads, that is, valve-cover, which is next to the opening F. The opening F is closed by a valve F^3. When the steam-pressure in chamber E^{10} becomes too great, it presses back the valve F^3 and finds exit through the passage F^2 into the exhaust. The degree of pressure with which the valve F^3 bears upon its valve-seat is duly regulated by means of a screw F^5, screwed into the boss on the cylinder-head and bearing against the inner end of the screw and compressing the latter between it and the valve. A stem F^6 is fixed to the valve F^3. There is a collar F^7 on the valve F^3 and stem F^6, which collar prevents the valve under pressure of spring F^4 from advancing in to the cushion-chamber of valve E. This stem operates as a guide to keep the valve F^3 in place and to retain the spring in place on the valve-collar. A screw F^5 engages a screw-thread in the boss aforementioned, and against this screw the outer end of this spring F^4 rests. Advancing the screw toward and against the spring F^4 increases the pressure of this spring upon the valve F^3 and requires greater pressure of the compressed steam to open the valve F^3 for enabling the steam to exhaust through passage F^2 and on into the exhaust-opening G and for enabling the valve E to come more gently to its seat.

It will be understood that a construction similar to that of the parts F, F^2, F^3, F^4, F^5, and F^6, already described, is present at the other side of the cylinder and is there efficient in providing, in combination with the adjacent chamber E^{10} of valve E, a cushioning device to prevent the valve E from seating itself too hard when its right or left hand wing is being seated on the periphery of the piston.

Steam to act as a cushion in that chamber E^{10}, which must necessarily be the one to ease the descent of the wing next to be seated, is admitted to that chamber through a branch port B^4, leading from the adjacent receiving-port LH or RH, as the case may be, to the adjacent chamber E^{10}. It matters not, therefore, which wing of the valve is being seated there is a cushioning device present which prevents that wing from seating hard.

The description has now advanced sufficiently far to describe in a connected manner the mode in which these interior parts operate and coact. Such operation is as follows: The valve B is first turned so as to cause the engine to rotate in the desired direction. Thus when the piston is to rotate in the direction of the arrow Z the valve E takes the position shown in Fig. 3. The valve B having the position shown in this figure, steam coming in through the inlet-port A passes through port LC, thence through port LD,

and then through port LH, and entering steam-space K of cylinder L courses to the right and then down around the piston, and the abutment J^2 pushes it forward in the direction indicated by the arrow Z. It will be understood that the steam acts between the left-hand wing E^5 as an abutment, temporarily stationary, on the one hand, and the abutment J^2 on the piston.

When the piston is approaching the valve E, the adjacent incline flanges J^7, preceding the piston-abutment, gradually lift the left-hand wing E^4 of the valve E, so that the right-hand wing E^4 of the valve seats upon the periphery of the piston. Steam is now cut off from the valve E and steam-space K, and the right-hand space E^7 is connected with steam-space K, (behind or to the left of the piston,) and the steam in the latter is exhausted therefrom into the adjacent exhaust G. The momentum of the piston carries its abutment J^2 under the uplifted left-hand wing of the valve E. The incline J^7 in front of the still rotating piston now lifts the right-hand wing of the valve and returns the left hand to its first position. By this time the piston-abutment is passing under the right-hand wing of the valve and steam enters the steam-space K between the abutment of valve E and right-hand piston-abutment and again presses it forward in the direction it is still moving. The space K (in front of the piston-abutment) is in communication through the left-exhaust space E^7 with the left exhaust G. Thus by a repetition of these movements the piston is kept rotating as long as supplied with steam. No matter how quickly the valve E is moved the air-cushions in chambers E^{10} E^{10} aforedescribed prevent its wings from seating hard the periphery of the piston.

It will be observed that when valve E is on a horizontal center each wing thereof is at an equal distance from the periphery or face of the piston and there is an exhaust-opening on each side of the valve E, which leads alternately from space K through exhaust-passages E^7 to exhaust G, thus relieving the space K of all undue pressure. While the valve E is horizontal there is no pressure in steam-space K on either side of the piston-abutment.

To cause the piston to move in a direction the opposite to that already mentioned, I reverse the position of the valve, so that it takes steam through the port RC, thereby passing steam through port RD and through the port RH of the valve E. The piston will then obviously be driven in a direction the opposite to that in which it heretofore ran. The operations will be conducted upon the same principle as heretofore specified, except that the position of those parts which are reversible will be reversed.

The aforedescribed mechanism will move with great facility and ease. The perfect balance of the parts is such that the engine will not only run with the mechanism aforedescribed, but can be reversed and operated by means of the valve B only.

In order to easily reverse the valve B and make steam-port connections and enable it to operate, I provide mechanism, also of my invention, and apply the same to the exterior of the engine, preferably as shown in Sheet 1, namely: M indicates a rocking device or lever fixed to a shaft M^2. The latter passes through and is fixed to valve B and at M^8 is journaled, preferably, in the extensions on the cylinder-heads, as shown in Fig. 4. To this shaft is fixed the lever and valve B, by which the valve is moved.

The device M has arms RM and LM, each provided with a handle RMH and LMH. The rocking device may be operated by these handles. Each arm has a wrist M^4, (shown by solid lines in Fig. 10,) which terminates in an annular flange M^5, and beyond the latter is a second projection or stud M^6.

A cam-rod N, with adjustable yoke N^2, surrounding an eccentric N^3, is fixed on the shaft P—viz., the shaft of the rotary piston—concentric with the latter and turned thereby. Rotation of the piston through the medium of the eccentric N^3 thus imparts to the cam-rod a reciprocatory movement in the direction of the length of the latter. The cam-rod is provided at its upper end with a handle N^{16} for moving it laterally from one end of the rocking device M to the other end. It is further provided on each side with a recess N^4 (shown by dotted lines in Fig. 1 and solid lines in Fig. 7) to receive one of the wrists M^4 of the rocking device M. The cam-rod is provided with a suitable device for locking it to either wrist of the lever or rocking device. A desirable device of this kind is shown and is as follows: A latch-piece N^7 is pivoted at N^8 to the cam-rod N and has a handle N^9. The lower part of the latch-piece N^7 is pressed toward the cam-rod handle for purposes now to be mentioned by a spring, as N^{10}. The lower portion of the latch has two openings N^{12} N^{12}, each of a size capable of receiving one of the studs M^6 of the wrists. The lower portion of the latch has also another opening N^{13}, adapted to receive a stud N^{14}, fixed in the cam-rod. The object of this last-mentioned construction is to enable the stud N^{14} to steady the latch and obviate a twisting strain upon the latter and to take part of the strain off of the pivot or hinge N^8.

As heretofore mentioned, the rocking device can be worked by means of either or both of its handles; but it can also be operated to reverse the valve B by means of the cam-rod N. For example, there is a downward extension M^7 of the rocking device provided at its lower end with the slot M^8, there being the sweeps M^9 M^9 on each side of the slot M^8. These sweeps are in curves described from the proper centers, so as to allow the roller on pin N^{15} to travel on the sweeps, while the cam-rod and the rocking device are hooked

together and in motion. This slot M^8 is for the reception of the pin N^{15} of the cam-rod N.

By unlocking the cam-rod N from the wrist to which it may be locked and moving the cam-rod back and forth, as desired, the valve B is reversed.

To enable the valve E to be reversed also when the valve B is reversed, I provide the device M with the studs M^{10}, and I affix to the shaft E^2 of the valve E a rock-arm E^9, whose upper free end lies between these studs M^{10}. Oscillation of the rocking device M or of the rock-shaft N in reversing valve B also reverses valve E. The cam-rod N also performs an additional function—viz., it operates as moved by the eccentric N^8 to make the valve B cut off steam at a given and desired period in the revolution of the piston. As at present arranged the eccentric, as shown, operates to cause the valve B to receive steam and transmit it by valve E to the steam-space K and later to cut off steam when the piston has made about two-thirds of its revolution from where it received steam. Cams of different shapes or throw can be respectively substituted for the eccentric N^8 and so as to cause valve B to cut off steam at any desired point of the revolution of the piston. The engine can thus be caused to work with more expansion of steam than that first mentioned.

The exterior mechanism for moving the abutment-valve E is substantially as follows: On the driven or driving shaft P of the piston is fixed a cam Q. Above the cam are two rollers R and R. Each roller is pivoted to a slide-piece S, sliding in its own guide T, fixed to the cylinder-head of the engine. Each of the slides has a toothed rack S^2, engaging toothed arms S^3 after the manner of sections of a pinion, and these arms are fixed on the shaft E^2 of the valve E. The operating point or nose Q^2 of the cam Q preferably coincides in shape and position with the position of the piston nose or abutment J^2 within the cylinder. Thus the nose of the cam and the piston-abutment lie in substantially same plane, this plane being transverse to the planes in which the piston is moving. As the piston revolves in direction of the arrow the cam Q lifts the right-hand roller R of Fig. 2, which latter moves the free or idle side of right-hand arm S^3 upward and turns the shaft E^2, thus lifting that side or wing of the valve E which (in Fig. 3) is on the left-hand and depressing the right-hand wing thereof and also depressing the roller R, which is on the left hand in Fig. 2. The valve remains thus while the piston-abutment is passing under the left wing and center of the valve E, and then the nose Q^2 of the cam raises the left-hand roller R of Fig. 2 and the right-hand wing of the valve E of Fig. 3 and correspondingly depresses the left-hand wing of valve E of Fig. 3 and the right-hand roller of Fig. 2, thus allowing the piston-abutment to pass altogether from under the valve E and seating the left-hand wing on the piston, so as to form steam-abutment back of the piston-abutment.

The action of the valve and of the functions it performs being the same as those already described in the aforespecified operation of the interior flanges or inclines J^7 J^7, adjacent to the piston-abutment, further description thereof here is deemed unnecessary.

The object and function of the outside cam Q are to relieve wear on inclines J^7 and prevent through wear of these inclines J^7 the abutment J^2 from coming at any time in contact with valve E and also preventing any irregular wear on valve E except that which is caused by the piston while in contact with the latter as the piston revolves.

When the valves are reversed, the action of the cam Q is in principle the same, although its movement is reversed, and causes the valve E to act in causing the steam to propel the piston in the opposite direction.

The valve E is so formed that while it is upon its horizontal center it balances without tendency to turn down toward either side; but as soon as it has been seated on one side or the other the pressure of steam contributes to retain it in that position until it is forcibly moved, either by human agency or the valve-reversing mechanism of the engine.

The reasons for the facts just stated are as follows: When the valve is placed horizontally, any pressure of steam in the cylinder is communicated to the entire bottom face of the valve. When the valve is thrown to the left and occupies the position shown in Fig. 3, the steam cannot press against the bottom of the portion or foot E^6 of the left wing of the valve, because it is in contact with the face of the piston; but it can press on the mid portion of the bottom—viz., that portion which lies between the left and right wings—and as the larger part of this middle portion E^8 is now to the right of a vertical plane or center passing through the axial center of the valve, as indicated by the dotted line Y Y, the extra pressure of steam contributes to keep the right-hand wing of the valve uplifted. Furthermore, the uplifted bottom or face E^6 of the right-hand wing is subject to the pressure of steam, while the steam cannot reach the bottom of the left-hand wing now resting on the face or periphery of the piston. Therefore the steam contributes pressure against the bottom of the right-hand wing, also to keep the same uplifted. Thus that amount of area (in inches) of surface of the valve which is on the right-hand side of the vertical axial plane of the valve in excess of that which is on the left-hand side of said vertical plane multiplied by the pressure of the steam per square inch will be the force which the steam in the cylinder exerts to keep the valve in the position named and by the aid of that wing which is seated on the face of the piston cause a steam-abutment to be present in space K. When the position of the valve has

been reversed, the pressure of the steam admitted to the space K will in like manner and with like force operate to keep the left-hand wing of the valve uplifted.

In Fig. 8 I have shown a diagram in connection with valve E which quite clearly illustrates the aforedescribed changes in the comparative amount of surface exposed to steam-pressure on opposite sides of the valve when the latter is raised or lowered on one side or the other of its central position as compared with the amount of surface exposed on each side when the valve is on its center. In this Fig. 8 the position of the valve when lowered on the right and seated on the surface of the piston is duly indicated by dotted lines. So, also, dotted lines are present to indicate the differences in area aforementioned. This illustration of the differences in area when the valve is seated on its right wing obtains in like manner (but on the opposite side of the valve) when the valve is seated on its left wing.

As before remarked in relation to the cutting off of steam from the steam-space K by means of the interior incline J^7 and valve E or by the outer eccentric N^8 and valve B, the steam is cut off after the piston has accomplished two-thirds of its revolution thereof. During one-half of this one-third—viz., one-sixth—of a revolution of the piston the steam has opportunity to act by expansion, and then during the remaining one-sixth of the revolution exhausting the steam is from one or both sides of the valve E, and the momentum of the revolving portions of the piston carries the piston-abutment past the valve E and changes the latter, so that it forms an abutment and admits steam behind the piston-abutment and again impels the piston forward.

The piston by its inclines J^7 and without any of the exterior mechanism for operating the valve E will operate this valve E in the same manner as does the exterior mechanism when present. In such case no expansion of the steam in space K will be employed to operate the piston, it being understood that the ports which convey steam to valve E will in such case remain open. This latter operation can be accomplished as follows: The cam-rod N is disconnected from the lever or rocking device, so that it (the cam-rod) shall not work the lever or rocking device. The valve B is then set to take steam all of the time. The valve E will be operated as before mentioned and without the valve B acting as a cut-off. Thus the cylinder-space K will take steam for five-sixths of the revolution of the piston, at which time the valve E will be moved and cuts off the steam, and exhaustion of the live steam in the steam-space K will take place.

By approximating the seating-surfaces E^6 of the valve E the amount of momentum necessary to carry the piston past the valve E will be correspondingly diminished and the live steam act on the piston-abutment for a longer time, and in case expansion of steam is employed the distance which the piston travels by expansion may be increased by the valve cutting the steam at the regular time.

It will be understood that I expect to apply two or more of such valves, as B and E, with their necessary accompaniments, to an engine, as I find desirable.

It will be understood that a packing is present between the inner sides of the cylinder-heads and the cylinder. A suitable packing V is shown in solid lines in Fig. 4 and in dotted lines in Fig. 3. The packing is pressed against the inner face of the cylinder-heads by spiral springs V^2. (Shown in dotted lines in Fig. 4.) A drain-pipe W, closed by a suitable cock W^2, can be operated so as to discharge from the cylinder the water resulting from condensed steam.

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

1. In a rotary engine, having a rotary piston, and piston-abutment, and a valve E adapted to oscillate, and having ports LH and RH, and wings E^4, E^4, on its lower side, near the outer edges of the valve, a space K being present below the middle of the valve and between the wings, each wing having a portion whose bottom is a seat for closely impinging at the proper occasion on the rotary piston, and the side of the wing being adapted to be received and fit closely against the adjacent wall of the valve-chamber, the said ports LH and RH having their outlets between the abutments E^5, E^5 of the wings E^4, E^4 and ports LD and RD, for respectively inletting steam to the ports LH and RH of the valve, according as the valve is turned, substantially as and for the purposes specified.

2. In a rotary engine, having a rotary piston, and piston-abutment, and a valve E adapted to oscillate, and having ports LH and RH, and wings E^4, E^4, on its lower side, near the outer edges of the valve, a space K being present below the middle of the valve and between the wings, each wing having a portion whose bottom is a seat for closely impinging at the proper occasion, on the face of the rotary piston, and the side of the wing being adapted to be received and fit closely against the adjacent wall of the valve-chamber, and ports LD and RD, for respectively inletting steam to the ports LH and RH of the valve, according as the valve is turned, a space E^7 above face-line of each wing E^4 being connected to the exhaust, and arranged as described, so that when a given wing of the valve is seated on the piston, the space E^7 on that side of the valve connects the steam-space K with the exhaust, and when the valve is balanced, both spaces E^7 connect with the steam-space and with the exhaust, substantially as and for the purposes specified.

3. In a rotary engine, having a rotary piston, and piston-abutment, and a valve E adapted to oscillate, and having ports LH and RH, and wings E^4, E^4, on its lower side, near

the outer edges of the valve, a space K being present below the middle of the valve and between the wings, each wing having a portion whose bottom is a seat for closely impinging at the proper occasion, on the rotary piston, and the edge or seating-face of the wing being adapted to be received and fit closely against the adjacent wall of the valve-chamber, and ports LD and RD, for respectively inletting steam to the ports LH and RH of the valve, according as the valve is turned, and spaces or compartments E^{10}, formed by the parts E^9 of the valve, and the cushioning-chamber of varying size as the valve is moved, and a passage F closed by a spring-valve F^3 and connected through a succeeding passage F^2 with the exhaust, substantially as and for the purposes specified.

4. In a rotary engine, having a rotary piston, and piston-abutment, and a valve E adapted to oscillate, and having ports LH and RH, and wings E^4, E^4, on its lower side, near the outer edges of the valve, a space K being present below the middle of the valve and between the wings, each wing having a portion whose bottom is a seat for closely impinging at the proper occasion, on the rotary piston, and the side of the wing being adapted to be received and fit closely against the adjacent wall of the valve-chamber, and ports LD and RD, for respectively inletting steam to the ports LH and RH of the valve, according as the valve is turned, a space E^7 above each wing E^4 being connected to the exhaust, and arranged as described, so that when a given wing of the valve is seated on the piston, the space E^7 on that side of the valve connects the steam-space K with the exhaust, and when the valve is balanced, both spaces E^7 connect with the steam-space and with the exhaust, and spaces or compartments E^{10} formed by the parts E^9 of the valve and the valve-cushioning chamber, of varying size as the valve is moved, and a passage F, closed by a spring-valve F^3, and connected through a succeeding passage with the exhaust, substantially as and for the purposes specified.

5. In a rotary engine, having a rotary piston, and piston-abutment, and a valve E adapted to oscillate, and having ports LH and RH, and wings E^4, E^4, on its lower side, near the outer edges of the valve, a space K being present below the middle of the valve and between the wings, each wing having a portion whose bottom is a seat for closely impinging at the proper occasion, on the rotary piston, and the side of the wing being adapted to be received and fit closely against the adjacent wall of the valve-chamber, and ports LD and RD, for respectively inletting steam to the ports LH and RH of the valve, according as the valve is turned, a space E^7 above each wing E^4 being connected to the exhaust, and arranged as described, so that when a given wing of the valve is seated on the piston, the space E^7 on that side of the valve connects the steam-space K with the exhaust, and when the valve is balanced, both spaces E^7 connect with the steam-space and with the exhaust, and spaces or compartments E^{10} formed by the parts E^9 of the valve, and the valve-chamber, and of varying size as the valve is moved, and a passage F closed by a spring-valve F^3, and connected to a passage formed in the face of the adjacent cylinder and walled in by the solid end of the valve, and continued across the engine and into the exhaust-orifice at the opposite side of the engine from where the said air-cushion apartment is located, substantially as and for the purposes specified.

6. In a rotary engine, an oscillating abutment-valve E having wings for impingement on the rotary piston, and a space between said wings and below the middle of said valve, and the piston-abutment having the inclines J^7, respectively on the front and rear side for operating the valve, and inlet-ports, and exhaust-ports of the valve located on the outer sides of the wings, substantially as and for the purposes specified.

7. In a rotary engine, an oscillating abutment-valve E having wings for impingement on the rotary piston, and a space between said wings and below the middle of said valve, and the exterior cam rotated with the piston, and the slidable arms adapted to be both operated successively, or alternately, by the cam at each revolution of the latter, and provided with projections engaging oscillating arms connected to the stem or shaft of the valve, substantially as and for the purposes specified.

8. In a rotary engine having an oscillatory valve for conveying steam to the principal valve, and for changing the direction of the steam, and for cutting off steam, and having the two ports, an oscillating or rocking device having the arms RM and LM, having handles, substantially as and for the purposes specified.

9. In a rotary engine having an oscillatory valve, for cutting off steam, and for changing the direction of the latter, an oscillating rocking device having arms RM and LM, each provided with a projection M^4, and a minor projection M^6 therefrom, and a cam-rod provided with the recesses N^4, and the latch-lever pivoted to the cam-rod, and having the openings for engaging respectively the projections M^6 of the rocking device, as presented, and while the projection M^4 is in its adjacent recess N^4, the latch-lever being caused to lock thus, by elastic means, substantially as and for the purposes specified.

10. In a rotary engine having an oscillatory valve, for cutting off steam, and for changing the direction of the latter, an oscillating rocking device having arms RM and LM, each provided with a projection M^4, and a minor projection M^6 therefrom, and a cam-rod provided with the recesses N^4, and the latch-lever pivoted to the cam-rod, and having the openings for engaging respectively the projections M^6 of the rocking device, as presented, and while the projection M^4 is in its ad-

jacent recess N^4, the latch-lever being caused to lock thus, by elastic means, there being a disk or annular flange M^5 between the projections M^4 and M^6, which flange is adapted to keep the cam-rod from lifting directly forward and off from connection with projection M^4, while the latch-lever also prevents the projection M^4 from moving sidewise out of the recess, substantially as and for the purposes specified.

11. In a rotary engine having an oscillatory valve, for cutting off steam, and for changing the direction of the latter, an oscillating rocking device having arms RM and LM, each provided with a projection M^4, and a minor projection M^6 therefrom, and a cam-rod provided with the recesses N^4, and the latch-lever pivoted to the cam-rod, and having the openings for engaging respectively the projections M^6 of the rocking device, as presented, and while the projection M^4 is in its adjacent recess N^4, the latch-lever being caused to lock thus, by elastic means, and the rocking device provided with extension M^6, having studs M^{10}, and the valve-rocking arm pivoted on shaft, and adapted to engage the studs M^{10}, according to the position of the rocking device, substantially as and for the purposes specified.

12. In a rotary engine having an oscillatory valve, for cutting off steam, and for changing the direction of the latter, an oscillating rocking device having arms RM and LM, each provided with a projection M^4, and a minor projection M^6 therefrom, and a cam-rod provided with the recesses N^4, and the latch-lever pivoted to the cam-rod, and having the openings for engaging respectively the projections M^6 of the rocking device, as presented, and while the projection M^4 is in its adjacent recess N^4, the latch-lever being caused to lock thus, by elastic means, and the rocking device provided with extension M^6, having studs M^{10}, and with a notch in its lower end and sweeps, the cam-rod having pin adapted to engage in said notch, as the cam-rod oscillates, and the rocking arm of valve E, adapted to engage the studs M^{10}, according to the position of the rocking device, substantially as and for the purposes specified.

13. In a rotary engine, having an oscillatory valve for conveying steam to the principal valve, and for changing the direction of the steam, and for cutting off steam, and having the two ports, an oscillating or rocking device having the arms RM and LM, provided with handles, for operating the first-named valve, eccentric N and the push-rod engaging the rocking device, and the exterior mechanism for operating the abutment-valve E, viz: rollers R, R, slide-pieces S carrying the rollers, guides T, T, and toothed racks on the slide-pieces, toothed arms fixed on shaft E^2 of the abutment-valve E, and the cam Q, Q^3, substantially as and for the purposes specified.

14. In a rotary engine, the rotary piston, abutment-valve, exterior mechanism for operating this valve, viz: cam Q, Q^3, slide-pieces S provided with device for receiving the impingement of the nose of the cam, guides T, T, and toothed racks on the slide-pieces, toothed arms engaging said racks, and fixed on shaft E^2 of the abutment-valve, substantially as and for the purposes specified.

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