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W. C. KNIGHT.

ROTARY STEAM ENGINE.

No. 500,398. Patented June 27, 1893.

Fig. 1.

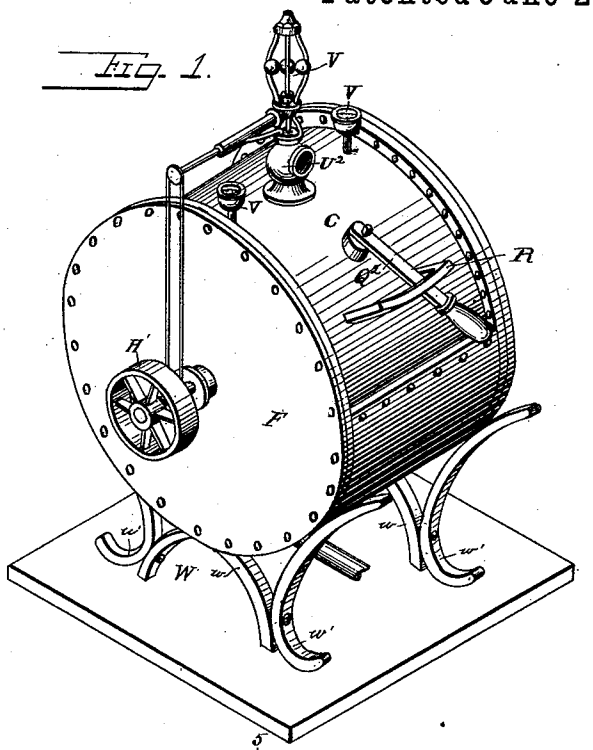

Fig. 2.

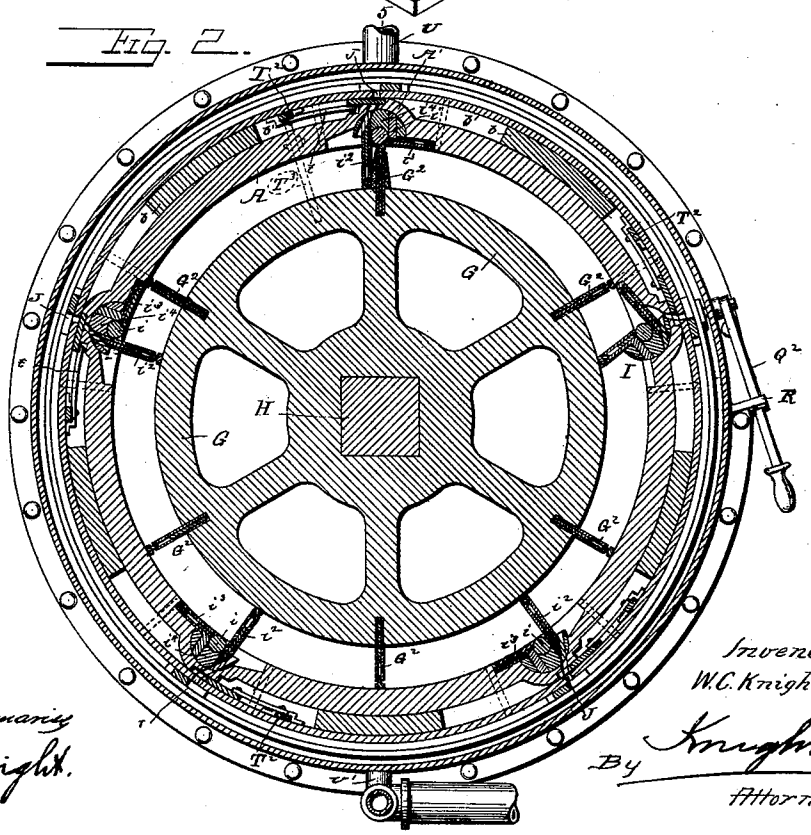

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Fig. 3

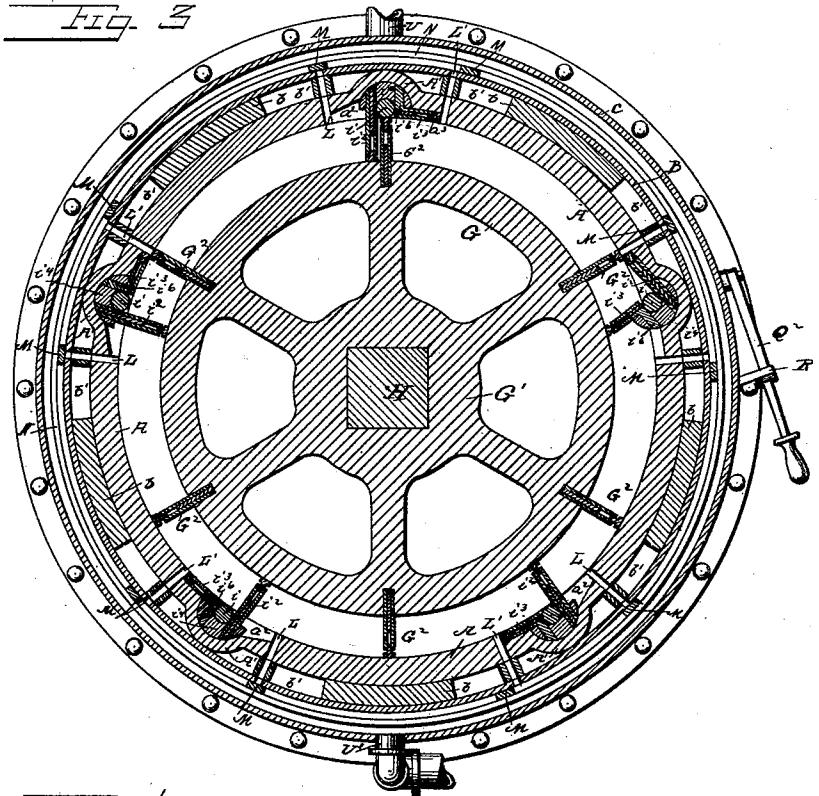
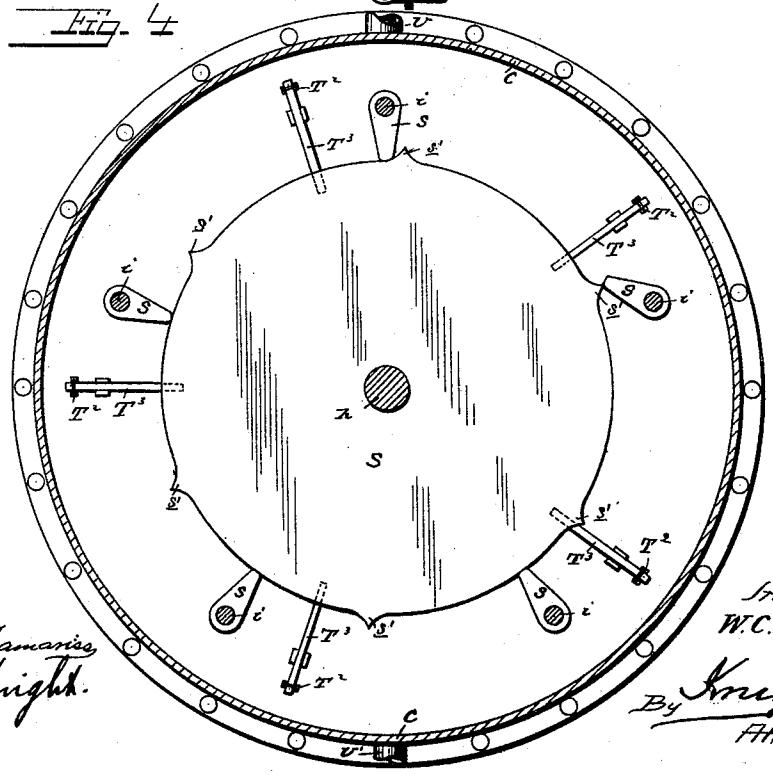


Fig. 4



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ROTARY STEAM ENGINE.

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Fig. 5

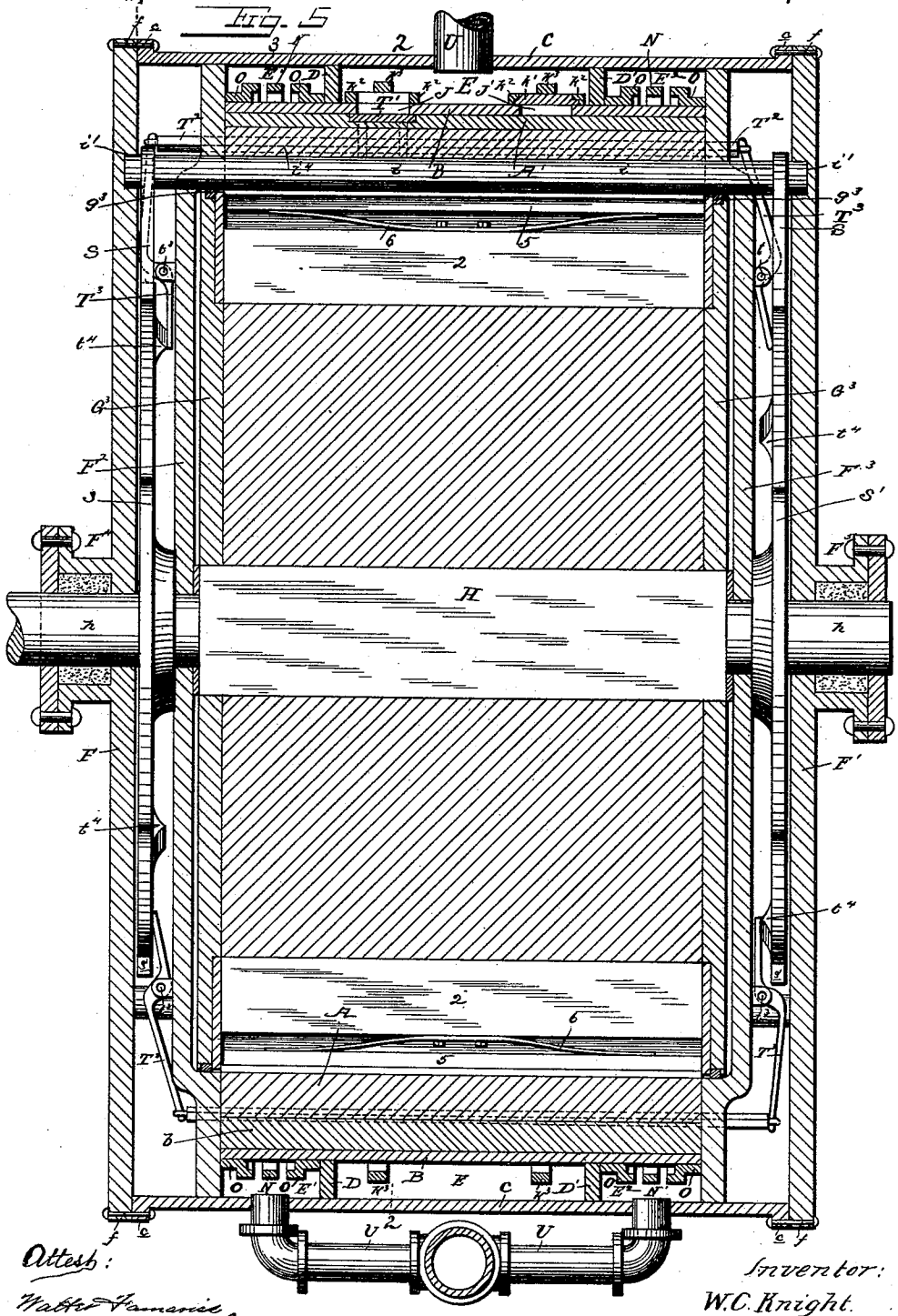

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Fig. 6.

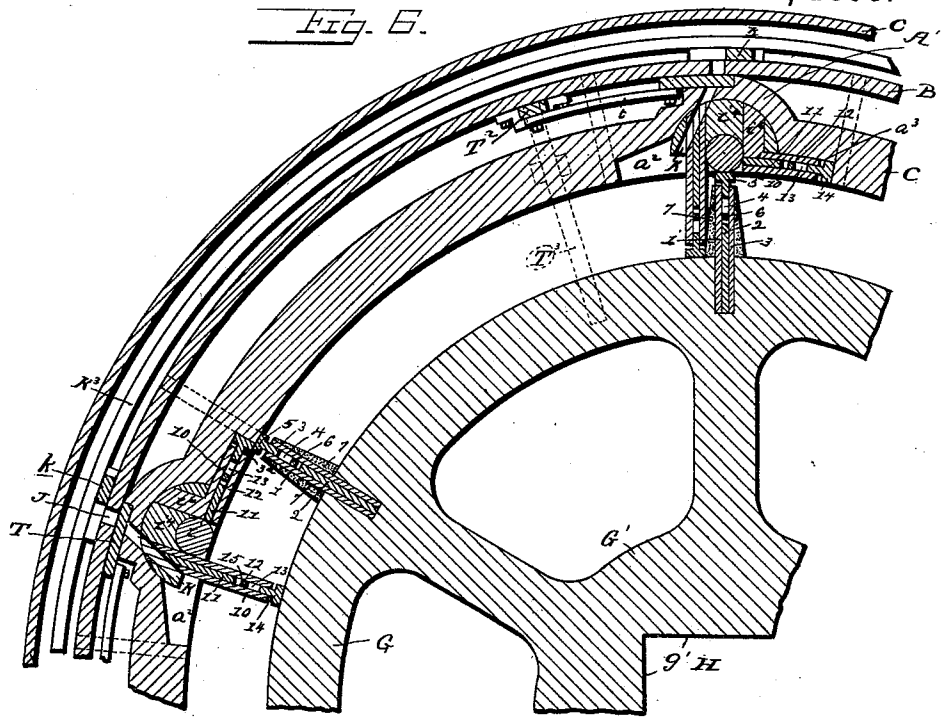
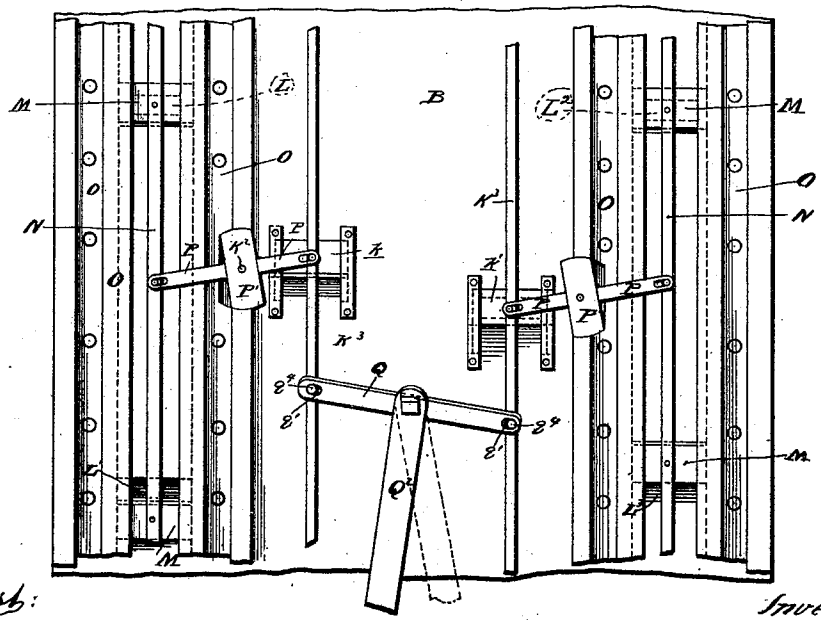


Fig. 7.



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ROTARY STEAM ENGINE.

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Fig. 8.

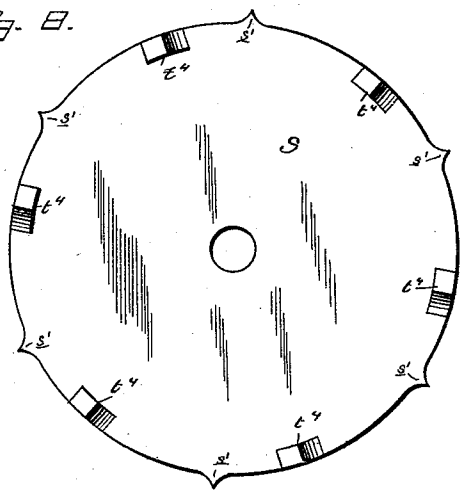


Fig. 9.

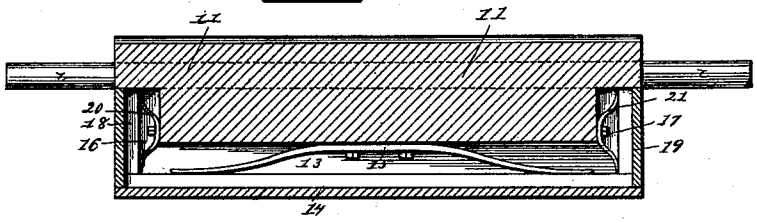
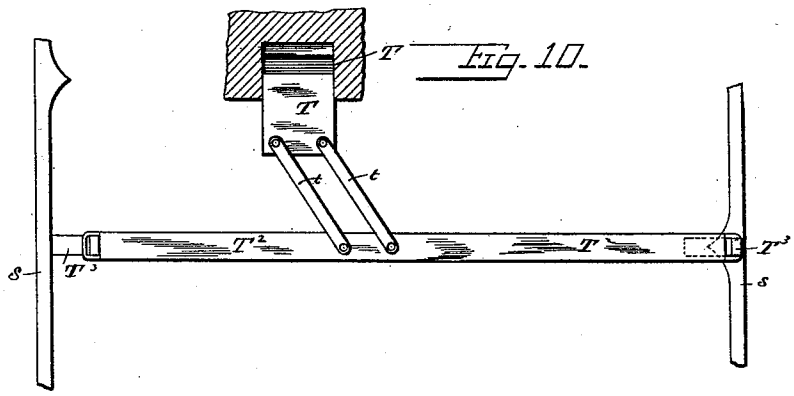


Fig. 10.



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UNITED STATES PATENT OFFICE.

WILLIAM C. KNIGHT, OF RICHMOND, VIRGINIA.

ROTARY STEAM-ENGINE.

SPECIFICATION forming part of Letters Patent No. 500,398, dated June 27, 1893.

Application filed October 10, 1892. Serial No. 448,386. (No model.)

To all whom it may concern:

Be it known that I, WILLIAM C. KNIGHT, a citizen of the United States, residing at Richmond, in the county of Henrico and State of Virginia, have invented certain new and useful Improvements in Rotary Steam-Engines, of which the following specification, taken in connection with the accompanying drawings, is a full, clear, and exact description, such as will enable those skilled in the art to make and use the same.

My invention relates to that class of rotary engines in which a rotary piston formed with suitable paddles or buckets is rotatably supported in a cylindrical casing which is provided with swinging abutments adapted to cooperate with the rotary piston head.

My invention consists first, in forming the swinging abutments with two wings which mutually brace each other and render it possible to run the engine either forward or backward by a simple change in the position of the steam and exhaust valves.

My invention consists secondly, in providing one less abutment than pistons or buckets in order to obviate "dead centers" and to have the engine run under a full head of steam at every portion of its stroke.

My invention consists thirdly, in a new arrangement of steam and exhaust ports and the controlling valves and operating mechanism.

My invention consists lastly, of various details of construction, all of which will first be described with reference to the accompanying drawings and afterward particularly pointed out in the annexed claims.

In said drawings:—Figure 1 is a front perspective view of my improved engine. Fig. 2 is a transverse sectional view of the same taken on the line 2—2 of Fig. 5, for showing the arrangement of steam ports. Fig. 3 is a transverse sectional view taken on the line 3—3 of Fig. 5 for showing the arrangements of exhaust ports. Fig. 4 a transverse sectional view taken on the line 4—4 of Fig. 5. Fig. 5 is an enlarged longitudinal sectional view taken on the line 5—5 of Fig. 2. Fig. 6 is an enlarged sectional detail view showing the construction of the abutments and arrangement of ports. Fig. 7 is an enlarged detail plan view of a section of the intermediate or valve supporting cylinder, the exterior shell being removed to show the arrangement of valves. Fig. 8 is an inside elevation of the cam which operates the abutments and cut-off valves. Fig. 9 is a detail sectional view of one of the swinging abutments, taken through one of the wings. Fig. 10 is a detail plan representation of one of the cut-off valves and operating cams.

I form the cylindrical casing of the engine of three concentric shells or cylinders A, B and C arranged one within the other. The inner cylinder A in which the piston head rotates is formed much thicker and stronger than the other two cylinders, and is provided with cut-out bulged portions A′ arranged equidistant around the circumference in which the swinging abutments operate. The intermediate shell B, which surrounds the shell A, is supported at intervals upon the cross-blocks *b* for the purpose of affording space for the bulged portions A′ and forming dead air spaces *b′* between the cylinders. The steam supply and exhaust ports are formed through the cylinders A and B; the cylinder B serving to support the valves which control said ports and the operating devices, as will presently appear.

D and D′ are parallel rings secured to the intermediate shell B for the purpose of dividing the space between said shell and the outer shell C into the central annular steam space E and the outer annular exhaust spaces E′ and E^2.

F^2 and F^3 are the inner dished cylinder heads secured to the ends of the cylinders A and B and projecting beyond said cylinders to the outer cylinder C as shown in Fig. 5. The outer shell or cylinder C is formed considerably wider than the inner cylinders A and B, and is supported upon the dividing rings D, D′ and the inner cylinder heads F^2 and F^3, and provided at its edges with the annular outturned flanges *c*.

F and F′ are the outer cylinder heads fitting snugly against the ends of the outer cylinder C and secured to the flanges *c* by means of the rivets *f*.

F^4 and F^5 are stuffing boxes formed on the outer faces of the cylinder heads F and F′ respectively.

The rotary piston consists of a cylindrical

body G formed integral with the core G′, the radial paddles or buckets G^2 extending from the body G, and the circular head plates G^3 secured to the body G and inclosing the paddles.

g^3 are packing rings in the peripheries of the head plates G^3 to form steam tight joints with the dished edges of the cylinder heads F^2 and F^3. The core G′ is formed with a squared opening g' through it for the passage of the squared central portion of the shaft H. The paddles G^2 are each formed of three flat metal plates 1, 2, 3, secured together and inserted in one of the longitudinal kerfs g formed in the periphery of the body G; the central plate 2, being narrower than the outer plates 1 and 3 so as to form a recess 4 at the outer end of the paddle for the reception of the movable packing strip 5, which is held normally out against the inner periphery of the inner cylinder by the leaf spring 6 secured to the central plate 2 and bearing against said strip 5. On each of the outer faces of the plates 1 and 3 are secured pads 7 to cushion the contact of the paddles with the wings of the swinging abutments.

The piston head is journaled centrally in the cylinder casing, and the radial paddles or buckets and the inclosing heads extend close up to the inner periphery of the inner cylinder A and dished heads F^2, F^3, with which they are concentric, and form close steam contact therewith.

The shaft H is formed with contracted ends h which are extended through and journaled in the heads F and F′ and stuffing boxes F^4 and F^5. H′ is a power-pulley keyed on the outer contracted end of said shaft from which the driving belt extends to the machinery to be driven.

I prefer to construct the piston by forming the body G of a single casting, and then securing the paddles, head-plates and shaft thereto and revolving and turning it to a true cylinder in a lathe.

I are the swinging abutments consisting of the cross shafts i extending the whole width of the casing and having their ends passed through the inner cylinder heads F^2 and F^3 and journaled in the recesses i' formed in the inner faces of the cylinder heads F and F′, and the wings i^2, i^3 extending approximately at right angles to each other and secured to the shafts i by means of the enlarged heads i^4 which are securely bolted or otherwise fastened to said shafts i. The shaft i, wings i^2, i^3, and enlarged heads i^4 are rigidly secured together so as to move as a whole on the journal ends of the shaft, said shaft being journaled out of the circle of rotation of the piston so as to allow it to pass. Each wing of the swinging abutment is formed of the same width as the depth of the buckets so as to extend from the casing to the periphery of the body G of the piston, and of such length as to fit in between the head plates G^3; and is constructed similarly to the paddles G^2, of outer plates 10 and 12, and inner narrower plate 11, secured together so as to form the longitudinal recess 13 in which are supported the packing strip 14 and its spring 15, and the end recesses 16, 17, in which are supported the packing strips 18, and 19 and their springs 20 and 21. These packing strips and springs operate the same as the strips 5 and springs 6 of the piston paddles, and form steam tight joints with the body G and head plates G^3 of the piston. The bulged portions A′ of the inner cylinder have the inner recesses a' which are curved concentric with the shaft i for the enlarged heads i^4 to work in.

a^2 and a^3 are tranverse oblong recesses formed in the inner periphery of the inner cylinder A and extending from the opposite sides of the curved recesses a' and adapted to receive the wings of the abutment when they are folded up against the cylinder, whereby they will not interfere with the rotation of the piston. It will be observed that the bottom walls of the recesses a^2 are inclined toward the curved recesses a', while the recesses a^3 are curved concentric with the shaft H. This is found necessary to accommodate the wings, as the wings i^2 extend from the shafts i on tangents, while the wings i^3 extend approximately radially therefrom. In constructing these double-winged abutments I have found it most convenient to cast the shaft and central portion of the enlarged head and the wings separately, and securely bolt them together by counter sunk bolts, the wings i^3 being provided with right angle pieces i^6 formed integral with one of the plates 1 or 3 for this purpose.

J, J′ are the two live steam ports extending through the cylinders A and B into the central steam ring E at points on each side of the center of said space and diagonally opposite each other so as to lead into the opposite sides of the recessed bulged portions A′. One of said ports J is for supplying steam for the forward movement of the engine, and the other port J′ is for supplying steam for the backward movement, both of said ports extending through said cylinder on an angle. The relative position of these ports is represented in Figs. 5, 6, and 7.

K and K′ are steam ports passing through the enlarged heads i^4 and registering respectively with the ports J and J′ for supplying steam on the opposite sides of the abutment for running the engine in both directions.

k and k' are slide valves covering the ports K and K′ and curved to fit the contour of the cylinder B and confined to their seats by the curved plates k^2.

K^3 are rings extending around the cylinder and connected to the slide valves k and k' for operating them.

L, L′, L^2 and L^3 are exhaust ports extending through the cylinders A and B into the exhaust rings or spaces E′, and E^2 respectively, the ports L and L′ extending into the exhaust space E′ on opposite sides of the

abutment, and the ports L^2 and L^3 extending into the exhaust space E^2 on opposite sides of the abutment, the ports on the same side of the abutment being designed to be open for exhaust at the same time when the engine is operating as will hereinafter appear.

M is a series of slide valves covering the ports L, L′, L^2 and L^3, and N are operating rings extending around the cylinder B and connected to all of said valves M by means of which they are operated. The valves M are connected at such points on the rings N with relation to each other that those covering the ports L and L′ will be open when those covering the ports L^2 and L^3 are closed, and vice versa.

O is a series of flanged rings riveted to the cylinder B for holding the valve covers M in place.

P are levers extending through the dividing rings D and D′ and pivoted at their opposite ends to the operating rings N and slide valves k and k' respectively. These levers are pivoted to the cylinder B at k^2, and their central portions are enlarged to form segmental plates P′ with curved ends which provide steam tight joints with the rings D, D′, and yet allow the levers to move back and forth.

Q is a rock-shaft journaled in the casing C, and Q′ is a double crank arm keyed to said rock-shaft and provided with elongated slots q' at its opposite ends which engage lugs q^4 on the operating rings K^3. Q^2 is an operating hand-lever also keyed to the rock-shaft Q on the outside of the cylinder C and extended through the guide rack R as shown. By operating the hand-lever Q^2 the exhaust ports and live steam ports are opened and closed simultaneously, the proper exhaust ports being opened in conjunction with the proper live steam ports, and the engine being run forward or back according to which set of ports is open.

S are cam arms keyed to and depending from the ends of the abutment shafts i in the spaces between the outer cylinder heads F, F′ and inner cylinder heads F^2, F^3, and S′, S′ are cam wheels keyed to the main shaft H between the inner and outer cylinder heads and formed with radially projecting cams s', which are adapted to engage the depending arms S for operating the abutments and raising the wings slightly before they are engaged and passed by the piston buckets.

T are sliding cut-off valves seated in the recesses T′ cut in the bulged portions A′ across the steam supply passages J, and adapted to cut off the supply of live steam at intervals in the forward movement of the engine so as to allow the paddles to be driven a portion of the distance between the abutments by the expansion of the steam.

T^2 is a longitudinally movable rod supported in suitable bearings on the inner periphery of the cylinder B and in the inner cylinder heads F^2 and F^3, and connected to the valve T by means of two parallel links t, t which are pivotally attached to the rod and valve as shown in Fig. 10.

T^3 are radially extending bent operating levers pivoted at t^3 to the outer faces of the cylinder heads F^2, F^3, and engaging at their upper ends the looped ends of the rods T^2 so as to move them longitudinally when they are rocked on their pivots.

t^4, are cams formed on the inner faces of the cam-wheels S′, S′ in proper relation to the pivoted levers T^3 to engage their lower ends and operate them. The cams t^4 are arranged intermittently on the inner faces of the opposite cam-wheels so that a cam on one wheel is half way between two cams on the opposite wheel. By this means each of the cut-off valves is closed by a valve on one wheel (when sufficient steam has entered between the abutment and paddle) so as to allow the paddle to be driven part of its stroke by the expansion of the confined steam, and opened by the next succeeding cam on the opposite wheel when the paddle has completed its stroke and reaches its exhaust, so as to open the steam supply for the next succeeding paddle; the abutment cutting off the supply of steam temporarily while the paddle is passing.

U is the steam supply pipe tapped into the cylinder C so as to communicate with the central live steam space E and U′ is the two-way exhaust pipe also tapped into the cylinder C so as to communicate with the two exhaust spaces E′ and E^2. The proper live steam ports and exhaust ports are always open to the live steam spaces and exhaust spaces during the operation of the engine, the live steam being cut off from the engine by the globe valve u^2 when it is desired to stop the engine. During the operation the live steam is automatically cut off from each paddle as it passes its exhaust by the succeeding paddle coming in contact with the depending wing of the abutment and revolving it as illustrated in Fig. 2.

V are oil cups and V′ is a governor geared up to the power-shaft H in any suitable manner.

W is my improved supporting cradle formed of the horizontal semi-circular bars w, and the vertical semi-circular bars w' secured together near the base, and having the engine cylinder supported in and secured to it. This has been found to be a very convenient form of support for the engine especially when it is employed as a marine engine.

It will be observed that I provide six paddles or buckets and only five abutments, by means of which dead centers are avoided and the engine can always be run with a full head of steam. The relative numbers of these abutments may vary with the size of the engine but there should always be one more paddle than abutment to produce satisfactory results. By providing each swinging abutment with two wings extending approximately at right angles to each other, each

serves as a brace for the other when in raised position.

The operation of the engine is as follows:—Assuming that the parts are in the position indicated in Figs. 2 and 3 with the piston traveling to the left. In this position all of the exhaust ports L^2 and L^3 are open except when temporarily closed by a passing paddle; and all of the live steam ports J, K are also open except when intermittently closed by the cut-off valves T or the rotation of the abutments by a passing paddle. As each paddle reaches the lowered wing of an abutment it is raised, and at the same time the cut-off valve at said abutment is opened; the raising of the abutment cutting off the steam for an instant until the paddle and cam s' have passed. The steam entering behind each paddle expands against the face of the depending abutment-wing and drives the piston head around; the cut-off valve being automatically closed by the cam when the paddle has traveled about one half of the distance between two abutments, so as to allow the remainder of its stroke to be made by the expansion of the confined steam. All the time the paddles are being driven forward by the steam the spaces in front of them have free communication with the exhaust; the exhaust ports being arranged at such points that they will be passed by a paddle and opened into communication with the space in front of the next succeeding paddle at the same instant that the succeeding paddle temporarily cuts off the live steam to said space by rotating the abutment head in passing as already explained. This action is continued for each paddle very rapidly, and during the portion of the stroke that each paddle is successively idle, (that is while each paddle is traveling from the exhaust past the abutment) it is carried forward by the remaining working paddles. Each abutment is returned to its normal position as soon as a paddle passes by the action of the steam against the inner face of the wing which has been raised to its recess, the recess being thrown directly into communication with the live port K (or K′) as shown clearly in Fig. 2.

For changing the direction of the engine the position of all the ports are changed by the hand-lever Q^2 as already explained.

Cut-off valves are not provided for the backward motion of the engine, as such motion is only temporarily used and can be accomplished by a full head of steam.

Having thus fully described the nature of my invention and the manner of carrying the same into practice, the following is what I claim as new therein and desire to secure by Letters Patent:

1. In a rotary engine, the combination of the cylindrical casing A, formed with a series of recesses in its inner periphery, a series of swinging abutments journaled in said recesses and each consisting of a head and two abutment wings, a rotary piston head provided with a series of buckets, a surrounding concentric casing B, suitable exhaust ports, and the live steam ports K, K′ and J, J′, substantially as set forth.

2. In a rotary engine, the combination of the cylindrical casing formed with suitable recesses and the steam ports J, J′, a series of abutments journaled in said recesses and each consisting of an enlarged head having steam ports K K′ therethrough and the two wings extending at right angles therefrom, suitable exhaust ports arranged on opposite sides of the abutments, and a rotary piston head formed with suitable actuating buckets, substantially as set forth.

3. In a reversible rotary engine, the combination of the cylindrical casing, recesses formed in the inner periphery of said casing, steam ports passing through said casing into said recesses for supplying steam for the forward and backward movements of the piston, swinging abutments journaled in said recesses and formed of suitable heads and projecting wings, steam ports extending through said abutment heads and adapted to register with the steam ports through the casing and to be cut off by the movement of the abutments, automatic cut-off valves controlling the entry of steam into the cylinder for the forward movement of the piston, suitable exhaust ports, a rotary piston head provided with suitable buckets and concentrically mounted in the casing, and main reversing valves controlling the entry of the steam to the steam ports for changing the direction of the piston, substantially as set forth.

4. In a rotary engine, the combination of the concentric cylinders A, B and C, the swinging abutments journaled in said inner cylinder A, the dividing rings D, D′ between the cylinders B and C for forming the live steam space E, and the exhaust spaces E′ and E^2, live steam ports passing through said cylinders A and B and communicating with said live steam space E, exhaust ports also extending through said cylinders A and B and communicating with the exhaust spaces E′ and E^2, and a suitable rotary piston, substantially as and for the purpose set forth.

5. In a rotary engine, the combination of a suitable cylinder formed with exhaust and live steam ports, suitable abutments, a piston, cut-off valves for the live steam ports confined in suitable recesses in the cylinder, longitudinally movable rods supported in suitable bearings, parallel links pivoted to said rods and cut-off valves, pivoted levers engaging the ends of said longitudinally movable rods, and cam-wheels adapted to actuate said operating rods, substantially as set forth.

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Witnesses:
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