C. J. FELIO.

ROTARY ENGINE.

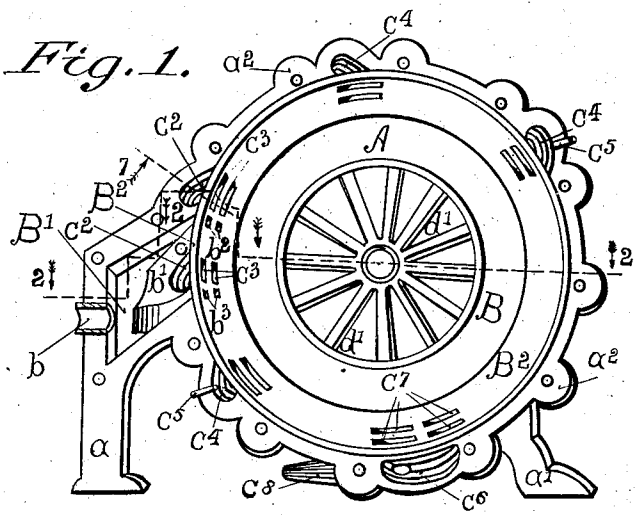
APPLICATION FILED JULY 16, 1910.

1,027,646.

Patented May 28, 1912.

2 SHEETS—SHEET 1.

Fig. 1.



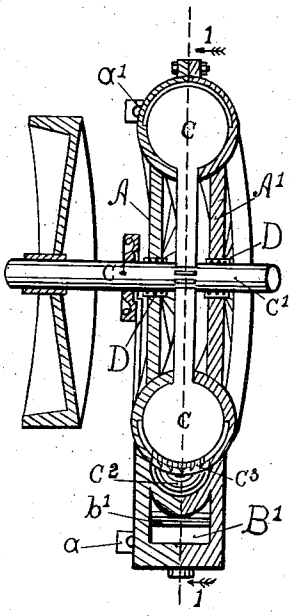


Fig. 2.

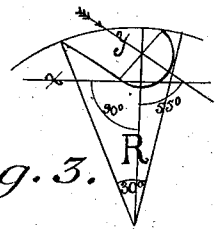


Fig. 3.

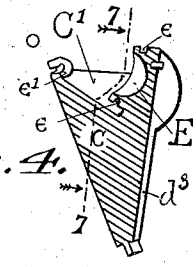


Fig. 4.

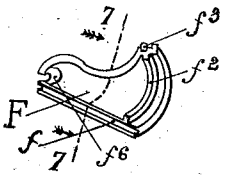


Fig. 5.

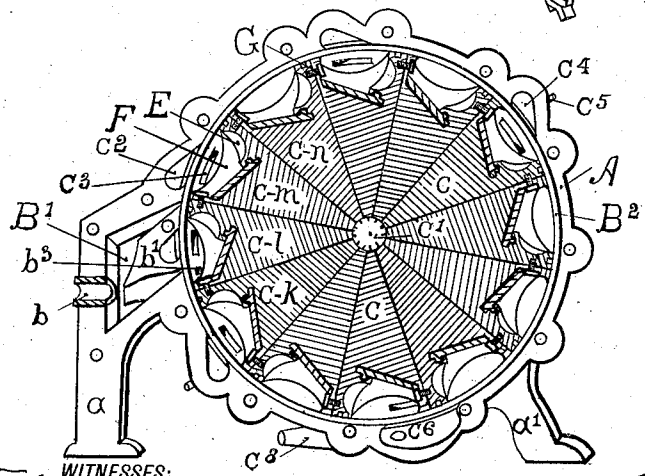


Fig. 9.

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2 SHEETS—SHEET 2.

Fig. 7.

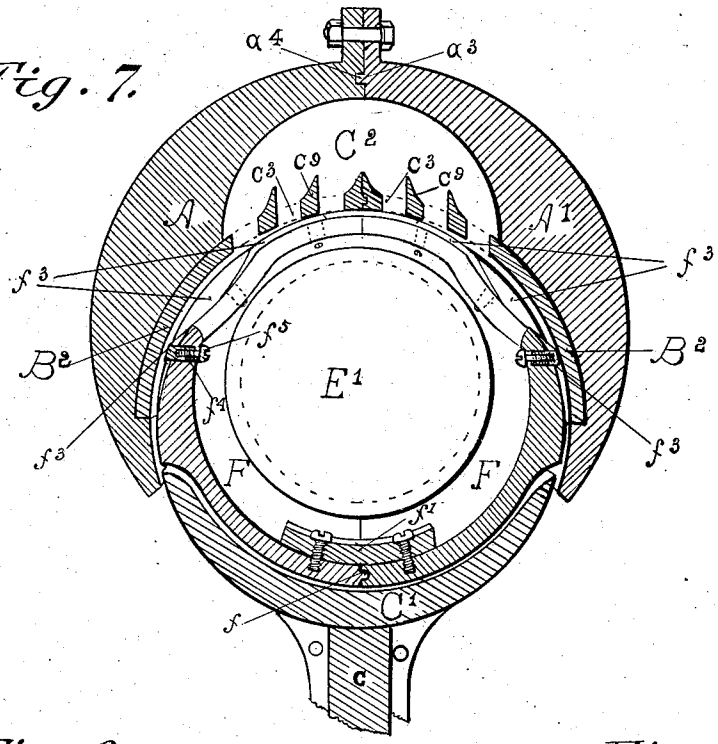


Fig. 6.

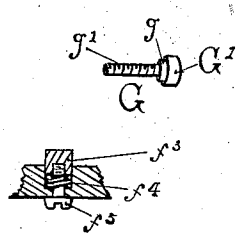
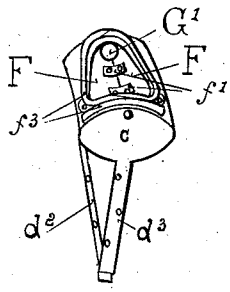


Fig. 8.



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UNITED STATES PATENT OFFICE.

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ROTARY ENGINE.

1,027,646. Specification of Letters Patent. Patented May 28, 1912.

Application filed July 16, 1910. Serial No. 572,409.

To all whom it may concern:

Be it known that I, CHESTER J. FELIO, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Rotary Engines and Methods of Operating the Same, of which the following is a specification.

My invention relates to improvements in that class of rotary engines commonly known as "turbine," and more particularly to a type which is driven by the impact of air or steam or like fluids, and it consists in a novel method of driving the same by expansion of the fluid in the provision of means whereby the wings, vanes or pistons of the turbine, after receiving the direct impact of the steam or other blast, are, in their progressive revolution, still further impelled by the expansive force of the same charge of motive power; in a novel construction of the rotary pistons, designed to secure an advantageous angle to the line of force; in proportioning the friction pressure of the packing to the energy of the motion fluid automatically by the pressure of the latter; in an improved packing of said pistons, closing against the cylinder wall with a force proportionate to the pressure of the steam; in securing more durability to the machine as a whole by the employment of a permanent outer shell or casing, with a removable lining for the working chamber or cylinder, which lining receives the wear, and in various other features and details of construction hereinafter described and claimed.

In the drawings; Figure 1 is a sectional view, looking toward the inner face of one of the half sections of the shell or casting, therefore embracing the farther half of the steam chest and the working chamber or cylinder; Fig. 2, a proximately horizontal sectional view through the entire machine, taken on the correspondingly numbered line in the preceding figure; Fig. 3, a diagram explanatory of the line of force of power when the engine is in operation; Fig. 4, a sectional perspective view, showing one half of one of the rotary arms or members, and of its piston-head; Fig. 5, a detail view of a half section of one of the cupped packing rings; Fig. 6, details of smaller and accessory features of said packing ring; Fig. 7, a transverse section enlarged, through packing ring and cupped piston, on the line indicated; Fig. 8, a perspective view of one of the rotary arms with its cupped packing ring and ring seat in position in the piston-head, and Fig. 9, a vertical sectional view through the complete engine, taken mainly on the line of cleavage between the twin sections of the shell or casing.

The preferred embodiment of my invention illustrated in said drawings comprises a shell or casing made in two similar half sections A, A^1, which are in the form of castings of iron, steel or other suitable material, the main portion being of substantially circular outline, with an enlargement at one side of the periphery, and the whole being provided with feet a, a^1, or other suitable supports. The half sections may be secured together in any appropriate manner, but I prefer to connect them by bolts passed through apertured lugs or ears a^2, arranged at intervals around the perimeter of the same. I also provide the two sections of the casing, in that part which encircles the annular working chamber or cylinder, with an interlocking and centering connection, by forming a groove a^3, on one of the sections and a corresponding tongue a^4 at the other, so that when bolted together they become not only perfectly centered but also air-tight.

The casing contains two chambers, B, B^1, the former of which is annular in shape, to constitute the working chamber or cylinder, and to receive the piston-heads carried by the rotary arms hereinafter described, and the latter of which is contained in the enlargement and forms a steam chest for supplying steam or other motive fluid, under pressure, to the cylinder and rotary parts. This steam chest or chamber has a suitable inlet b for the motive fluid, and arranged within said chest is a divider b^1, pyramidal or wedgeform in shape. This divider is so arranged that it forms in the steam chest two tapered outlet passages which direct the steam, in the proportion of about two thirds to one third, toward ports b^2, b^3, formed in an annular lining B^2 arranged in the annular working chamber of the casing. Owing to the tapering shape of the outlets or discharge passages of this steam chest, it will be apparent that the motive fluid or power will tend to be compressed as it leaves the chest

and enters the working chamber. This increases the kinetic energy developed by the motive fluid on its impact upon any one of three or more successive piston-heads C, having cups or chamber C^1, that form vanes or abutments at the outer extremities of rotary arms c which radiate from a shaft c^1, rotating in bearings in the casing.

The space between the steam ports b^2, b^3 is greater than the distance across the cup C^1 in the direction of rotation, so that both of said ports will not be closed at the same time, and consequently when the upper or foremost port b^2, which receives most steam or motive fluid, is closed by the passage of the solid portions of the piston-heads, forming an unbroken ring completely choking the working chamber except for the cups, sufficient steam will enter the cup of some succeeding piston-head through the rear or lesser port b^3 to move the rotary parts and uncover the forward port, that is, to bring a cup beneath it, when starting the machine.

For the purpose of utilizing the expansive action of steam, as well as its impact or vis inertia, I prefer to provide slightly in advance of each of the steam inlet ports, expansion chambers or pockets c^2, directed forward and communicating with the effective working chamber through openings c^3 in the annular lining. These latter openings are in the form of narrow slots extending lengthwise of the chamber and constituting a grating to permit the free passage of steam, and consequently its expansion, but effectively prevent the packing rings, or other packing, hereinafter described, on the rotary parts, from entering the pockets or expansion chambers. If desired, similar pockets or expansion chambers c^4 may be provided at intervals around the working chamber, and these latter expansion chambers may contain inwardly opening safety valves c^5 to allow air to enter should a vacuum be produced, as when running the engine with compressed air. The cups C^1 are spaced sufficiently far apart to cut them off, one from another, in passing these expansion chambers, so that each receives the full benefit of the expansion of the steam it delivers thereto.

A depression or cavity c^6, to receive the exhaust steam and water of condensation, is provided at the bottom of the engine, and communicates with the working chamber through ports c^7, cut in the annular lining thereof. An outlet port c^8 leads from this exhaust chamber to any suitable discharge, as a governing device controlling the exhaust and the speed of the engine in the usual manner.

The annular lining B^2 is milled and its several slots or ports are stamped or otherwise bent in to leave smooth exposed edges and provide small bracing flanges c^9 which, as it were, form supporting bridges, and also, by taking into the corresponding apertures in the casing, prevent slip of the lining and consequent loss of alinement. It is removably arranged between the twin sections of the casing, to permit it to be readily replaced when injured or worn. By providing this removable lining and making the shell or casing out of twin castings, the engine can be constructed at comparatively small cost; the shell can be used indefinitely, and the lining and other parts exposed to wear can be removed and replaced from time to time at an economical rate.

The shaft c^1 is rotatably mounted in a suitable bearing D, axially arranged in the central portion d of the two half sections of the casing, and said central portion is formed with openings d^1, herein shown as radial, but not necessarily so, for the purpose of allowing air to circulate around the revolving arms or members c which carry the cupped piston-heads. These arms are removably fixed to the shaft at their inner ends, and their side portions may be formed with apertured flanges d^2 and d^3 adapted, respectively, to be bolted to corresponding flanges on the arms in front and rear, whereby the several radiating arms are securely united and the piston-heads assembled in the before mentioned unbroken ring.

The piston-cup C^1 is substantially pear-shaped, or truncate-conoidal, with the butt end in advance, the longest diameter, therefore, coinciding with the plane of revolution, and it has at said butt end a circular enlargement E, containing a supplemental bulbous or semi-spherical chamber E^1, which communicates with and forms a part of said piston-cup. This enlargement, E, has an exterior annular groove e for the reception of the packing. The small end of the piston-cup is formed with an upwardly and outwardly projecting, apertured lug e^1 which can be bolted to the front end of the next succeeding piston-head. The intermediate or main portion of the piston-cup or chamber is adapted to contain a packing device which will retain steam or other motive fluid within the cup as it travels around the annular steam space or working chamber, and which will automatically respond to increase or decrease in the fluid pressure, to press against the walls of said chamber with increased or diminished force, thereby accommodating the friction to the strength of the propelling agency. This packing device I preferably make in the form of a two section cup-ring F, divided along the center coincidentally with the major axis of the piston-cup. The two sections of this packing ring or cup have a tongue and groove connection or joint f which allows some pliancy, and they are fixedly joined together by leaf-springs f^1, one end of which is fastened to each sec-

tion, in such manner as to hold their upper and outer edges against the inner face of the annular lining, but permit the pressure of a charge of steam or other motive fluid to force these edges still further against the lining with a potency proportional to the degree of pressure, thus insuring a steam-tight fit at all times, and an increase or decrease of friction in ratio with the power. The forward or enlarged ends of the sections of the cup-ring fit around the enlargement E, at the butt end of the piston cup C^1, in which it loosely fits, and these ends are formed with inwardly extending curved ribs f^2 to enter the annular groove e in said enlargement. The outer faces of the sections at these ends, opposite said ribs, are grooved to receive sectional packing rings f^3, pressed outwardly by springs f^4, and limited in this outward movement by retaining screws f^5, upon which the springs are arranged. The object of these sectional packing rings, with their limited play and independently yielding pressure, is to afford relief from what otherwise might be abnormally high friction at this point under an exceptionally high head of steam. The small rear ends of the two sections of the cup or packing ring are formed with inwardly extending notched and overlapping parts or flanges f^6, which are opposed to the apertured lug e^1, and which receive in their notches the cylindrical sub-head g, of a bolt G, which latter has a major head G^1, serving as a ring seat. The threaded portion g^1 of this bolt passes through the apertured lug and into a threaded opening in the next adjacent piston-head, the bolt thereby serving not only to retain the cup-ring in position, but to unite the outer portions of the several rotary arms. Owing to this peculiar construction of the packing device, it will be seen that the steam admitted to the piston cup as it passes the ports of the steam chest, will be confined and allowed to expand only when said cup is in communication with one of the expansion chambers, the packing device preventing escape of steam, and also automatically graduating the friction to the driving head, as above explained.

In Fig. 3 I have shown a diagram illustrating the line of force of the steam or other expansive fluid in the packed or steam tight chamber or cup C^1, otherwise termed the piston cup. When steam enters the cup or chamber from the inlet port b^2 the line of force will be at right angles, or at 90° to the radius R of the rotary arm, as indicated by arrow x in said figure. The line of force of the expansive power of the steam is shown by the arrow y, said line being a line perpendicular to the diameter of the secondary cup E^1, and passing through the center of said diameter. The effective angle of the expansive power is the angle made by the intersection of that line of force with the radius passing through the center of the diameter of the cup E^1, from the axis of the rotary engine, which angle, in a rotary or turbine engine containing twelve arms, would be 55°. This angle, less than 60°, but more than 45°, tends to cause the arms to revolve and so produce a rotary or turbine engine worked by the expansive power of steam or other motive fluid.

Fig. 9 of the accompanying drawings shows a sectional elevation of a complete turbine having twelve arms and packing or cup rings attached to the piston-cups of each arm. The steam or other fluid, introduced into the steam chest through pipe inlet b, is divided or separated into two currents by divider b^1 in such manner that the larger portion, say two-thirds, passes through port b^2, into one of the steam-tight cups or chambers in the piston-head of one of the rotary arms c, for instance the arm c—m in said figure. The steam first enters the main cup or chamber C^1, and then the supplemental, communicating chamber E^1 of bulbous shape, and presses against the cup ring or packing F, to force the outer or upper portion of its sections against the sides of the working chamber, rendering the piston-cup steam tight. Since the top of the piston-cup is not closed thereby, but only limited to its own area, its charge of steam will continue to press against the exposed portion of the working chamber, and thereby tend to carry the piston-head forward and rotate its arm. The arm c—m is forced by this action of the steam from the position c—m to the position c—n, and into communication with the expansion chamber c^2, the next arm c—l being at the same time moved forward from communication with the preceding expansion chamber c^2 into the position c—m and communication with the steam port b^2, whereupon the steam will act as before, upon the piston-cup and packing of c—l, to drive said arm on.

The port or opening b^3 of the steam chest, placed in rear of port b^2, is used to supply power to the steam-tight cup of the arm c—l at a point where the steam-tight cup of the arm c—m has broken connection with port b^2, and the steam-tight cup of arm c—l has not yet reached that port. It is also useful in starting the machine when it last stopped.

When the air-tight cups or chambers on the piston-heads of the several arms communicate with the expansion chambers or cavities around the shell or casing, the steam expands to exert fresh energy, so that the engine will be driven both by the impact or inertia of the steam, and the expansion of the same.

I am aware that, prior to my invention, turbine or rotary engines have been con-

structed for the use of water, air or steam as motive power, having revolving pistons in the form of buckets or paddles, but in none of them is employed a continuous ring-piston conforming to and closely fitting into a cylindriform annular working chamber, and operating after the fashion of my invention, and I do not know or believe that any one before me has originated the hereinbefore described method of forcing the packing of the piston cups out against the wall of the working chamber and of automatically graduating the pressure of the packing thereagainst by and according to the pressure of the steam or other motive fluid itself.

What I claim as my invention and desire to secure by Letters Patent of the United States is:

1. In an engine of the nature described, the combination of a casing having a working chamber with inlet and exhaust ports, a closely fitting rotor operating in said chamber and having a peripheral force receiving cup, and a measurably pliant lining to said cup, the edges of which lining are forced outwardly against the opposing wall of the inclosing chamber by the pressure of the charge of motive fluid.

2. In an engine of the nature described, the combination of a casing having a working chamber with inlet and exhaust ports, a closely fitting rotor operating in said chamber and having a series of peripheral cups or cavities, and individual, measurably pliant linings to each cup, the edges of which linings are forced outwardly against the opposing wall of the inclosing chamber by the pressure of the charge of motive fluid, so as to cut off the escape of the charge in any direction until an intentional relief is reached.

3. In an engine of the class described the combination of a casing having an annular chamber circular in cross section, and further provided with an inlet and exhaust, a rotor in the casing having a piston head operating in the annular chamber thereof, said piston head having a peripheral force receiving cup, the said cup being provided with a measurably pliant lining the edges of which are forced outwardly against the opposing wall of the annular chamber by the pressure of the charge of motive fluid.

4. In an engine of the class described the combination of a casing having an annular chamber circular in cross section and provided with a removable lining, the said casing being also provided with inlet and exhaust ports for the said chamber, in combination with a rotor having peripheral piston heads operating in the chamber of the casing and each provided with a force receiving cup, opening into said chamber, each of the said cups being provided with a lining measurably pliant and the edges of which are forced outwardly against the opposing wall presented by the lining of the casing chamber, by the pressure of motive fluid.

5. In a turbine engine, the combination of a casing having a cylindriform annular chamber, and a steam chest, the chamber and chest being in communication with each other through spaced ports, one in advance of the other, a divider in the chest, forming tapered passages trending in the direction of rotation of the piston and leading to said ports, and a rotary ring piston conforming to the cylindriform chamber and fitting closely therein, and provided with cups or cavities to receive the steam from said ports.

6. In a turbine engine, the combination of a casing composed of separable castings and containing an annular chamber and a steam chest, the chamber and chest being in communication with each other through spaced ports, one in advance of the other, a divider in the chest forming tapered passages for directing steam to said ports, a removable lining in the annular chamber of the casing, and retained in position between the separable castings forming the casing, said lining having openings or ports registering with the first mentioned ports, and a rotary ring piston having cavities or cups to receive steam from said ports.

7. In a turbine engine, the combination of a casing having a cylindriform annular chamber and a steam chest, the chamber and chest being in communication through spaced ports, one in advance of the other, and a rotary ring piston conforming to the cylindriform chamber and closely fitting therein, and provided with an annular series of cups or cavities to receive the steam from said ports, the latter being spaced apart a distance greater than the length of one of the cups or cavities in the piston, as and for the purposes set forth.

8. In a turbine engine, the combination with a casing provided with a cylindriform, annular chamber, steam inlet and exhaust port, and an expansion chamber in communication with said annular chamber at a point in advance of the steam inlet, of a rotary ring-piston filling said chamber throughout its length and provided peripherally with spaced cups or cavities, cut off one from another, which receive steam from the inlet, whereby the piston will be driven by impact, and which also bring the steam to the expansion chamber, whereby the steam will expand while still in communication with the cup and drive the piston by such expansive action.

9. In a turbine engine, the combination with a casing provided with a cylindriform, annular chamber, a steam inlet and an exhaust opening, and a series of expansion chambers arranged between the inlet and the exhaust opening and communicating with the annular chamber, of a rotary ring-piston

snugly filling the chamber throughout its entire length and having a peripheral series of open cups or cavities, spaced apart and cut off from each other, which receive the impact of steam from the inlet and carry said steam to the expansion chambers to expand therein while the cup is therebeneath.

10. In a turbine engine, the combination of a casing provided with a cylindriform annular chamber, a steam inlet for said chamber, and an expansion cavity, a rotary ring piston conforming to and closely fitting in said chamber throughout its length and provided with cups or cavities to pass said inlet and said expansion chamber, and individual means for packing the independent cups or cavities of the piston to retain the steam therein.

11. In a turbine engine, the combination of a casing provided with an annular chamber, a steam inlet for said chamber, and an expansion cavity, a rotary ring piston provided with cups or cavities to pass said inlet and said expansion chamber, expansible packing devices for the cups or cavities of the piston, to render the same steam-tight, and a grating arranged over the expansion chamber or cavity to prevent said packing devices from entering the same.

12. In a turbine engine, the combination of a casing having an annular chamber provided with inlet and exhaust openings, the casing also having one or more expansion chambers communicating with said annular chamber, a rotary ring piston consisting of a shaft, and radiating arms, the latter having at their outer end piston-heads and piston-cups or cavities, packing devices for the said cups or cavities, adapted to isolate the motive charge contained therein.

13. In a turbine engine, the combination of a casing having an annular chamber provided with inlet and exhaust openings, the casing also having one or more expansion chambers communicating with the said annular chamber, a rotary ring piston consisting of a shaft, and radiating arms, the latter having at their outer ends piston-heads and piston-cups or cavities, the loosely connected pressure-responsive packing members in the piston cups and the expansible sectional packing members on said pressure-responding members.

14. The combination in an expansive turbine engine, of a steam chest having a divider between its two successive outlets, with an annular working chamber in which a rotating ring piston revolves about the common axis, ringed cups formed on said piston, which ringed cups pass over the said outlets from the steam chest, said arms while revolving being steam tight in the said annular chamber, and suitable exhaust openings, all substantially as shown and for the purposes specified.

15. The combination in an expansive turbine engine of three or more detachable rotary arms having in the upper cylinder end of each a pear-shaped opening consisting of two cups, one oval in shape and opening on the top into a chamber in which the arms revolve and the other cup semispherical in shape, adjoining and opening into one end of the oval shaped cup, the center line of the two cups being at an angle of between forty-five and sixty degrees with a radius from the axis of a turbine engine and a diameter of the semispherical cup, all substantially as shown and for the purposes specified.

16. In an expansive turbine engine, the combination of a steam chest having two successive outlets and a divider arranged between said outlets, an annular working chamber adjacent to the steam chest and into which its outlets open; a cupped packing ring arranged in a pear-shaped opening on the outer piston-like extremity of each of the several arms revolving about a common axis in said working chamber, said cupped packing ring consisting of two halves attached to each other by a tongue and groove jointure with two or more springs holding the said halves together, and flanged shaped projections on the inside at either end of each half of the said ring where the said ring fits over an opening into the spherical shaped chamber and the ring seat respectively, and with flanged shaped projections on the outside of each half of said cupped ring at the top and at either end of each half, all substantially as set forth and for the purposes specified.

17. In an expansive turbine engine, the combination of an annular chamber in which ringed, steam-tight cups revolve, said cups having an opening on the outer side adjoining the inner circumference of said chamber, with a steam chest chamber adjacent to and opening into said annular chamber, said steam chest having a divider and two outlets, one on either side of said divider, each taper in shape but different in size, the forward outlet discharging a greater volume of steam, both of said outlets opening into said annular chamber at points on the inner circumference of said annular chamber over which the ringed cups pass in revolving, all substantially as shown and for the purposes specified.

18. In an expansive turbine engine of the nature described, the combination of the rotary arms and their piston-heads, the pear-shaped piston-cup, the cupped packing ring lining the same, and the ring seat having a screw shank connecting the piston-head with the one next succeeding, and having also a cylindrical shoulder or sub-head and a major head around and underneath which the cupped ring fits.

19. The combination, to form a turbine casing, of twin section castings, each containing its half of an annular working chamber, a steam chest, and appropriate ports, and having lugs or ears whereby they may be bolted together, a centering and packing groove on one section and a corresponding projection on the other, and a removable and replaceable lining for said annular chamber, adapted to take up wear.

In testimony whereof I hereunto affix my signature in the presence of two witnesses.

CHESTER J. FELIO.

Witnesses:

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P. PLUDER.