

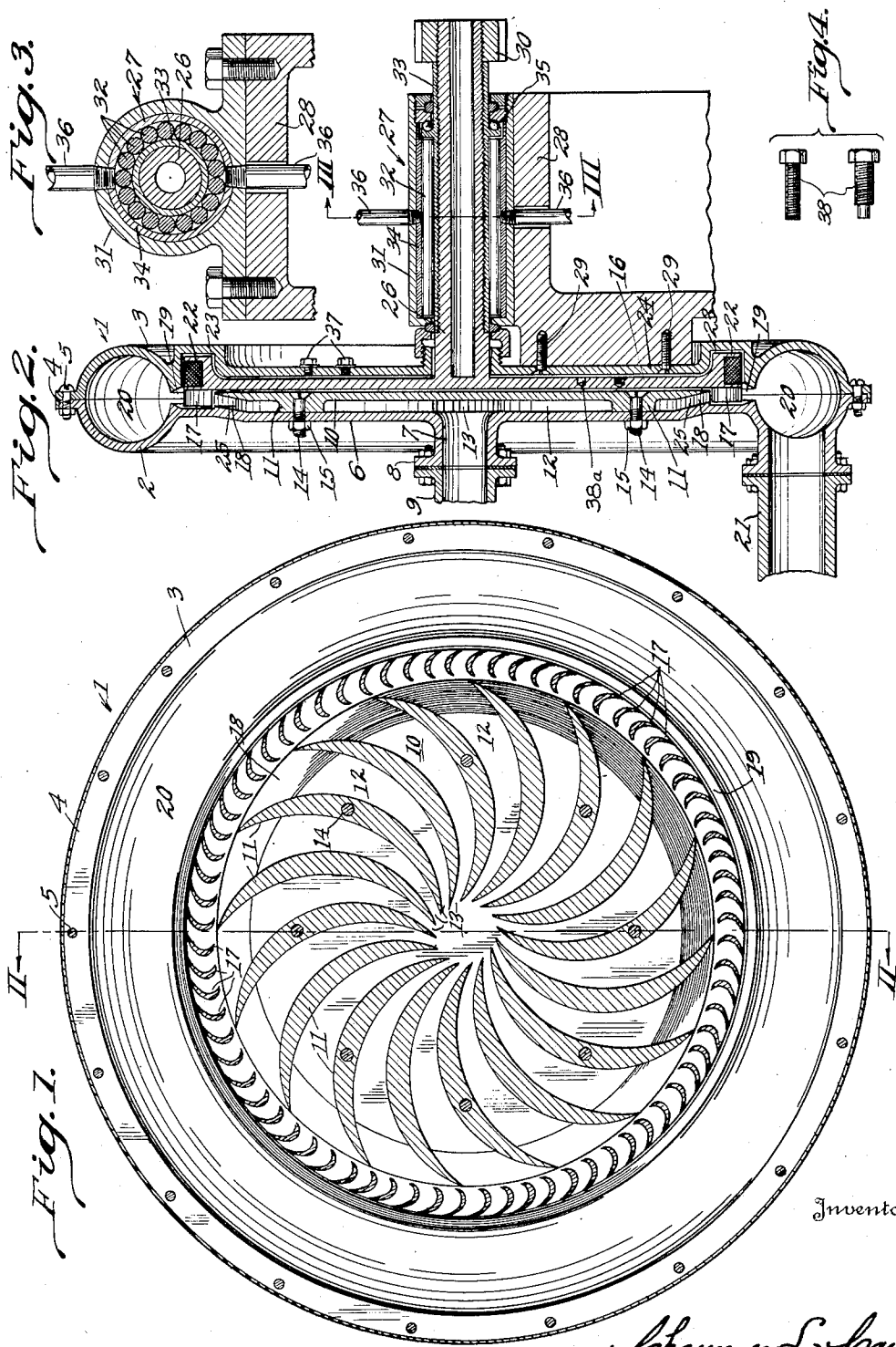
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ROTARY STEAM ENGINE

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ROTARY STEAM ENGINE

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This invention relates to rotary steam engines, and has particular reference to an improved form of engine of the impact type using a single circle or row only of blades.

5 The object of the present invention resides in the provision of a rotary steam engine of strong, simple, compact and efficient design, devoid of undue mechanical complication and economical to manufacture and operate.

10 For a further understanding of the invention, reference is to be had to the following description and the accompanying drawing, wherein:

Fig. 1 is a vertical transverse sectional view taken through my improved rotary steam engine;

15 Fig. 2 is a vertical transverse sectional view taken through the engine on the plane indicated by the line II—II of Fig. 1;

20 Fig. 3 is a detail transverse vertical sectional view taken through the bearing structure for the rotor of the engine on the plane indicated by the line III—III of Fig. 2;

Fig. 4 is a detail view of the stator positioning bolts.

Referring more particularly to the drawing, the 25 numeral 1 designates the casing of my improved engine. In the specific embodiment of my engine as illustrated, this casing comprises a pair of separable annular sections 2 and 3, provided with abutting outer peripheral flanges 4, which are 30 adapted to be bolted or otherwise secured together as at 5. The outer section 2 includes a flat, vertically disposed, disk-like body 6, formed axially with a steam admitting passageway 7, the latter terminating at its outer end in a flange 8 to which 35 may be bolted, or otherwise secured, a steam supply pipe 9, leading from a generator or other source of steam supply.

Secured to the inner surface of the body 6 of the casing section 2 is a vertically arranged 40 stator disk 10. In the present instance, the disk 10 has integrally formed with one side thereof a plurality of circularly arranged crescent-shaped ribs 11, which are relatively spaced with respect to each other in order to form therebetween a plurality of accurately calculated steam-expansion and deflection nozzles or passageways 12. These passageways have their restricted 45 inner ends 13 arranged in open non-restrictive communication with the steam admitting passageway 7 of the casing 1, the combined area of the inlets 13 being substantially equivalent to the cross sectional area of the passageway 7, and whereby the resulting sheet of steam in its advance, although by accurate calculation and 50 design progressively and rapidly expanding, is

nevertheless constantly held very closely to the same narrow sheet width from point of nozzle admission to the final reunited and undivided annular nozzle discharge at a very low and correctly deflected angle upon the blades which latter 5 scientifically recede before the steam at half its speed of impact, the crescent ribs of the compound nozzle merely serving to conduct and direct the steam along a progressively widening and evenly curving pathway in said final correct deflection 10 upon the blades and at the same time providing abundant bolting space between the individual nozzle conduits, and therefore outside the path of the steam on the way to the blades.

It will be noted that the nozzles or passageways 15 12 of said oblong or narrow rectangular formation are in marked contrast with the round or circular type of nozzles heretofore employed in the impulse type of steam turbine. The outer surfaces of the ribs 11 engage with the inner sur- 20 faces of the body 6 of the casing section 2, and are suitably secured thereto by means of bolts, or other equivalent type of fasteners 14. These bolts pass transversely through the body of the stator disk 10 and thence outside the conduits 25 through certain or all of the ribs 11 and through registering openings provided in the body 6, the outer ends of said bolts being equipped with nuts 15, or their equivalents, by which the disk 10 and the casing section 2 are unitarily joined. The 30 specific construction illustrated is unquestionably much to be preferred, but nevertheless leaving the vital principle subject of course to considerable variation without departing from the essential features involved, namely, the provision of the 35 curved, circularly arranged, outwardly expanding and advantageously deflecting individual nozzles or conduit passageways 12 which, at their restricted inner ends, are in open communication with the steam supplying means and which at 40 their outer ends terminate in registration with the circumferential portion of the stator indicated at 10, so the steam or other elastic fluid may issue therefrom in the form of flat elongated and advantageously deflected jets, of course an- 45 nularly reunited as an unbroken flat sheet circle of steam, the correct angle of impinging stroke circularly trained to strike all the blades of the circle simultaneously and correctly, the whole circle jet or film of steam being of relatively nar- 50 row cross sectional thickness.

Cooperating with this structure is a wheel or rotor 16. In the preferred form of the rotor, as disclosed in the drawing, the same provides a relatively thin disk-like body mounted for rota- 55

tion in a vertical plane and disposed between the stator disk 10 and the inner section 3 of the casing 1. Adjacent to its outer peripheral edge, the rotor 16 has integrally therewith at one side a series of circularly arranged, laterally projecting, substantially crescent shaped blades or buckets, which are relatively spaced and are indicated in the drawing by the numerals 17. These blades, buckets or vanes are disposed for unitary rotation in connection with the rotor 16 immediately adjacent to the wide exhaust end 18 of the nozzle passageways 12, so that the steam, expanding in the passageways 12 and traveling at high velocity will, immediately upon leaving said passageways, directly impinge the curved surfaces of the element 17 to effect high speed rotation of the wheel or rotor 16. I have proportioned the nozzle passageways 12 and arranged and formed the element 17 so that theoretically the element 17 will move at approximately one-half of the rate of travel of the steam issuing from the nozzle passageways. It will be understood that the expanding steam acquires great velocity, because the original confined or static pressure only of the steam is thus suddenly released, and therefore explosively lost wholly to directed motion, or mass velocity only, not forgetting that to be able to follow even half this speed of impact is a vital objective of this invention.

After passing through the nozzles, the steam is thus completely expanded, and in impinging on the element 17, its kinetic energy, or energy of directed motion only is transferred to and taken up by the turbine wheel. Leaving the element 17, over their outer edges, the spent steam now passes into an annular passageway 19 formed between the casing sections 2 and 3, and whereat is noted also a deflection or leaning conformation of the respective sides of the casing towards each other to effect a slight constriction of the flow of the exhaust steam outwardly thereby to create a vacuum inside the outer leaning tips of the respective casing walls, and therefore also within the space enclosed around blades, wheel and shaft extending to the bearing, and said vacuum operating to prevent condensate from working back again and around and into the blades, and also to prevent the exhaust steam from working along the shaft to the bearing. The exhaust now passing said constrictive tips just outside the blades, enters an enlarged circular manifold 20 in the outer circumferential region of the casing 1. This manifold communicates at its lower end with a steam discharge pipe 21 which leads to a condenser (not shown) or to the atmosphere as the case may be.

Inasmuch as the rotor will revolve at extreme or ultra speeds, involving problems of well known extremely difficult mastery, it becomes a highly important requirement that the rotor be specially designed and mounted so that it may revolve at the requisite rate of speed to insure recovery in a practical and efficient manner the power of the impacting steam. Often, in metal castings of the character from which the rotor 16 is formed, there may exist internal structural defects, cracks or other flaws very difficult to detect, or even if apparently not existing by the closest possible inspection, may develop under high rotation to cause disruption of the rotor when the latter is subjected to ultra speeds.

To strengthen or reenforce the construction of the rotor, and yet to permit the same to remain relatively light in weight, I provide the outer peripheral edge thereof with a transversely wid-

ened spool 22. At the time of manufacture of the rotor, I wind on the spool 22, under tension, a wire or other form of metallic cable, with the successive wrappings thereof disposed in closely related order. Since the wire or cable is applied to the rotor while under tension, it exerts a progressively compressive or clamping action thereon which eliminates or minimizes cross grain fracture or other local weaknesses which are present or may develop in the rotor when it is in use. The outer spool shaped portion 22 of the rotor is received within an annular recess 23 formed in the inner surface of the body 24 of the casing section 3.

The strength and compactness of the engine is augmented by the fact that the blades or buckets 17 of the rotor are relatively narrow in width and project but a short distance laterally from the surface of the rotor body. To permit the short width buckets to be employed, it will be noted that the outer ends of the nozzle passageways 12 are annularly deflected as indicated at 25. By thus deflecting said passageway, I consistently follow up the inward slant of the stator disk 10 with a like sealing slant of the casing side, and because of the momentum of the steam by this deflection holding the steam within the blades on its passage through them, I am enabled at the same time to utilize buckets of narrow width and great mechanical advantage of strength, because of said deflection shifting the strain of the impact from the blades to the stronger wheel.

To effect the support of the rotor, the latter is provided at one side only thereof with a longitudinally extending long or short, hollow and somewhat flexible shaft as indicated at 26. This shaft is mounted for rotation in a bearing structure 27, supported in connection with a stationary engine base 28, to which the casing section 2 also is secured as indicated at 29. The construction of the shaft 26 is such as to provide for a slight flexure of the shaft. Beyond the bearing structure 27, the shaft 26 may be provided with a spiral or other form of gear 30 which may be employed to drive suitable speed reducing means, (not shown), in order to transmit the power of the rotor for practical purposes. Also, the speed of the engine may be regulated by any suitable type of governor, (not shown), operating, as usual, to govern the admission of steam to the turbine.

The bearing structure which I prefer to employ in connection with the engine comprises a housing 31 as shown in Figs. 2 and 3, in which is mounted a plurality of longitudinally extending rollers 32, which are arranged between a sleeve 33 threaded in connection with the shaft 26 and the outer race 34 securedly fitted within the housing. At one end of the housing there is disposed an end thrust bearing 35, which is designed to take up outward thrust on the shaft imparted thereto by the lateral action of the steam on the buckets or blades 17 shifting as side thrust upon the wheel, as well as automatically taking up all wear on end thrust shoulder.

Oil may be admitted to and drained from the bearing structure by way of the conduits 36, or the circulation made continuous if desired to keep the bearing cool and properly lubricated. It is evident that with little change of construction, a row of balls, in place of the rollers may be substituted, if balls only be preferred.

In mounting the rotor within the casing, the threaded plugs indicated at 37 in Fig. 2 are first

removed, the outer casing section being of course detached from the inner section 3. I then thread into the openings which receive the plugs 37 positioning screws 38 which have shank lengths sufficient to permit the same to enter registering openings 38a provided in the rotor 16, there being two sets of said position screws, the one set having free projecting tips or shanks, unthreaded, and upon which tips the wheel by its corresponding register of unthreaded sockets rests, and which resulting correct assembly and future rotative position for the wheel is temporarily fixed by inserting the complementary all threaded set of screws into the corresponding register of threaded sockets in the wheel and the wheel is conveniently so held in correct position awaiting the remaining general assembly, or, as the case may be, for the removal of the bearings only from the shaft for inspection or repairs. The bearings also now duly brought on and installed, and the whole turbine in final assembly, both sets of position screws may now be turned away from their corresponding sockets in the side of the wheel, and being also removed from the casing, the openings now left in the side of the casing are again closed up by the plugs 37, and with the turbine now ready for the steam. By this method, the assembly is made easily, quickly and accurately.

In view of the foregoing, it will be seen that the present invention provides a simple, compact and efficient steam turbine wherein full advantage is taken of the energy derivable from impactly expanded steam. The turbine may be manufactured and assembled with considerable facility at relatively low cost in comparison with other steam actuated prime movers of corresponding horse power. While the turbine is adapted for ultra speed operation, yet due to its simplicity and efficiency in design and construction, there will be little, if any, wear on the essential moving parts with corresponding low maintenance costs.

While it is entirely within the scope of this invention to ignore the intense consolidation of parts it presents, as for instance the blades being subject to strain and erosion more than the wheel, it might be thought desirable to provide for replacement of the blades, and therefore to cast or construct them separately from the wheel, so they could be replaced without loss of the entire wheel. But it must not be forgotten that by design, the strain on the blades is shifted to the wheel itself, and inasmuch as the erosion of the blades from the impact of dry steam alone is extremely negligible, and there being no condensate possible to work back into the blades due to the vacuum provided, therefore the blades being practically immune from both strain and erosion, it becomes practical to cast them as one piece with the wheel.

It is well known that could a method of construction be found that would hold the wheel intact under the high speeds called for ultimate impact efficiency, the efficiency of the impact form would not only be very substantially advanced, but a wide field of usefulness would be immediately opened to it in the upper brackets of high pressure steam. And inasmuch as even bands of forged alloy steel of the highest known tensile strength have failed to provide this needed structure and suffice for the needs of ultra speeds, I am herein advancing an improved construction in two directions: first, the adequate shifting upon the wheel itself of the double

strain of centrifugal force and of the impact of the steam upon the blades; second, by the reinforcement of the periphery of the wheel by a spool of wire wrapped into the spool on the same principle exactly that cannon are wrapped with wire, to bind within all likelihood of explosive or rupturing force due to the extreme centrifugal power impossible to avoid otherwise in the higher brackets of pressure and speed of rotation required for corresponding impact efficiency and wherein a single row of blades become entirely practical in these higher brackets.

The basic construction principles upon which the single piece consolidations noted in this invention are, primarily: First, the combined inflection and sub- or lateral deflection of the steam to provide for six points: (a) advantageous stroke of the steam upon the blades and in closely holding juxtaposition to the wheel, (b) necessitating only short lateral extension of blades, (c) eliminating wiring or shrouding of the blades, (d) providing a slight side thrust, which (e) calling for only a single compact bearing at one side only, and wherein (f) all side thrust and side wear is taken up automatically by the side thrust itself. Second, conformation of the side walls of the casing just without the blades, to convergently lean and tip into the outward flow of the exhaust steam to produce a vacuum for two purposes: (1) to prevent the return of steam and exhaust condensate around and into the blades again, the condensate of which would damage the blade and make impractical the casting of the blades as one piece into and with the wheel and (2) to prevent the working of even the exhaust steam around the wheel, down at center and to the bearing. Third, the peripheral wiring of the spool cast into the wheel for the counteraction against possible flaws within the wheel at the outset, or which may develop and otherwise dismember the wheel under high ultra rotative strain.

Secondarily: 1. The general ease and practical possibility (a) of the complexly formative wall cast into a single piece at side (b) of the stator and stator wall or plate also cast into a single piece, and (c) the rotor, including blades, reel, wheel, hub, shaft and single bearing shoulder also cast as a single piece. 2. Cooperation of wiring of the periphery and hollow flexion of the shaft to amply provide a non-fracturable structure for both shaft and wheel as the needs of ultra speed rotation.

Shaft flexion may be provided for high speed by a small shaft extending out to hold the bearing a considerable distance in extension from the wheel. But this involves extreme clumsiness of construction, and breaks with the general plan of compactness followed throughout the construction of my design. But in order to set the wheel very close in to the bearing, and to provide flexion and prevent likelihood of fracture of the shaft, it is hollowed. It therefore becomes practical to cast the shaft into the wheel. With no likelihood of breakage at point of contact between close in positioned bearing and wheel, the non-fracturable close-in flexure of the shaft provided by its hollowing, it immediately becomes practical for even a close-in connected shaft to be cast with the wheel as one piece.

Therefore we see cooperating the four basic principles of construction which make dependable and practical a compact, simple, single piece rotor comprising in one piece blades, reel, wheel and shaft.

These four principles are (a) shaft hollowing to

provide unbreakable flexion for a shaft cast into the wheel and positioning the bearing in close juxtaposition to the wheel; (b) in combination with this principle, to provide indefinite speed possibilities for the wheel as a whole without likelihood of centrifugal fracture, by the reel of wire wound in the periphery of the wheel and (c) the two foregoing principles in combination with the lateral or sub-deflection of the steam, this latter principle making practical the casting of the blades with the wheel without necessary shrouding or reenforcement, by reason of the now only required shortness of the blades provided for by said deflection and (d) the shielding of the blades from condensate by the vacuum provided by the tipping of the exhaust flow just outside the blades by the slanting inward of the two walls of the casing, which shields the blades from condensate return into and destructive erosion of the blades, which would otherwise throw out the wheel, and necessitate individual insertion of the blades for future replacement, but by said shielding, replacement becoming superfluous, the blades may at once be cast into the wheel, and presenting, save for the wiring, a single piece rotor of indefinite speed possibilities and comprising compactly and efficiently all the functions of blades, reel, wheel and shaft.

The stator does the following things: Receives the steam; expands the steam; deflects the steam; sub-deflects the steam; jets or discharges the steam so received, expanded, deflected and sub-deflected upon the blades; subdivides into individual conduits, or steam conducting channels or passageways, otherwise known as nozzles, and which individual conduits or nozzles lying in a plain circle and constructively contacting with each other at their inner and outer tips, receive the whole steam of the main supply both in unbroken annular admission and annular discharge of the steam; utilizes crescents formed by the intersection of circles of different diameter, these crescents lying apart relatively and regularly space off the conduits in their properly calculated shape to, during said conduction, produce the combined required result of expansion, deflection, sub-deflection, and annular discharge upon the blades; all these individual conduits, or the whole stator as a unit, at their outer edge incline inwardly towards the wheel to produce the said sub-, or lateral deflection of the steam.

The whole stator, comprehending all the conduits, holds to a narrow or disk formation, but the angle of strike of the steam at all times following up and conforming to the whole surrounding circle of blades simultaneously discharged against, the sub- or lateral deflection of the steam so deflected holding the steam within the blades narrowly and closely to the wheel in its passage through the blades to the annular exhaust channel surrounding the blades. The stator also provides abundant bolting space between the conduits, whereby no obstructions are set up in the path of the steam on its way to the blades. By providing bolting spaces between the conduits which at first widen, and again recede or narrow down, the whole conduit passageway from beginning to end in rapidly progressive and unbroken expansive widening is left without either constriction or abrupt turn at any point of the said conduit passageway, as narrow, but perfect expansive and deflective conditions in final advantageous and true impact of the steam.

Notwithstanding its intensely complex functioning, the thinness of the stator disk as a whole

and its general crescent construction specially lends itself as so presenting a highly advantageous opportunity of casting the whole stator or compound nozzle into a simple, single piece, to be sealed or closed at the side by only the simple conformation and attachment of the immediately adjacent wall or siding of the casing to it. The stator disk as a whole relatively thin, cooperates with the wheel disk and the close juxtaposition of the walls or casing side members to form an intensely compact motor as a whole. The individual conduits of the stator meeting at both inner and outer ends in sharp tips only, present neither obstruction to the steam at its entrance to the conduits, nor division of the steam in its final disk discharge upon the blades, and likewise in the whole passageway offering no interference with the steam in its expansive and deflective preparation for the final blow or impact upon the blades. Using the said full annularly discharging stator, in simultaneous and continuous whole circle impact upon all the blades of the wheel during said admission of steam to the stator, and said thin disk stator preparing the steam for its final hurl upon the blades, the extreme compactness and efficiency of the whole turbine continues to be fulfilled in a blade carrying disk wheel of relatively very small diameter as ordinarily compared in ratio to the diameter of the steam supply main, the steam main itself in comparative ratio being of relatively large diameter, and therefore supplying a relatively enlarged supply of steam and consequent power delivery as per the comparative size of the motor as a whole, and of course with impact mastery of ultra pressures and velocities, representing a very wide difference between simple, instantaneous abstraction of power, and the prolonged and highly complex abstraction of the power of the steam, the latter being represented both by the old reciprocating engine and not any less truly also by the modern stage turbine, which by its plurality of stages or at least of blade rows, both stationary and rotative, and which by their abrupt obstruction in the path of the steam and operating to vastly slow down the flow of the steam, cause it to fall far behind the ability of the impact principle in the latter's nature of instantaneous and perfect abstraction of the power of the steam, having of course first met the structural conditions which ultra impact mastery necessarily calls for.

What is claimed is:

1. A rotary steam engine comprising a stationary casing formed with an internal rotor chamber, an axially disposed steam inlet entering said casing from one side thereof, a plurality of relatively spaced circularly arranged expansion passages formed in said casing, the restricted inner ends of said passages being in open communication with the axially disposed steam inlet, the enlarged outer ends of said passages terminating in immediate contiguous adjoining relationship, a rotor revolvably supported in the chamber of said casing, impulse receiving blades projecting laterally from one side of said rotor adjacent to its outer circumferential edge to register with the enlarged discharge ends of said passages, an exhaust manifold formed in connection with said casing and surrounding said rotor blades in continuous open communication therewith, and a supporting shaft for said rotor projecting axially from one side thereof in alignment with the steam inlet on the opposite side of said casing.

2. A rotary steam engine comprising a stationary casing, a steam inlet entering said casing from 75

one side and axially thereof, a stator disk arranged within said casing and stationarily carried in connection with one of the walls thereof, a circularly arranged row of relatively spaced crescent-shaped ribs separating the body of said stator disk from the adjoining casing wall, said ribs, stator and casing wall forming a plurality of arcuate outwardly expanding steam passages, the inner restricted ends of said passages being arranged in open communication with said steam inlet and the enlarged outer ends of said passages terminating in immediate contiguous adjoining relationship at the perimeter of the stator disk, a rotor revolvably supported in said casing immediately to one side of the stator disk, impulse receiving blades projecting laterally from one side of said rotor adjacent to its outer circumferential edge in registration with the enlarged outer ends of said passages, an exhaust steam manifold formed in connection with said casing and surrounding said rotor blades in continuous open communication therewith, and a supporting shaft for said rotor projecting axially from one side thereof in alignment with the steam inlet on the opposite side of said casing.

3. A rotary steam engine of the type specified in claim 2 characterized by the angular deflection of the outer ends of the steam expansion passages toward the outer peripheral portion of the rotor and the blades carried thereby.

4. A rotary steam engine of the type specified in claim 2 and further characterized by forming the casing with an annular slot between the exhaust steam manifold and the outer peripheral portions of the rotor blade, the walls of said slot being disposed in spaced order and converging toward said manifold.

5. A rotor for steam turbines comprising a disk-like body, impulse receiving blades projecting laterally from one side of said body adjacent to its outer circumferential edge, a laterally directed flange projecting from the circumferential edge of said body on the opposite side of the latter as regards said blades, said flange being provided with an annular groove, and a wrapped wire reinforcement positioned in said groove and retained therein under tension.

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