July 24, 1934. J. F. METTEN 1,967,962

STEAM TURBINE ROTOR

Filed Sept. 9, 1933

Fig. 1.

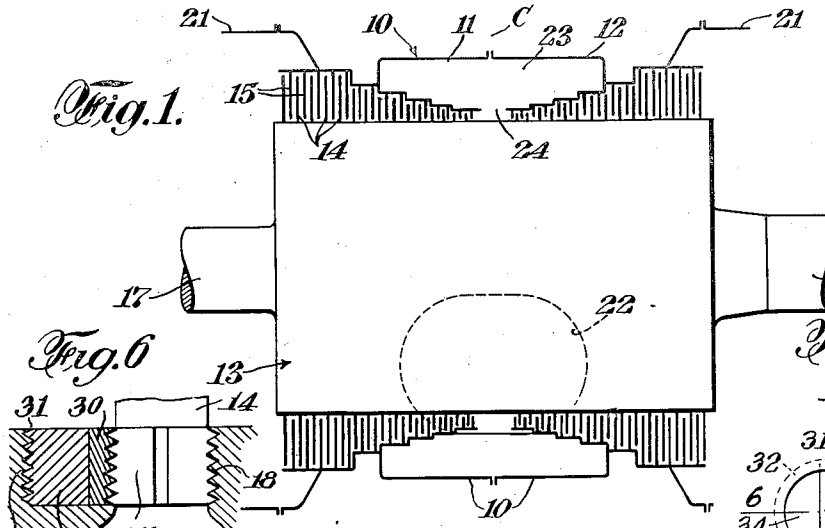


Fig. 6

Fig. 5

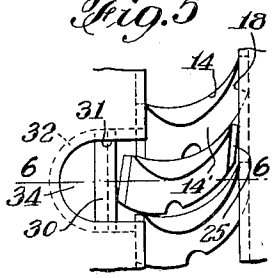


Fig. 2.

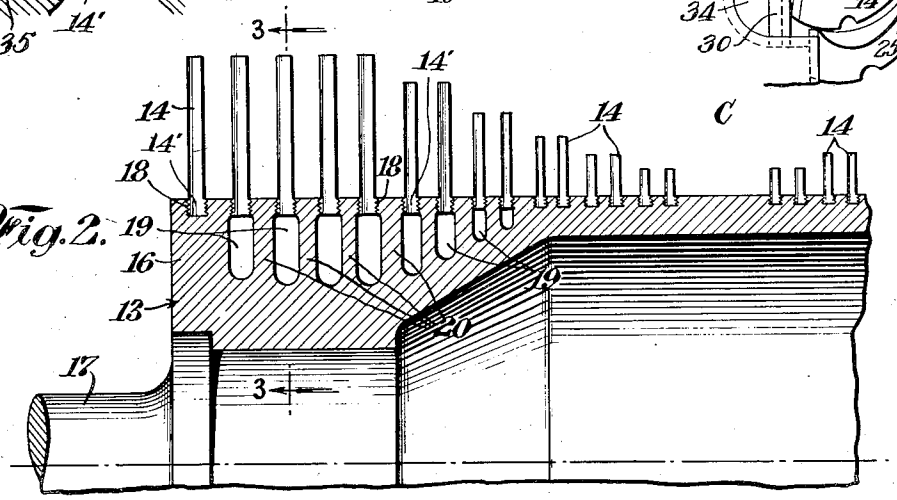
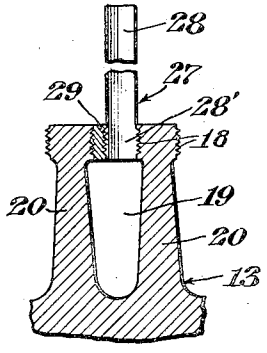


Fig. 7.



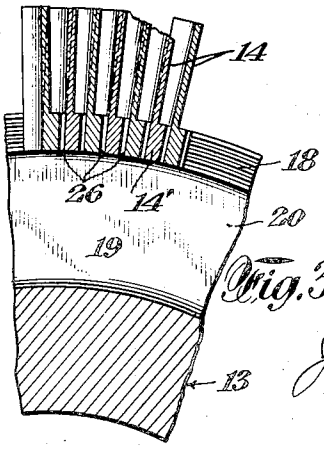
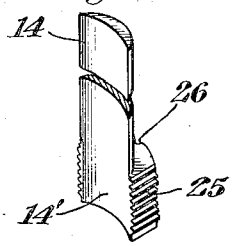


Fig. 3.

Fig. 4.



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STEAM TURBINE ROTOR

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Application September 9, 1933, Serial No. 688,706

10 Claims. (Cl. 253—39)

This invention relates to turbine rotors and particularly to those in which the blades are carried by a rotor of the drum type. Such rotors have the drum in general form of a cylinder into the ends of which the spindle extensions for bearings, glands, etc. are secured by shrink fits or bolts.

The main object of this invention is to provide a rotor drum of this type which is of great strength and light weight avoiding axial flexibility even at high speeds and maintaining close clearances between the relatively movable parts.

Turbine rotors have been generally of the drum type or built up of a series of disks carried by a central spindle or, in rotors for impulse type turbines, formed by turning blade carrying disks and spindles in one piece from a forging. In impulse turbines the spaces required between the disks for the diaphragms separating the stages are ample to permit the necessary machining operation. In reaction turbines, however, no diaphragms are fitted and the close spacing of the blading has heretofore prohibited the machining of solid rotors so as to provide blade carrying disks integral with the shaft or spindle, and this also holds true of impulse turbines where the diaphragms are omitted in the final stages of the low pressure unit.

The drum construction is not objectionable for lower rotative speeds or where with relatively higher speeds the diameter can be kept small and the blades short, for instance, by subdividing the expansion between two or more separate turbines in high pressure turbine design. Where however, the turbine operates under high vacuum conditions at exhaust, the very great increase in vapor volume provided for in the final stages necessitates long blades and with higher powers these blade lengths become excessive. The double flow type of turbine permits these blade lengths to be reduced, but at the same time requires twice the length of the drum that would be necessary with a single flow turbine. Separate disks mounted on a spindle have the advantage of permitting high radial loads, but this construction has such high axial flexibility that its use is practically limited to short rotors of the single flow low pressure type. When employed for longer rotors the critical speed values due to high deflection become so low that the better distribution of metal for high speeds of rotation characteristic of this disk construction cannot be utilized at high speeds, and the stiffer more rigid drum type rotors must be resorted to. These drum type rotors, however, involve limitations due to their relatively poor distribution of metal tending to concentrate weight near the periphery and causing excessive radial loading for high speed operation.

In the turbine rotor of this invention these objections to both the disk and drum type of rotor are overcome so that the high radial loading permissible with the disk construction is combined with the rigidity of the drum type structure preserving the advantages of both constructions and overcoming the limitations of each. To attain this the rotor of this invention provides a disk formation at the blade roots attaining the most favorable distribution of metal to carry the high radial loads, while at the same time maintaining the necessary axial stiffness and rigidity by preserving an integral drum structure wherein each disk is cut from the solid metal and reinforced at the outer portion by the inter-position of the rows of blade roots giving continuous peripheral support.

In the accompanying drawing illustrating the invention:

Fig. 1 is a diagrammatic view showing in vertical section the relation of the rotor and blading of the casing of the turbine;

Fig. 2 is a longitudinal sectional view through a portion of the rotor;

Fig. 3 is a transverse sectional view showing in fragmentary form a portion of the rotor and blading;

Fig. 4 is a perspective view of a typical blade structure;

Fig. 5 is a partial plan view of a detail of the blade locking means;

Fig. 6 is a sectional view taken on the line 6—6 of Fig. 5, but illustrating the parts in a different position, and

Fig. 7 is a sectional view illustrating a modified form of rotor and blade fastening.

Referring to Fig. 1 reference character 10 represents a cylindrical casing of a double flow turbine comprising complementary sections 11, 12 disposed on either side of the center plane C. These cylindrical sections are of the usual construction, that is, the internal periphery is of stepped formation increasing in diameter toward the discharge end in opposite directions from the center plane, thereby forming zones of increasing capacity in conformity with the expansion of the steam.

Disposed centrally of the casing is a cylindrical rotor 13 on the periphery of which are the radiating blades 14 of various sizes, the blades being fitted in correspondingly corrugated grooves in the surface of the cylinder. The lengths of

the blades, of course, increase by stages in the direction of the flow and with the stator blades 15 extending inward from the casing 10 and intervening between the rotor blades.

The grooves 18 at the periphery of the drum or cylinder 13 carry the rotor blades 14 and these grooves vary in size with the sizes of the corresponding blades, the grooves toward the ends tending to be larger for the longer blades.

The stud or spindle extensions of the shafts 17 are adapted to be carried in suitable bearings which may be secured to or form part of the casing sections 11, 12. The sections 11, 12 are suitably flanged and bolted together as shown, and an inlet passage 22 provided to communicate with an annular inlet zone 23 which surrounds an annular inlet space 24 between the sections. The steam is adapted thereby to enter into the working zones at the center plane.

It is desirable that the clearances between the relatively moving units be small and accurately maintained so as to attain high efficiency, and difficulty has been found in maintaining these clearances due to the flexing of the parts.

The rotor 13 preferably comprises a single cylinder or drum 16 of substantially hollow construction with the ends of the cylinder of thickened metal required for structural strength and formed to receive the supporting studs or shafts 17. This, however, locates an excessive weight of metal at the ends of the drum adjacent the periphery increasing the radial loads to be carried but unnecessary in supporting or reinforcing the rotor structure.

In the drum construction of this invention these thickened ends are reformed by having the metal cut away radial in width from the bottom of the blade grooves 18 as indicated at 19, these undercuts varying in depth according to the radial loads and the strength required in the resulting structure.

This construction while reducing the weight of the cylinder preserves the proper distribution of the metal for the necessary strength in holding the high radial loads exerted by the blades. At the same time the desired axial thickness of metal is maintained throughout the entire cylinder so that high speeds may be used with safety and with the maintenance of the established clearances between the parts. Each disk or annular projection 20 between the undercuts 19 carries only half the radial load of the blades on each side of it, and the roots 14′ of the blade 14 wedged in place between the ends of the disk provide a continuous cylindrical periphery acting to stiffen the entire structure. At the center portions of the drum the cylinder is in solid formation without the deepening of the blade root grooves, so that combined with the disk structure at the ends of the rotor there is a central solid drum structure, the two cooperating to provide a continuous solid cylindrical periphery for stiffness with end disks most efficiently distributing the metal for high radial loads.

In Fig. 4 a typical blade 14 is shown in perspective with its root 14′ provided with side serrations or corrugations 25 exactly fitting the correspondingly machined corrugations of the rotor grooves 18. These blades nest tightly together in series and where the root grooves are extended downward as at 19, the blades are provided between them with relief grooves 26 to permit any liquid within the portions 19 to escape outward. In the separate blade as shown in these Figs. 1, 2, 3 and 4 a side stop piece 30 is fitted in the wake of the last blade installed in a row so as to close that row and hold the blades in place as shown in Figs. 5 and 6 illustrating the method of inserting the last blade of a row, and vertical groove 31 (Fig. 5), is milled at one side of each row and the width of this groove 31 is a little larger than the thickness of a blade root 14′ and packing piece or side stop piece 30. This groove 31 has the serrations 32 carried around its inner surface and conforming to the serrations 25 in the blade root 14′. The packing piece or block 30 is fitted in this groove with serrations carried around three sides of the block, the serrations in the ends of the block matching the serrations in the sides of the milled groove which is made deep enough to permit the block to be moved away from its final position far enough to allow the blade root 14′ to be inserted in the last space as shown in plan view in Fig. 5. While the two radii of the blade root surfaces are not exactly concentric the last or inserted blade root may be filed enough on one side to permit its being driven down radially a little off center (Fig. 5) after which it is driven around in place in alinement with the other blades (Fig. 6). The side piece 30 is then moved over so that its inner serrations on the side next to the blade root engage with the blade root serrations (Fig. 6), and the space 34 behind the side piece is then filled up by copper 35 caulked in to form a packing with the blade thus inserted and driven sidewise into place, and with the block 30 serrated to fit the sides of the grooves 31 and forced over so that the serrations on the face of the block match those on the sides of the blade root. The radial pull of the blade is transmitted to the block 30 and from the block to the side serrations 32 in the groove 31. The caulked packing that fills the space 34 behind the block 30 prevents the block from moving away from the blade.

In Fig. 7 a sectional view of a modified form of blading is shown similar to the form of Figs. 1 to 4 except that a segmental type of blading 27 is shown consisting of blades 28 and root pieces 28′ pressed or otherwise secured to the blades. These root pieces and blades are made up in segments of over four to eight inches long and secured by a serrated side locking ring 29 also in segmental form.

The cut away portions 19 being formed as inward extensions of the blade root grooves 18 are readily machined out to desired depth and shape. The dimensions of these spaces for the resulting dimensions of the integral disk structure will be determined in each case by the calculated distribution of the metal necessary for high radial loads at the intended speeds of the turbine. Each of the disks or annular projections 20 so formed is proportioned to carry one half of the radial load of the blading at each side of the disk. The resulting structure provides a series of disks and rows of blades alternating and with the radial center line of each disk or annular projection between the center lines of the blade rows on each side. This structure thus has all the advantages of the separate disk type of rotor where a series of disks are mounted on a central spindle or shaft, but with greater stiffness and rigidity due to the maintenance of the drum construction and the integral formation of the entire structure. After the formation of the cut outs the assembly of the blade roots in the grooves 18 completes the cylinder at the periphery and provides longitudinal peripheral reinforcement necessary to avoid flexing and distortion under high speeds of

rotation. The structure provided by this invention thus combines the advantages of the disk and drum types of rotors and avoids the disadvantages of each.

Although the invention has been illustrated as specially adapted to a turbine of the double flow reaction type, it is understood that it may be used with other types.

I claim:

1. In a steam turbine a rotor of the drum type in the general form of a hollow integral cylindrical member having its ends provided with spindle extensions, and formed on the peripheral portions at the ends into a series of annular projections separated at their peripheries and integrally joined at their inner portions, blade grooves formed by the sides of the said projections at the peripheries thereof, and blades having their roots mounted in said blade grooves.

2. In a steam turbine a rotor of the drum type in the general form of a hollow integral cylindrical member having its ends provided with spindle extensions, and formed on the peripheral portions at the ends into a series of annular projections separated at their peripheries and integrally joined at their inner portions, blade grooves formed by the sides of the said projections at the peripheries thereof, said grooves being narrower in width than the spaces between said projections below the corresponding grooves, and blades having their roots mounted in said blade grooves.

3. In a steam turbine a rotor having an integral hollow cylindrical member of varying radial depth recessed from the periphery inward so as to be formed at one portion with peripheral blade grooves of substantially the same depth as the corresponding blade roots, and at another portion with blade grooves having cut-away spaces below the blade roots shaping said portion of said cylindrical member into a series of annular projections between the corresponding blade grooves, and blades having their roots fastened in said grooves, the blades in said second-mentioned grooves being longer than the blades in said first-mentioned grooves.

4. In a steam turbine a rotor comprising an integral hollow cylindrical member of varying radial depth having a series of blade grooves and recessed from the periphery inward so as to be formed at one portion thereof into a series of annular projections by increasing the depths of the blade grooves between said projections to widths greater than the widths of the corresponding grooves, and blades having their roots fastened in said grooves.

5. In a steam turbine a rotor comprising an integral cylindrical member having a series of peripheral blade grooves of varying radial depths, the grooves at the end portion thereof being increased in depth to form the said member into a series of annular projections so as to effect a distribution of metal adaptable for high radial loads while maintaining axial stiffness of the rotor as a whole for high critical speed values, and blades adapted to be mounted in said grooves.

6. In a steam turbine a rotor comprising an integral cylindrical member having a series of peripheral blade grooves of varying radial depths, the grooves at the end portion thereof being increased in depth to form the said member into a series of annular projections so as to effect a distribution of metal adaptable for high radial loads while maintaining axial stiffness of the rotor as a whole for high critical speed values, and blades adapted to be mounted in said grooves, each of said projections being so formed and proportioned as to carry one-half of the radial load of the blade at each side of the corresponding projection.

7. In a steam turbine a rotor having an integral generally cylindrical part hollow at the center and supported at the ends and having its ends provided with a series of recesses extending from the periphery inward so as to be formed at the ends into a series of annular projections of varying radial extent by intermediate recesses of varying depth, and blades having their roots mounted between the outer portions of said projections.

8. In a steam turbine a rotor having a portion of generally hollow cylindrical form varying in radial depth of metal and recessed from the periphery inward so as to be cut into a series of annular projections by intermediate spaces of varying radial depth so as to form projections of different radial extent, and blades having their roots mounted between said projections.

9. In a steam turbine a rotor structure comprising a generally hollow cylindrical drum tapering to less thickness of metal toward the center, annular projections formed in the thicker portion of said drum by intermediate spaces, and blades having their roots fastened to the outer portions of said projections, said projections being of progressively greater radial extent toward the end of said drum.

10. In a steam turbine a rotor of the drum type in the general form of a hollow integral cylindrical member having its ends supported by spindle extensions and having a series of grooves cut inward from its outer surface to form a series of annular projections separated at their peripheries and integrally joined at their inner portions, means for mounting blades between the outer portions of said annular projections so that said grooves extend beyond the lower end of the mounted blade roots, and rows of blades having their roots fitted solidly between the peripheral portions of said projections so as to provide a continuous solid cylindrical periphery.

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