Oct. 19, 1926. 1,603,966

C. LORENZEN

TURBINE ROTOR

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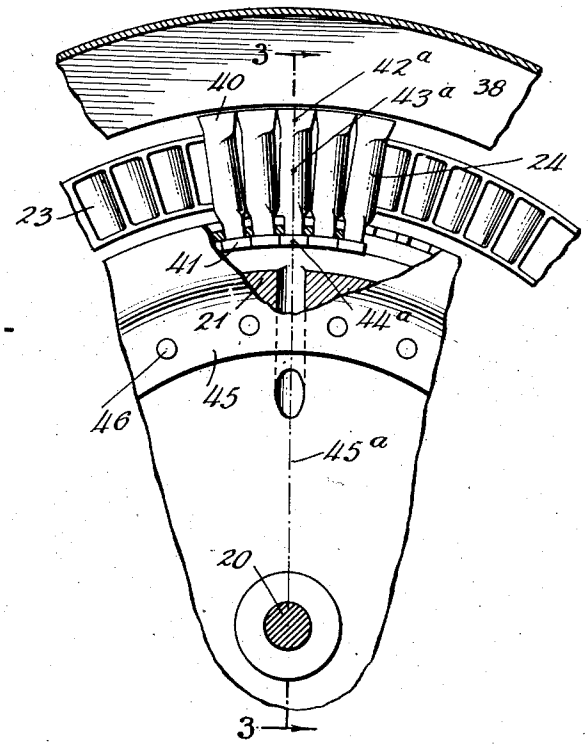
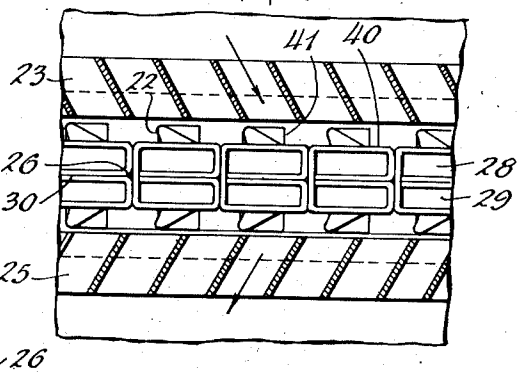


Fig. 1.

Fig. 2.



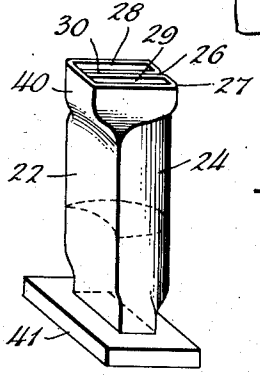


Fig. 3.

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Fig. 3.

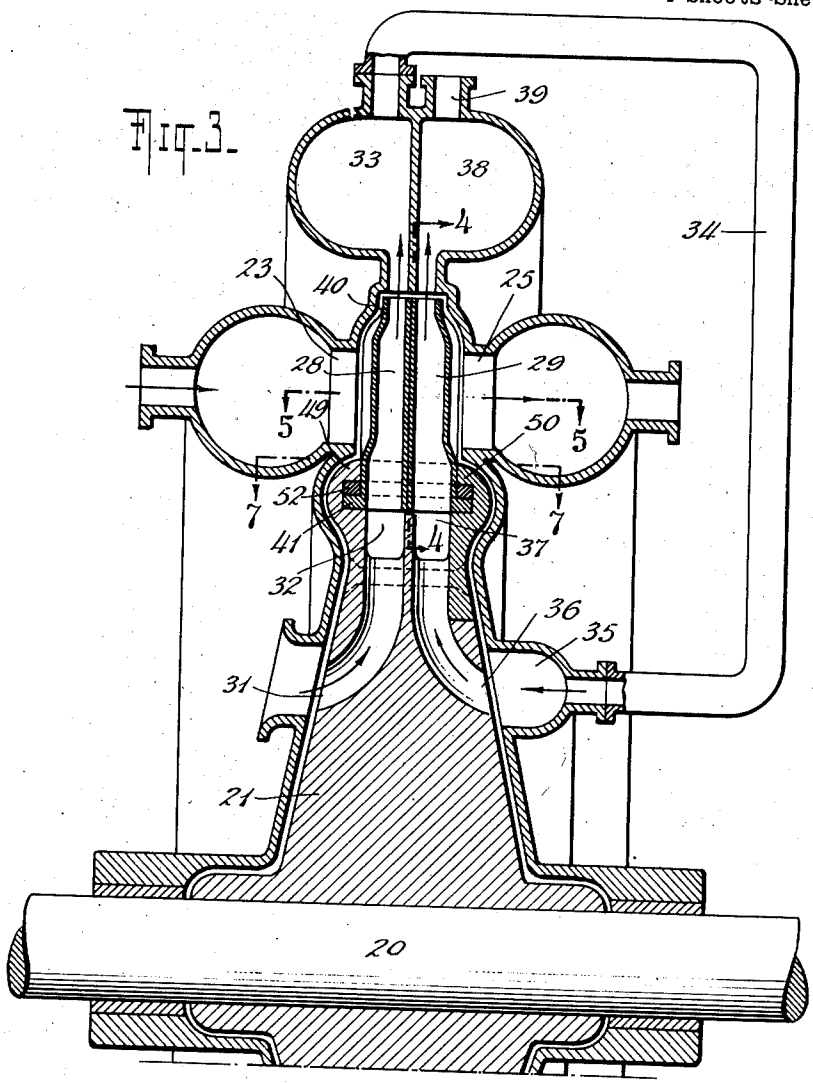


Fig. 5.

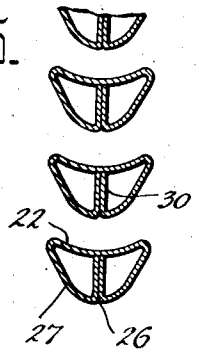


Fig. 4.

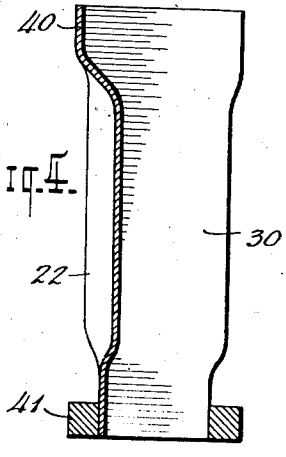
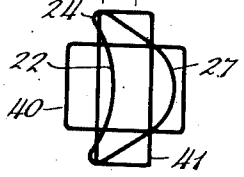


Fig. 6.



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Fig. 7.

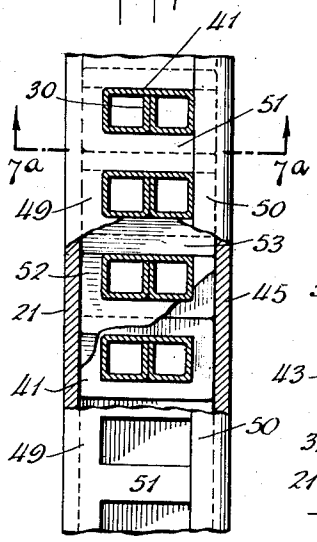


Fig. 7a.

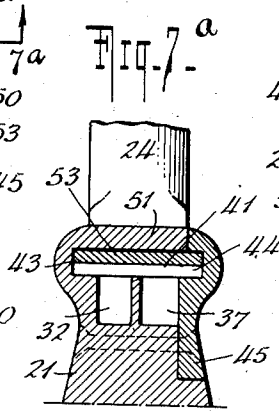


Fig. 10.

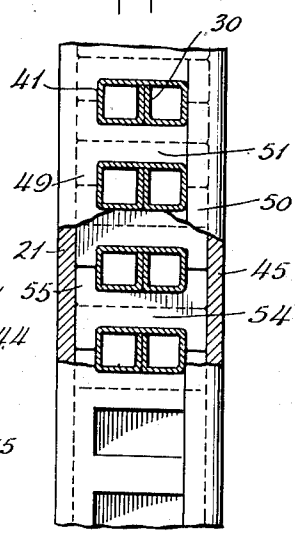


Fig. 8.

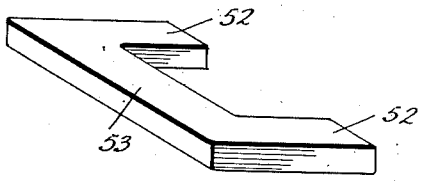


Fig. 11.

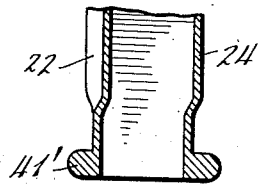


Fig. 12.

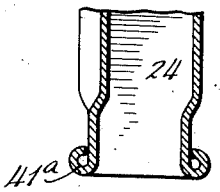
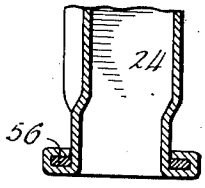


Fig. 13.



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Fig. 14.

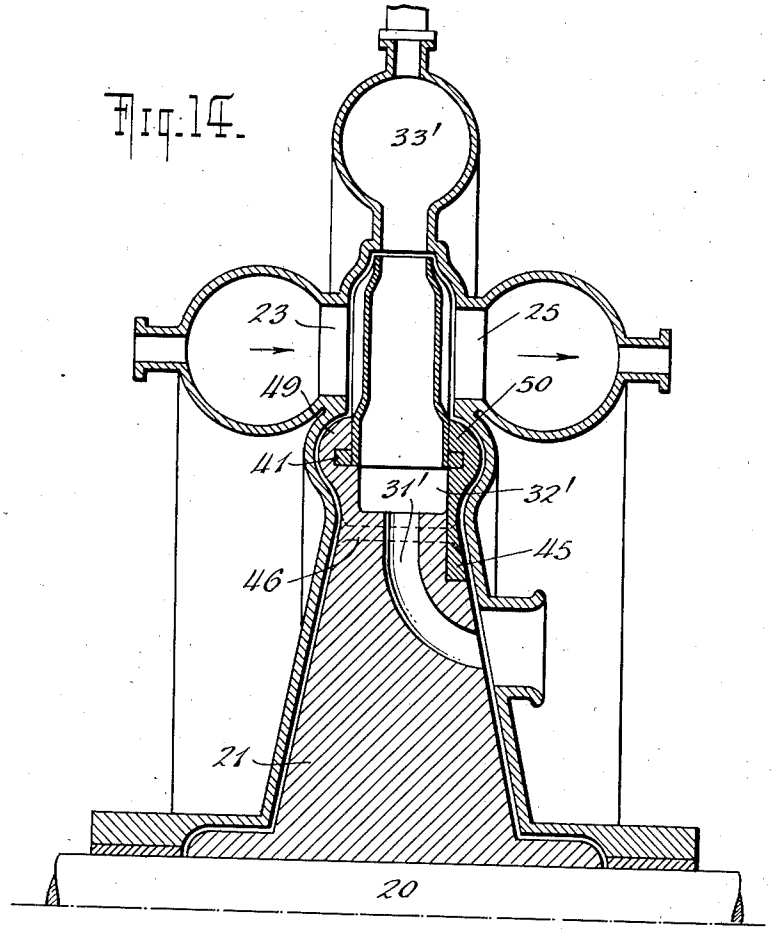


Fig. 15.

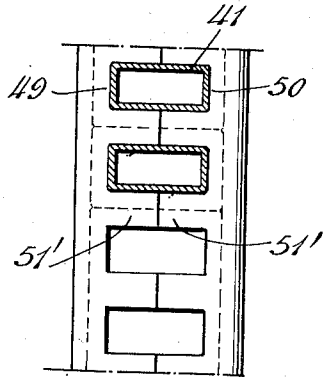


Fig. 16.

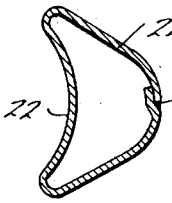


Fig. 17.

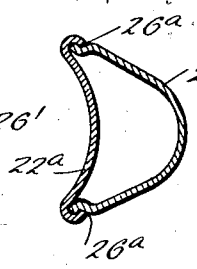
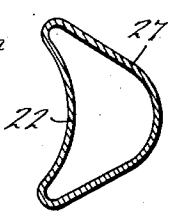


Fig. 18.



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Patented Oct. 19, 1926. 1,603,966

UNITED STATES PATENT OFFICE.

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TURBINE ROTOR.

Application filed June 2, 1925, Serial No. 34,345, and in Germany January 29, 1924.

My present invention relates to turbine rotors, and particularly to the blades and the means for holding or fastening them upon the rotor bodies. The object of my invention is to secure the blades firmly, to guard them against distortion even at high speeds, to provide a construction enabling the blades to act efficiently as elements of a centrifugal air compressor, and to obtain other advantages which will appear from the disclosure made in the accompanying drawings and in the description following hereinafter:

Several satisfactory embodiments of the invention are illustrated in the accompanying drawings, in which Fig. 1 is a view looking in the direction of the turbine axis, showing a portion of the rotor and of the stator, with parts in section; Fig. 2 is a partial edge view; Fig. 3 is a sectional detail view on the line 3—3 of Fig. 1; Fig. 4 is a longitudinal section on line 4—4 of Fig. 3, showing the blade alone; Fig. 5 is a section on line 5—5 of Fig. 3; Fig. 6 is a diagrammatic view illustrating the relation of cross sections of the blade taken at different points thereof; Fig. 7 is a section on line 7—7 of Fig. 3; Fig 7^a is a section on line 7^a—7^a of Fig. 7; Fig. 8 is a perspective view of one of the fillers used in Figs. 1 to 7; Fig. 9 is a perspective view of the blade; Fig. 10 is a view similar to Fig. 7 but showing a modified form of filler; Figs. 11, 12 and 13 are partial longitudinal sections showing modified forms of the inner or "foot" portion of the blade; Figs. 14 and 15 are views corresponding to Figs. 3 and 7 respectively, and illustrating another form of my invention; and Figs. 16, 17, and 18 are cross sections illustrating modified forms of the body portion of the blade.

My present application is a continuation in part of my co-pending application Serial No. 536,562, filed in the United States Patent Office on February 14, 1922.

In the construction illustrated by Figs. 1 to 8 the shaft 20 carries the rotor body 21 to the outer portion of which are secured, in the manner described hereinafter, the inner ends or "feet" of the blades, which rotate in unison with said body. Against the outer surfaces of these blades, the impelling medium (which may be heated air, combustion gases, or any other suitable agent) is directed by any well-known or approved devices. Thus, in Figs. 1 and 2, I have indicated stationary nozzles 23 for discharging the driving medium against the blades, such medium passing between the body portions 24 of adjacent blades and then between stationary directing blades 25 (Fig. 2) which may be of well-known character.

The body portions 24 of the blades may be given any well-known or approved external configuration to be properly impelled by the medium discharged from the nozzles 23. In order that the turbine may at the same time act as a compressor for air or other gaseous fluid, the blades are made hollow so that the fluid to be compressed may pass through them lengthwise, from their inner ends to their outer ends. The blade may be made of sheet metal bent to the desired shape, the body portion being shown with a concave front face 22 against which the impelling fluid strikes. In the particular construction shown in Figs. 1 to 8, the blade has a longitudinal seam or joint 26, and whenever such a joint is employed in constructing my improved blade, I prefer to arrange it on the rear surface 27 of the blade, so that there will be no joint or unevenness on the front or active face 22, and this smoothness of the front face insures a ready passage of the motive fluid and increases the efficiency of the turbine. Fig. 2 to 6 show the sub-division of the internal compressor channel of the blade into a plurality of channels 28, 29 by means of a partition or partitions 30, here shown as extending in planes of rotation, or in other words, in planes perpendicular to the axis of the shaft 20. This is of especial advantage when compression is to effected in two or more stages. Air may enter through channels 31 provided in the rotor body 21 and extending outwardly so that centrifugal force, by throwing the air outwardly in said channels, will exert suction at the inner ends of the channels, while an annular channel 32 distributes the air from the outer ends of the channels 31 to the inner ends of one set of blade channels (for instance 28). The compressed air issuing from the outer ends of these blade channels 28 is received in a stationary collector channel or diffusor 33, from which a pipe or other suitable connection 34 leads to a chamber 35 in a stationary casing,

said chamber communicating with the inner ends or inlets of blade channels 36, similar to the channels 31. The ends of the channels 36 communicate with an annular distributing channel 37, similar to the channel 32, and communicating with the blade channels of the other set, 29. The latter discharge the air, which has thus been compressed in two stages, into a stationary collector channel or diffusor 38, from the outlet 39 of which the air is taken to the place of use or further treatment.

The arrangement of the blades, the relation of their portions to each other, and the manner of fastening the blades to the rotor body at their inner portions or "feet", constitute important features of my invention.

In Figs. 1 to 8, the body portion 24 of the blade has the well-known crescent shape, in cross-section. The blade heads 40 are rectangular, with the shorter side of the rectangle parallel to the turbine axis. The "feet" 41 of the blades are also rectangular, but with the longer sides of the rectangle parallel to the turbine axis. The centers of gravity of the body portion 24, head 40, and foot 41 have been indicated at 42^a, 43^a, and 44^a respectively, and these three centers lie in a straight line 45^a which, if extended, will pass through the turbine axis, as shown in Fig. 1. Of course, the center of gravity of the entire blade will necessarily also be on the line 45^a (said center generally coinciding with the center of gravity 42^a of the body portion 24, or being close thereto). Since the foot 41 constitutes that portion of the blade which is held or fastened in the rotor body, it follows that the center of gravity of the entire blade lies in radial alignment with the center of gravity of the portion held fast in the rotor, and a very secure attachment is thus obtained together with the avoidance of circumferential bending strains which would result if the center of gravity of the entire blade were not in a radial line with the center of gravity of its attached portion or foot.

The foot 41 of the blade may be a separate piece welded or otherwise secured to the inner end of the blade body. The interior cross sectional area of the foot is preferably greater than that of the body portion, as is indicated in the diagram Fig. 6, and the interior cross sectional area of the head 40 is likewise preferably greater than that of the body portion. The purpose of this arrangement is to cause the cooling fluid to flow faster in the main portion of the blade, which portion is struck by the hot gases; a better cooling effect is thus obtained. On the other hand, the velocity of the medium flowing through the blade is reduced at the other portions of the blade and thus lessens the frictional resistance and is therefore an advantage of considerable importance.

The blade feet 41 are preferably in contact with each other at their adjacent transverse edge, see Fig. 7. Their circumferential edges are fitted on one side into a recess 43 of the rotor body 21 and on the other side into a similar circumferential recess 44 of a rotor portion 45 which is firmly secured to the said body, as by rivets 46. The recesses 43, 44 are preferably continuous. In this particular form of my invention, the recesses 43, 44, are of sufficient depth to receive not only the flanges of the blade feet, but suitable fillers which hold the blades against being thrown outwardly by centrifugal force. The parts 21, 45 have circumferential extensions of lips 49, 50 respectively, the inner edges of which are adapted to engage the sides of the blades, as shown in Figs. 7 and 15, to hold the blades against bending lengthwise of the turbine axis. Futhermore, the front and rear surfaces of the blades, adjacent to their feet 41, are engaged by teeth or projections 51 which extend from one lip 49 to the other lip 50, the inner faces of said teeth (that is, the faces toward the turbine axis) engaging the transverse foot portions at their outer faces. In Fig. 7, the teeth 51 are formed exclusively on one member (the body 21) and extend therefrom all the way across the gap between the lips 49, 50. Of course, I do not wish to limit myself to this specific construction. The fillers fitted into the recesses 43, 44, may be U-shaped, with their parallel end members 52 extending under the lips 49, 50, while the transverse central members 53 of the fillers lie directly under the teeth 51, the ends of adjacent fillers being preferably in contact with each other.

With the construction described, the blades are held in position very firmly and rigidly, and will not be deformed by centrifugal force or by the other forces acting on them.

I-shaped fillers, as shown in Fig. 10, may be employed instead of U-shaped ones, as will be evident from an inspection of the drawings. The transverse members 54 would be placed in exactly the same position as the members 53, but the circumferential end members 55 of a filler engage the feet 41 of two adjacent blades, whereas the end members 52 of a U-shaped filler engage the foot of one blade only.

The construction may be modified in various ways without departing from the nature of my invention as set forth in the appended claims. For instance, instead of a blade of the form described above, I may employ one in which the foot 41′ is integral with the other parts of the blade, as indicated in Fig. 11. Or I may adopt the form shown in Fig. 12, where the foot 41^a consists of a rolled edge portion at the inner end of the body portion 24. If desired, a strengthen-

ing member 56 may be enclosed in said rolled edge portion, see Fig. 13.

The blade may be made without any internal partition. Such a construction is shown in Figs. 14, 15 where the air intake channels 31′ are located exclusively in the body portion 21 of the rotor, the rotor having a single peripheral channel 32′, and a single stationary collector channel or diffusor 33′ is provided. In other respects, the construction is very similar to the one first described, as will be evident without further explanation, similar reference numerals having been used to designate analogous parts. There is another difference, however, in that no fillers such as 52, 53 or 54, 55 are employed, the upper or outer surfaces of the blade feet 41 being in direct engagement with the lips 49, 50. Furthermore, instead of forming teeth exclusively on one of the members 21. 45 as in Fig. 7, I have, in Fig. 15, provided teeth 51′ on both of said members, such teeth extending from each member about half-way across the space or gap between the lips 49, 50.

A few of the numerous possible modifications of the blade, and particularly its body, have been shown in Figs. 16 to 18. In Fig. 16, the blade edges are lapped on its rear face to form a joint 26′. Fig. 17 illustrates the blade as made of a front section 22^a and a rear section 27^a, with the longitudinal joints 26^a located on the rear face of the front section, near the edges thereof. Fig. 18 shows a hollow or tubular blade made of a single piece and without any joints or seams.

I claim:

1. A turbine blade having a concave forward face and a convex rear face, a longitudinal seam in the middle of said rear face, and a longitudinal partition between said faces, said partition being formed integral with said rear face.

2. A turbine blade having an active body portion of crescent-shaped cross section, a rectangular foot portion at one end of said body portion, and a rectangular head portion at the other end of said body portion, all three portions being tubular so as to form a longitudinal passage through the blade.

3. A turbine blade having an active body portion of crescent-shaped cross section, a rectangular foot portion at one end of said body portion, and a rectangular head portion at the other end of said body portion, the longer side of the rectangular foot portion being disposed in a direction at right angles to the longer side of the head portion, all three portions being tubular so as to form a longitudinal passage through the blade.

4. A turbine blade provided with a longitudinal channel subdivided by a longitudinal partition, said blade comprising an active body portion of crescent-shaped cross section, a rectangular foot portion at one end of said body portion, the shorter side of the rectangle extending parallel to said partition, and a rectangular head portion located at the other end of said body portion, the longer side of the head rectangle extending parallel to said partition.

5. A tubular turbine blade having an active body portion of crescent-shaped cross section, a rectangular foot portion at one end of said body portion, a rectangular head portion at the other end of said body portion, and means for supplying fluid to the interior of said blade, the interior cross sectional area of said body portion being smaller than either that of the foot portion or that of said head portion, whereby the velocity of the fluid passing through the blade will be greater in the body portion than in the other portions.

6. A tubular turbine blade having an active body portion and a tubular foot portion for attaching said blade to its carrier, the interior cross-sectional area of said body portion being smaller than that of said foot portion.

7. A turbine blade comprising a hollow body portion of crescent shaped cross section and a rectangular foot portion, said foot portion being provided with an external flange extending around its periphery.

8. A blade for gas turbines comprising a hollow body portion of crescent shaped cross section having a concave forward surface and a convex rear surface, said body portion being provided with a double longitudinal partition formed integral with said rear surface.

9. A turbine rotor having a rotor body and tubular blades secured to said body, each blade comprising an active hollow body portion, a rectangular hollow foot portion located at the inner end of said body portion and attached to the rotor body, the longer side of the rectangular foot portion being parallel to the rotor axis, and a rectangular hollow head portion located at the outer end of the said body portion, the shorter side of the rectangular head portion being parallel to the rotor axis.

10. A turbine rotor comprising a rotor body and tubular blades carried thereby, each blade having a hollow inner portion or foot provided with an external flange extending all the way around such foot, and means on the rotor body engaging said flange all around the foot.

11. A turbine rotor comprising a rotor body and tubular blades carried thereby, each blade having a hollow inner portion or foot of rectangular outline provided with an external flange having two sides extending transversely of the rotor body, parallel to

the turbine axis, and two other sides extending circumferentially of the rotor body, and means carried by the rotor body and engaging said flange both along its transverse sides and along its circumferential sides.

12. A turbine rotor comprising a rotor body provided with a circumferential groove, spaced lips adjacent to groove, and spaced teeth extending transversely from one lip to the other, and tubular blades having hollow inner portions or feet provided with flanges fitted into said groove, said teeth extending between adjacent blades and engaging them, and said lips overhanging portions of said flanges.

13. A turbine rotor comprising a rotor body provided with a circumferential groove, spaced lips located adjacent to said groove, at a greater distance from the turbine axis, and likewise extending circumferentially of the rotor body, and spaced teeth extending transversely from one lip to the other, and tubular blades having hollow inner portions or feet provided with flanges fitted into said groove, said teeth extending between adjacent blades and engaging them, and also engaging the transverse portions of said flanges on the outer faces thereof, while said lips engage the circumferential portions of said flanges.

14. A turbine rotor comprising a rotor body provided with blade-holding recesses having overhanging portions to block the outward movement of the blades, and blades having flanges fitted in said recesses, said body further having transverse fillers extending between adjacent blades and holding said blades in a circumferential direction against circumferential movement.

15. A turbine rotor comprising a blade-holding body and tubular blades the interior cross sectional area of which varies lengthwise of the blade, said blade having hollow inner ends or feet of which are attached to said body, the center of gravity of the entire blade and that of its attached portion or foot being in a straight line which intersects the rotor axis.

16. A turbine rotor comprising a blade-holding body and tubular blades each of which has a body portion adapted to receive the impact of the driving fluid, a foot portion consisting of a rectangular prism located at the inner end of said body portion and attached to the rotor body, and a head located at the outer end of said body portion and engaging the heads of the adjacent blades, the centers of gravity of the head portion, the body portion, and the foot portion of the same blade lying in a straight line which intersects the rotor axis.

In testimony whereof I have hereunto set my hand.

CHRISTIAN LORENZEN.