PUBLISHED

MAY 25, 1943.

BY A. P. C.

U. MEININGHAUS

BLADE CARRYING ROTORS FOR AXIAL FLOW ROTARY MACHINES

Filed Jan. 3, 1941

Serial No. 373,008

3 Sheets-Sheet 1

Fig. 1

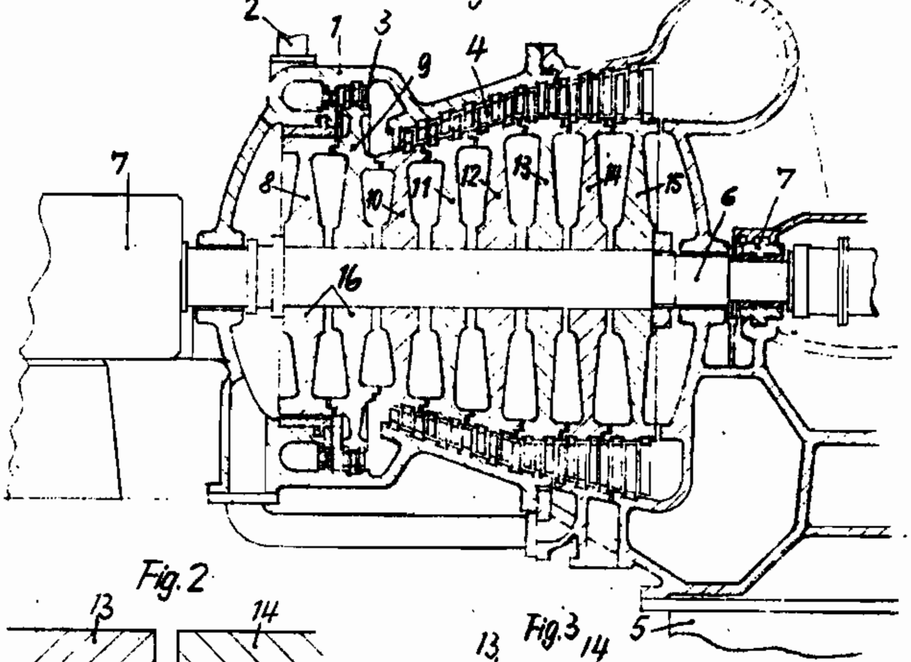


Fig. 2

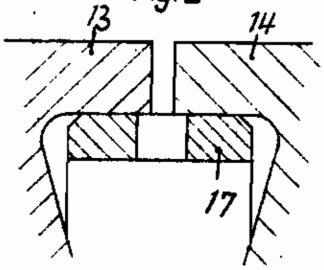
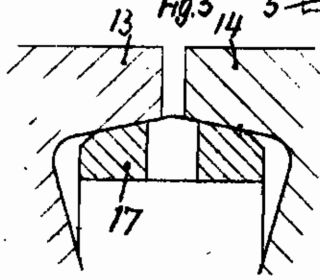


Fig. 3



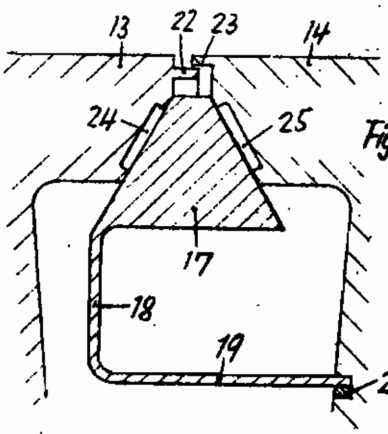


Fig. 4

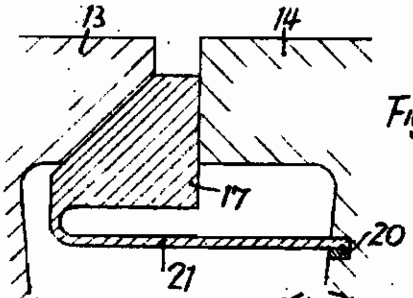


Fig. 5

U. Meininghaus
INVENTOR

BY [illegible]
ATTORNEYS

PUBLISHED
MAY 25, 1943.
BY A. P. C.

U. MEININGHAUS
BLADE CARRYING ROTORS FOR AXIAL
FLOW ROTARY MACHINES
Filed Jan. 3, 1941

Serial No.
373,008
3 Sheets-Sheet 2

Fig. 6

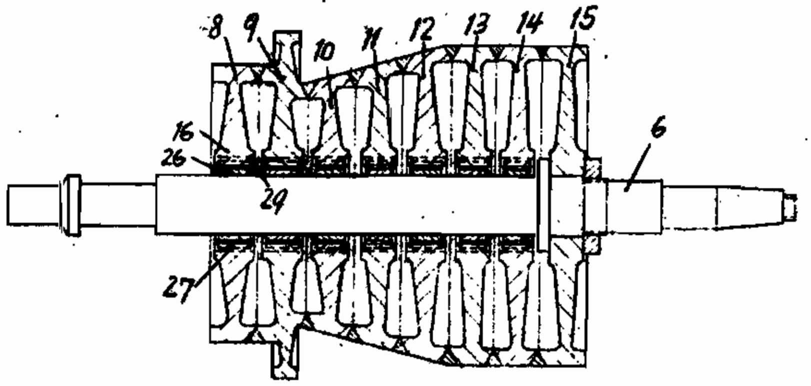


Fig. 7

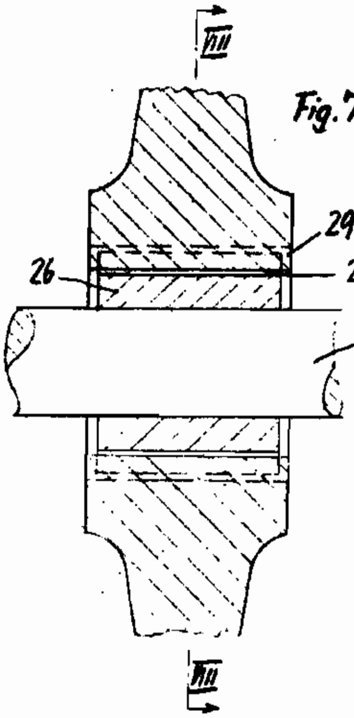
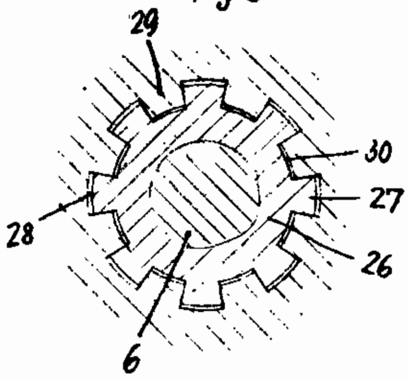


Fig. 8



U. Meininghaus
INVENTOR
BY [signature]
ATTORNEYS

PUBLISHED

MAY 25, 1943.

BY A. P. C.

U. MEININGHAUS
BLADE CARRYING ROTORS FOR AXIAL
FLOW ROTARY MACHINES
Filed Jan. 3, 1941

Serial No.
373,008

3 Sheets—Sheet 3

Fig. 9

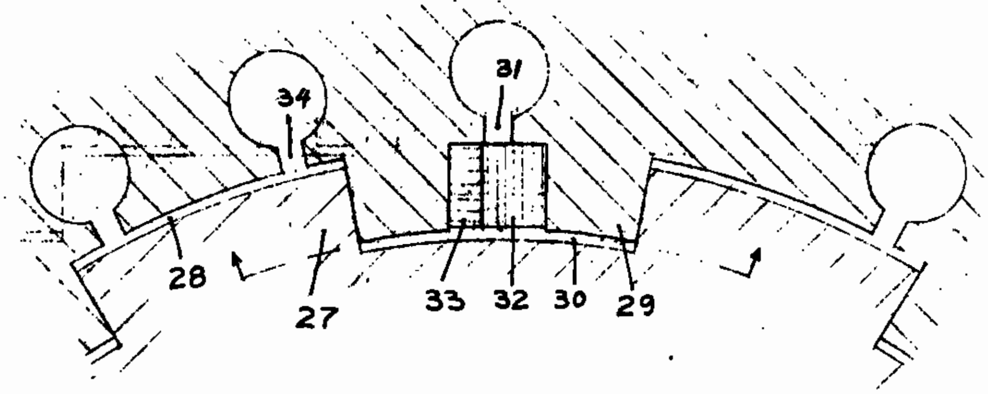
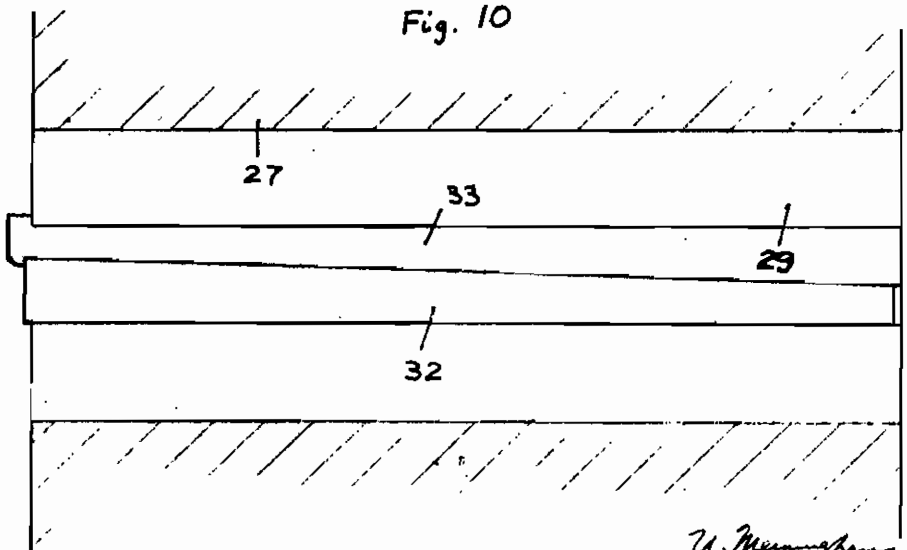


Fig. 10



U. Meininghaus
INVENTOR
BY [signature]
ATTORNEYS

Published May 25, 1943 **Serial No. 373,008**

ALIEN PROPERTY CUSTODIAN

BLADE CARRYING ROTORS FOR AXIAL FLOW ROTARY MACHINES

Ulrich Meininghaus, Muelheim-Ruhr, Germany; vested in the Alien Property Custodian

Application filed January 3, 1941

The present invention relates to the construction of rotors carrying blades for axial flow rotary machines, and especially for steam and gas turbines.

It is the general object of the invention to provide an improved rotor for axial flow engines which is capable of running with a high number of revolutions per minute without showing any noticeable critical speed over the total actually used range of speed, and in particular a rotor which is easily to manufacture from parts kept in storage and formed to give a high resistance to centrifugal forces and which, therefore, is built up of a plurality of single discs with axially extending rims. Other, more specific objects of the invention will appear from the detailed description hereinafter.

The accompanying drawings illustrate by way of example different embodiments of the invention. Fig. 1 gives a vertical section through a steam turbine with a rotor according to the invention; Fig. 2 shows in an enlarged scale a section through a part of the rim of the rotor with a cylindrical ring inside of the rims of two adjacent discs; Fig. 3 the same section with a conical ring inside of the rims of two adjacent discs; Figs. 4 and 5 with a conical ring between the rims of two adjacent discs; Fig. 6 illustrates a rotor wherein the rims of adjacent discs are welded together and Figs. 7 and 8 give in detail the way of supporting the hubs of these discs on the shaft.

In Fig. 1 the steam enters the turbine housing 1 at 2, impinges the Curtis-blading 3 and flows then through the reaction blading 4 leaving the housing at 5. On the shaft 6 which is supported in the bearings 7 the discs 8—15 are shrunk. At the same time the rim of the disc 9 is rigidly supported in radial direction against the rim of the disc 8, the rim of the disc 10 against the rim of the disc 9 and so on. This support of the rims against each other in radial direction prevents any radial displacement of the rims relative to each other and therewith any radial displacement of the adjacent hubs 16 and of the different sections of the shaft 6 on which the hubs 16 are shrunk. In this way the shaft 6 is stiffened in a way that rises the critical speed of the shaft considerably. In fact the rotor construction as shown provides for higher critical speeds than heretofore known constructions. Compared with a rotor wrought of one piece of steel the total weight as one factor determining the critical speed is considerably reduced the shaft ends being just as rigidly connected to the whole assembly. Compared with a rotor welded together of single discs without centre bore the total weight is the same, but the shaft ends are more rigidly connected to the whole assembly than the two stub ends which are in direct connection with the end discs only.

The stiffness of the rotor will be further increased when the rims of adjacent wheels are additionally supported against each other in axial direction. For instance the rims of adjacent discs may be welded together as shown in Fig. 6. This may be done if the temporary difference in expansion between the rims and the shaft is taken up by axial gliding of the support between the hubs and the shaft. But dampening any relative lateral movement of the rims of adjacent discs will be sufficient in general. The construction of Fig. 2 provides a support of the rims of adjacent discs in radial direction which allows for gliding in axial direction so that any differential expansion of the rims as compared with the expansion of the shaft may be taken up by the rim support. This axially gliding support of the rims is effected by a ring 17 arranged inside of the rims 13 and 14 and pressed with its cylindrical outer circumference against the inner cylindrical surfaces of the rims 13 and 14 thus allowing to provide a rigid connection between the hubs and the shaft. The radial pressure exerted by the ring 17 is determined to the main part by the centrifugal force acting on the ring according to the chosen relation of the radial thickness of the ring wall to the mean ring radius. Additionally the ring may be pressed or shrunk into the rims without increasing the radial pressure considerably on account of the high elasticity of such thin walled rings. The radial pressure may, therefore, be determined practically independent of small deviations in the fit. This is a great advantage compared with the rotor construction shown in Fig. 1. The friction damping lateral movements of the rims will be comparatively small, constant and equally distributed on the circumference thus practically eliminating additional bending forces on the shaft in case of differential expansion of the rims. According to this part of the invention a comparatively small friction will suffice to prevent temporarily relative lateral movements of adjacent rims and thus allow for safely going through a critical speed. Thus the first critical speed may be chosen below the normal running speed of the rotor and will notwithstanding not effect the starting and stopping of the turbine.

In this way the advantages of actually running above the first critical speed are made use of at the same time eliminating the disadvantages.

In the construction of Fig. 3 the outer circumference of the rings 17 is provided with conical surfaces which press against corresponding conical surfaces of the rims 13 and 14. This construction facilitates the mounting of the rings 17 if these rings are inserted with some initial radial pressure to insure a tight fit in all conditions. At the same time it allows to increase the resistance against gliding of the rings 17 against the rims 13 and 14 and thus to prevent any gliding which may be caused continuously during each revolution by the slight bending of horizontal shaft due to the weight imposed on it. The friction should be such that gliding of the ring 17 against the rims 13 and 14 should occur only if a differential expansion between the rims and the shaft has to be equalized.

If the slant of the conical surfaces of ring 17 is increased as shown in Fig. 4 the rings 17 will be positioned between the rims of the adjacent discs. To secure an absolute centric position of the ring 17 it is held in position by an elastic wall 18 and an elastic ring 19 which is fastened to one of the discs by means of a caulking wire 20. The one end of the ring 17 may even press against the rim 14 with a radial surface if only the other end presses against the rim 13 with an inclined surface according to Fig. 5. The ring 17 must only have a smaller axial thickness at the outer circumference than at the inner circumference. Means for securing the relative centric position of ring 17 and the rim 14 are then indispensable but simpler. One elastic ring 21 is sufficient. With the increased slant the ring 17 is now positioned between the rims 13 and 14. The slant surfaces and the elastic connection between ring and rim will still support the rims against each other in radial direction, but at the same time in axial direction. At the same time the ring 17 will allow for relative axial movements caused by differential expansion of the rims and the shaft. If the rims expand in axial direction they expand also in diameter. The slant of the ring surfaces may be chosen in such a way, that axial and radial expansion balance out. To secure a nearly equal heating of the ring 17 and the shaft 6 the ring 17 is shielded against the steam by means of projections 22 and 23 and recesses 24 and 25 cut into the rims to decrease the transfer of heat. But the rings 17 are easily compressed by small axial forces and will easily expand by centrifugal force if the total axial length of rims plus rings does not coincide with the length of the corresponding shaft section. Similar slanted rings are assembled to springs for railways as is well known. The rings 17 will during all movements keep the axial distance between the rims equal along the whole circumference thus enforcing absolute parallelity of the discs. Thus the rotor is free to expand axially but at the same time stiffened against any bending. In this way the critical speed is actually raised.

A perfect stiffness of the total rotor is attainable by welding together the adjacent rims as shown in Fig. 6. It is then necessary to provide for a support between the hubs of the discs and the shaft which allows for axial gliding and yet keeps the centre of the shaft in line with the centres of the wheel hubs under all conditions. A construction securing such alignment is illustrated in Figs. 7 and 8. A bush 26 is shrunk on the shaft 6 and meshes with teeth 27 with radial flanks into corresponding recesses 28 of the hub 16 while the teeth 29 of the hub 16 mesh in the same way with recesses 30 of the bush 26.

As shown in Figs. 9 and 10 it will be easier to ensure a tight fit between the teeth 27 and the gaps 28 as well as between the teeth 29 and the gaps 30 if the teeth 28 are split in the centre by slots 31. Wedges 32 and 33 may then be driven into these slots 31 to drive the halves of the teeth 29 apart and bring to a close fit with the side walls of the gaps 30. The process of manufacturing the teeth is simplified because the thickness of the teeth and the width of the slots may differ to some extent before the teeth are driven apart. Slots 34 will make the bending of one half of the teeth 29 easier. To ensure absolute rigid connection between the parts the half of the teeth 29 transferring the torque is left rigid against bending. As three surfaces will always come in touch with the corresponding surfaces of the gaps 30 it is my preferred construction to employ three rigid halves of teeth 29 only.

ULRICH MEININGHAUS.