United States Patent

[11] **3,572,969**

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[54] **TURBOMACHINE ROTOR**
8 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** **416/194,** 416/230
[51] **Int. Cl.** **F04d 29/26,** F04f 5/00
[50] **Field of Search** 230/134; 416/230, 95, 210, 223; 416/193, 194, 203

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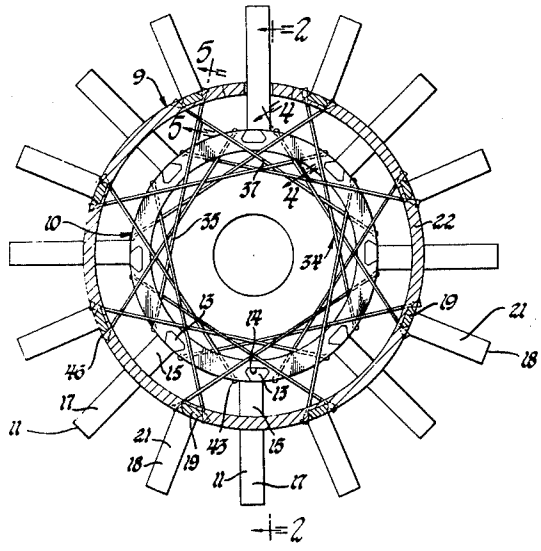
ABSTRACT: A bladed rotor drum or wheel for an axial flow compressor or turbine is made up of an outer ring and an inner ring within the outer ring and spokes connecting the two rings, the spokes being so directed as to exert an inward component of force on both rings. Blades extend into the gas path from the inner ring through openings in the outer ring. Preferably, blades are also mounted on the outer ring. End bells or discs may be provided on one or the other or both of the rings.



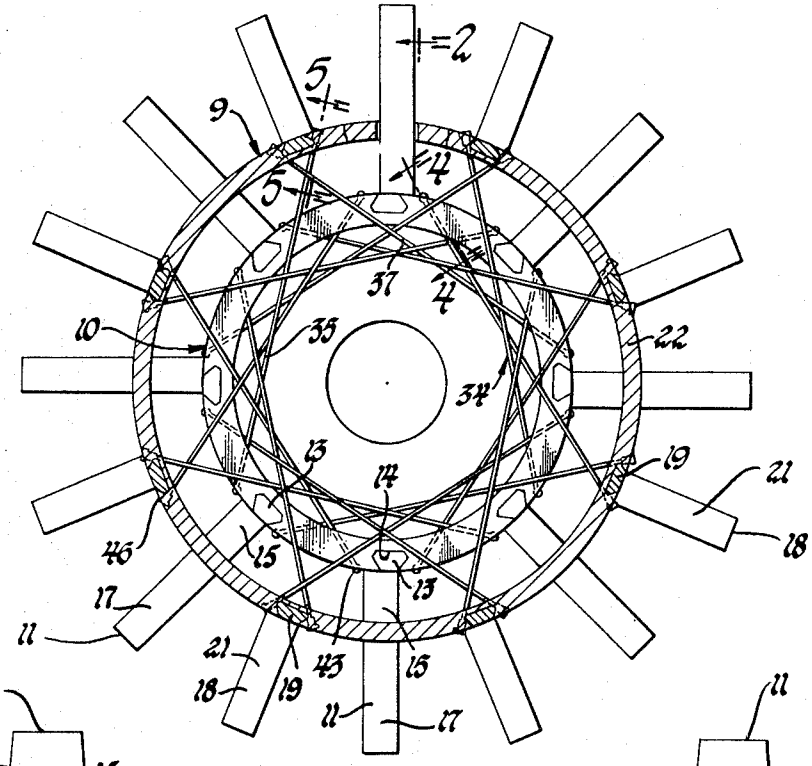


Fig. 1

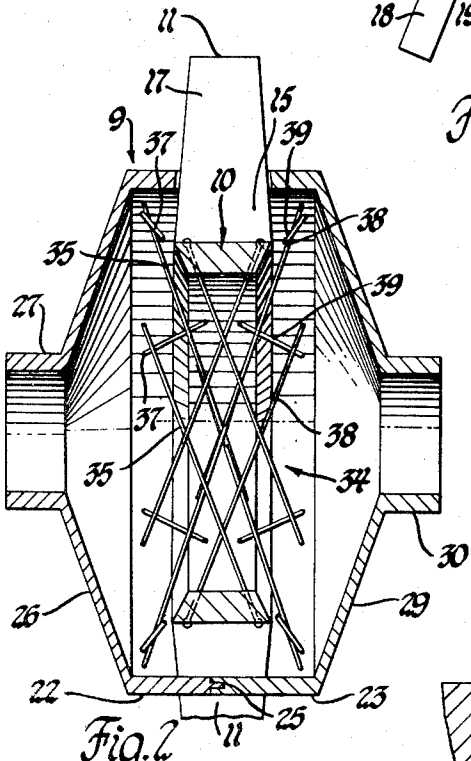


Fig. 2

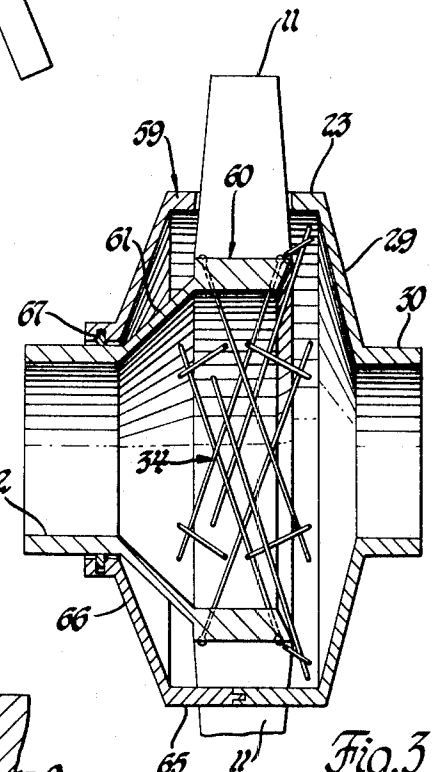


Fig. 3

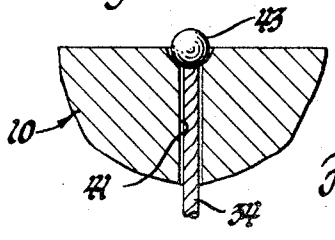


Fig. 4

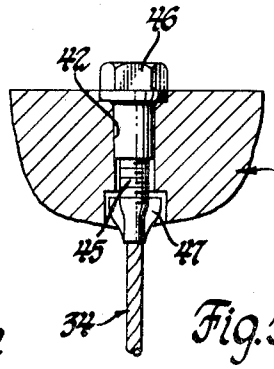


Fig. 5

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TURBOMACHINE ROTOR

The invention herein described was made in the course of work under a contract or subcontract thereunder with the Department of Defense.

My invention is directed to rotor structures of turbomachines, particularly axial-flow compressors and turbines. It is well known that such structures rotate at very high-speeds and bear blades of substantial construction to withstand the gas loads and centrifugal loads on the blades. The loads transmitted from the blades to the wheel or drum in which they are mounted are thus quite substantial. This requires a strong mounting structure or rotor drum.

The principal purpose of my invention is to take best advantage of the properties of materials so as to provide a lightweight rotor structure better adapted to the requirements of practice than such structures heretofore known. Primarily, according to my invention, the blade-mounting structure or rotor drum is made of two substantially concentric inner and outer rings or drums with tension members or spokes extending between the two rings. These spokes are so directed as to have an inward component of direction from both the inner and outer rings, so that they exert a compressive force on both rings tending to counteract to some extent the hoop stress in each ring due to centrifugal force exerted by the mass of the ring itself and of the blades, if any, mounted on the ring.

The invention also involves arrangements for sealing structures of this sort against flow of gas through the rotor below the active portion of the blade.

The principal object of my invention is to provide a strong lightweight rotor less likely to suffer from casualties and taking best advantage of the properties of materials now known, and particularly to take advantage of the tensile properties of materials which may be used as spokes to reduce hoop stress in the elements of the rotor.

The nature of my invention and the advantages thereof will be clear to those skilled in the art from the succeeding detailed description of preferred embodiments of the invention, which are presented to illustrate the principles of the invention and not in a limiting sense.

FIG. 1 is a sectional view of a single-stage compressor or turbine rotor structure taken in a plane perpendicular to the axis of rotation.

FIG. 2 is a sectional view of such a structure taken on the plane indicated by the line 2–2 in FIG. 1.

FIG. 3 is a similar view of a second form of rotor.

FIG. 4 is a detail of a spoke anchorage.

FIG. 5 is a detail of an adjustable spoke anchorage.

Referring first to FIGS. 1 and 2, the rotor structure comprises an outer ring or drum 9 and an inner ring or drum 10, these rings being coaxial and at least substantially concentric. Gas-directing blades 11 mounted on the inner ring 10 extend through the outer ring 9. The blades 11 may have any suitable known type of attachment to the inner ring, indicated by the dovetail root 13 mounted in slots 14 in the ring. Each blade includes a stalk portion 15 between the rings and a flow-directing or airfoil portion 17 exteriorly of the outer ring 9. The stalk portion may be in cross section a continuation of the airfoil portion if desired, but it is not intended that this portion be exposed to the fluid to be compressed or expanded in the turbomachine. Blades 11 are evenly distributed around the ring 10 and may be closely spaced. A second or outer row of blades 18 mounted on the outer ring 9 may also be provided. If provided, these blades are mounted intermediate the blades 11. Blades 18 may be attached by roots 19 similarly to the blades 11 but ordinarily would not include a stalk portion. The airfoil portion 21 of these blades ordinarily would have the same configuration as the exposed portion 17 of the blades 11.

As shown more clearly in FIG. 2, the outer ring 9 is made up of a forward ring 22 and the rear ring 23, these being connected in any suitable way as by the dovetail connection indicated at 25, so that they may be assembled around the blades 11. As illustrated, the forward ring is integral with a disc 26 which in turn is integral with a hub or hollow shaft 27, and the rear ring 23 is integral with a disc 29 integral with a hub or shaft 30. Thus the parts 22, 23, 26, 27, 29, and 30 comprise a rotor wheel or drum which may be mounted on or connected to a shaft in any suitable manner.

In the form shown in FIG. 2, the inner ring 10 is connected to the discs and hubs only through the two portions of the outer ring 9 and the spokes 34 to be described. These spokes are tension members interconnecting the two rings and preferably are disposed as indicated so that half the spokes exert a tangential pull in one direction and half in the other direction around the axis of rotation; also, so that some of the spokes pull forwardly on the inner ring and rearwardly on the outer ring whereas other spokes pull rearwardly on the inner ring and forwardly on the outer ring. This last feature may be utilized to hold the two rings together.

It is important that all the spokes 34 extend initially inwardly from the inner ring 10 so that they exert a component of force radially inwardly of this ring rather than radially outwardly as in a conventional spoke arrangement. These spokes are of a material of high tensile strength to weight ratio. The spokes may thus be considered as falling onto four groups; spokes 35 which extend from the forward outer ring 22 in a counterclockwise direction as illustrated in FIG. 1, spokes 37 which extend in the opposite direction from the outer ring 22; and spokes 38 and 39 extending in opposite circumferential directions inwardly from the rear outer ring portion 23 to the inner ring 10. Spokes 35 and 37 trend rearwardly from ring 22 and spokes 38 and 39 forwardly from ring 23.

Any suitable arrangements may be provided for anchoring the spokes and for adjusting them to provide the desired tension and to properly align and center the two rings. As illustrated in FIGS. 4 and 5, each spoke extends through a hole 41 in the inner ring and a hole 42 in the outer ring. It has a ball end 43 seated against the outer surface of the inner ring and a threaded end 45 upon which is threaded a nut 46 bearing against the outer surface of the outer ring 9. These spokes may, therefore, be tensioned or relaxed by adjustment of the nuts 46. As will be appreciated, this is not greatly different from the adjustment of spokes for bicycle wheels. Ribs or wings 47 may be provided on the end of the spokes adjacent to the threads 45 lodging in grooves in the ring 9 so as to prevent the outer end of the spoke from rotating as the nut 46 is adjusted. Disc 26 or 29 and the corresponding hub may be omitted if it is desired to have the rotor overhung from one hub only. Also, various other means of attachment of the rotating structure to a suitable shaft or other drum portions of the turbomachine may be employed if desired.

FIG. 3 illustrates a different form of rotor structure in which many of the parts are essentially the same as those previously described, the principal difference being the provision of a disc on the inner ring 11 at one end of the inner ring and a modification of the forward portion of the outer ring. In FIG. 3, the outer ring is referred to as 59 and the inner ring as 60, the blades retaining the number 11 and the spokes 34 being the same as previously described. Inner ring 60 is integral with a disc or end bell 61 which terminates in a shaft or hub 62. The forward portion 65 of the outer ring continues into an annular disc 66 which surrounds the shaft 62 with a piston ring seal 67 between them. It will be clear that this structure could be supported from either the hub 62 or the hub 30 and the other hub could be omitted if desired. The two rings are structurally connected by the spokes 34. It will also be apparent that many other arrangements to seal between the inner ring 10 or 60 and outer ring 9 or 59 may be provided. Such sealing arrangements are well known in rotor structures embodying stalked blades in which it becomes necessary to block flow under the blade platforms between the blade stalks or to confine cooling air in this area.

It is preferred to have some of the blades mounted on the outer ring to obtain a balance in centrifugal forces. Thus, the centrifugal force exerted by the blades on the outer ring tends to counteract, through the force transmitted by the spokes 34, the centrifugal force exerted outwardly on the inner ring by the blades 11 mounted upon it.

The detailed description of preferred embodiments of the invention is for the purpose of explaining the principles of the invention. It will be clear to those skilled in the art that many modifications in structure may be made without departing from the principles of the invention.

I claim:

1. A bladed rotor for a turbomachine or the like comprising an outer drum, an inner drum coaxial with and substantially concentric with the outer drum mounted within the outer drum, a first disc and hub at one end of the rotor fixed to the outer drum, a second disc and hub at the other end of the rotor fixed to one of the drums, blades mounted on the inner drum and extending through the outer drum with fluid-directing portions of the blades externally of the outer drum, and tension spokes anchored at each end to the outer and inner drums, respectively, distributed around the peripheries of the drums, the spokes extending radially inwardly of each drum at the points of attachment so as to direct a radially inward force component on each drum.

2. A bladed rotor wheel for a turbomachine or the like comprising, in combination, a rigid outer ring, a rigid inner ring, the rings being coaxial and substantially concentric, fluid-directing blades mounted on and supported by at least one of said rings and extending radially outward of the outer ring, and tension spokes fixed to and extending between the rings distributed around the perimeter of the rings, the spokes having an inward component of direction from the point of attachment at each ring to the point of attachment at the other ring so as to put both rings in compression and oppose centrifugal forces on the rings.

3. A rotor as recited in claim 2 in which the blades are mounted on the inner ring and extend through the outer ring.

4. A rotor as recited in claim 3 including also blades mounted on and extending radially outwardly from the outer ring.

5. A rotor as recited in claim 3 in which the outer ring is split at a circumferential split line into a forward and a rear ring portion.

6. A rotor as recited in claim 5 in which the spokes are disposed so as to pull and said ring portions together.

7. A rotor as recited in claim 2 including also a disc integral with one of said rings providing a mounting for the rotor.

8. A rotor as recited in claim 2 including also means providing a barrier against fluid flow axially of the rotor between the rings.