United States Patent

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[72] Inventor **Richard C. Jensen**
Greensburg, Pa.

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[73] Assignee **Carrier Corporation**
Syracuse, N.Y.

[54] **ROTOR ASSEMBLY**
2 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** **416/220**
[51] **Int. Cl.** **F01d 5/32**
[50] **Field of Search** 416/214–218, 220, 198

[56] **References Cited**

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Primary Examiner—Everette A. Powell, Jr.
Attorneys—Harry G. Martin, Jr. and J. Raymond Curtin

ABSTRACT: A rotor for use in a turbomachine comprising a shaft, a plurality of wheels axially connected to the shaft, and a plurality of blades mounted circumferentially about each of the wheels. Spacer rings are disposed between alternate wheels and are connected thereto to maintain the wheels in their spaced axial positions. Disposed above alternate spacer rings are a plurality of substantially cylindrical members having a removable portion. When a blade becomes defective, the cylindrical member adjacent thereto will be rotated to align the removable portion with the defective blade. The removable portion of the member is withdrawn to leave an opening adjacent to the base of the defective blade. The defective blade may then be slid into this opening and be removed from the machine.

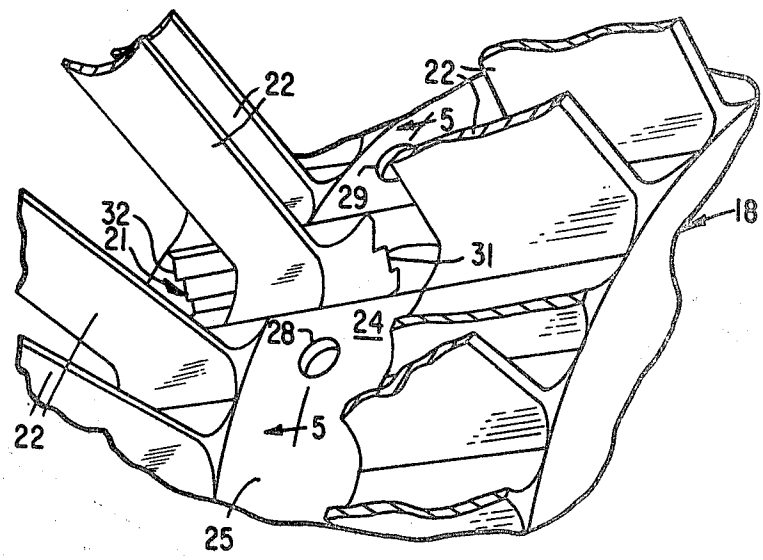


FIG. 1

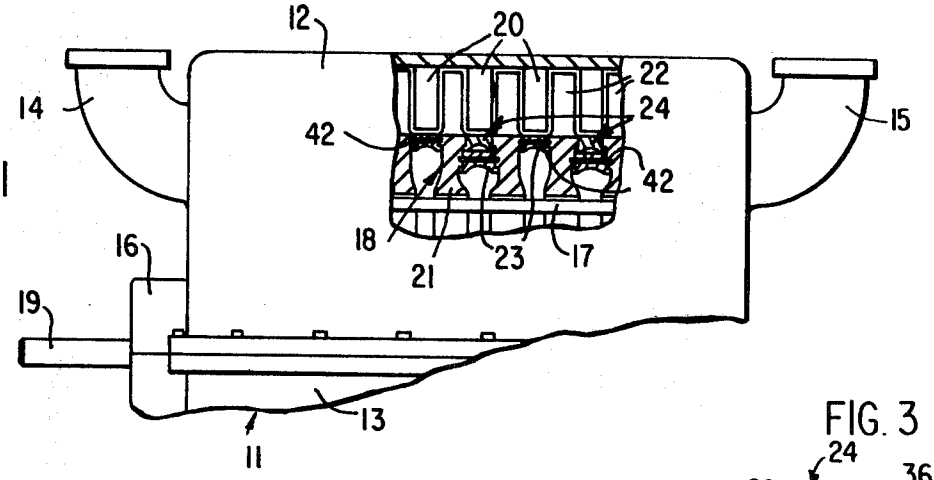


FIG. 3

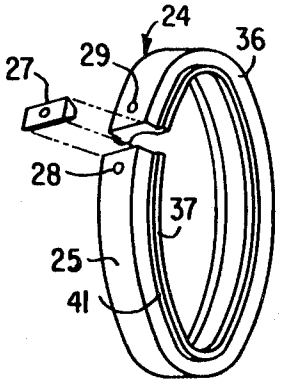
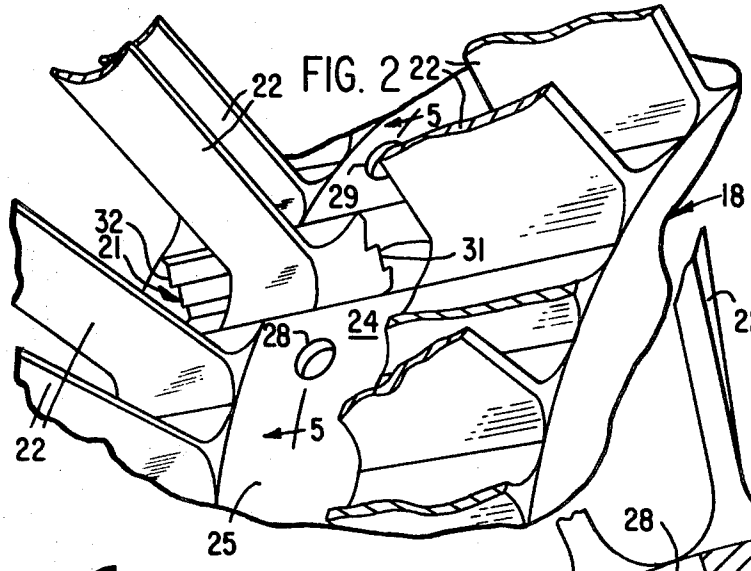


FIG. 2



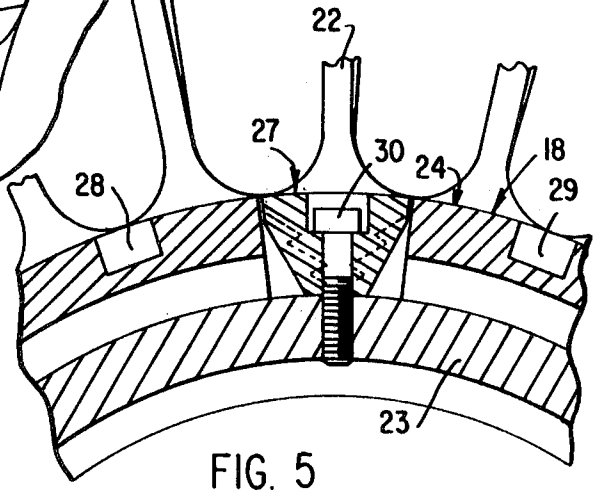
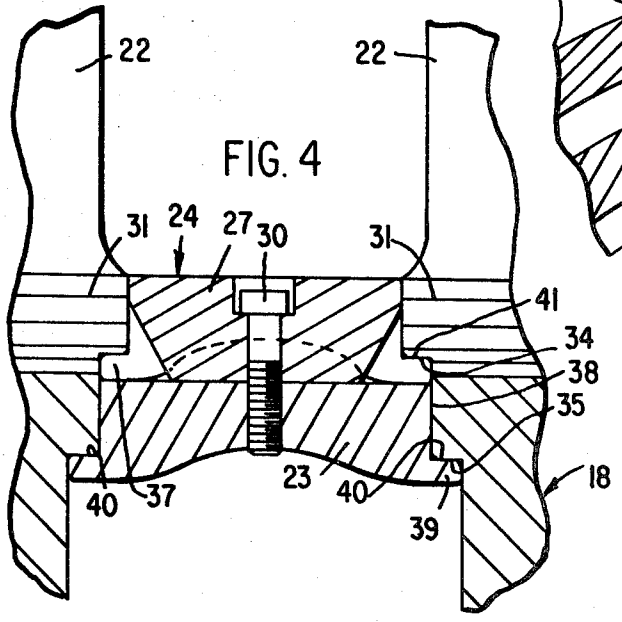


FIG. 5

FIG. 4



INVENTOR.
RICHARD C. JENSEN
BY Raymond Curtin
ATTORNEY.

ROTOR ASSEMBLY

BACKGROUND OF THE INVENTION

This invention relates broadly to bladed turbomachinery including steam turbines, gas turbines, and axial compressors. More particularly, this invention relates to a novel rotor construction permitting defective blades to be removed and new blades to be installed expeditiously.

A frequent cause of defective blades in turbomachinery is vibration of the blades producing bending stresses in the blades. When the bending stresses exceed the maximum working stress of the blade material, a crack may develop at a blade edge. As the crack enlarges under further stress, a point is soon reached where the entire blade fractures and a substantial portion of the blade is loose in the machine and is free to damage the other blades of the machine. Since machines of the type described frequently rotate at a high speed, it has been observed that in some instances a broken blade has developed sufficient centrifugal force to crack the outer casing of the machine and be propelled completely through it. Thus, it is readily apparent that a defective blade should be removed from a rotor wheel as quickly as possible.

Heretofore, the removal of a defective blade has generally been a costly and time consuming process, especially where a multistage machine is involved. The rotor for multistage apparatus generally comprises a shaft, a plurality of wheels or discs secured to the shaft, and a plurality of blades circumferentially secured to the wheels. If a blade secured to a wheel intermediately positioned on the shaft becomes defective, all the wheels closer to one end of the shaft than the wheel mounting the defective blade must be disconnected from the shaft to permit the wheel mounting the defective blade to be removed therefrom. The defective blade may then be withdrawn from the wheel and a new blade inserted therefor.

The object of the invention herein disclosed is to reduce the high cost of removing and replacing a defective turbomachine blade and to permit such repair to be accomplished as expeditiously as possible.

SUMMARY OF THE INVENTION

A novel rotor to obtain the desiderata discussed hereinabove for multistage turbomachines of the type under discussion is herein disclosed. The rotor comprises shaft means, a plurality of wheels or discs mounted axially on the shaft means, and a plurality of blades mounted circumferentially on each of the wheels. Separating adjacent wheels are a plurality of substantially cylindrical rings, hereinafter referred to as spacer rings. Each spacer ring is nested in the rims of the wheels adjacent thereto, thereby increasing the structural strength of the rotor. The spacer rings are mounted in a substantially vertical plane beneath the stator blades which are attached to the turbomachine's casing. Concentric to every other spacer ring and mounted thereabove is a second substantially cylindrical member. The width of the top surface of this member is at least as wide as the width of any blade contained on the rotor wheels for a reason that will become more apparent. The cylindrical member forms an incomplete circle. A filler piece will be fitted between the two adjacent ends of the member and will be joined to the lower spacer ring by appropriate means such as a screw or bolt. The two concentric rings are thus joined together and will rotate simultaneously with the wheels of the rotor. If it is desired to remove a defective blade, the apparatus is stopped and the top half of the casing is removed. The second cylindrical member adjacent the wheel mounting the defective blade will be disconnected from its lower spacer ring, so the upper ring may be rotated relative to the lower ring. This disengagement is accomplished by loosening the joining means holding the filler piece to the lower spacer ring. The upper member is then rotated to align the filler piece with the defective blade. The filler piece is then completely removed from the upper member, leaving an opening adjacent the defective blade. The blade can then be axially slid into this opening and thereby removed from the wheel. A new blade can then be installed by reversing the procedure.

Thus, the novel construction herein disclosed will permit the removal of a defective blade without completely disassembling the rotor at a substantial savings in the cost of repair and the time to effectuate such repair. Additionally, the construction herein disclosed affords maximum structural strength, consequently permitting the rotor to be utilized over a much larger speed range.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side view of a turbomachine having a part of the casing broken away, embodying the novel construction;

FIG. 2 is a fragmentary perspective view of the rotor assembly showing the novel construction with the filler piece omitted;

FIG. 3 is a perspective exploded view of the fairing ring assembly;

FIG. 4 is a fragmentary sectional view of the rotor; and

FIG. 5 is a sectional view taken along lines 5—5 of FIG. 2, with the filler piece in place.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, there is shown a typical turbomachine known generally as an electric fluid machine, such as an axial type gas or air compressor, wherein the invention herein disclosed is embodied. In referring to the drawings, like numerals shall refer to like parts.

Referring now to FIG. 1, there is depicted an axial compressor. It should be understood that the invention herein disclosed may be used with other turbomachines, such as gas turbines and steam turbines. The axial compressor comprises a housing or casing 11 divided axially into two sections, an upper section 12 and a lower section 13. The fluid to be compressed, such as air, enters the machine through inlet 14 and exits therefrom at a greatly increased pressure via outlet 15. Bearing caps, such as the one shown at 16, enclose bearings (not shown); the bearings support the compressor rotor assembly 18 disposed within the housing 11.

The rotor assembly comprises shaft means having a stub shaft 19 extending axially from the housing 11. The stub shaft is coupled to driving means such as an electrical motor (not shown), which will provide the necessary power for operating the compressor. The portion of the stub shaft closest to the vertical center line of the compressor is formed in the shape of the frustum of a cone. Extending into this frustum-shaped portion is through bolt 17. The through bolt will extend axially through the housing and will connect to a similar frustum-shaped portion of a stub shaft positioned at the opposite end of the casing (not shown). Positioned axially about the through bolt 17 are a plurality of discs or wheels 21. One end of the through bolt will be screwed into the stub shaft, while the other end of the through bolt will have means, such as a nut, bearing against the last wheel to axially position the wheels about the bolt. Interconnecting each of the wheels 21 are a plurality of pins 42 extending through a member 23 that will be more fully explained hereinafter. The pins will transmit the torque supplied by the driving means from one wheel to the wheel connected thereto. Additionally, any forces tending to twist one wheel relative to the other about the axis of rotation are resisted by the sheer strength of the pins 42. Other rotor constructions, such as a shaft extending axially through the housing, having the wheels connected thereto to rotate therewith, may be utilized with the invention herein disclosed.

Mounted circumferentially about the wheels 21 are a plurality of rotor blades 22. As is best seen in FIG. 2, the base of each blade 22 will be formed into a pine treelike configuration 31, adapted to fit into mating portions 32 circumferentially Positioned about the wheels. The interlocking relationship there formed between the blades and the wheels will prevent the blades from being thrown radially from the wheels by the

centrifugal force developed during normal operation of the machine. Other similar configurations known in the art may be used instead of the "pine tree" construction shown. The air flowing through the machine is compressed by the aerodynamic action of the rotating blades. Stationary or stator blades **20**, mounted on the inner surface of the casing **11**, direct the air to each succeeding row of rotating blades.

Positioned between each pair of wheels **21** are a plurality of spacer members **23**. Preferably, the spacer members will be ring-shaped, and as best shown by FIG. 4, will have a first section **38** of reduced width and a second section **39** of somewhat greater width, the two sections forming a shoulder **40**. As will be more fully explained hereinafter, spacer members of this type will aid in the stability and strength of the rotor during operation of the machine.

Mounted above alternate spacer members is a substantially cylindrical member or fairing ring assembly **24** having a first portion **25** forming an incomplete circle, note FIG. **3**. As is seen in FIG. 3 and 4, a separable filler piece **27** is fitted between two adjacent edges of the ring portion **25**, and is joined to the underlying spacer member **23** by joining means such as a bolt **30** to complete the circle. Thus, the fairing ring assembly **24** is joined to the spacer member **23** and will rotate therewith. The filler piece **27** may be wedge shaped as shown and made of a lightweight material such as plastic to reduce the weight thereof. Preferably, as seen in FIG. **3** and 4, the portion **25** will have a first section **36** of a reduced width and a second section **37** of somewhat greater width, the two sections forming a shoulder **41**.

The top surface of the spacer members not associated with a fairing ring assembly will be aligned with the top portion of the pine tree configuration of the blades **22**. Thus, these spacer members will maintain the blades in their axial positions on the wheels. Where a fairing ring assembly is utilized, as shown in FIG. 2 and 5, the top surface of the assembly will be aligned with the base portion of the blades and thus the assembly will be utilized to properly maintain the blades in their axial positions on the wheels. Additionally, the spacer members and fairing ring assemblies will separate adjacent wheels to accommodate stator blades positioned between the wheels, and they will also define a passage for the gas flowing from one wheel to the next.

A major cause of problems in the operation of turbomachines of the type under discussion is the rotor blades becoming defective. Heretofore, when a rotor blade becomes defective, rotor constructions required costly and time consuming repairs as outlined hereinbefore.

The rotor construction herein disclosed alleviates this problem. If a rotor blade becomes defective, the top half of the casing **11** is first removed. Next the bolt **30** joining the filler piece **27** to the spacer member **23** is loosened to permit the fairing ring assembly **24** to be rotated relative to the spacer member **23**. The fairing ring assembly will be rotated to align the filler piece with the defective blade. Openings **28** and **29** in the fairing ring assembly are provided to accommodate a suitable tool, such as a spanner wrench, for rotating the assembly. As seen in FIG. **2**, the filler piece would then be removed so an opening is created adjacent the defective blade. The width of the top surface of the filler piece is at least as wide as the width of the blade; therefore, the blade may be slid from its mating portion **32** on the wheel into the opening and thereby be removed from the rotor. By reversing this procedure, a new blade can then be installed. It is apparent that such a repair would be done in less time and at a much lesser expense when compared to repairs effected on rotor constructions heretofore used.

In addition to the alleviation of the rotor repair problem, the novel construction herein disclosed will also provide a greatly strengthened rotor that may be utilized over a greater range of speed. As noted hereinbefore, the spacer members and the fairing ring assemblies have shoulder portions formed thereon. The wheels are designed to have mating shoulder portions, as can be seen in FIG. 4. The surfaces of the wheels in contact with the fairing ring assembly and spacer members will have two shoulder portions defined thereon, the first shoulder portion **34** being interengaged with the shoulder **41** of the fairing ring assembly and the second shoulder portion **35** of the wheel being interengaged with the shoulder **40** of the spacer member. The surface of the wheels not in contact with the fairing ring assembly will only have the first shoulder portion **34** formed thereon, the shoulder being integrated with the shoulder **40** of the spacer member. The interlocking fits thus formed will substantially increase the stability and strength of the rotor.

While I have described and illustrated a preferred embodiment of my invention, it is to be understood the invention is not limited thereto, but may be otherwise embodied within the scope of the following claims.

I claim:

1. A rotor for use in a turbomachine comprising:

A. shaft means;

B. a plurality of wheels mounted on said shaft means;

C. a plurality of blades circumferentially mounted on each of said wheels, said blades including a tip portion and a base portion; and

D. substantially cylindrical means disposed axially about said shaft means between alternate pairs of wheels, at least a portion of each of said substantially cylindrical means being removable when said turbomachine is inactive, said substantially cylindrical means being rotatable relative to said wheels when said turbomachine is inactive, thereby permitting said removable portion of said cylindrical means to be aligned with a blade that is to be removed from said wheel adjacent to said cylindrical means, said removable portion upon separation from said cylindrical means defining an opening adjacent to said base of said blade into which said blade may be slidably positioned for removal.

2. A rotor for use in a turbomachine comprising:

A. shaft means;

B. a plurality of wheels mounted on said shaft means having a relatively wide section and a relatively narrow section defining therebetween a first shoulder portion, a portion of said relatively narrow section being further reduced to define a second shoulder portion:

C. a plurality of blades circumferentially mounted on each of said wheels, said blades including a tip portion and a base portion;

D. a plurality of spacer members mounted axially about said shaft means between consecutive wheels, said spacer members having a relatively wide section and a relatively narrow section defining therebetween a shoulder portion; and

E. a plurality of substantially cylindrical assemblies disposed axially about said shaft means between alternate pairs of wheels, said substantially cylindrical assemblies having a portion provided with a relatively wide section and a relatively narrow section defining therebetween a shoulder portion, said substantially cylindrical assemblies being mounted radially above said spacer members associated therewith and connected thereto, at least a section of each of said substantially cylindrical assemblies being removable when said turbomachine is inactive, each of said substantially cylindrical assemblies being rotatable relative to said wheels when said turbomachine is inactive, thereby permitting said removable section to be aligned with a blade that is to be removed from said wheel adjacent thereto, said removable section defining an opening adjacent to said base of said blade when removed, for slidably receiving said blade preparatory to removal thereof, said substantially cylindrical assemblies being positioned relative to the wheels adjacent thereto so said shoulder portion of said cylindrical member and said first shoulder portion of said wheels interengage one another; said spacer members underlying said substantially cylindrical assembly being positioned relative to

said adjacent wheels so said shoulder portion of said spacer members and said second shoulder portion of said wheels interengage one another, said spacer members alternate from said spacer members underlying said substantially cylindrical members being positioned relative to said wheels adjacent thereto so said shoulder portion of said spacer members and said first shoulder portion of said wheels interengage one another.