United States Patent

Kriesten

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[54] **APPARATUS FOR TESTING THE BLADE ANCHORAGE OF TURBINE BLADES**

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[52] **U.S. Cl.** **73/95,** 73/99, 73/103, 308/DIG. 1

[51] **Int. Cl.**.....**G01m 19/00**

[58] **Field of Search**.....308/DIG. 1; 73/95, 103, 100, 73/99

[56] **References Cited**

UNITED STATES PATENTS

3,176,507	4/1965	Digesu et al.	73/103
3,603,143	9/1971	Detert et al.	73/92

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[57] **ABSTRACT**

An improved testing apparatus for determining tightness, deformations and weak points of the blade anchorage of a turbine blade. The apparatus operates by applying forces to a blade or portion thereof which includes a blade base, attached in the normal fashion to a simulated portion of a turbine rotor. A force in a direction corresponding to the radial direction in a turbine rotor and hence to the centrifugal force in a rotating rotor is applied by attaching the blade and rotor portion to respective first and second yokes and drawing the blade and rotor portions apart. A force corresponding to the damping forces in the axial and/or tangential directions of a turbine rotor is applied by an additional device while the blade and rotor portions are held in the yokes. At least one end of the blade is mounted on its respective yoke by means of fluid pressure bearing system whereby the various forces can be applied to the blade in a substantially frictionless manner.

5 Claims, 3 Drawing Figures

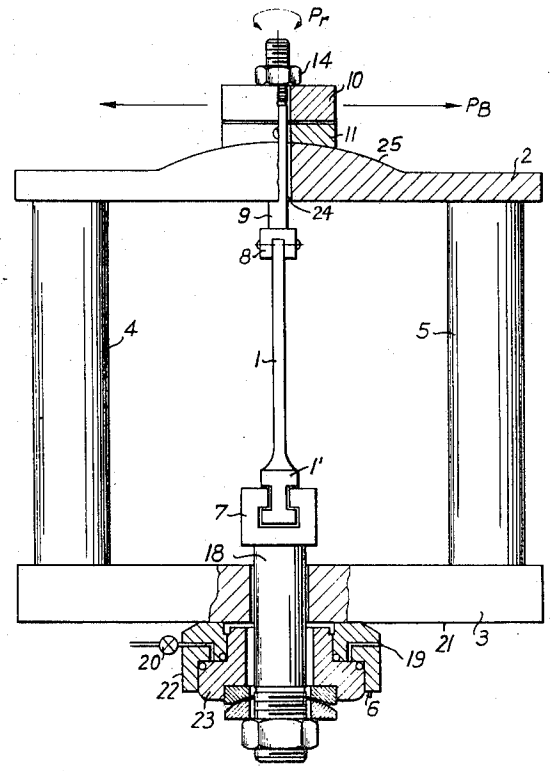


Fig. 1

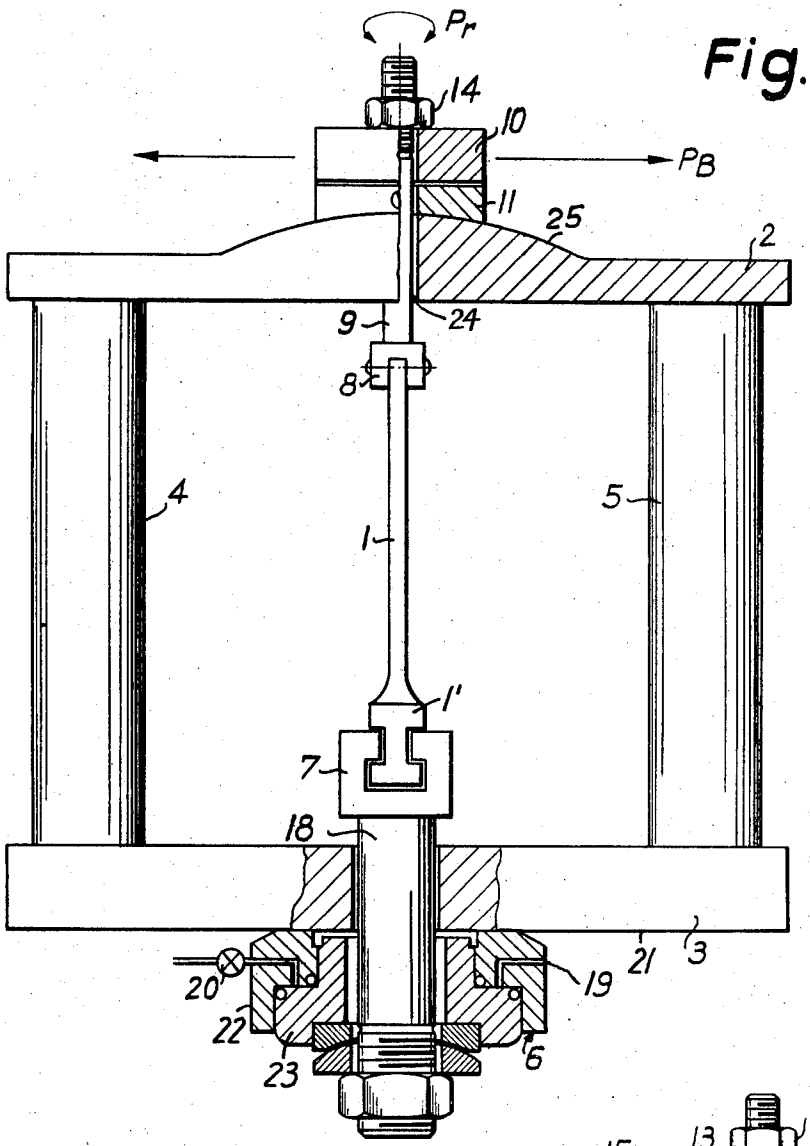
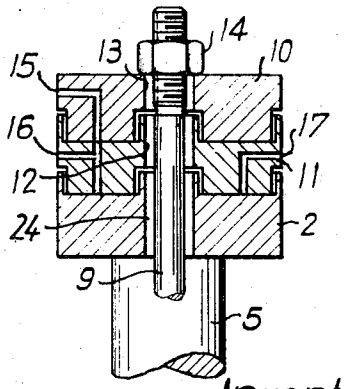


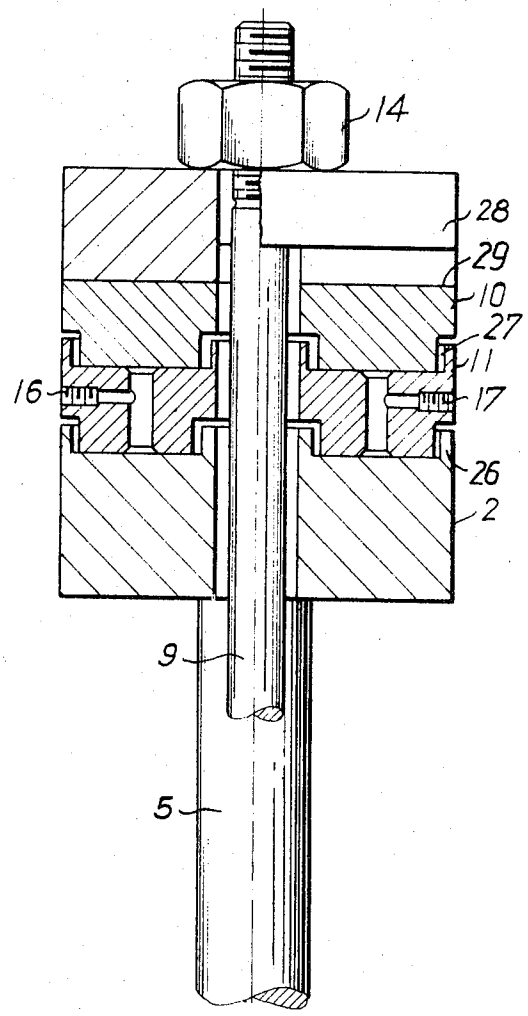
Fig. 2



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Fig. 3



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APPARATUS FOR TESTING THE BLADE ANCHORAGE OF TURBINE BLADES

BACKGROUND OF THE INVENTION

The present invention relates to a testing device for determining tightness or fit, deformations (warping) and weak points of the blade anchorage of turbine blades.

When constructing large turbines, such as steam turbines, it is necessary to design the turbine vanes or blades so that when attached or anchored to the turbine rotor and placed under the stresses of operation they will not be subject to failure, e.g., by cracking at their base where the greatest stresses appear. In order to avoid this type of damage in completed turbines, it is desirable to provide apparatus which is capable of simulating the various stresses that act on turbine blades during normal operation to permit an experimental verification of the stresses determined by theoretical calculation.

In co-pending U.S. application Ser. No 827,537 filed May 26, 1969, by K. Detert, H. Lipp and E. Winschuh, now U.S. Pat. No. 3,603,143 issued Sept. 7, 1971, which is assigned to the same assignee as this application, a testing device for determining the accuracy of the fit, deformations and weak points of the blade anchorage of turbine vanes has already been proposed. This device has a clamping frame having a pair of yokes to one of which the blade or a portion of the blade with its blade foot or base and a simulated rotor segment of the rotor are fastened. The support for this yoke by the opposite yoke is accomplished by a spring element. A device which exerts a force corresponding to the centrifugal force of the rotating vane on the rotor segment is disposed at one of the yokes whereas a further device is provided to exert forces on the vane which correspond to the damping forces occurring in an axial and tangential direction with respect to the rotor.

It is the object of the present invention to improve the previously proposed test apparatus by providing a bearing for the blade to be tested which permits the forces acting on the blade to be applied in an almost frictionless manner.

SUMMARY OF THE INVENTION

The above object and others are accomplished, according to the present invention, in that one end of the blade is mounted in its respective yoke so that it is freely suspended by means of a fluid pressure bearing. Advisably the fluid pressure bearing includes a rotating plate and a tilting pad, which are both provided with connections for a fluid pressure medium and which are moreover provided with a central bore for the passage of the blade end or its support, and the yoke, which is associated with the fluid pressure bearing, has a rounded surface juxtaposed and adapted to the rounded surface of the tilting pad.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows an embodiment of a testing device according to the invention.

FIG. 2 is an enlarged sectional view of the fluid pressure bearing system employed in the testing device of FIG. 1.

FIG. 3 illustrates a modification of the fluid pressure bearing system employed.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings wherein the same elements bear the same reference numerals in all figures, there is shown a testing apparatus having a frame which serves to hold a turbine blade 1 having a blade base 1'. The frame includes a pair of yokes 2, 3 which are spaced by means of two supporting sleeves 4, 5. Disposed on the outer surface 21 of the yoke 3 is a hydraulic jack 6 including cylinder 22 and piston 23. Mounted on the piston 23 for axial movement therewith is a rod or bolt 18 which extends through bore 24 in the yoke 3. Connected to the end of the rod 18 is a jaw 7 which simulates a turbine rotor segment and engages the blade base or anchorage 1'. The other end of blade 1 is securely held in a clamping jaw 8 which is connected to the end of a bolt 9 which passes through a bore 24 in the yoke 2.

According to the present invention, the bolt 9 is mounted on the yoke 2 by means of a fluid pressure bearing system consisting essentially of a rotary plate 10 mounted on the upper surface of a tilting pad 11, which in turn is adjacent the upper surface 25 of the yoke 2. In order to provide for a tilting action of the pad 11, the portion of the upper surface 25 surrounding the bore 24 is provided with a rounded contour which is adapted to the juxtaposed rounded lower surface of the tilting pad 11.

Referring now to FIGS. 2 and 3 which show the detailed construction of the fluid pressure bearing system the bolt 9 after passing through the bore 24 is passes through a bore 12 in the tilting pad 11 and a bore 13 in the rotary plate 10. A nut 14 connected to the end of bolt or rod 9 normally presses the rotary plate 10 and the tilting pad 11 against the upper surface 25 of the yoke 2. The upper surface 25 of the yoke 2 and the upper surface of the tilting pad 11 are each provided with a groove, 26, 27 respectively into which a corresponding protrusion on the lower surface of the tilting pad 11 and the rotary plate 10 extend respectively. The grooves 26 and 27 tend to maintain the members 10, 11 in their operative positions when forces are applied to the bearing.

Formed within the rotary plate 10 is a fluid passage 15 for receiving and directing a fluid pressure medium, which may be compressed liquid or air, between the adjacent surfaces of the rotary plate 10 and the tilting pad 11 within the groove 27. Similarly the tilting pad 11 is provided with a pair of diametrically opposed fluid passages 16, 17, for receiving and directing a fluid pressure medium both between the adjacent surfaces of the rotary plate 10 and the tilting pad 11 and between the adjacent surfaces of the tilting pad 11 and the yoke 2.

The described embodiment of the testing apparatus operates as follows:

By means of a hydraulic pressure medium introduced at inlet 19, the hydraulic jack 6 applies a static force through bolt 18 to the simulated rotor segment 7 which force corresponds for testing purposes of turbine blades to the centrifugal force acting on the rotating blade. As in the above-mentioned patent application this force also stresses the blade 1 connected to the

member 7 since its upper end is constrained by this mounting to the yoke 2.

According the the present invention a liquid and/or gases are moreover forced, under high pressure, through the fluid passages 15, 16, 17, of rotary plate 10 and tilting pad 11, and exits at the periphery of the grooves 26 and 27. Thus, the tilting pad 11 is lifted off yoke 2 and the rotary plate 10 is lifted off tilting pad 11 by an amount which corresponds to the amount of pressure medium flowing through the passages, thus resulting in a liquid or gas cushion being formed for members 10 and 11. Due to these fluid cushions, the forces corresponding to the damping forces acting on the blade in the axial and tangential directions of the turbine rotor, i.e., the bending and torsional forces P_B, P_r, can thus be applied to blade 1 in an almost friction less manner. Since the formation of the fluid cushions results in an additional static force being applied to the turbine blade 1, a controllable valve 20, may be provided in the output pressure line from the jack 7 to provide compensation and eliminate these additional stresses.

The fluid passages 16, 17 for only the tilting pad 11, are shown greatly enlarged in FIG. 3. According to a further modification according to the invention a knife-edge bearing 28 may be placed between the nut 14 and the rotary plate 10 with its knife-edge 29 engaging the upper surface of the plate 10 to further reduce the friction caused by the application of the bending forces.

It will be understood that the above description of the present invention is susceptible to various modifications, changes and adaptations, and the same are intended to be comprehended within the meaning and range of equivalents of the appended claims.

I claim:

1. In a testing apparatus for determining the fit, deformations and weak points of the blade base of a turbine blade of the type having a frame having a pair of spaced yokes, means, including a simulated turbine rotor segment, for fastening at least the portion of a turbine blade with the blade base between the two yokes with said blade base being connected to one of said yokes via said simulated rotor segment, means for exerting a force on said simulated rotor segment and rotor blade corresponding in direction and magnitude to the centrifugal force acting on a rotating blade of a rotor segment, and means for exerting forces on the blade corresponding to damping forces acting on a rotating rotor blade in the axial and tangential directions of a turbine rotor, the improvement wherein one end of said blade is fastened to its respective yoke by means of a pressurized fluid bearing system so that said one end is freely suspended and the said forces can be applied to the blade in a substantially frictionless manner.

2. The testing apparatus as defined in claim 1 wherein at least a portion of the outer surface of the yoke associated with said pressurized fluid bearing system has a rounded contour; wherein said fluid bearing system comprises a tilting pad having a rounded surface corresponding to and juxtaposed said rounded portion of said yoke, a rotary plate disposed adjacent the surface of said tilting pad opposite its rounded surface, said tilting pad and said rotary plate being provided with central bores, fluid passage means formed within at least said tilting pad for directing the pressurized fluid between the adjacent surfaces of said yoke and said tilting pad and between the adjacent surfaces of said tilting pad and said rotary plate causing fluid cushions to be formed between said adjacent surfaces; and wherein said blade is coupled to said fluid bearing system by means of a rod which extends through an opening in said yoke and through said central bores in said tilting pad and said rotary plate, and, locking means connected to the end of said rod.

3. The testing apparatus as defined in claim 2 wherein the end of said blade supported by said fluid pressure bearing system is the end opposite the blade base.

4. The testing apparatus as defined in claim 3 wherein said damping forces applying means applies said forces to the blade adjacent the end thereof supported by said fluid pressure bearing system.

5. The testing apparatus as defined in claim 3 including a knife-edge bearing engaging the outer surface of said rotary plate, said knife-edge bearing having a central bore through which said rod extends.

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