United States Patent [19]

Pierpoline et al.

[11] **3,893,782**

[45] **July 8, 1975**

[54] **TURBINE BLADE DAMPING**

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[22] Filed: **Mar. 20, 1974**

[21] Appl. No.: **452,867**

[52] **U.S. Cl.** **415/119**
[51] **Int. Cl.** **F01d 5/16**; F01d 5/10
[58] **Field of Search**... 415/119, 172, DIG. 1, 219 R; 416/190, 500

[56] **References Cited**

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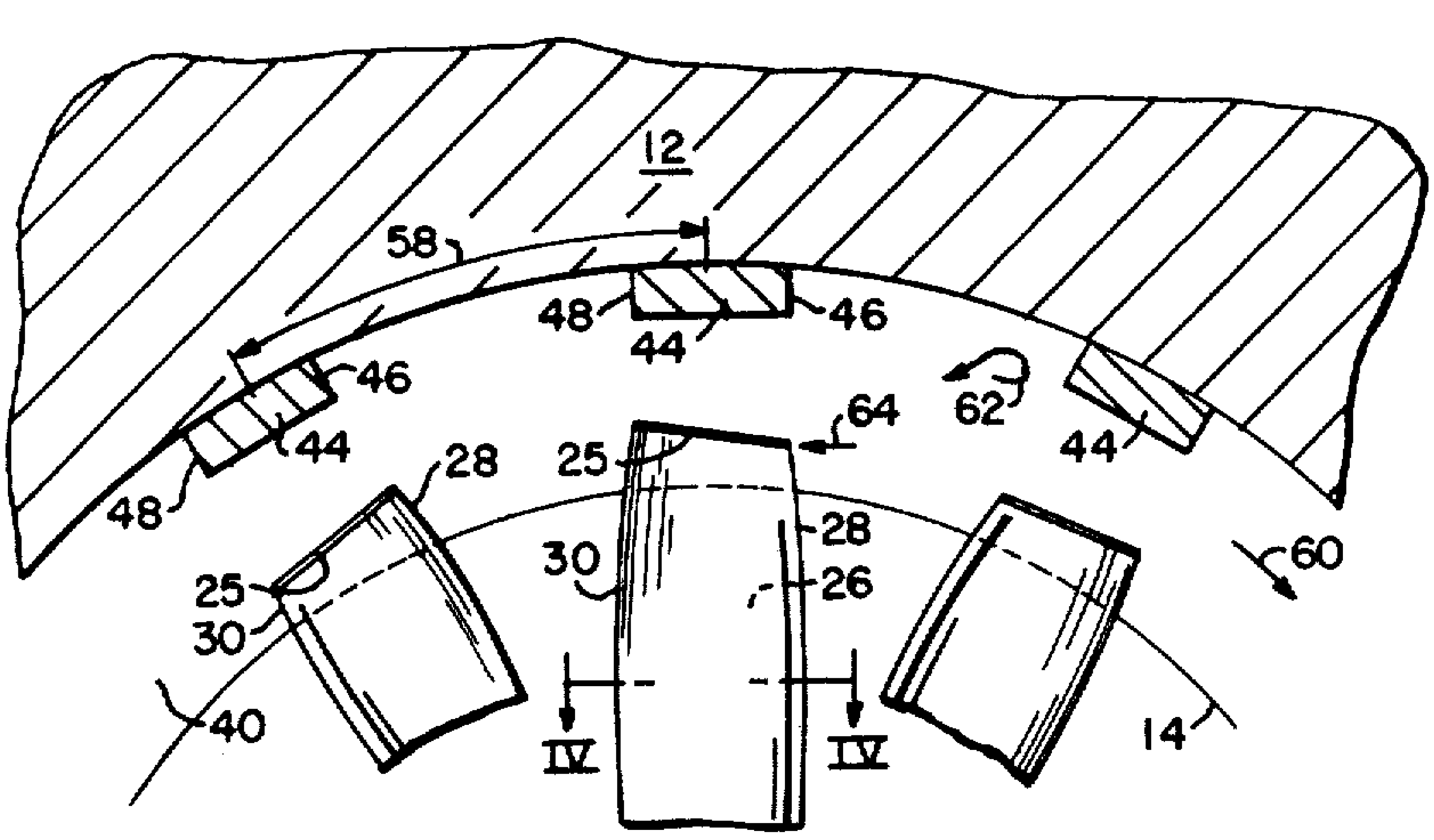
[57] **ABSTRACT**

A baffle arrangement to limit vibration in rotating blades of a elastic fluid turbine apparatus. The turbine comprises a casing enclosing a rotating shaft having a plurality of blades thereon. The casing has a circumferential groove disposed on the interior surface thereof. A predetermined number of radial baffles traverse the groove. The baffles are disposed in the circumferential groove at a predetermined circumferential distance from one another. The elastic fluid is directed by the rotating blades into the groove. Fluid in the groove is deflected by the baffles against the backside of the rotating blades. The impingement of the deflected elastic fluid on the rotating blades exerts a force on the blade in a direction opposite the direction of rotation of the blade and thereby limits vibration in the blade to provide an effective blade damper. In addition, each blade is contour fitted with a metallic coating of a predetermined thickness to provide added rigidity to the blade and limit vibration in the blade.

6 Claims, 4 Drawing Figures



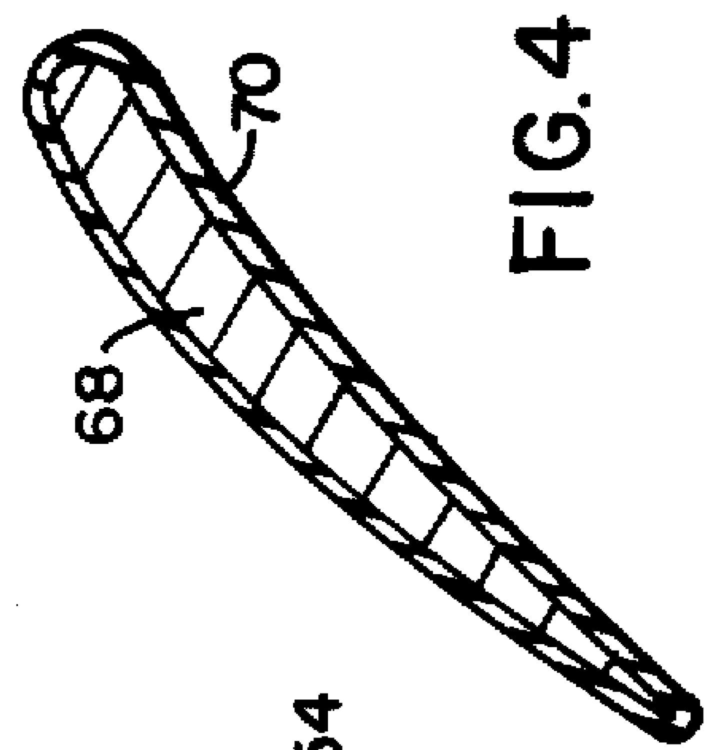


FIG.4

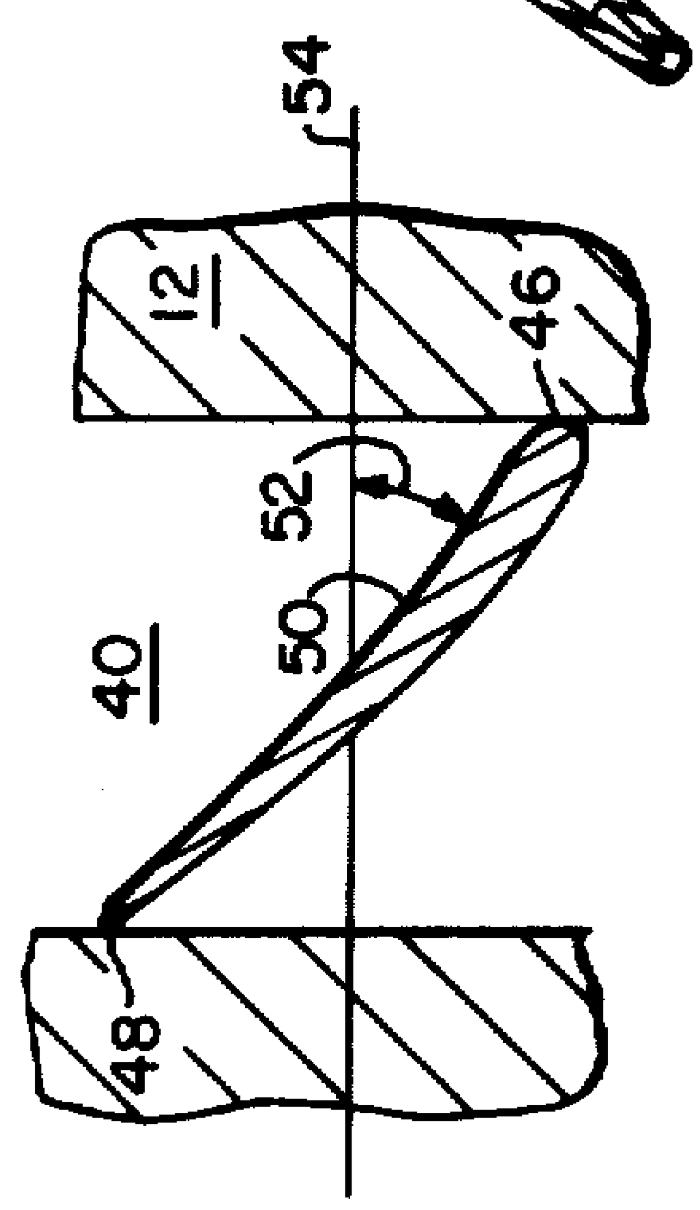


FIG.2

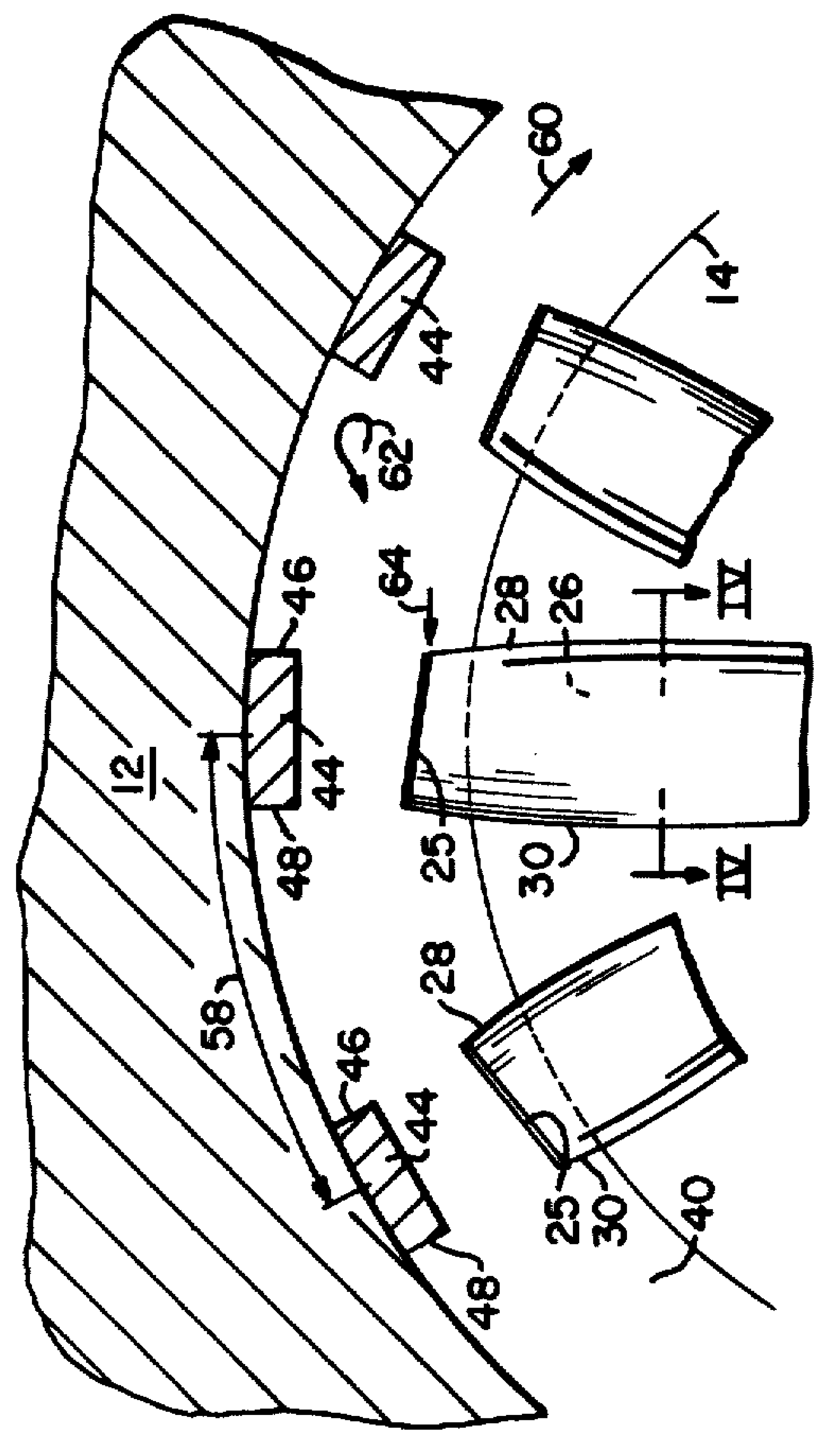


FIG.3

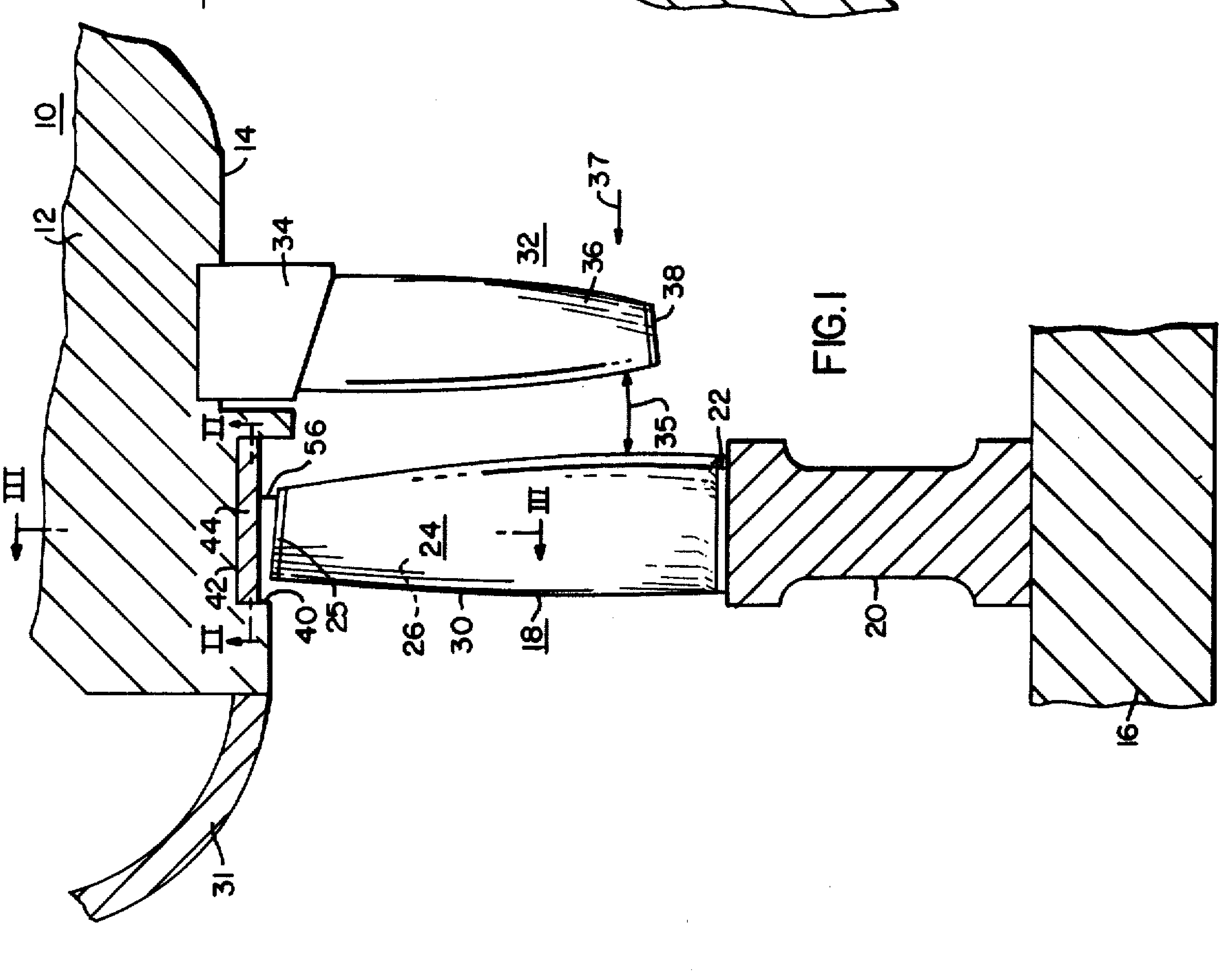


FIG.1

TURBINE BLADE DAMPING

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to steam turbines, and in particular, to an improved damping arrangement for limiting vibration in the rotating blades of an axial flow steam turbine apparatus.

2. Description of the Prior Art

In an axial flow elastic fluid turbine apparatus having a rotating shaft with a plurality of blades thereon, uncontrolled vibration in the rotating blades is an undesirable element of turbine operation. Vibration in the blades can limit the efficiency of the turbine apparatus in many ways. Vibration can, for example, damage the bearings on which the shaft member rotates or can cause undue stress and fatigue of blades, leading to the possibility of early failure in the rotating blades.

The vibration has a variety of sources, including operational vibration of the rotating shaft, or the periodic impingement of the elastic fluid on the blades at the nozzles of the turbine. In addition, turbulence caused by leakage of the elastic fluid through a narrow clearance that exists between the tip of the rotating blade and the interior surface of the casing a reverse flow striking the backside of the blades in the last rotating blade row, thus adding to the vibration of those blades.

In the prior art, the rotating blades are braced by the disposition of a shroud member on the blade. The shroud serves to brace the turbine blades against one another so as to minimize or limit vibration of the blades. Various methods of disposing the shroud are utilized by the prior art, including rim shrouding, which places the shroud between the tip portions of the blades to brace the blades against each other. Another method utilized in the prior art is lashing, or tieing the blades together at a point intermediate between the root and the tip of each blade, to brace each blade against the other. However, disposition of the shroud or blade lashing is an expensive and time-consuming process, and does not completely eliminate blade vibration.

SUMMARY OF THE INVENTION

This invention limits vibration of the rotating turbine blades by use of an improved damping arrangement disposed in the casing of the turbine. A groove is disposed circumferentially about the interior surface of the casing of the turbine apparatus. The groove is disposed so that the tips of the corresponding rotating blade row lie adjacent the groove. A predetermined number of baffles are disposed at predetermined circumferential positions in the groove. The baffles are disposed so as to substantially traverse the width of the groove. As the shaft rotates, the elastic fluid in the turbine is directed by the rotating blades into the groove disposed on the interior surface of the casing. The elastic fluid in the groove is carried circumferentially about the interior of the casing groove, and impinges upon the baffles disposed in the groove. The elastic fluid flow in the groove is deflected and disrupted by the radial baffles disposed in the groove. The deflected elastic fluid strikes against the blades and imparts a force on the blades directed in a direction opposite the direction of rotation of the blades. The force exerted by the deflected elastic fluid on the back surface of the rotating blades acts in the direction opposite the direction of rotation of the blades to limit vibration in the blades.

In addition, a contoured application of a metallic material to the rotating blades provides a further mechanical damper to prevent vibration in the blades.

An object of the invention is to provide a damping arrangement to limit vibration in the rotating blades of an axial flow elastic fluid turbine apparatus.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be more fully understood from the following detailed description of an illustrative embodiment taken in connection with the accompanying drawings in which:

FIG. **1** is an elevation view, partially in section, of the last row of turbine blades in an axial flow, elastic fluid turbine;

FIG. **2** is a view, partially in section, taken along section lines II—II of FIG. **1**;

FIG. **3** is a section view taken along section line III—III in FIG. **1**; and,

FIG. **4** is a section view taken along section line IV—IV in FIG. **3**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Throughout the following description similar reference characters refer to similar elements in all figures of the drawings.

Referring first to FIG. **1**, an elevation view of the last row of rotating blades and nozzles in an elastic fluid turbine **10** is shown.

The turbine **10** comprises a steel casing **12** having a central axial bore **14** extending therethrough, with a rotating shaft **16** disposed centrally and axially in the bore **14**. The shaft **16** has a plurality of radially outward extending rotating blades **18** thereon. Each of the rotating blades **18** has a root portion (not shown) which is attached to a disc **20** which is securely affixed to the shaft **16** by suitable means of attachment, such as a shrink fit. A platform portion **22** of the blade **18** supports a curved airfoil portion **24** which ends in a tip **25**. The blade **18** has a correspondingly curved back portion **26**. The airfoil portion **24** is a curved surface of predetermined curvature having a rounded leading edge **28** and a trailing edge **30**. The last rotating blade row **18** is disposed immediately before a diffuser **31** leading to a condenser element (not shown).

A nozzle diaphragm **32** has a nozzle ring **34** attached to the casing **12**. A plurality of nozzle blades **36** are attached to the nozzle ring **34** and are spaced a predetermined axial distance **35** from the rotating blades **18**. The nozzle blades **36** direct an axial flow **37** of elastic fluid, usually high temperature and high pressure steam, onto the rotating blades **18**. The steam is directed onto the curved airfoil portion **24** of the blade **18** at a predetermined angle so as to provide the maximum possible conversion of energy carried by the steam to rotating mechanical energy of the shaft **16**. The nozzle blades **36** are braced against each other by a shroud **38** to limit vibration therein.

Although the drawing illustrates the last row of rotating blades **18** and nozzles **32**, it is to be understood that the invention can be utilized with any predetermined array of rotating blades within the turbine **10**.

A circumferential groove **40** is disposed about the interior of the casing **12**. The groove lies adjacent the tips **25** of blades **18**. The groove **40** has a predetermined number of radial baffles **44** disposed along the inner surface 42 of the groove 40. The baffles 44 are disposed so as to completely traverse the width of the groove 40. There have been instances in the prior art where circumferential grooves have been cut within the casing of the turbine, for example, U.S. Pat. No. 1,999,711 and U.S. Pat. No. 3,011,763, which deal primarily with preventing leakages of fluid between the close clearances between the rotating and stationary members of the turbine.

Referring now to FIG. 2, section view of the radial baffle 44, taken along section line II—II of FIG. 1 is shown. The baffle 44 is a thin, metallic member, ⅛inch thick, and extends completely across the groove 40 in the casing 12. The baffle 44 is a curved member having a first end 46 and a second end 48, with a curved surface 50 between the ends 46 and 48. The baffle 44 is disposed in the groove 40 so that the first end 46 and the second end 48 of the baffle 44 occupy the same relative positions on the baffle 44 as the leading edge 28 and the trailing edge 30 occupy on the blade 18. The curved surface 50 of the baffle 44 occupies the same relative position on the baffle 44 as the curved surface 24 occupies on the blade 18. It is to be understood, however, that the baffle 44 can be of any desired shape or configuration.

The baffle 44 defines a predetermined angle 52 with a predetermined axis 54, the axis 54 lying parallel to the axis of the turbine 10. Although the ends 46 and 48 of the baffle 44 occupy corresponding positions with the ends 28 and 30 respectively of the blade 18, it is to be understood that the correspondence between the baffles 44 and the blades 18 describes only the orientation of the baffle 44 in the groove 40. It is also to be understood that the number of baffles 44 disposed in the groove 40 is not necessarily equal to the number of blades 18 disposed in the particular blade row of the turbine 10.

As shown in FIG. 1, the tips 25 of the last row 18 of rotating blades are adjacent the groove 40 disposed about the interior of the casing 12. The tips 25 of the last row of blades 18 is of a dimension sufficient to just fill the central bore 14 of the casing. However, as the blades 18 rotate, thermal expansion of the blades 18 and centrifugal force effects on the blades 18 tend to cause the blade tips 25 to extend into the groove 40 for a predetermined distance. A predetermined radial clearance 56 lies between the tips 25 of the blades 18 and the radial baffle 44.

Referring now to FIG. 3, a section view of the turbine taken along section line III—III of FIG. 1 is shown. In FIG. 3, each of the plurality of radial baffles 44 is shown disposed a predetermined circumferential distance 58 from the other. The tip 25 of the blade 18 is shown as extending into the groove 40 disposed in the casing 12. The portion of the blade 18 adjacent the tip 25 which extends into the groove 40 is not subjected to the axial flow 37 (FIG. 1) of elastic fluid and is not loaded as compared to that section of the blade upon which the axial flow 37 (FIG. 1) of elastic fluid impinges.

As the blades 18 rotate on the shaft 16 in a direction indicated by the arrow 60, the elastic fluid is directed by the rotating blades 18, and by centrifugal force, into the groove 40 disposed on the interior surface of the casing 12. The elastic fluid so directed then begins to circumferentially flow in the direction 60, the flow direction being the same as the direction of rotation of the blade 18. The elastic fluid flow in the groove 40 impinges upon the plurality of radially disposed baffles 44 disposed traversely across the groove 40. The baffles 44 deflect the circumferentially rotating elastic fluid in the groove 40 and disrupt the flow of fluid from the circumferential flow path in the groove 40.

A portion of the deflected fluid is deflected in a direction indicated by an arrow 62 and impinges the backside 26 of the rotating blades 18. The deflected elastic fluid imposes a force on the backside 26 of the blades 18 in a direction 64 that is opposite to the direction of motion 60. The force in direction 64 tends to limit vibration in the rotating blades 18. By judicious spacing a predetermined number of the radial baffles 44 in the groove 40, selected harmonics of the frequency of vibration imposed on the blades 18, such as particular vibratory modes at the blade tip 25, can be eliminated.

As stated previously, one source of vibration to the rotating blades 18 is the leakage of the elastic fluid through clearance spaces which lie between the tip of the blade and interior portion of the casing. Utilization of the teachings of the invention eliminates this leakage flow. Without the groove 40 disposed on the interior surface of the casing, the flow of the elastic fluid would continue, as in the prior art, through a clearance space between the tip of the blade and the interior surface of the casing and cause reverse flow in certain portions of the last blade row. However, since the groove 40 is disposed substantially perpendicular to the axial flow path 37 of the elastic fluid, to leak past the blade tip 25 the steam flow 37 must take a right angle turn into the groove 40, therefore the leakage flow as just described in the prior art is eliminated. The vibrations in the blade 18 are also limited by the shearing action of the baffle 44 in shearing a portion of the volume of steam that is moving circumferentially in the groove 40.

Referring now to FIG. 4, a section view of a rotating blade 18 taken along section line IV—IV of FIG. 1 is illustrated. It is common practice to place on the backside of each of the rotating blades 18 a strip of metallic material, commonly a Stellite, to protect the blades, especially the last blade row, from corrosion or erosion caused by impingement of condensed steam on the blade. In this invention, the stellite strip is eliminated and a contour fitting of Stellite is disposed on each of the rotating blades 18. The Stellite possesses a modulus of elasticity which differs from the modulus of elasticity of the steel utilized to fabricate the rotating blades 18. Juxtapositioning of two materials having dissimilar moduli of elasticity provides a further mechanical damper to limit vibration of the rotating blades 18. The Stellite is plasma applied in a manner well-known to those skilled in the art so as to form a uniformly contoured coating 70, approximately ⅛ inch thick around each rotating blade 18.

It is thus seen that disposing a predetermined number of baffles at predetermined spacing in a groove cut circumferentially into the interior surface of the casing of an axial flow elastic fluid turbine provides an effective damper arrangement to limit vibration in the rotating blades of the turbine. The baffles deflect the elastic fluid onto the rotating blades so that a force is exerted in a direction that opposes limiting vibration in the blades. In addition, disposing a coating of metallic material uniformly about the blade also limits vibration in the rotating blades of an elastic fluid turbine apparatus.

What we claim is:

1. An axial flow elastic fluid turbine apparatus comprising:

a casing having a central axial bore extending therethrough, said casing having a circumferential groove disposed on the interior surface thereof,

a predetermined plurality of baffle members disposed in said groove, said baffle members being disposed at a predetermined circumferential distance from one another, each of said baffle members traversing said groove and extending radially inward from said groove relative to an axis extending through said bore,

a predetermined number of nozzles directing the flow of elastic fluid in said turbine, and,

a rotating member extending centrally and axially through said bore, said rotating member having a predetermined number of rotating blades thereon, each of said blades having a root portion attached to said rotating member and a tip portion thereon, said tip portion of each of said blades being adjacent to said groove in said casing, said rotating member being operable to direct said elastic fluid from said nozzles into said groove, said elastic fluid directed into said groove being deflected by said baffle members against said rotating blades to reduce vibration in said blades.

2. The turbine of claim 1, wherein said tip of said blades are disposed so as to extend a radial distance into said circumferential groove.

3. The turbine of claim 1, wherein said baffle members are disposed so as to define a predetermined oblique angle with said axis extending through said bore.

4. The turbine of claim 3 wherein said baffles are disposed so as to align with said tip portion of one of said predetermined number of rotating blades.

5. The turbine of claim 1, wherein said predetermined number of baffles is different from said predetermined number of rotating blades disposed on said rotating member.

6. The turbine of claim 5, wherein said predetermined number of baffles is different from said predetermined number of nozzles.

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