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DAMPED TURBOMACHINE ROTOR ASSEMBLY

Filed Oct. 5, 1970

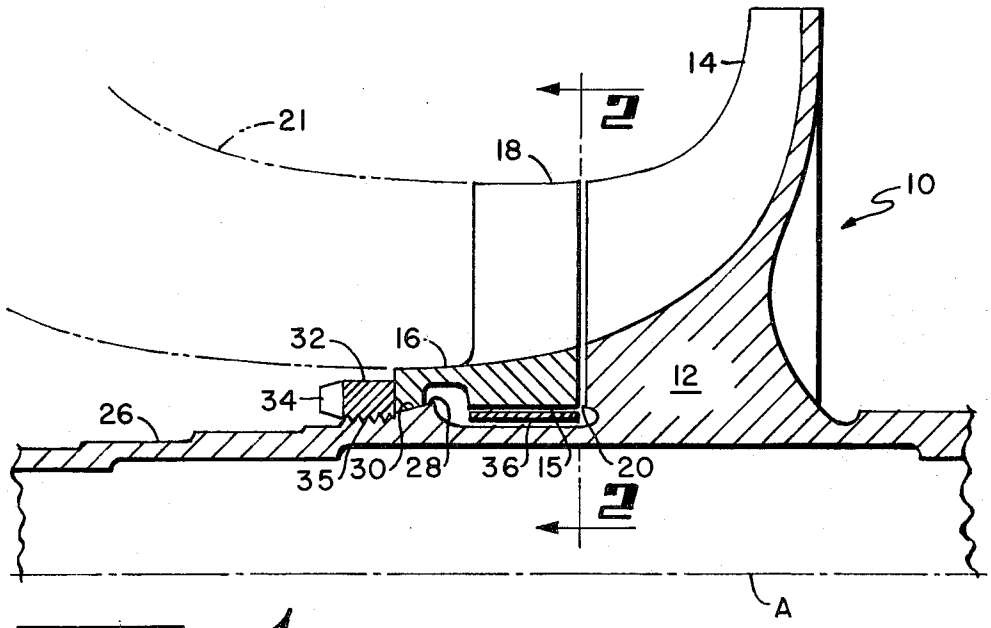


Fig 1

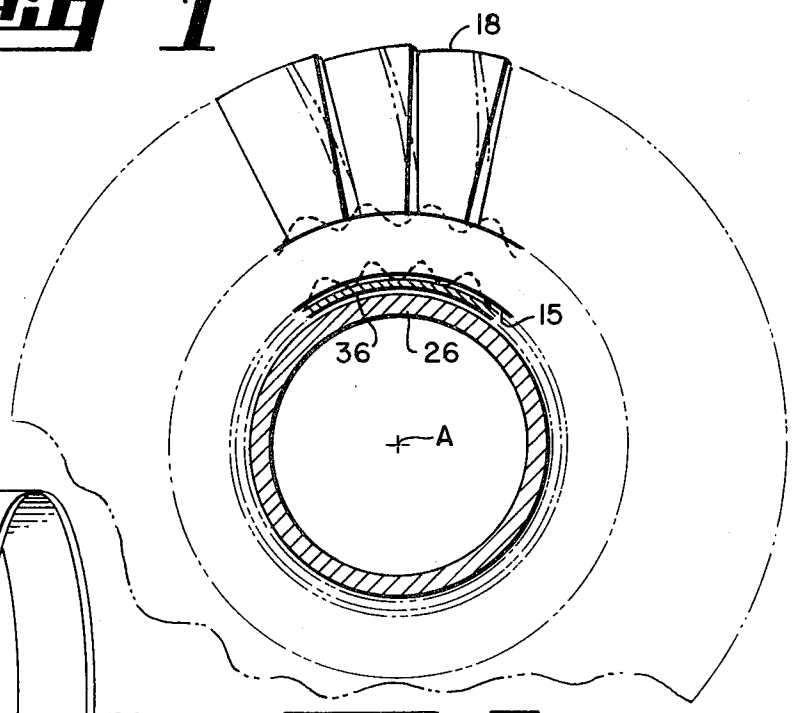


Fig 2

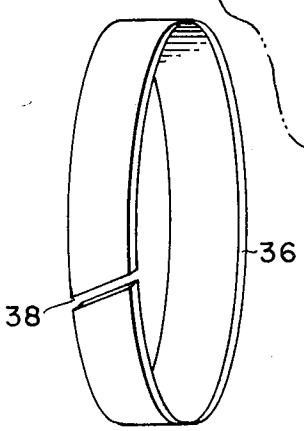


Fig 3

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DAMPED TURBOMACHINE ROTOR ASSEMBLY

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ABSTRACT OF THE DISCLOSURE

The disclosure illustrates a centrifugal compressor comprising an inducer hub telescoped over an adjacent shoulder of an impeller hub. The inducer hub has an inner annular surface which receives an annular relatively thin split ring element. When the compressor rotates at high r.p.m.'s the split ring frictionally engages the inner annular surface of the inducer hub to damp vibrations.

The present invention relates to turbomachine rotor assemblies and more particularly to assemblies of the type that have provisions for damping.

In the gas turbine art there have been numerous devices developed for minimizing vibration in rotor assemblies. For the most part these damping arrangements utilize the principle of frictional engagement of the tips of adjacent blades on hub assemblies.

An example of this approach may be found in the U.S. patent to Birmann No. 2,405,283. This patent illustrates a machined-away shoulder adjacent the inner portions of one set of blades so that only the tips of the blades abut adjacent blades. The blade assemblies are held with sufficient axial force to cause the edges of the blades to frictionally engage and damp vibrations. There are many other approaches to this problem that utilize this principle. However, they all suffer from the disadvantage of either disturbing the flow path through the impeller or requiring expensive manufacturing techniques.

Therefore it is an object of the present invention to provide a highly simplified and economical means for damping a turbomachine rotor.

The above end is achieved by a damped turbomachine rotor comprising a generally annular hub spaced outward from its axis of rotation and having an inner annular surface. An annular, relatively thin ring element is received within and conforms to this surface so that centrifugal force urges the ring member into frictional engagement with the inner surface to damp vibrations in the blades.

The above and other related objects and features of the present invention will be apparent from a reading of the description of the accompanying drawing and the novelty thereof pointed out in the appended claims.

In the drawing:

FIG. 1 is a longitudinal sectional view of a centrifugal compressor rotor assembly embodying the present invention;

FIG. 2 is a view taken on lines 2—2 of FIG. 1 which illustrates the fundamental mode of vibration of the compressor hub;

FIG. 3 is a perspective illustration of a split ring element incorporated in the impeller of FIG. 1.

Referring now to FIG. 1, there is shown a centrifugal compressor rotor assembly **10** with which the present invention may be used. The rotor assembly comprises a first generally annular shaped hub **12** spaced outwardly from its axis of rotation A. The hub **12** has a series of radially extending blades **14** to form the impeller portion of the rotor assembly **10**. A second hub **16** is positioned upstream

of the hub **12** and is also annular and spaced outwardly from the axis of rotation A. An annular surface **15** is formed on the inner side of hub **16**. Hub **16** has a series of inducer blades **18** which extend radially outward but are cambered so as to efficiently receive air from an axially directed inlet, shown in phantom and designated by reference character **21**. The inducer blades **18** are spaced from but correspond with the impeller blades **14** to form a generally annular accelerating flow across the centrifugal compressor rotor **10**.

Hub **12** has an elongated shaft portion **26** over which hub **16** is telescoped. A tapered pilot diameter **28** on the elongated shaft portion **26** and a corresponding tapered diameter **30** on the inducer hub **16** centers it on elongated shaft portion **26** of hub **16**. An internally threaded nut **32** is screwed onto the threaded portion **35** of the elongated portion **26** by a suitable tool which engages slots **34** in element **32**. Element **32** holds the inducer hub **16** against a shoulder **20** on the impeller hub **12**.

An annular relatively thin ring element **36** is received within and conforms to the inner annular surface **15** of hub **12**. Preferably the ring **36** is split at **38**, as shown in FIG. 3, and formed to have an outside diameter slightly greater than the diameter of the inner annular surface **15**. Element **36** is then compressed for insertion into the inner annular surface **15** and once in position is yieldably maintained in place.

In operation the centrifugal compressor rotor assembly **10** rotates at a high rate of speed. Due to many exciting forces the blades **18** and **14** tend to vibrate in their several modes. As shown in FIG. 2, the resultant vibration causes deformation of the inner annular surface **15** of annular inducer hub **16** from which the blades **18** extend radially. The deflection of the hub for a swing of blades **18** to the left is shown in exaggerated proportion by the phantom lines of FIG. 2. It can be seen that this deflection generally resembles a sine wave superimposed on the annular shape of the inner annular surface **15**. A swing of the blades to the right causes a similar deflection in the opposite direction.

The ring element **36** is urged radially outward by centrifugal force into frictional engagement with the deflected portion of the inner annular surface **15**. As the blades swing the resultant ridges and valleys in the inner annular surface rub against the ring element **36**. The resultant frictional engagement absorbs energy created by the deflection of the rotation of the blades. Damping at this radially inward portion requires a high degree of energy. However, for a speed of over 50,000 r.p.m. the weight of the split ring is magnified approximately 100,000 lbs. times its radius in inches. Even for a small spacing from the axis of rotation the ring element **36** exerts a sufficient outward force to effectively damp vibrations.

While the present invention has been described in connection with the inducer portion of a centrifugal compressor, it is believed that those skilled in the art can adapt the invention to other turbomachine rotors, such as axial flow type or centripetal turbine assemblies without departing from the spirit and scope of the present invention.

Having thus described the invention, what is claimed as novel and desired to be secured by Letters Patent of the United States is:

1. A damped turbomachine rotor assembly adapted to rotate at relatively high rates, said rotor assembly comprising:

a generally annular hub spaced outward from its axis of rotation having an outer surface defining the inner bounds of a flow path for fluid and an inner annular surface;

a plurality of blades extending radially outward from the outer surface of said hub substantially radially

outward from said inner annular surface, said blades being subjected to vibratory bending forces thereby producing deflections in said interior surface; and

an annular relatively thin ring element received within the inner annular surface of said hub member and conforming thereto, whereby centrifugal force urges said ring member into frictional engagement with the inner surface of said hub for damping vibrations.

2. A rotor assembly as in claim 1 wherein said ring element is split and has an outside diameter slightly larger than the diameter of said inner annular surface whereby the ring element is compressed for insertion into said inner annular surface and is yieldably maintained in position.

3. A rotor assembly as in claim 1 wherein said hub and blades comprise an inducer of a centrifugal radial outflow compressor and said rotor assembly further comprises:

a downstream radial outflow impeller hub;

a plurality of blades extending radially outward from said impeller hub, said blades being out of contact with said inducer blades.

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