June 28, 1966 E. D. ALDERSON 3,258,245

BLADE STIFFENING MEANS

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Fig 1

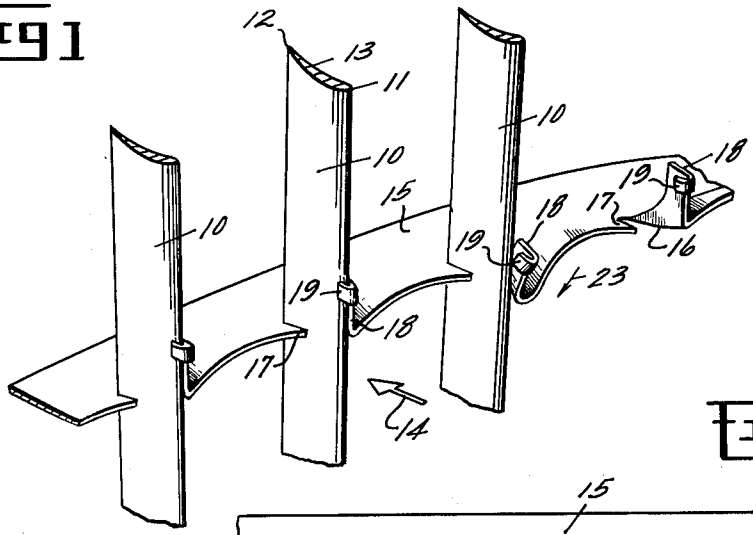


Fig 2

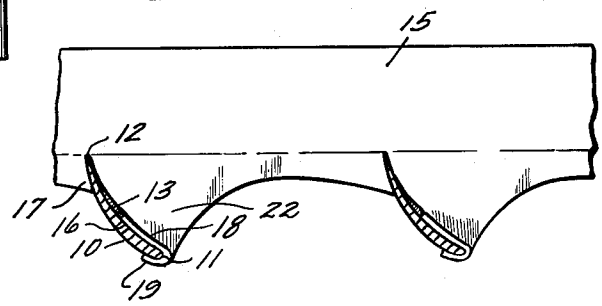


Fig 3

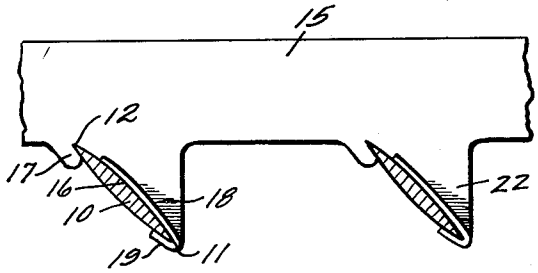
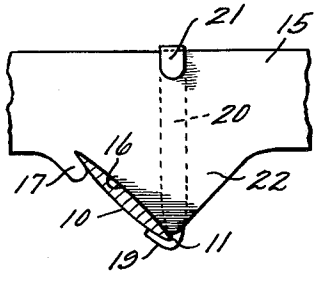


Fig 4



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BLADE STIFFENING MEANS

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The present invention relates to a blade stiffening means and, more particularly, to a shroud or stiffening ring for turbomachinery blades, such as compressors, which is detachable for easy replacement of blades.

In many pieces of turbomachinery high aspect ratio blades are used. The aspect ratio is the ratio of the length over the width or the chord of the blades. Very large aspect ratio blades will generally be found in fan devices that move a high volume of air at low velocity. For purposes of the present invention the structure is described as used in a fan although it is applicable to any high aspect ratio blades as will be apparent. The stiffness of any given blade of course depends on many factors such as the thickness ratio of the blade, the area distribution along the blade, the amount of tip mass as applied to the end of the blade and the degree of fixity of the tip of the blade against torsion rotation. It is generally accepted that problems are encountered when the blade is designed with an aspect ratio over six. The solution to the problem of the long thin flexible blades is to tie them together at some mid-span point to reduce their vibration. This is necessary because, at a high aspect ratio, both rotor blades and even stator blades become so flexible that their natural frequency of vibration tends to get into the operating region of the device in which they are employed with the possibility of getting in tune with the rotational frequency of the rotor. This results in resonance in the blade in tune with the blade's natural vibration frequency so that very high stresses and ruptures can and do occur.

In the high aspect ratio or real long blades, it is possible to force the blades to higher vibration natural frequencies and out of the range of operation by fixing some point along the blade so that it acts like two shorter blades. This is done with a mid-span shroud in fans or the equivalent in turbines and compressors of which the fan is an example. The problem of vibration in the long limber blades may be overcome by putting a platform out along the length of the blade so that adjacent blades touch each other at the platforms and damp or dissipate the energy of vibration by impact. Alternately, the platforms may be fastened to each other. This results in expensive blades because the forgings require the platform material and numerous machining operations are involved. Another method of providing a node at some mid-point in order to create higher vibration natural frequencies is to put holes in the blades and thread wires or bars through them and either fasten them or merely allow the frictional vibration between the blades and the wire or bar to dampen vibration. It will be apparent that numerous machining operations are involved in this method and the blade must be thickened at the point of the hole if the hole is not to weaken the blade. This thickening is a modification of the forgings and is an extra expense and complication. Still a further method of attaching the mid-span stiffening means is with a ring with holes cut through it and then merely thread the vanes through the ring and braze the ring and blades together. This is satisfactory but it is difficult to replace the blades since it is a unitary structure.

The main object of the present invention is to provide a blade stiffening means for a stage of airfoils that does not alter the airfoils and permits replacement of individual airfoils.

Another object is to provide such a stiffening means in the form of a ring that tends to grip the individual blades tighter under operation and yet is immediately detachable for individual replacement of any blade.

A further object is to provide such a stiffening ring that does not require any alteration whatever to the individual blades.

Briefly stated, the invention provides a blade stiffening means for gripping near the mid-span of airfoils for turbomachinery such as a compressor or fan which comprises a sheet metal member having spaced cut-out portions in one edge of the member and shaped to conform to an airfoil blade surface. The member, in the form of a continuous hoop or ring, has a tab to overlap one edge of the airfoil and means, either in the form of a separate clamp or an upstanding portion of the member itself, connected with the member to overlap the other edge of the airfoil and clamp the airfoil in the cut-out portion to the sheet metal ring. For a snug griping action, the cut-out portions may be provided in an axially-extending portion of the sheet metal hoop member to deflect under centrifugal load whereby the clamping action is increased. Additionally, the whole clamping action may take place on the pressure portion of the blade for most efficient operation of the airfoil.

While the specification concludes with claims particularly pointing out and distinctly claiming the subject matter which is regarded as the invention, it is believed the invention will be better understood from the following description taken in connection with the accompanying drawings in which:

FIG. 1 is a partial perspective view of a fan with the blade stiffening means attached thereto and illustrating the operation thereof;

FIG. 2 is a partial cross-sectional view looking down on the top of an individual blade of FIG. 1;

FIG. 3 is a view similar to FIG. 2 showing an alternate form of hoop construction; and

FIG. 4 is a partial cross-sectional view showing an alternate form of clamp construction.

The invention herein will be described as applied to a high aspect ratio compressor such as a fan although it will be appreciated that its use is not confined to such an application but may be used anywhere a clamping action is desired to reduce the frequency of vibration of airfoils.

Referring first to FIG. 1, there is shown a partial view of a group or segment of high aspect ratio fan blades which are preferably, but not necessarily, in the shape of cambered airfoils with a leading edge **11** and trailing edge **12** in the conventional manner. This results in a concave blade with high pressure side **13** which is well known. Air flow through these blades **10** will be in the direction of arrow **14**.

Since these blades **10** are long thin blades, or blades of high aspect ratio, they tend to vibrate which impairs their efficiency. Additionally, when the vibration gets in tune with the operational frequency of the system in which the fan is used, high stresses and ruptures can result. This is well known and means are generally provided to grip and dampen the blades' vibration at some mid-point.

In order to accomplish this without altering the blade in any manner, and still permit the replacement of individual blades when necessary, according to the invention there is provided a sheet metal hoop member **15** which may be conveniently in the form of a continuous hoop. This is desired where blades **10** are rotating blades or, alternately, member **15** may, in the case of stator blades, be made in segments with suitable attaching means between the ends of the segments in which case FIG. 1 would represent a segment. It will be convenient to

think of member **15** as a continuous hoop and blades **10** as rotor blades. With the aspect ratio of blades **10**, as defined by the length of the blades over the chord as shown in FIG. 1 being very high, hoop member **15** is generally applied substantially at the mid-span of blades **10**. The term mid-span is intended to cover the member when it is between the blade ends where vibration occurs and is not limited to the exact middle as is obvious. If necessary, several can be used at different lengths along the blades. Member **15** is of sheet metal in the sense that it provides resiliency or flexibility for some distortion as will be apparent. By sheet metal it is merely meant that the hoop member is an easily stamped-out or formed part normally understood as associated with lightweight flexible material whether of metal or plastic or similar material and the term is selected as convenient ot cover all such modifications.

In order to provide a place to grasp the individual blades **10**, the sheet metal member **15** has spaced cut-out portions **16** in one edge of the member as better shown in FIG. 2. These cut-out portions **16** may, in the case of a cambered airfoil, be conveniently shaped to conform to only one side as the concave surface **13** of the airfoil. The reason for this is that attachment of the hoop member along the pressure surface **13** is the best way to maintain the aerodynamic efficiency of the blades as opposed to attachment on the low pressure or opposite surface. Thus, each individual blade **10** snugly fits within its cut-out portion **16** in hoop member **15**.

In order to retain the blade members **10** in the hoop member, the hoop is provided with an offset or tab **17** to overlap the trailing edge **12** of the airfoil. The airfoil is further retained in the cut-out portion in conjunction with tab **17** by an additional clamping means that may take several forms. As shown in FIG. 1, this can conveniently take the form of a flexible finger portion **18** with an overlapping grip piece **19** thereon to clamp and grip against leading edge **11**. These are formed from the hoop and are upstanding from the hoop surface as shown substantially at right angles to the hoop surface. Alternately as shown in FIG. 4, a separate clip **20** may be provided to span the hoop member **15**. It has a second tab **21** overlapping member **15** opposite the leading edge **11** which is gripped as shown. In this case tab **21** would merely be bent into position to hold the parts together.

In order to provide a tightening or form a clamping action and avoid any slipping during operation, the cut-out portions in the clamping means heretofore described extend beyond the edge of the hoop in an axially-extending portion **22** as shown in FIG. 2. This overhung or extending portion **22** tends to rotate the ring about its centroid moving portion **22** radially outward or upward in FIG. 1 under centrifugal force and, carrying the grip piece **19** or its equivalent overlapping clip piece shown in FIG. 4, will tighten on the blade **10** to grasp it firmly and this clamping action is increased under load. Thus, centrifugal action forces the clamping means tighter against the blade because portion **22** tends to be forced radially outward.

It will be seen that the cut-out portion, the tabs, and the grip piece are all connected together along the concave portion of the airfoil for best aerodynamic efficiency. Additionally, any movement between the clamping structure and the individual blades **10** will of course result in a damping action although, because of the construction of the blade stiffening means, this is relatively small. Since no permanent connections are made it is possible to replace individual blades **10**. This is accomplished merely by springing the ring to disengage grip piece **19**, then bending the flexible finger portion **18** back slightly as shown in FIG. 1 at arrow **23** and snapping the blade **10** out of member **15**. A new or replacement blade **10** may then be inserted and snapped into position in much the manner of twisting a Venetian blind.

As shown in FIG. 2, the axially-extending portion **22** is faired into the hoop member **15** but may be a straight angular section as shown in FIG. 3 requiring only the extending portion that provides for the tightening action under centrifugal load.

It will be seen that the stiffening means employed requires no alteration whatsoever to the blades, may be applied to the blades so as not to destroy their aerodynamic efficiency, requires no specially formed blade in the form of built-up portions, and permits easy removal of individual blades and an increased clamping action that tightens under load.

While there have been described preferred forms of the invention, obvious modifications and variations are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

I claim:

1. A blade stiffening means for turbomachinery, airfoils on said turbomachinery, said means adapted for mid-span gripping of said airfoils and comprising,
- a resilient sheet metal member,
- edges on said metal member,
- spaced cut-out portions in one edge of said member and each cut-out being shaped to conform to only one surface of an airfoil,
- said member having a tab to overlap an edge of said airfoil, and
- means including an upstanding flexible finger portion with a grip piece thereon connecting with said member and overlapping the other edge of said airfoil to clamp and grip said airfoil to said member in said cut-out portion.

2. Apparatus as described in claim **1** wherein said airfoil is cambered and said cut-out portion, tab, and grip piece are connected together along the concave portion of said airfoil.

3. Apparatus as described in claim **1** wherein said tab and grip piece contact said trailing and leading edges of said airfoil respectively.

4. A blade stiffening means for a compressor, cambered airfoil blades with a pressure concave surface and leading and trailing edges on said compressor, said stiffening means comprising,
- a continuous hoop sheet metal member,
- spaced cut-out portions along one edge of said member extending beyond said continuous hoop,
- said cut-out portions being shaped to conform to only the pressure surface of a blade,
- said member having a tab to overlap the trailing edge of said blade, and
- means including a flexible finger portion upstanding from the hoop surface substantially at right angles thereto and having a grip piece thereon and connecting with said member and overlapping the leading edge of said blade to clamp said blade to said member in said cut-out portion.

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