Sept. 4, 1956 J. T. PURVIS 2,761,648

ROTOR BLADE LOCKING DEVICE

Filed Sept. 18, 1951

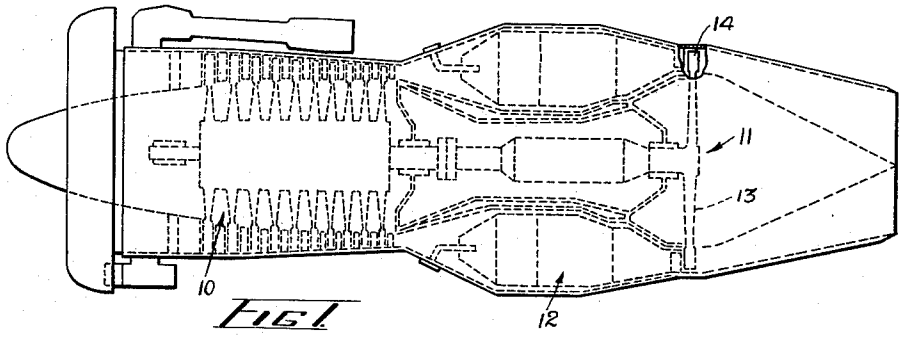


FIG 1.

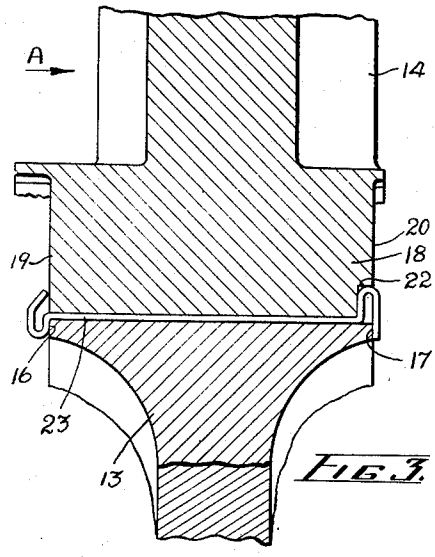


FIG 3.

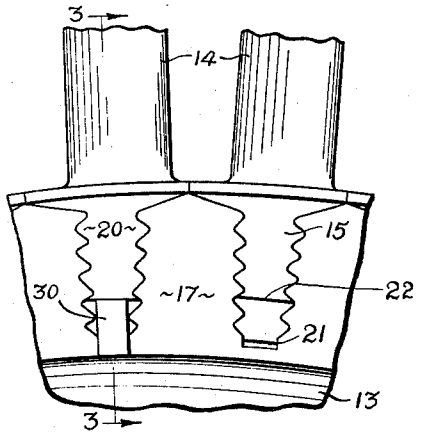


FIG 2.

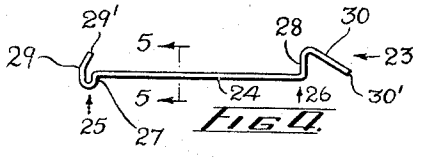


FIG 4.

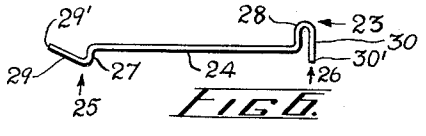


FIG 6.

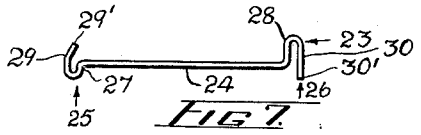


FIG 7.

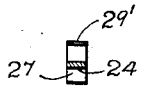


FIG 5.

INVENTOR
J.T.PURVIS
PER

Carl R. Mayhew

ATTORNEY.

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ROTOR BLADE LOCKING DEVICE

Joseph Thompson Purvis, North York Township, Ontario, Canada, assignor to A. V. Roe Canada Limited, Walton, Ontario, Canada, a corporation

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5 Claims. (Cl. 253—77)

This invention relates to blading for rotary power conversion machines and the like and particularly to improved fastening means for such blading.

Blading of this type normally requires such accuracy of form and finish that the blades have to be manufactured individually. This practice, however, introduces fresh problems in connection with mounting of the blade in the machine, problems which are particularly critical if the blade is to be mounted on a compressor or turbine rotor which is to be rotated at high speed. Not only is centrifugal loading imposed upon the blade under these conditions but there is also axial loading due to the momentum of the working fluid and although this axial loading is usually small in comparison with the centrifugal loading some provision must nevertheless be made to absorb it.

Various locking devices have been developed for this purpose but most of these are complicated and involve machining or drilling of the rotor disc, processes which it is preferable to reduce to a minimum since they produce undesirable stress concentrations in a component already highly stressed. In the co-pending application No. 214,072 of J. T. Purvis and R. M. Sachs an improved form of locking device was disclosed and the invention described herein is an extension of this earlier idea.

It is the object of this invention to provide improved retaining means for withstanding this axial loading.

In the accompanying drawings which form a part of this specification and in which like reference characters denote like parts throughout the same,

Fig. 1 illustrates a gas turbine engine having a turbine rotor with blades attached thereto in accordance with the invention;

Fig. 2 is a fragmentary side elevational view of a portion of the turbine rotor with blades attached, one blade being shown with the locking device removed for greater clarity;

Fig. 3 is a sectional view taken on the line 3—3 in Fig. 2;

Fig. 4 is an elevational view on a slightly reduced scale of one form of the retaining pin before assembly;

Fig. 5 is a cross sectional view on the line 5—5 in Fig. 4;

Fig. 6 is an elevational view, on the same scale as Fig. 4, of another form of the retaining pin before assembly, and

Fig. 7 is an elevational view, on the same scale as Fig. 4, of the retaining pin after assembly, shown apart from the associated structure.

The gas turbine illustrated in Fig. 1 is of conventional design, with a compressor **10**, a turbine assembly **11** and a combustion system **12** located between them. The turbine assembly comprises a blade supporting element or rotor **13** supporting a series of radially extending blades **14**, the blades being mounted in a series of peripheral slots **15**, which in the embodiment illustrated are of "fir tree" cross-section, as shown in Fig. 2. The slots extend from the front or upstream face **16** of the rotor to its rear or downstream face **17** in a substantially axial direction, parallel to the general flow of air through the engine as indicated by the arrow A in Fig. 3.

The blades **14** are formed with blade roots **18** of "fir tree" shape conforming to the shape of the slots, the length of the roots being equal to the length of the slots so that

upon assembly the exposed end faces **19** and **20** of the roots are flush with the adjacent end faces **16** and **17** respectively of the rotor. The basal extremity of each of the blade roots is machined flat to provide a passage **21** running axially between the basal extremity of the root and the base of the slot; further, the downstream end face **20** of the root is machined at its tip to provide a recess **22**.

A retaining pin **23** (Fig. 7) is formed from a strip of metal of flattened cross-section, the pin having a shank **24** of the same length as the blade root **18** less the depth of the recess **22**. At the ends of the shank **24** stops **25** and **26** extend on opposite sides of the shank, each of the stops being formed by bending the pin at an end of the shank through 90° to provide a shoulder **27** or **28**, as the case may be, on one side of the shank **24**, and making a further bend through about 180° at a location spaced from the axis of the shank to dispose the tip part **29** or **30**, as the case may be, laterally near the first bend to bring its extreme tip **29'** or **30'**, as the case may be, into final position beyond the axis of the shank from the shoulder; the bends are made so that the shoulder **27** of the stop **25** and the shoulder **28** of the stop **26** are located on opposite sides of the shank with respect to each other. In effect, each of the stops **25** and **26** is formed by making a bend having one reversal of curvature. The dimensional conformation of the stop **26** is such that its reverse bend will fit closely into the recess **22** and its tip **30'** will overlie the rear face **17** of the rotor, whereas the tip portion **29** of the stop **25** is so bent that the tip **29'** is laterally opposite the shoulder **27**, meeting the forward face **19** of the blade root obliquely and holding the face **19** substantially flush with the face **16** of the rotor.

Since a strip of metal normally will not conform exactly to the shape of a form around which it is being bent but will spring back to a material extent on account of the elasticity of the metal, the shoulders **27** and **28** may fail to provide firm location of the blade root in the rotor if they are formed on assembly. Consequently it is preferable to pre-form the shoulder **28** and both bends of the stop **25** before assembly, as shown in Fig. 4, the reverse bend of the other stop **26** not being completed so that the tip **30'** does not come below the longitudinal axis of the shank **24**; alternatively, the shoulder **27** and both bends of the stop **26** may be pre-formed and the reverse bend of the other stop **25** left incomplete so that the tip **29'** does not come above the longitudinal axis of the shank as in Fig. 6.

To assemble the blade on the rotor with a pin which has been pre-formed as in Fig. 4, the pin **23** is first fitted to the root **18** so that the shank **24** of the pin butts against the basal portion of the root, the shoulder **28** of the stop **26** engaging the forward face of the recess **22** and the tip **29'** of the stop **25** engaging the front face **19** of the blade root. The root is then fitted into the slot **15** and, with the tip **30'** of the stop **26** clearing the base of the slot, the root and the attached pin is slid rearwardly in the slot until shoulder **27** of the stop **25** meets the front face **16** of the rotor. The reverse bend of the stop **26** is then completed to bring the tip **30'** into engagement with the rear face **17** of the rotor and lock the blade in the rotor.

It will be noted that the blade is held against the main air loading (indicated by the direction of the arrow A in Fig. 3) by the pre-formed shoulders **27** and **28**, while the tips **39'** and **30'** of the stops serve to locate the blade against reverse loading, which is of lesser magnitude than the main air loading.

If the alternative form of the pin shown in Fig. 6 is to be used, the pin is first fitted to the base of the slot **15**, rather than to the blade root, with the shoulder **27** of the stop **25** and tip **30'** of the stop **26** engaging the front face **16** and the rear face **17** of the rotor respectively.

The blade root 18 is then slid rearwardly into the slot 15 until the forward face of the recess 22 meets the shoulder 23 of the stop 25; and the reverse bend of the stop 25 is then completed to bring the tip 29' into engagement with the front face 19 of the blade root, and lock the blade in position. As before, the tip of the incompletely formed stop does not interfere with the insertion of the root because, in this case, it lies below the basal portion of the root.

Of the two methods shown for pre-forming the pin 23, that illustrated in Fig. 4 is preferred since the assembled position and final configuration of the stop 26 lends itself better to the forming operation after assembly: the tip portion 39 of the stop can be bent through the remainder of the 180° with a larger radius of bend since the bend lies within the recess 22, and the bend may be compressed slightly to compensate for spring back in the metal without danger of breaking the metal at the bend. Thus, the tip of the stop can be made to engage the adjacent rotor face more tightly than is the case if the configuration shown in Fig. 6 is used, unless by an additional step in assembly the stop 26 in the latter case is given a final tightening bend after the reverse bend of the stop 25 is completed.

The construction described in the foregoing provides a form of blade locking which has the advantage of lightness and at the same time is simple and inexpensive to manufacture. Not only does it permit individual blades to be replaced without disturbing the remaining blades, but it also provides positive predetermined location of the blades in the sense counter to that of the main air loads.

It will be understood that the forms of the invention herewith shown and described are to be taken as preferred examples of the same and that various changes may be made in the shape, size and arrangement of the parts without departing from the spirit of the invention or the scope of the subjoined claims.

What I claim as my invention is:

1. A locking pin for locking the blading of a rotary power conversion machine having a shank of flattened cross section, a bent part at each end of the shank and a tip part at each end of the pin on the side of the bent part remote from the shank, the bent parts each having a first bend away from the axis of the shank and a second band of reverse curvature at a location spaced from the axis of the shank, the first bends forming shoulders at the ends of the shank and the second bends disposing the tip parts laterally near the first bends, the tip part at one end of the pin extending and protruding in a lateral direction beyond the axis of the shank from the shoulder at that end of the shank, and the tip part at the other end of the shank extending in an oblique direction with respect to the axis of the shank from the adjacent second bend to a point axially spaced from that end of the shank and not protruding beyond the axis of the shank from the shoulder at that end of the shank.

2. A locking pin for locking the blading of a rotary power conversion machine comprising a shank, a bent part at each end of the shank, and a tip part at each end of the pin on the side of the bent part remote from the shank, the bent parts each having a first bend away from the axis of the shank and forming a transverse shoulder at the end of the shank, the said shoulders extending at opposite sides of the shank at opposite ends thereof, and the bent parts each having a second bend of reverse curvature, at a location spaced from the axis of the shank, the tip parts each extending and protruding in a lateral direction beyond the axis of the shank from the shoulder at that end of the shank.

3. A locking arrangement as claimed in claim 2 in which the recess is in the downstream end face of the blade root.

4. A locking structure for the blading of a rotary power conversion machine in which a stream of fluid flows past a ring of rooted blades in a blade supporting member comprising, a blade supporting element, and a blade having a blade root, the blade and the supporting element each having exposed upstream and downstream end faces, interlocking means on the blade root and on the support element securing the said element against relative movement in all directions save one which intersects the said faces, the said means being inoperative to secure the said elements against relative sliding movement in the said one direction, a recess in one of the said faces, and a pin having a shank of flattened cross section fittingly positioned between the blade root and the support element and having a bent part at each end of the shank and a tip part at each end of the pin on the side of the bent part remote from the shank, the bent part and the tip part engaging the said faces to prevent relative movement in the said one direction, each bent part having a first bend away from the axis of the shank and a second bend of reverse curvature at a location spaced from the axis of the shank, each of the first bends forming a transverse shoulder at one side of the axis of the shank, one of the shoulders extending into the recess in the said one of the faces, and the other shoulder overlying another one of the said faces, the second bends disposing the tip parts laterally near the first bends, each of the tip parts extending generally radially with respect to the ring of blades from the corresponding shoulder to the other side of the axis of the shank to overlie one of the remaining two faces.

5. A locking structure for the blading of a rotary power conversion machine in which a stream of fluid flows past a ring of rooted blades in a blade support comprising, a blade supporting element and a blade having a blade root, the blade having an exposed downstream end face and the supporting element having an exposed upstream end face, interlocking means on the blade root and on the supporting element securing the blade root and supporting element against relative movement in all directions save one which intersects the said faces, the said means being inoperative to secure the said elements against relative sliding movement in the said one direction, a recess in one of the said faces, and a pin having a shank of flattened cross-section fittingly positioned between the supporting element and the blade and having a bent part at each end of the shank and a tip part at each end of the pin on the side of the bent part remote from the shank, the bent parts and tip parts engaging the said faces to restrain the supporting element and the blade against relative movement, the bent parts each having a first bend away from the axis of the shank and a second bend of reverse curvature at a location spaced from the axis of the shank, each of the first bends forming a transverse shoulder at one side of the axis of the shank, one of the shoulders extending into the recess in the said one of the said faces and the other shoulder overlying the other one of the said faces, the second bend disposing the tip parts laterally near the first bends, each of the tip parts extending generally radially with respect to the ring of blades from the corresponding shoulder to the other side of the axis of the shank.

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