Oct. 21, 1947. G. K. W. BOESTAD 2,429,215

TURBINE BLADE

Filed Nov. 10, 1943

Fig.2

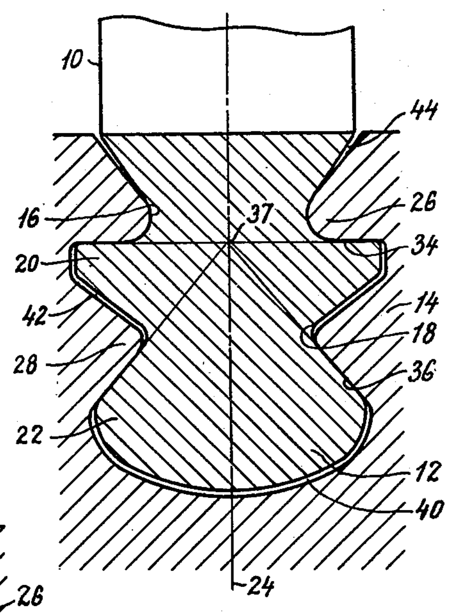
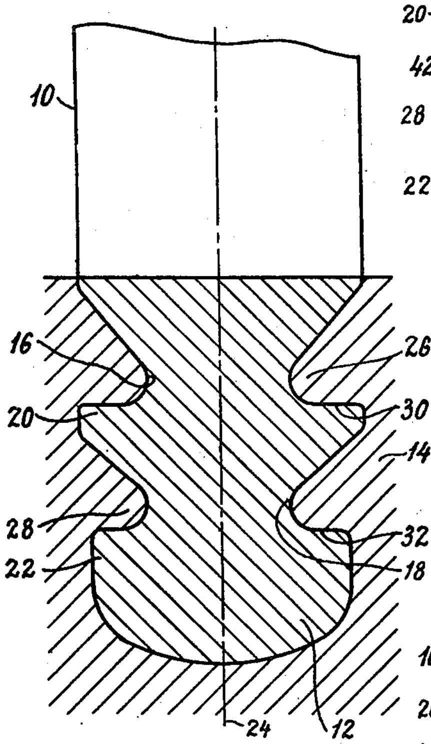
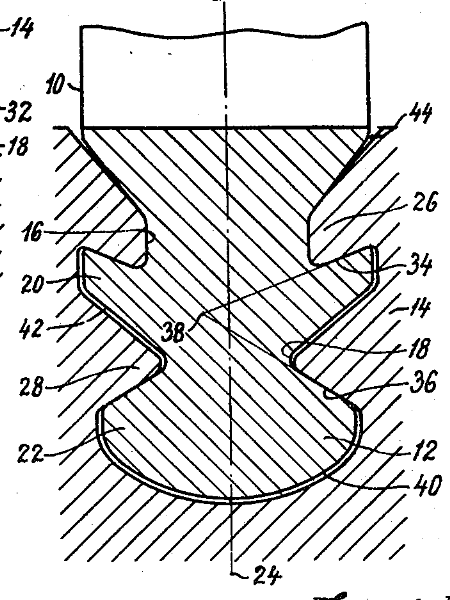


Fig.1



Prior Art

Fig.3



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TURBINE BLADE

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7 Claims. (Cl. 253—77)

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This invention relates to turbine blades the root of which is provided with two or more projections laterally of the central plane thereof, having load transmitting surfaces engaging and transmitting to the element in which the blade is secured the load due to centrifugal force on the blade. These load transmitting surfaces on each side of the central plane of the rotor are adapted together to transfer the centrifugal force acting upon the turbine blade onto said element, and the intention is to reduce the tensile strains in the blade root and the surface pressures in the load transmitting surfaces, without it being necessary to increase the dimensions of the rotor at right angles to the longitudinal direction of the blade.

The known turbine blade attachment appears from Fig. 1 in the accompanying drawing, which is a partial section at right angles to the axis of rotation of a turbine blade ring. The figure shows a portion **10** of a turbine blade with blade root **12** and a portion **14** of a rotor. The blade root **12** is recessed at **16**, **18** to form two projections, shoulders or the like **20**, **22** on both sides of the central plane **24** of the blade root. Entering the recesses **16**, **18** are projections or the like **26**, **28** extending from the rotor **14**, against which the projections **20**, **22** bear with load transmitting surfaces **30**, **32**. In the known construction, these load transmitting surfaces are at least approximately parallel to each other on both sides of the centre line **24** of the blade root.

This known construction has a drawback which manifests itself particularly in operation with high temperatures and, above all, in gas turbine operation. When the hot driving medium is admitted, the blades will be rapidly heated, inasmuch as their surfaces subjected to the driving medium is large relatively to the mass thereof, so that the rates of heat transfer become high. Furthermore, heat is rapidly conveyed to the blade root **12**, which becomes hotter than the rotor element **14** and may remain so permanently should the rotor element be kept at a lower temperature than the blade **10**. The blade root **12** will then expand between the surfaces **30**, **32** more than does the surrounding structure, by reason of which only the surface **30** becomes load transmitting. It may then happen, of course, that such creeping takes place in the material that both surfaces will be load transmitting. However, when the turbine is brought to a stop (particularly in gas turbines when the fuel supply is cut off), the blade will be cooled down much more rapidly than the rotor, whereby the

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blade root portion between the surfaces **30** and **32** is stretched, or the rotor projections will be compressed, so that there will be a gap in the cold state at the surface **32**. In this manner, the root portion will soon be altered to a detrimental extent or destroyed after repeated startings and stoppings of the turbine.

According to the present invention, these difficulties are eliminated substantially by the fact that the load transmitting surfaces provided on one and the same side of the central plane of the blade root are at an angle with one another. According to another feature of the invention, planes extending through the supporting surfaces intersect the central plane of the blade root in lines the distance between which in said plane is essentially less than the average distance between the load transmitting surfaces on one and the same side of the central plane.

Further objects and advantages of the invention will be apparent from the following description considered in connection with Figs. 2 and 3 of the accompanying drawing, which forms part of this specification.

Said figures show portions of a blade and a rotor according to two embodiments of the invention. The figures are illustrated in the same way as in Fig. 1 and moreover the same designations are used for corresponding parts in the figures.

In the embodiment according to Fig. 2, the load transmitting surfaces **34** between the projections or the like **20**, **26** on the blade root **12** and the rotor **14**, respectively, extend at least substantially normally, that is to say, at right angles to the centre line **24** of the blade. The load transmitting surfaces **36** between the inner projections or the like **22**, **28** form an angle with the load transmitting surfaces **34** on both sides of the central plane **24** of the blade root. Planes extending through the surfaces **34**, **36** meet the central plane **24** in lines coinciding with (see point **37** in Fig. 2) or situated near one another, that is to say so that the spacing of these lines is less than the average spacing of the load transmitting surfaces. Now, when the temperature of the blade root changes relatively to that of the rotor **14**, the dimensions of the blade between the load transmitting surfaces are altered radially and peripherally, so that all of the load transmitting surfaces will always be actively operative to take up the active forces and an inadmissible creeping or deformation of the projections is prevented. It is obvious that the temperature variations only result in that the load transmitting surfaces 36 of the projections 22 slide on the projections 28 of the rotor. To permit free movement or sliding of the blade root, clearances 40, 42 are provided at the root end and between the load transmitting surfaces 34, 36. To obtain the requisite guidance, the projection 26 in the rotor may bear on the recess 16 of the blade root beside the bottom of the recess. The surfaces then preferably move apart in a direction toward the blade 10, as indicated at 44.

The embodiment according to Fig. 3 differs from that according to Fig. 2 substantially only in that the load transmitting surface 34 also forms an angle with the blade axis, but in the opposite direction to the load transmitting surface 36. Planes extending through the load transmitting surfaces 34, 36 on the same side of the centre line 24 may intersect each other in a point 38 according to Fig. 3, which is situated on the opposite side of the centre line 24. The construction according to Fig. 3 has the advantage that the angle of inclination of the load transmitting surface 36 may be made less steep.

According to the invention, the advantage is gained that higher operation temperatures may be used than in the known construction. It is of special importance that the blades may be made from austenitic steel, while the rotor, which is adapted to be cooled, if desired, is made from martensitic steel, as will appear more fully from the co-pending patent application No. 509,800 of G. K. W. Boestad et al., filed November 10, 1943, to which reference is made for a more detailed description.

The fact that the load transmitting surfaces need not be directed to the same point on the central plane 24 depends on the fact that the elastic deformation of the blade compensates, to a certain extent, for deviations from the mathematically correct form where the intersecting points lie on the center line of the blade root. An uneven distribution of the temperature in the root also exerts an influence on the desired inclination of the surfaces.

The invention is primarily intended to be used in rotational blades, but in certain cases it may also be applied to guide blades. The projections, bosses or teeth of the blade root may be placed non-symmetrically laterally of the central plane of the rotor, and may be displaced relatively to each other in the longitudinal direction of the blade.

While several embodiments of the invention have been shown, it is to be understood that these are for purpose of illustration only, and that the invention is not to be limited thereby, but its scope is to be determined by the appended claims.

What I claim is:

1. In a turbine having a blade carrying element, a blade having a root portion with a plurality of laterally extending projections on the same side of the central plane of the blade providing radially spaced load transmitting surfaces engaging and transmitting to said element the load due to centrifugal force on the blade, said surfaces being at different angles relative to said central plane and clearance being provided between said element and other surfaces of said projections to permit expansion and contraction of the projections.

2. In a turbine having a blade carrying element, a blade having a root portion with a plurality of laterally extending projections on the same side of the central plane of the blade providing radially spaced load transmitting surfaces engaging and transmitting to said element the load due to centrifugal force on the blade, said surfaces being located so that the projected planes thereof converge in the direction toward said central plane and clearance being provided between said element and other surfaces of said projections to permit expansion and contraction of the projections.

3. In a turbine having a blade carrying element, a blade having a root portion with a plurality of laterally extending projections on the same side of the central plane of the blade providing radially spaced load transmitting surfaces engaging and transmitting to said element the load due to centrifugal force on the blade, said surfaces being located so that the projected planes thereof converge to intersect at a place substantially coincident with said central plane and clearance being provided between said element and other surfaces of said projections to permit expansion and contraction of the projections.

4. In a turbine having a blade carrying element, a blade having a root portion with a plurality of laterally extending projections on the same side of the central plane of the blade providing radially spaced load transmitting surfaces engaging and transmitting to said element the load due to centrifugal force on the blade, said surfaces being located so that the projected planes thereof converge to intersect at a place on the side of said central plane opposite the side thereof on which said surfaces are located and clearance being provided between said element and other surfaces of said projections to permit expansion and contraction of the projections.

5. In a turbine having a blade carrying element, a blade having a root portion with a plurality of laterally extending projections on the same side of the central plane of the blade providing radially spaced load transmitting surfaces engaging and transmitting to said element the load due to centrifugal force on the blade, the radially innermost and the radially outermost of said surfaces being located obliquely with respect to said central plane, the projected planes of said surfaces converging to intersect at a place located radially intermediate said surfaces and clearance being provided between said element and other surfaces of said projections to permit expansion and contraction of the projections.

6. In a turbine having a blade carrying element, a blade having a root portion with a plurality of laterally extending projections on the same side of the central plane of the blade providing radially spaced load transmitting surfaces engaging and transmitting to said element the load due to centrifugal force on the blade, the radially outermost of said surfaces being substantially normal to said central plane, the radially innermost of said surfaces being located obliquely relative to said plane and sloping radially outwardly in the direction toward said plane and clearance being provided between said element and other surfaces of said projections to permit expansion and contraction of the projections.

7. In a turbine having a blade carrying element, a blade having a root portion with a plurality of laterally extending projections on the same side of the central plane of the blade providing radially spaced load transmitting surfaces engaging and transmitting to said element

the load due to centrifugal force on the blade, the planes of said surfaces converging in the direction toward said central plane and radial and lateral clearances being provided between said projections and the non-load transmitting surfaces of said element to permit freedom of expansion of said projections by sliding movement of said load transmitting surfaces on the cooperating loaded surfaces of said element.

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