June 19, 1956

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2,751,189

BLADE FASTENING MEANS

Filed Sept. 8, 1950

Fig. 2.

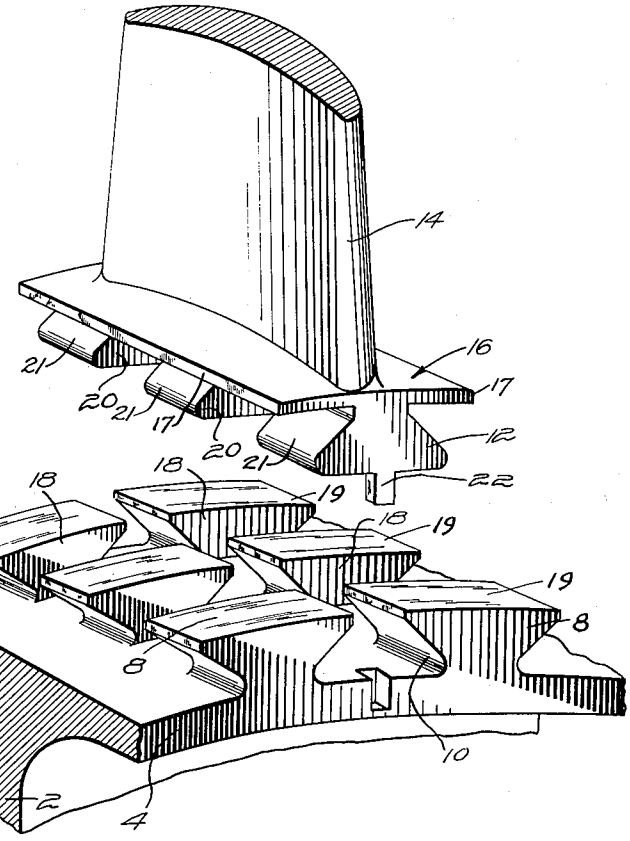


Fig. 1.

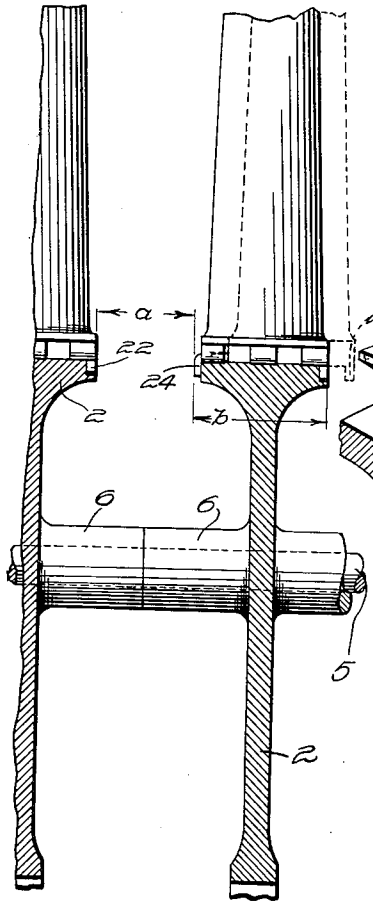


Fig. 3.

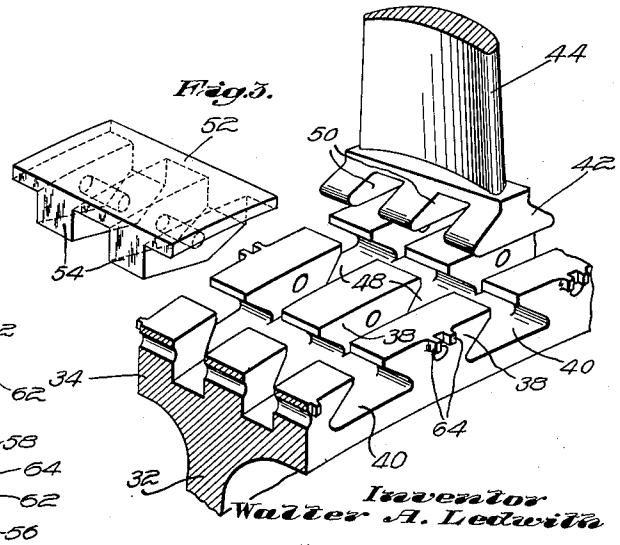


Fig. 4.

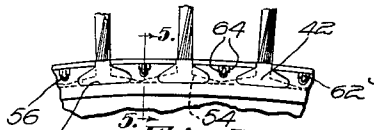
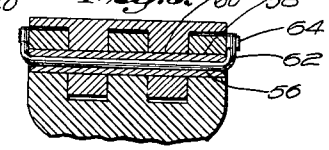


Fig. 5.



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United States Patent Office

2,751,189

Patented June 19, 1956

2,751,189

BLADE FASTENING MEANS

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Application September 8, 1950, Serial No. 183,714

14 Claims. (Cl. 253—77)

The present invention relates to means for fastening the blading to the supporting disc or rotor in axial flow compressors or turbines.

In certain turbine or compressor constructions, particularly in axial-flow multistage compressors, the axial spacing of adjacent supporting structures for successive stages is so close that the axially inserted blade root construction cannot be utilized. It will be obvious that the conventional, axially inserted fastening, one example of which is the "pine tree" type of blade root, requires, for insertion in the supporting structure, an axial spacing at least as great as the length of the fastening itself and generally a slightly greater length. The blade lock, which prevents axial movement of the blade after it is positioned on the supporting structure, makes the blade root before insertion slightly longer than the supporting structure. The principal object of the present invention is an arrangement by which to permit insertion of blade roots in the supporting structure where the axial spacing of adjacent stages does not permit the use of conventional blade mountings. This arrangement is particularly advantageous in a built-up rotor where it would otherwise be necessary to disassemble the rotor for the replacement of one or more damaged blades.

Another feature of the invention is a blade mounting which will permit, if desired, the use of a solid or unitary rotor in which the stages are more closely spaced than the axial length of the blade root.

Other objects and advantages will be apparent from the specification and claims, and from the accompanying drawings which illustrate an embodiment of the invention.

Fig. 1 is a sectional view through a rotor utilizing the blade mounting.

Fig. 2 is a perspective view of a part of the supporting structure and the blade construction ready to be positioned therein.

Fig. 3 is a view similar to Fig. 2 showing a modification where the blades are widely spaced circumferentially.

Fig. 4 is a fragmentary side elevation of the disc and blade of Fig. 3 in assembled position.

Fig. 5 is a sectional view on the line 5—5 of Fig. 4.

The invention is shown in a built-up rotor construction in which the successive rows of blades are carried by separate discs 2 with the several stacked discs bolted together in axial alignment by a row of bolts 5 extending through bosses 6 arranged in a ring concentric to the axis of the disc. In the arrangement shown, the axial spacing of the discs 2 is such that the distance *a* between adjacent discs as the periphery of the disc where the blade root engages the disc is less than the dimension *b* of the blade root itself. It will be obvious that the blade root structure herein described is applicable to other rotor constructions, as for example to a unitary construction in which the adjacent discs 2 are integrally connected together.

The periphery of each disc 2 has a wide rim 4 having circumferentially spaced projection 8 defining between

them axially extending slots 10 to receive the similarly shaped blade root 12 on the blade 14. In the arrangement shown in Fig. 2 the blade has a platform 16 defined by flanges 17 projecting circumferentially from opposite sides of the blade root so that the platforms on adjacent blades will abut and provide a smooth inner surface for the flow of fluid over the operative or airfoil section of the blade. The circumferentially spaced slots 10 and blade root 12 are dovetail in shape, although other shapes of blade root may be utilized, such that the blade root has an axially extending enlargement thereon and the slot is undercut to receive the enlargement to prevent radial outward movement of the blade relative to the slot.

With the arrangement so far described, the blade root 12 could be inserted endwise into the slot 10 provided the rim 4 was suitably spaced from adjacent structures to leave ample space axially of the rim for the placing of the entire blade root in alignment with the slot adapted to receive it. Since this is not always possible, the invention contemplates an arrangement by which the blade root may be inserted radially into the receiving slot and then moved only a short distance axially into locked position. To accomplish this, each of the projections 8 is divided axially by circumferentially extending grooves 18 thereby in effect forming a number of axially spaced dovetail projections 19. The dovetail blade root 12 is similarly broken up by transverse grooves or notches 20 as deep as the grooves 18 forming spaced dovetail projections or root elements 21 which are substantially equal in width to the grooves 18. Both grooves 18 and 20 are equal in width to the axial dimension of the dovetail projections 21 and 19 on the blade root and the disc respectively.

With this arrangement it will be apparent that the blade may be placed in position by inserting it radially into the dotted line position of Fig. 1 such that the projections 21 on the blade root will line up with the grooves 18 on the disc. The blade is then moved axially a distance equal to the widths of the grooves 18 or 20 and is then in its operative position on the disc. A projecting tang 22 formed on the blade root and extending radially inward therefrom limits the axial movement of the blade beyond its operative position. After the blade has been inserted axially to its proper position a laterally projecting tang 24 on the blade root opposite to the tang 22 may then be bent downwardly into the position shown in Fig. 1 thereby supporting the blade against axial movement in either direction.

In the arrangement shown in Figs. 3, 4 and 5 the disc 32 has a rim 34 with projections 38 thereon providing axially extending, circumferentially spaced blade root receiving slots 40 and the blade 44 has a blade root 42 adapted to fit in the slot. Projections 38 on the rim and the projections on the blade root are both interrupted by circumferential grooves 48 and 50 in the manner above described in Fig. 2 and the blades are inserted in the manner above described.

In this arrangement, however, which is particularly adapted for a wider circumferential spacing of the blades, the blade itself has no platform corresponding to the platform 16 of Fig. 2. The space between adjacent blades after they have been positioned on the rim is filled by filler pieces or plates 52 having inwardly extending projections 54 corresponding in number and axial dimension to the grooves 48. In the circumferential direction, however, the projections 54 are of such a shape as to project beyond the side edges of the projections 38 and into the grooves 50 of the blade roots as shown in the dotted line in Fig. 4 thereby effectively locking the blades in their operative position and preventing any axial movement of the blades. The plates extend circumferentially from blade to blade and into engagement with adjacent

blades at the outer portion of the roots as clearly shown in Fig. 4.

The filler plates may be held in position by pins **56**, Fig. 5, extending through axially aligned openings **58** and **60** in the projections **38** on the rim of the disc and the projections **54** on the filler plate. If desired, the locking pin **56** may be hollow to receive a locking wire **62** which extends beyond the end of the pin and may have its ends bent radially outward to fit between positioning lugs **64** on the ends of the dovetail projections **38**. In this arrangement the filler plates **52** in conjunction with the blade roots **42** form a continuous surface for the inner boundary of the gas path over the operative sections of the blades. With this arrangement the required axial spacing of adjacent rows of blades need be only slightly greater than the axial dimension of each of the individual projections making up the blade root **42**. Obviously, the radial dimension of adjacent discs must be sufficiently different to permit the insertion of the pins **56**.

It is to be understood that the invention is not limited to the specific embodiment herein illustrated and described, but may be used in other ways without departure from its spirit as defined by the following claims.

I claim:

1. In a blade fastening, a disc having a number of circumferentially spaced axially extending slots, blades having roots corresponding in shape to, and fitting in, said slots, each of said slots being undercut to receive the root to prevent radial outward movement of the blade, said disc having circumferential grooves therein at least as deep as and intersecting said slots, and each blade root having similarly shaped notches at least as deep as the slots and defining spaced projections spaced apart to correspond to the spacing of the circumferential grooves, each projection having an axial dimension at least as small as the associated groove in the disc to provide for radial insertion of the blade root into alignment with the slots, and filler pieces located between and overlying the surface of the disc between adjacent blades mounted on the disc, said filler pieces having projections on the inner surface fitting into the circumferential grooves in the disc, and means engaging said projections and disc for holding said filler pieces in position.

2. In a blade fastening, a disc having a number of circumferentially spaced axially extending slots, blades having roots corresponding in shape to, and fitting in, said slots, each of said slots being undercut to receive the root to prevent radial outward movement of the blade, said disc having circumferential grooves therein at least as deep as and intersecting said slots, each blade root having similarly shaped notches at least as deep as the slots and defining spaced projections spaced apart to correspond to the spacing of the circumferential grooves, each projection having an axial dimension at least as small as the associated groove in the disc to provide for radial insertion of the projections into alignment with its slot, and filler pieces located between adjacent blades and mounted on the disc, said filler pieces having projections fitting into the circumferential grooves in the disc, and means engaging said projections and disc for holding said filler pieces in position, each of said filler pieces being wide enough circumferentially to fill the space between adjacent blades on the disc.

3. In a blade fastening, a disc having a number of circumferentially spaced axially extending slots, blades having roots corresponding in shape to, and fitting in, said slots, each of said slots being undercut to receive the root to prevent radial outward movement of the blade, said disc having circumferential grooves therein at least as deep as and intersecting said slots, and each blade root having similarly shaped notches at least as deep as the slots and defining spaced projections spaced apart to correspond to the spacing of the circumferential grooves, each projection having an axial dimension at least as small as the associated groove in the disc to provide for radial insertion of the projections on said root into alignment with its slot, and filler pieces between adjacent blades having projections fitting into the circumferential grooves and of such a dimension as to project into the notches in the blade roots to prevent axial movement of the blades after they have been assembled.

4. In a blade fastening, a disc having a number of circumferentially spaced axially extending slots, blades having roots corresponding in shape to, and fitting in, said slots, each of said slots being undercut to receive the root to prevent radial outward movement of the blade, said disc having circumferential grooves therein at least as deep as and intersecting said slots, and each blade root having similarly shaped notches at least as deep as the slots and defining spaced projections spaced apart to correspond to the spacing of the circumferential grooves, each projection having an axial dimension at least as small as the associated groove in the disc to provide for radial insertion of said projections on said root into alignment with its slot, and filler pieces between adjacent blades having projections fitting into the circumferential grooves and of such a dimension as to project into the notches in the blade roots to prevent axial movement of the blades after they have been assembled, and means engaging said projections and disc for holding said filler pieces in position on the disc.

5. In a blade fastening, a disc having a number of circumferentially spaced axially extending slots, blades having roots corresponding in shape to, and fitting in, said slots, each of said slots being undercut to receive the root to prevent radial outward movement of the blade, said disc having circumferential grooves therein at least as deep as and intersecting said slots, and each blade root having similarly shaped notches at least as deep as the slots and defining spaced projections spaced apart to correspond to the spacing of the circumferential grooves, each projection having an axial dimension at least as small as the associated groove in the disc to provide for radial insertion of the said projections on the blade root into alignment with its slot, and filler pieces between adjacent blades having projections fitting into the circumferential grooves and of such a dimension as to project into the notches in the blade roots to prevent axial movement of the blades after they have been assembled, and a pin extending through said projections and through the disc for retaining the filler pieces in position.

6. In a blade fastening, a disc having an axial slot in its periphery, said slot extending the entire width of the disc, a blade having a root corresponding in shape to, and fitting in, said slot, said slot being undercut to prevent radial outward movement of the blade, said root and disc having a number of circumferentially extending matching grooves substantially the depth of the slot to provide for radial insertion of the root into the slot, said grooves in the root separating said root into a number of axially spaced root elements, the axial dimension of each of which is at least as small as the axial dimension of the associated groove in the disc.

7. In a blade fastening, a disc having an axial slot in its periphery, said slot extending the entire width of the disc, a blade having a root corresponding in shape to, and fitting in, said slot, said slot being undercut to prevent radial outward movement of the blade, said root and disc having a number of circumferentially extending matching grooves substantially the depth of the slot to provide for radial insertion of the root into the slot, said grooves in the root separating said root into a number of axially spaced root elements, the axial dimension of each of which is at least as small as the axial dimension of the associated groove in the disc, and means engaging with said disc for locking said blade against axial movement after it is positioned in the slot.

8. In a blade fastening, a rotor having a substantially cylindrical surface, a plurality of circumferentially spaced axial slots extending the entire width of the outer surface

of the disc, a plurality of blades having roots corresponding in shape to the slots in the rotor, each of said slots being undercut and each slot receiving the root of the associated blade to prevent radial outward movement of the blade, said cylindrical surface and said blade roots having a series of matching circumferential grooves at least as deep as the slots to form spaced projections on the blade root thereby providing for radial insertion of the blade into a position such that the blade root projections may be positioned in axial alignment with the corresponding slot in the rotor, the axial dimension of each projection on the root being at least as small as the axial dimension of the associated groove in the disc and locking means on the ends of each blade root for engagement with the ends of the disc.

9. In a blade fastening, a disc having a number of circumferentially spaced axial slots extending the entire width of the disc, blades having roots corresponding in shape to, and fitting in, said slots there being one blade for each axial slot, each of said slots being undercut and each slot receiving the root of the associated blade to prevent radial outward movement of the blade, said disc having circumferential grooves at least as deep as, and intersecting, said slots, and said blade root having similarly shaped notches as deep as the slots and defining spaced projections spaced apart to correspond to the spacing of the circumferential grooves, each projection having an axial dimension at least as small as the associated groove in the disc to provide for radial insertion of the blade root projection into alignment with the slots and locking means cooperating with said blade root and the disc to prevent relative axial movement after assembly is completed.

10. In a blade fastening, a disc having a number of circumferentially spaced axially extending slots, blades having roots corresponding in shape to, and received in, said slots, each of said slots being undercut and each slot receiving the root of the associated blade to prevent radial outward movement of the blade, said disc having circumferential grooves intersecting said slots, and said blade root having similarly shaped notches defining spaced projections spaced apart to correspond to the spacing of the circumferential grooves, each projection having an axial dimension at least as small as the associated groove in the disc to provide for radial insertion of the blade root projection into alignment with the slots, each blade having laterally extending flanges thereon overlying the disc and extending circumferentially far enough for engagement with a similar flange on an adjacent blade on the disc.

11. In a blade fastening, a disc having a plurality of circumferentially spaced axial slots in the outer surface extending the full width of said disc, a plurality of blades having roots corresponding in cross-sectional shape to the aforementioned slots in the disc, said roots and slots being dove-tailed to prevent radial outward movement of the blades, said outer surface and each blade root having a plurality of matching circumferential grooves, at least as deep as the slots, to form spaced projections on each blade root and on the outer surface of the disc, the axial dimension of each of the projections on each of the blade roots and the disc being at least as small as the axial dimension of the corresponding groove in the disc and root respectively, thereby providing for radial insertion of the spaced projections on one of the blade roots into the grooves in the disc in alignment with the corresponding slot in the outer surface of said disc, and thereafter for sliding said blade axially until the projections on the root are out of circumferential alignment with the corresponding grooves in the disc.

12. In a blade fastening, a disc having a plurality of circumferentially spaced axial slots in the outer surface extending the full width of said disc, a plurality of blades having roots corresponding in cross-sectional shape to the

aforementioned slots in the discs, said roots and slots being dovetailed to prevent radial outward movement of the blades, said outer surface and each blade root having a plurality of matching circumferential grooves, at least as deep as the slots, to form spaced projections on each blade root and on the outer surface of the disc, the axial dimension of each of the projections on each of the blade roots and the disc being at least as small as the axial dimension of the corresponding groove in the disc and root respectively, thereby providing for radial insertion of the spaced projections on the blade root into alignment with the corresponding slot in the outer surface of said disc, and thereafter sliding said blade axially until the projections on the root are out of circumferential alignment with the corresponding grooves in the disc, and an individual fastening means associated with each blade root and engaging with the disc for holding the blade against axial movement on the disc.

13. In a blade fastening, a rotor disc having a substantially cylindrical surface, a plurality of circumferentially spaced axial slots extending the entire width of the outer surface of the disc, a plurality of blades having roots corresponding in shape to the slots in the disc, said roots and slots being dovetailed to prevent radial outward movement of the blades, said cylindrical surface and said blade roots having a series of matching circumferential grooves, at least as deep as the slots, to form spaced projections on each blade root and on the outer surface of the disc, the axial dimension of each of the projections on each of the blade roots and the disc being at least as small as the axial dimension of the corresponding groove in the disc and root respectively, thereby providing for radial insertion of the blade into a position such that the blade root may be positioned in axial alignment with the corresponding slot in the rotor, and subsequently shifted axially such that the root projections and associated axially extending projections on the disc interengage and prevent radial movement of the blade, and locking means associated with each blade and engaging the disc for holding the blade in axial position after assembly with the rotor.

14. In a blade fastening, a rotor disc having a substantially cylindrical surface, a plurality of circumferentially spaced axial slots extending the entire width of the outer surface of the disc, a plurality of blades having roots corresponding in shape to the slots in the disc, said roots and slots being dovetailed to prevent radial outward movement of the blades, said cylindrical surface and each of said blade roots having a series of matching circumferential grooves, at least as deep as the slots, to form spaced projections on each blade root, and on the outer surface of the disc, the axial dimension of each of the projections on each of the blade roots and the disc being at least as small as the axial dimension of the corresponding groove in the disc and root respectively, thereby providing for radial insertion of the blade into a position such that the blade root may be positioned in axial alignment with the corresponding slot in the rotor, and subsequently shifted axially such that the root projections and associated axially extending projections on the disc interengage and prevent radial movement of the blade, and locking means on each blade root and engaging the ends of the disc for holding the blades in axial position after assembly with the rotor.

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