

[54] **BLADE MOUNTING**  
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 [58] Field of Search..... 416/215, 216, 219,  
 416/220, 217, 218

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[57] **ABSTRACT**  
 A blade fastening for the blades of compressors and/or turbines, especially for blades retained in dove-tail tangential grooves provided along the outer diameter of the rotor disks; the webs of the tangential grooves cover the hammer-head-like bases of the blades substantially over the entire rotor disk circumference while the blades provided with the hammer-head-like bases are adapted to be inserted by rotation into the tangential groove provided with small apertures; in order to fix the blades in a predetermined position relative to the rotor disk diameter, filler, clamping and locking elements are provided.

**33 Claims, 9 Drawing Figures**

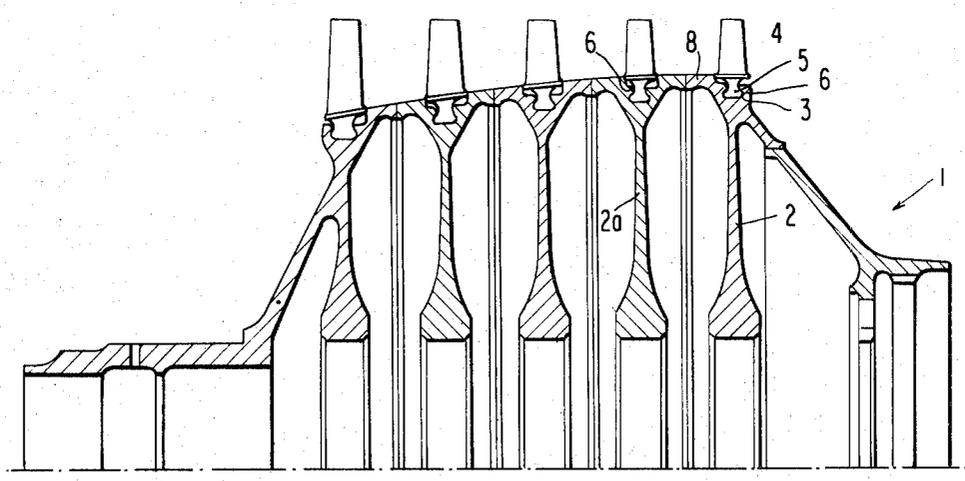


FIG. 1

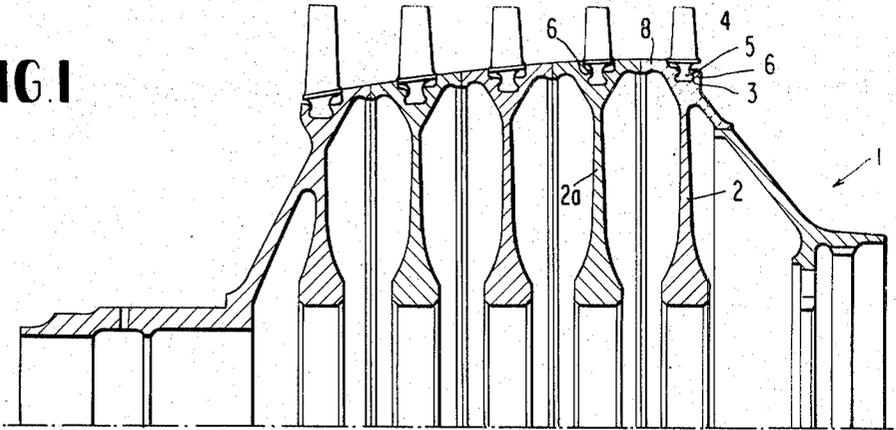


FIG. 2

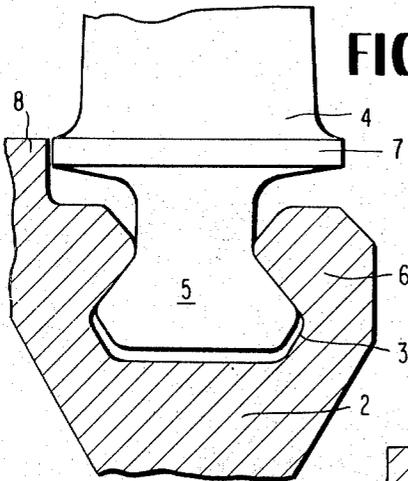


FIG. 4

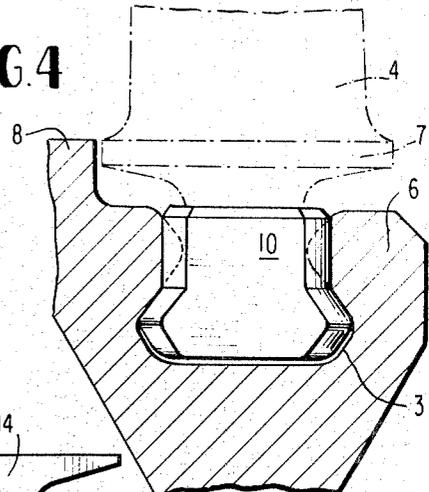


FIG. 6

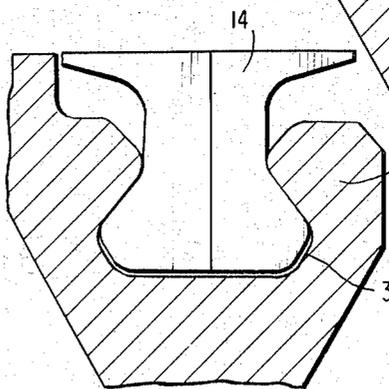


FIG. 7

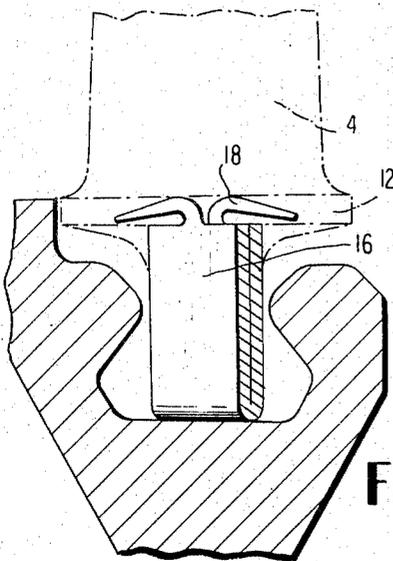
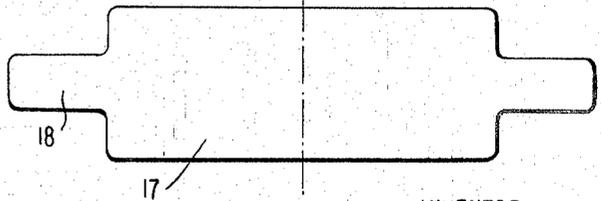


FIG. 9

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FIG 3

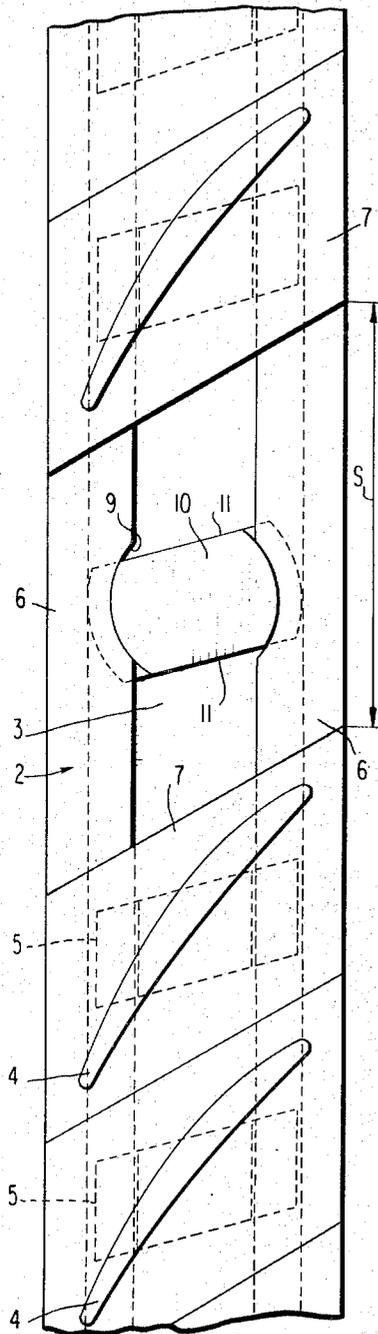


FIG 5

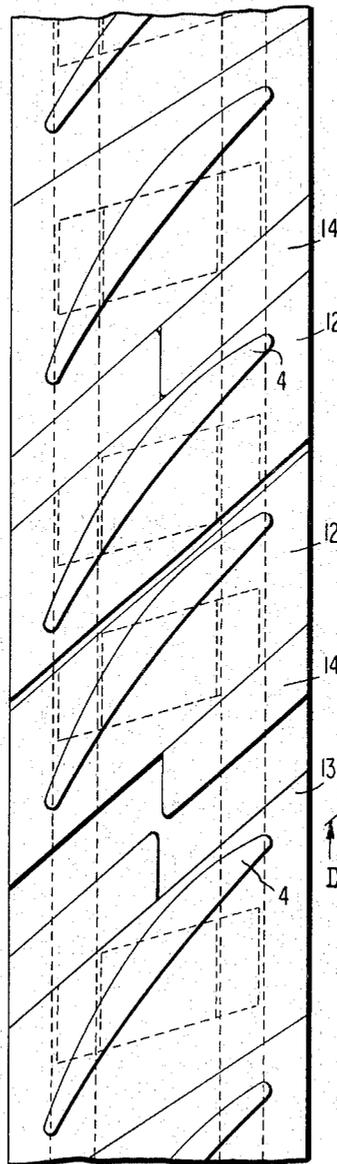
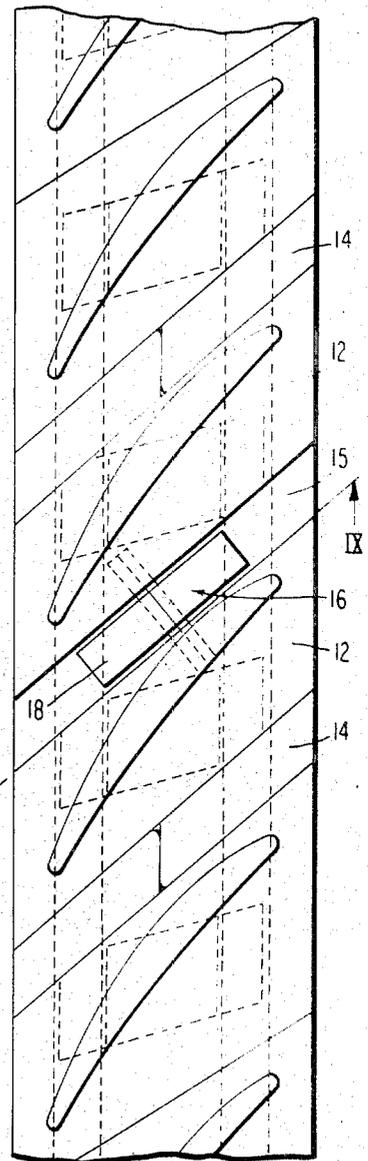


FIG 8



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## BLADE MOUNTING

The present invention relates to a blade fastening for the blades of compressors and/or turbines, especially for blades retained in dovetail shaped tangential grooves at the outer diameter of rotor disks.

This type of blade-rotor connection permits a very simple type of construction; for example, the rotor may be manufactured of a welded construction realizable in a very simple manner and the rotor blades are inserted into the rotor following the assembly of the rotor. This groove shape is particularly advantageous for rotors of fiber-reinforced plastic materials such as synthetic resinous materials of any conventional type, because the fiber-flow is not interrupted thereby. It is known to construct rotor blades with hammer-head shaped bases and to introduce the same into the tangential groove of the rotating disk. For that purpose, local apertures in the axial direction are provided in the disk and the rotor blades are introduced into the apertures of the groove which are enlarged toward the right and the left, and then are displaced in the circumferential direction. As a final step, a securing sheet metal plate is inserted into a further aperture of the disk of the rotor between two rotor blade bases and is threadably secured at the rotor. This known prior art construction of the rotor blade fastening, however, entails considerable disadvantages. On the one hand, relatively large local apertures at the rotor are required in order that the rotor blades can be inserted with their hammer-head-shaped bases into the groove and can be displaced completely unobjectionably in the groove. These apertures disturb the flow of the lines of force at the outer circumference of the rotor, which in particular, in case of turbines with very high rotational speeds and larger dimensions, leads to large stresses in the rotor as a result of the occurring centrifugal forces, which can be absorbed only by additional reinforcements and greater structural weight. On the other hand, the apertures for the fastening sheet metal member represent a further interruption for the flow of the lines of force.

The present invention is concerned with the task to avoid these disadvantages and to provide a blade fastening or blade mounting, in which the blades are adapted to be inserted into the rotor in a simple manner and a displacement or movement of the blades on the rotor is prevented. Furthermore, for the installation of the blades, no apertures extending transversely over the disk width in the tangential groove at the outer diameter of the rotor disk have to be provided which interrupt the force flow.

The underlying problems are solved according to the present invention in that the webs of the tangential groove cover the hammer-head-shaped bases of the blades over the entire rotor-disk circumference and the blades provided with the hammer-head-shaped bases are adapted to be inserted radially into the tangential groove provided with small apertures by a rotation about the longitudinal axis thereof, and in that for the fixing of the blades in a predetermined position with respect to the rotor disk diameter, filler, wedging and locking elements are provided. It is particularly appropriate if the hammer-head-shaped bases are arranged obliquely to the rotor disk axis and are adapted to be so inserted into the tangential groove by a rotation that they almost completely fill the groove cross section.

According to a further feature of the present invention, the base plates of the blades may have a differing width in the circumferential direction and the base plates, especially of the blades inserted last, may be shortened on one side or on both sides thereof in relation to the blades. By the rotation of the blades about their longitudinal axis through about 60°-90°, the hammer-head-shaped bases of the blades can be inserted into the tangential groove of the rotor and the blades can be displaced on the rotor in the circumferential direction after a completed back-rotation. A considerably smaller aperture at the rotor is required in that connection than with the blade fastening according to the heretofore known type of construction.

A residual gap remains between the blades inserted last, into which a further blade cannot be inserted by reason of the necessary rotation. Since the blades in the assembled condition must have a constant spacing from one another, and since this constant spacing is not attained by the shortened base plates of the blades inserted last, it is very appropriate if the gaps formed between the shortened base plates are filled by filler elements. The filler elements may be advantageously subdivided centrally thereof in a radial direction and in the assembled condition may exhibit the outer contour of the blade base with a base plate and may be retained underneath the webs of the grooves. The gap forming between the base plates, however, is filled by two filler elements which in the pushed-together condition bridge the gap between the base plates.

In order to prevent the movement of the blades in the circumferential direction on the rotor, one or several transmitting elements may be inserted into the arcuately shaped apertures disposed opposite the webs of the tangential groove. These transmitting elements may be provided advantageously with rounded-off outer edges that are adapted essentially to the base shape of the blades and are retained in the apertures by locking or wedging. In the radial height thereof the transmitting elements may appropriately terminate underneath the base plates of the blades and may be covered in the assembled and installed condition by the blade plates pushed against one another so that they are not visible with a completely assembled rotor.

After the blades are brought into the correct position thereof and the gaps are closed by the filler elements except for a remaining residual gap, a locking element may be inserted into the remaining residual gap which is arranged in the assembled condition transversely to the base plate edges by a rotation and engages from below the adjacent blade base plates. It is advantageous if the locking means is constituted by a curved double sheet metal element or plate and is provided at its upper edge with two tab or lug-shaped tongue portions that are bent in between the adjacent base plates of the blades in the installed and assembled condition of the locking means and fill out the residual gap in its width in that they adapt themselves to the gap shape between the two base plates of the blades. The locking element thus cannot rotate back and furthermore the two adjacent blades can no longer move toward one another. It is thereby appropriate if the length of the plate-shaped tongue portions is so selected that in their length they do not fill out the entire residual gap so that, if necessary, they can be readily bent open again with a hook-shaped tool during the disassembly and the lock can be disassembled and removed again by rotation. The lock

can be economically manufactured in its starting shape from sheet metal, for example, advantageously by spray-etching. After it has been brought into the shape necessary for the installation by appropriate bending together, the two surfaces with the exception of the tabs or lugs may be caused to adhere at one another by any conventional appropriate process.

In order to eliminate any possible imbalances during the operation, it is advantageous if several transmitting, filler and blocking elements each are provided, arranged several times symmetrically over the disk circumference of the rotor.

Accordingly, it is an object of the present invention to provide a blade fastening which avoids by simple means the aforementioned shortcomings and drawbacks encountered in the prior art.

Another object of the present invention resides in a blade fastening which eliminates the need for relatively large apertures in the rotor while minimizing large stresses in the rotor which may be caused by centrifugal forces.

A further object of the present invention resides in a blade fastening for rotors of compressors or turbines made of plastic material which does not disturb the flow of the lines of force along the outer circumference of the rotor.

Still a further object of the present invention resides in a blade fastening for the blades of a rotor of compressors or turbines which permits an easy assembly of the blades in the rotor yet precludes any movement of the blades along the rotor circumference.

A further object of the present invention resides in a blade fastening for rotor blades of compressors and/or turbines which permits the use of relatively simple elements, easy to manufacture, and assures a completely safe and secure mounting of the blades in the rotor without danger of any displacements of the blades.

These and further objects, features and advantages of the present invention will become more obvious from the following description when taken in connection with the accompanying drawing which shows, for purposes of illustration only, one embodiment according to the present invention, and wherein:

FIG. 1 is a schematic longitudinal cross-sectional view of one-half of a welded rotor with blades inserted into the rotor disks;

FIG. 2 is a partial cross-sectional view, on an enlarged scale, through a rotor disk with an inserted blade;

FIG. 3 is a plan view on the rotor disk with inserted blades and with an inserted transmitting element;

FIG. 4 is a cross-sectional view, on an enlarged scale, through the rotor disk with an inserted blade and with an inserted transmitting element;

FIG. 5 is a plan view on the rotor disk, with inserted filler elements in the upper part thereof and with filler elements not yet assembled in the lower part thereof;

FIG. 6 is a partial cross-sectional view, on an enlarged scale, through the rotor disk with inserted filler elements;

FIG. 7 is an elevational view of a lock in prefinished condition;

FIG. 8 is a plan view on the rotor disk with inserted filler elements and with an inserted lock; and

FIG. 9 is a partial cross-sectional view, on an enlarged scale, through the rotor disk with inserted lock, taken in the direction of arrow IX—IX of FIG. 8.

Referring now to the drawing wherein like reference numerals are used throughout the various views to designate like parts, and more particularly to FIG. 1, a welded compressor rotor is schematically indicated in this figure in longitudinal cross section. Five rotor disks 2, 2a are provided which have a tangential groove 3 at the outer diameter thereof, into which are inserted the rotor blades 4. The rotor blades 4 possess hammer-head-shaped bases 5 which are arranged obliquely to the rotor disk axis and in the assembled condition engage underneath the webs 6 of the tangential groove 3 and fill out the groove cross section. The present invention will be explained now in detail hereinafter with reference to a rotor disk 2 of the rotor 1.

FIG. 2 illustrates an enlarged cross section through the outermost right rotor disk 2 of FIG. 1 with an inserted rotor blade 4 and the hammer-head-shaped base 5 thereof engaging underneath the webs 6 of the circumferential groove 3. The base plate 7 of the rotor blade 4 terminates at the left upper edge 8 of the rotor disk 2. The base plates 7 of the remaining rotor blades in the rotor disks 2a which on both sides thereof adjoin further rotor disks, terminate on both sides with the edges 8 of the rotor disk. The rotor blade 4 is rotated about its longitudinal axis by about 60°–90° and is then inserted with its base 5 radially into the circumferential groove 3 of the rotor disk 2, is then turned back and thereafter displaced in the circumferential direction.

An aperture 9 is provided in the webs 6 of the tangential groove 3 for the insertion of the rotor blades 4 as can be seen from FIG. 3. The base plates 7 of the blades 4 are pushed against one another and the hammer-head-shaped bases 5 which are shown in dash line have a constant spacing from one another. After the last blades 4 have been inserted into the tangential groove 3 of the rotor disk 2 and the base plates 7 have been displaced toward one another, there remains a residual gap having the length S. No blade can be inserted by rotation into this residual gap of the length S because the large diagonal of the base plate would no longer permit a rotation of the blade.

It is therefore necessary that in connection with some blades 4 which have been inserted beforehand, the base plates 7 are so reduced in size compared to the normal blades that the blades during the assembly operation are disposed closer to one another in the circumferential direction and thus result in the necessary gap for the insertion of the last blade, which can be seen in particular from FIGS. 5 and 8.

According to the present invention after the insertion of the last blade a transmitting element 10 (FIG. 4) for preventing movement of the blades in the circumferential direction is inserted also by rotation into the aperture 9 of the rotor disk 2. The transmitting member 10 has essentially the same shape as the hammer-head-shaped base 5 of a blade 4 and as a result of the rotation wedges or locks itself between the arcuately-shaped apertures 9 in the webs 6 of the tangential groove 3 of the rotor disk 2. An automatic rotating back of the transmitting element 10 is not possible since the blade bases 5 in the pushed together condition of the blades 4 abut against the lateral surfaces 11 of the transmitting member 10, in case a displacement should take place along the circumference of the rotor disk 2. In the condition in which the blades are pushed against one another, the base plates 7 cover the transmitting element 10 so that the transmitting element 10 is not visible in the assem-

bled condition of the blades. This can be clearly seen from FIG. 4. The radial height of the transmitting element 10 is so selected that the transmitting element 10 forms approximately an end, i.e., is approximately flush with the upper edge of the web 6 of the tangential groove 3 and thereby results in a minimum of weight.

Several blades 4 can be seen in a plan view on the rotor disk 2 in FIG. 5, whose base plates are reduced in length either on both sides or on one side. In contradistinction to the base plates 7 of the rotor blades 4 illustrated in FIG. 3, for example, the base plates 12 of two rotor blades 4 illustrated in FIG. 5 are shortened on both sides with respect to the rotor blade and the base plate 13 of a rotor blade illustrated in FIG. 5 is shortened on one side thereof. That is, base plates 12 are shortened on both sides in the circumferential direction and base plate 13 is shortened only on one side thereof.

After all of the blades have been brought into their respective position, i.e., into a position in which they have the same distance from one another, gaps will result between the blades which must be filled out by the filler elements 14 (FIG. 6). The filler elements 14 are divided centrally in a radial direction and possess in the assembled condition the outer contour of the blade base 5 with a base plate 7 and are also retained underneath the webs 6 of the groove 3. The filler elements 14 are locked in the illustrated manner by mutual displacement and locking. After the filling in of the filler elements, the two blades 4 with base plates 12 shortened on both sides are moved apart from one another and the residual gap 15 resulting between the same is filled out by a locking element generally designated by reference numeral 16 (FIG. 8).

The lock 16 is illustrated in its initial shape in FIG. 7. It can be economically manufactured from sheet metal, for example, by spray-etching. The sheet metal plate 17 can be transformed into the shape necessary for the installation by bending together so that the lock 16 has the shape illustrated in FIGS. 8 and 9. Tab-shaped tongue portions 18 are provided at the upper edge. The lock 16 is now inserted into the residual gap 15 and is retained underneath the two adjacent base plates 12 of the blades by a rotation so that it cannot fall out. Subsequently, the two lug-shaped tongue portions 18 are bent down which then adapt themselves to the gap shape of the gap 15 between the two blade base plates 12. The lock 16 thus cannot rotate back and furthermore the two adjacent blades cannot move any longer toward one another. The two tab-like tongue portions 18 are so constructed in their length that they do not fill out completely the entire residual gap 15 and can again be bent upwardly at any time with a hook-shaped tool and the lock can again be removed during the disassembly. In order to avoid any possible imbalances, transmitting element 10, filler element 14 and locking element 16 may be provided each several times, distributed symmetrically at the circumference.

While I have shown and described only one embodiment in accordance with the present invention, it is understood that the same is not limited thereto, but is susceptible of numerous changes and modifications as known to those skilled in the art, and I therefore do not wish to be limited to the details shown and described herein, but intend to cover all such changes and modifications as are encompassed by the scope of the appended claims.

I claim:

1. A blade fastening arrangement for blade means of compressors or turbines of the type having circumferentially extending blade holding groove means provided at the outer circumference of rotor disk means; said arrangement comprising hammer-head-like base portions on each of said blade means, web portions formed in said groove means and extending substantially over the entire circumference of the rotor disk for covering said base portions, said blade means being radially insertable into relatively small aperture means of the groove means by rotation of the blade means about their longitudinal axis and fixing means including base plate means, transmitting means, and locking means for fixing the blade means in a predetermined position in said groove means, said base plate means being formed radially outwardly of said base portions on each of said blade means, said base plate means having a greater width in the circumferential direction than the base portions, at least some of said base plate means being in abutting contact with the base plate means of the next adjacent blade means, said transmitting means including at least one transmitting element separate from said blade means and said locking means, said at least one transmitting element being clampingly engageable with portions of said groove means to circumferentially fix said transmitting element in said groove means between adjacent blade means such that said transmitting element transfers circumferentially directed forces between said blade means and said rotor disk means, said locking means including at least one locking element which fills a residual gap remaining between base plate means of adjacent blade means in the assembled condition of the blade means.

2. A blade fastening arrangement according to claim 1, characterized in that said at least one locking element for the residual gap remaining in the assembled condition of the blade means is arranged in the assembled condition transversely to the edges of the base plate means with portions engaging underneath the adjacent base plate means to prevent withdrawal thereof in a radial direction.

3. A blade fastening arrangement according to claim 1, characterized in that said groove means is of dove-tail cross-sectional shape.

4. A blade fastening arrangement according to claim 1, characterized in that the hammer-head-like base portions are arranged obliquely to the rotor disk axis and are adapted to be inserted by rotation into the groove means in such a manner that they fill nearly completely the groove cross-section.

5. A blade fastening for blade means of compressor or turbines retained in tangential groove means provided at the outer circumference of rotor disk means, characterized in that the tangential groove means form web portions covering hammer-head-like base portions of the blade means substantially over the entire circumference of the rotor disk means, in that the blade means provided with the hammer-head-like base portions are adapted to be inserted radially into the tangential groove means provided with relatively small aperture means by rotation of the blade means about their longitudinal axis, in that means are provided for fixing the blade means in a predetermined position relative to the outer diameter of the disk means, in that transmitting means with rounded-off outer corners are provided as clamping means which are matched essentially to the

base shape of the blade means and are retained in the aperture means by a wedging action, and in that the transmitting means terminate in the radial height thereof below base plate means provided on said blade means radially outwardly of said base portions and in the assembled condition are covered by the base plate means pushed against one another.

6. A blade fastening arrangement according to claim 1, characterized in that some base plate means are shortened in the circumferential direction on at least one side in relation to the other blade means.

7. A blade fastening arrangement according to claim 1, characterized in that the base plate means of the blade means inserted last are shortened in the circumferential direction at least on one side in relation to the other blade means.

8. A blade fastening arrangement according to claim 1, characterized in that the base plate means of at least one blade means is shortened in the circumferential direction on one side in relation to other blade means and at least one other base plate means is shortened on both sides in relation to other blade means.

9. A blade fastening arrangement according to claim 6, characterized in that an arcuately shaped aperture means is provided in mutually opposite web portions of the groove means for accommodating insertion of said at least one transmitting element.

10. A blade fastening arrangement according to claim 9, characterized in that the blade means have a constant spacing from one another in the assembled condition and in that the gaps formed by the shortened base plate means are filled by filler means.

11. A blade fastening arrangement according to claim 10, characterized in that the filler means are divided centrally in the radial direction and in the assembled condition possess substantially the outer contour of the blade base portion with base plate means and are retained underneath the web portions of the groove means.

12. A blade fastening arrangement according to claim 11, characterized in that the cross-sectional shape of said at least one transmitting element is matched essentially to the shape of the base portions of the blade means.

13. A blade fastening arrangement according to claim 12, characterized in that the at least one transmitting element terminates in the radial height thereof below the base plate means and in the assembled condition are covered by the base plate means pushed against one another.

14. A blade fastening arrangement according to claim 13, characterized in that said at least one locking element for the residual gap remaining in the assembled condition of the blade means is arranged in the assembled condition transversely to the edges of the base plate means with portions engaging underneath the adjacent base plate means to prevent withdrawal thereof in a radial direction.

15. A blade fastening arrangement according to claim 14, characterized in that each of the at least one locking elements is formed of a bent, double sheet metal element and is provided at its upper edge with two tab-shaped tongue portions which are bent in the assembled condition of the locking element between the adjacent base plate means and fill the residual gap in its width.

16. A blade fastening arrangement according to claim 15, characterized in that transmitting, filler and locking means are provided several times symmetrically along the circumference of the rotor disk means.

17. A blade fastening arrangement according to claim 16, characterized in that said groove means is of dove-tail cross-sectional shape.

18. A blade fastening arrangement according to claim 1, characterized in that the cross-sectional shape of said at least one transmitting element is matched essentially to the shape of the base portions of the blade means.

19. A blade fastening arrangement for blade means of compressors or turbines of the type having tangential blade holding groove means provided at the outer circumference of rotor disk means; said arrangement comprising hammer-head-like base portions on each of said blade means, web portions formed in said groove means and extending substantially over the entire circumference of the rotor disk for covering said base portions, said blade means being radially insertable into relatively small aperture means of the tangential groove means by rotation of the blade means about their longitudinal axis, and fixing means for fixing the blade means in a predetermined position in said groove means, said fixing means including base plate means formed radially outwardly of said base portions on each of said blade means, said base plate means having a greater width in the circumferential direction than the base portions, and wherein at least some of said base plate means are in abutting contact with the base plate means of the next adjacent blade means so as to maintain said blade means in a predetermined circumferential position with respect to one another, characterized in that a locking means is provided as locking element for the residual gap remaining in the assembled condition of the blade means, said locking means being arranged in the assembled condition transversely to the edges of the base plate means by rotation and engaging underneath the adjacent base plate means, and characterized in that the locking means is formed of a bent, double sheet metal element and is provided at its upper edge with two tab-shaped tongue portions which are bent in the assembled condition of the locking means between the adjacent base plate means and fill the residual gap in its width.

20. A blade fastening arrangement according to claim 1, wherein the base plate means of some blade means have a different circumferential width than the base plate means of other blade means.

21. A blade fastening arrangement according to claim 20, characterized in that the blade means have a constant spacing from one another in the assembled condition and in that the gaps formed by the shortened base plate means are filled by filler means which are separate from the transmitting and locking means.

22. A blade fastening arrangement according to claim 21, characterized in that the filler means are divided centrally in the radial direction and in the assembled condition possess substantially the outer contour of the blade base portion with base plate means and are retained underneath the web portions of the groove means.

23. A blade fastening arrangement according to claim 19, characterized in that said transmitting, filler and locking means are provided several times symmetrically along the circumference of the rotor disk means.

24. A blade fastening arrangement according to claim 1, wherein said aperture means includes an opening having oppositely facing arcuately shaped edges formed in said web portions.

25. A blade fastening arrangement according to claim 24, wherein said transmitting element is inserted into said opening.

26. A blade fastening arrangement according to claim 1, wherein said at least one locking element is formed of a single piece of sheet metal bent into a configuration which simultaneously prevents radial withdrawal thereof and circumferentially spaces base plate means of adjacent blade means.

27. A blade fastening arrangement according to claim 26, wherein said at least one locking element is positioned and configured so as to substantially preclude transfer of circumferentially directed forces between said rotor disk means and said blade means by way of said locking element.

28. A blade fastening arrangement according to claim 1, wherein said at least one locking element is positioned and configured so as to substantially preclude transfer of circumferentially directed forces between said rotor disk means and said blade means by way of said locking element.

29. A blade fastening arrangement according to claim 1, wherein said at least one transmitting element exhibits rounded-off outer corners which clampingly

engage circumferentially extending side walls of said groove means.

30. A blade fastening arrangement according to claim 1, wherein said at least one transmitting element clampingly engages circumferentially extending side walls of said groove means at positions radially inwardly of said base plate means and wherein the radial outermost portions of said at least one transmitting element in the assembled condition of the blade means are radially inward of the base plate means.

31. A blade fastening arrangement according to claim 30, wherein said radial outermost portions of said at least one transmitting element are completely covered in a radially outward direction by the base plate means.

32. A blade fastening arrangement according to claim 31, wherein said at least one locking element is positioned and configured so as to substantially preclude transfer of circumferentially directed forces between said rotor disk means and said blade means by way of said locking element.

33. A blade fastening arrangement according to claim 32, wherein said at least one locking element is formed of a single piece of sheet metal bent into a configuration which simultaneously prevents radial withdrawal thereof and circumferentially spaces base plate means of adjacent blade means.

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