United States Patent [19]

Strub

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[54] **TURBINE BLADE ASSEMBLY**

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[52] **U.S. Cl.** **416/214**, 416/215, 416/216, 416/218

[51] **Int. Cl.**...**F01d 5/30**

[58] **Field of Search**.......................416/214, 215, 216, 416/214 A, 208, 217, 218

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[57] **ABSTRACT**

The blades of a blade row in a turbine or similar machine possess roots having two pairs of opposite faces and are disposed in an annular array with the help of wedge-shaped spacers between the roots of adjacent blades. The blade root faces of one of these pairs define at each axial end of the array an annular stepped or sawtooth-shaped surface, according to the angular orientation of the blades about their individual longitudinal axes, and the blades are held in a selected orientation by means of rings having mating annular stepped or sawtooth-shaped surfaces thereon.

4 Claims, 6 Drawing Figures

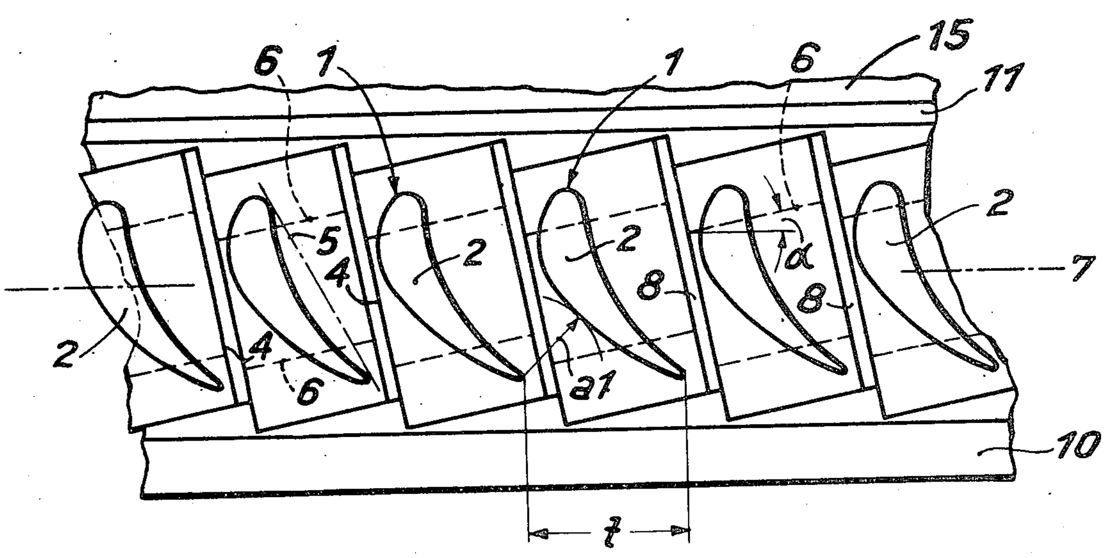

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Fig. 1

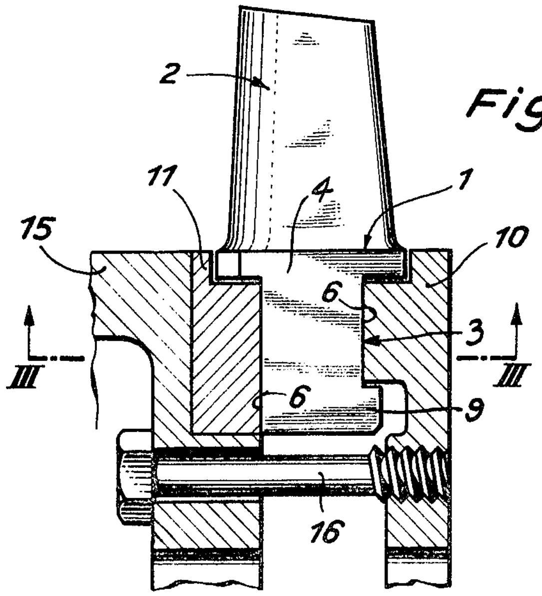

Fig. 2

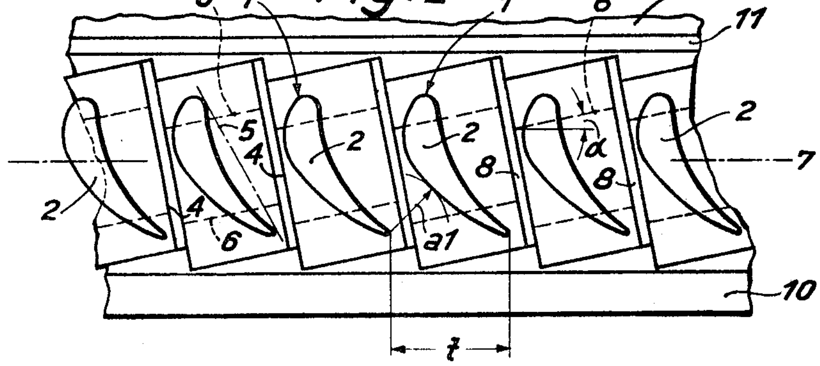

Fig. 3

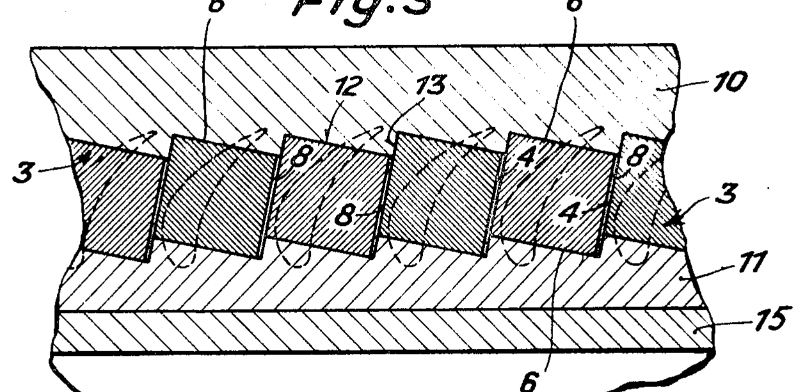

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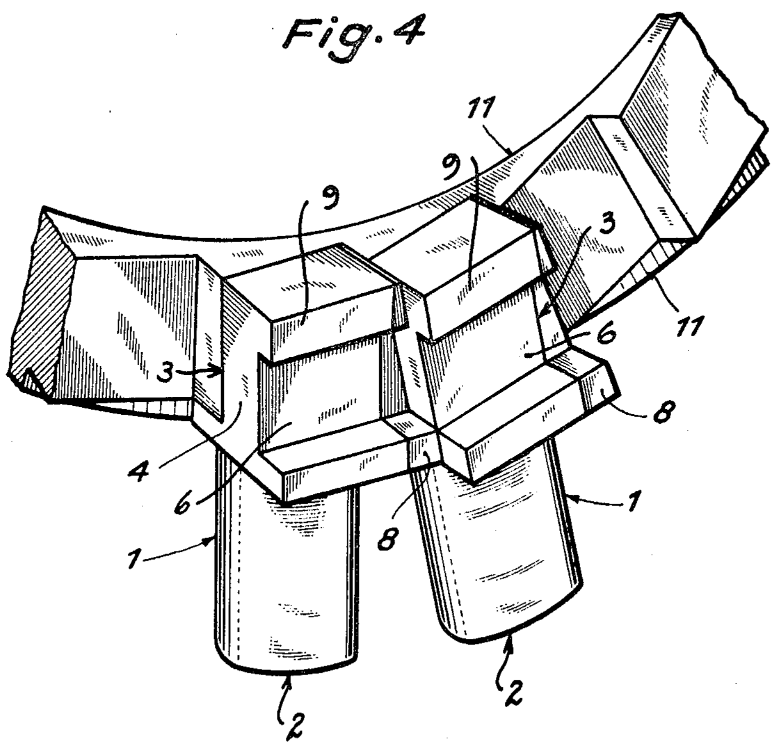
Fig. 4



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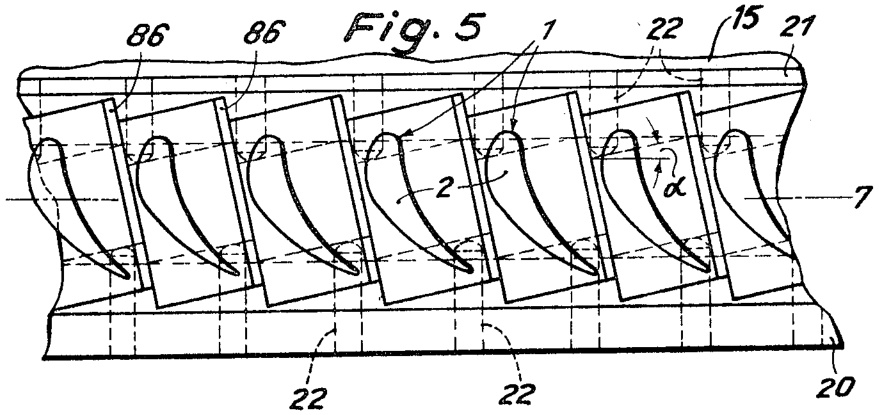

Fig. 5

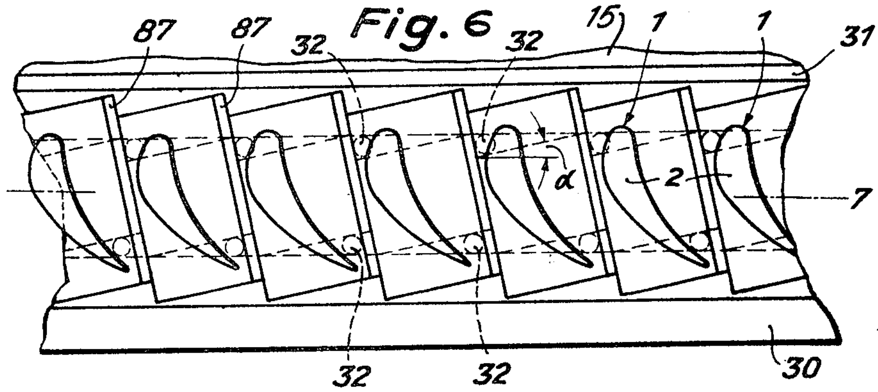

Fig. 6

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TURBINE BLADE ASSEMBLY

The present invention pertains to a blade array construction for turbomachines. The term turbomachine is used to denote a turbine-type machine whether for development of mechanical energy at a rotating shaft from a fluid flowing through the machine as in a turbine, or for the delivery of energy from a rotating shaft to the fluid, as in a pump or compressor.

It is well-known that in turbine-type machines, a blade row in which the blades are of fixed and non-adjustable angular orientation about their individual axes radially of the machine operates with maximum efficiency only at one condition of load on the machine, the efficiency declining with loads which are larger or smaller than those of this optimum operating point. For convenience, and by analogy to screw propellers, this angular orientation of the blades will be hereinafter referred to as their pitch. The blade rows are accordingly customarily designed for the load expected to be most frequently encountered, and special measures to accommodate the blading to other loads by changing the pitch thereof are dispensed with. It is only in unusual cases that the blades are made rotatable about their individual axes for variation of the pitch thereof. When provision is made for varying the pitch of the blades of a row, whether of stator or of rotor blades, the pitch changing mechanism is coupled to control apparatus so as to keep the blades set to the pitch which is optimum for the existing load. If however substantial changes in load occur only infrequently, means to permit adjustment in blade pitch while the machine is in operation can be dispensed with. It is then customary to provide blades which can be reset in pitch, at the roots thereof, only when the machine is brought to rest and with at least partial disassembly of the machine to make the rotor accessible. If the time intervals in operation can be dispensed with. It is then customary to provide blades which can be reset in pitch, at the roots thereof, only when the machine is brought to rest and with at least partial disassembly of the machine to make the rotor accessible. If the time intervals between changes in load are extremely long, or if a change in blade pitch is required only once in the life of the installation, for example in the event of building of the plant to increased size, it has heretofore been customary simply to replace the old blading.

Blades which are rotatable at the roots thereof for pitch change have the disadvantage that they can come loose in operation, especially when subjected to large temperature changes, with consequent possibility of severe damage to the machine. On the other hand when no provision is made for change of blade pitch, change of the blading is extremely costly.

The invention dispenses with a rotatable disposition of the individual blades in their mounting and yet makes it possible to change blade pitch without replacing the blades. In accordance with the invention the blade roots include a portion of quadrilateral shape. This portion has two faces which may be parallel to each other and to the long dimension of the blade and which are approximately parallel to the chord of the blade. With the help of wedge-shaped inserts between adjacent blade roots which engage the blade roots at these faces, the blade roots of an assembled blade row make up a ring, in which however these faces typically do not lie in planes containing the axis of symmetry of the ring or ring-shaped array but are instead skewed with respect to that axis. Each blade root includes two additional faces which may be parallel to each other and to the long dimension of the blade and which may be perpendicular to the pair of faces first mentioned. The faces of this second pair usually are not perpendicular to the ring axis but instead are also skewed with respect thereto.

In accordance with the invention the blades of a row are held together in a ring-shaped array by means of two rings each having an end face notched or otherwise shaped to match the circular sawtooth surface defined at each axial end of the array of blades by the second-mentioned lateral faces of the blade roots. By means of the invention it is possible to employ blades with integral roots and nevertheless to permit change of blade pitch, such change requiring only replacement or adjustment of the end rings and replacement of the wedge-shaped spacers between circumferentially adjacent blades.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be further described in terms of a number of presently preferred non-limitative exemplary embodiments thereof and with respect to the accompanying drawings in which:

FIG. 1 is a fragmentary axial sectional view through a blade assembly in accordance with the present invention;

FIG. 2 is a fragmentary radially inwardly directed developed view of the blade assembly of FIG. 1;

FIG. 3 is a fragmentary radially outwardly directed developed sectional view of the blade assembly of FIG. 1, taken on the line III—III of FIG. 1;

FIG. 4 is a fragmentary perspective view of the assembly of FIGS. 1 to 3 in partially assembled condition, showing two blades, their adjacent wedge-shaped spacers, and one of the end rings;

FIG. 5 is a further figure similar to that of FIG. 2 but illustrating a modified construction according to the invention in which the end rings are provided with axially directed pins instead of notches for the purpose of holding the blades at a desired pitch; and

FIG. 6 is still another figure similar to that of FIG. 2 but illustrating still another embodiment in which the rings are provided with radially directed pins having a portion of conical shape to define sawtooth-shaped surfaces to hold the blades of the row in a desired pitch setting.

DESCRIPTION OF PREFERRED EMBODIMENT

The turbine blade assembly illustrated in FIGS. 1 to 4 comprises a single row of blades each generally indicated at the reference character 1. The blades are disposed on a circumferential interval t measured either angularly or linearly, for example at the root end of the blades proper. It is to be noted that while this interval is sometimes termed blade pitch, the term pitch is not so used herein, but is used instead to denote the angular orientation of the individual blades about their longitudinal axes, which extend radially of the machine. The blade proper 2 and the root 3 (FIG. 1) of each blade form an integral whole and are hence fixed in position with respect to each other. They can however be made of different metals welded or otherwise fastened together, as for example by casting techniques. The blade root 3 includes a portion having a quadrilateral section, as indicated by the closely hatched areas in FIG. 3. This portion is, on each blade, bounded by two first faces **4** which may be parallel to each other and to the long dimension of the blade and which are approximately parallel to the chord of the blade, indicated at **5** in FIG. **2.** As illustrated in FIG. **4,** it is at these faces **4** that the roots of adjacent blades bear against each other in the blade assembly of the invention, with the interposition of wedge-shaped spacers **8.** For a typical desired blade pitch, these faces **4** do not lie in meridian planes of the assembly, i.e., in planes containing the axis of symmetry of the assembly, but rather in planes skew thereto. Thus in such a case the face **4** seen in FIG. **1** will not lie in the plane of that figure, but will be inclined to it instead.

The quadrilateral portion of the blade root is bounded by two additional faces **6,** desirably also parallel to the long dimension of the blade proper and to each other but transverse (e.g. perpendicular) to the faces **4.** For a typical pitch setting of the blades, these faces **6** are skewed to the axis of symmetry of the assembly, and hence present a sawtooth surface formed into a circle, much like that of the teeth on a crown saw. This is seen in FIG. **4** at the exposed faces **6** of two adjacent blades.

To hold the blades in the desired position about their individual longitudinal axes, which axes extend radially of the assembly, end rings **10** and **11** are provided, each having one face having a sawtooth shape matching or substantially matching the ring-shaped sawtooth surface presented by one of the sets of end faces **6** of the blade roots. The construction of one of these rings, namely the ring **11,** is shown in the fragmentary perspective view of FIG. **4.**

As will also be seen in FIG. **4,** the sawtooth-shaped surface at each axial end of the row of blade roots includes an axial end face of each of the wedges **8.** Moreover, the sawtooth-shaped surface on the blade row at one axial end of the blade row (the end near the reader in FIG. **4**) includes a part of one face **4** from each of the blade roots whereas the sawtooth-shaped surface on the blade row at the opposite axial end of the blade row includes a part of one of the slant faces on each of the wedges.

Each blade root may include, in the case of a row of radially outwardly extending blades such as the rotor blades in FIGS. **1** to **4,** an axial extension **9** over which one of the rings **10** and **11** extends, to impose on the blades during rotation the central acceleration necessary to hold them in the assembly. Other blade anchoring arrangements can of course be employed consistently with the invention. By means of screws **16** extending parallel to the axis of the blade row assembly and hence parallel to the axis of the turbomachine, the rings **10** and **11** are drawn toward each other and against a flanged ring **15.** In this way, in the case of a row of stator blades, the blades may be fixed in position in a turbine housing, of which the ring **15** may form a part or to which it may be fastened, and can consequently operate to deflect the flow of a working fluid either at the inlet or at the outlet of rotor blade rows in axial turbines or compressors.

If there is desired a flow cross-section for the blade row of the assembly different from that shown in FIG. **2** in order to change the operating characteristics of the machine, the angle α between the side faces **6** of the blade roots and the peripheral direction **7** must be changed. If the cross-section is to be increased in size, the angle α (as shown in FIGS. **2, 5** and **6**) must be reduced in value and vice versa. For such a change, the rings **10** and **11** must be replaced with new rings having notches corresponding to the desired altered value of the angle α. Obviously such a change also makes it necessary to replace the spacers **8** since the separation of the side faces **4** of adjacent blade roots will be smaller or larger, as will also be the angular separation of those faces.

For all pitch settings the circumferential blade interval t (FIG. **2**) remains unchanged. Notwithstanding the constancy of the circumferential blade interval t, the flow cross-section varies with pitch setting between minimum and maximum values, for a given number of blades in the row. The maximum value can be increased if one or more blades are removed from the row, the larger spacing between blade roots thus permitted being filled up by spacer elements **8.** It is thus possible, without changing the total flow-through capacity of the blade row, to vary over a range of values the angle of attack for the working substance through the blade row.

In the embodiment of FIG. **5** there are employed, in place of the notched rings **10** and **11** of FIGS. **1** to **4,** rings **20** and **21** which may have smooth faces but which are provided each with a set of axially extending pins **22,** one for each blade of the row. The pins desirably have rounded ends, as indicated in the phantom view of FIG. **5.** The pins are desirably threaded into their rings so as to be axially adjustable. These pins extend into the notches of the saw-toothed surfaces provided by the faces **6** of the blade roots, and thereby serve to hold the blades of a row in fixed relative position. For variation of the angle α it is in such an embodiment necessary only to adjust the position of the pins **22** in their rings **20** or **21** and to dispose between the blade roots replacement spacer elements or wedges **86** of changed dimension corresponding to the new angle α and themselves of properly corrected wedge angle. The pins can be prevented from undesired creeping or turning by provision of a suitably eccentric surface on the heads thereof against which the blade roots will bear.

FIG. **6** illustrates still a further embodiment employing radially extending bolts or pins **32** to provide on end rings **30** and **31** the equivalent of the sawtooth-shaped surface seen on the ring **11** of FIG. **4.** These pins **32** may advantageously have a conical shape helping to define for their ring a sawtooth-shaped surface similar to that of the ring **11** of FIG. **4.** The shape of the bolts **32** must of course be adjusted to the desired angle α and also to the circumferential interval of the blading. For changing the pitch of a blade row in such an embodiment it is necessary only to change the bolts **32** which themselves make up then the saw-toothed surface on the rings, and also the spacers **87.**

Blade assemblies according to the invention can be employed in blowers, compressors and turbines and are especially useful in axial-flow and single-stage machines.

The invention thus provides a blade assembly for a turbomachine comprising a plurality of blades disposed in an annular array. The blades have roots including a portion having two opposite sides as shown at **4** in the drawings, and spacer elements are disposed between circumferentially adjacent ones of the blade roots. Adjacent of these spacer elements engage these two opposite sides on the root of a blade. The blade roots include at least one and preferably two additional sides, as indicated at **6** in the drawings, extending transversely of the sides **4**. Two rings are provided, and at least one of these includes means to define thereon end surface substantially matching the annular sawtooth-shaped surface presented by the sum of those additional sides on the blade roots facing in one direction axially of the array. Of course the blade roots may have more than four sides, and the end rings may be provided with more complex sawtooth surfaces to match them.

While the invention has been described hereinabove in terms of a number of presently preferred embodiments thereof, the invention itself is not limited thereto, but rather includes all modifications of and departures from those embodiments properly falling within the scope of the appended claims.

I claim:

1. A blade assembly for a turbomachine, said assembly comprising a plurality of blades disposed in an annular array, said blades having each a root including a portion of quadrilateral cross-section having two first opposed faces skewed to the axis of the array, spacer elements between circumferentially adjacent ones of said blade roots, adjacent of said spacer elements engaging said first opposed faces on one of said blade roots, said blade root portions having each two additional opposed faces extending transversely of said first opposed faces, said additional faces being skewed to the axis of the array, whereby said blade roots and spacer elements constitute an annular array having two sawtooth-shaped end faces, two rings on axially opposed sides of the array, each of said rings including means to define adjacent said array an annular sawtoothed-shaped surface of which the teeth extend axially of the array and are equal in number to said plurality, each tooth on one of said rings engaging the root of one of said blades at one of said first opposed faces and also engaging the root of a circumferentially adjacent one of said blades at one of its said additional opposed faces, each tooth on the other of said rings engaging one of said spacer elements and also engaging the root of one of said blades at the other of its said additional faces, and means to stress said rings together with said blade roots and spacers between them.

2. A blade assembly according to claim **1** wherein said means comprise an annular sawtooth-shaped surface on each of said rings.

3. A blade assembly according to claim **1** wherein said means comprise on each of said rings a plurality of axially extending pins, one for each of said blades.

4. A blade assembly according to claim **1** wherein said means comprise on each of said rings a plurality of conical radially directed bolts, one for each of said blades.

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