Dec. 25, 1951 W. C. JOHNSON 2,579,583

SEGMENTAL BLADING

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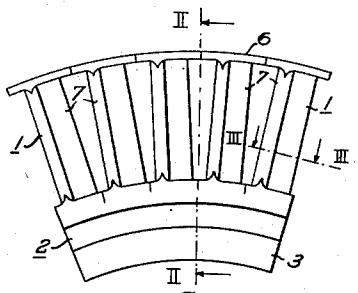


Fig. 1

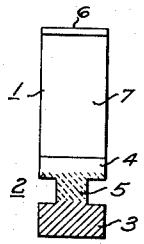


Fig. 2

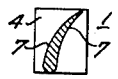


Fig. 3

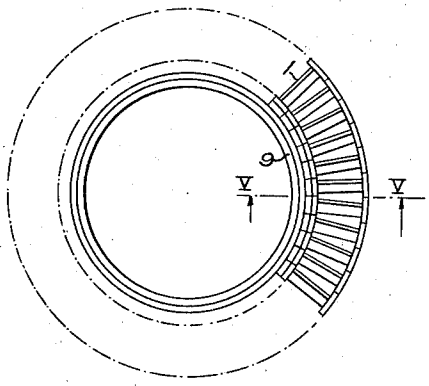


Fig. 4

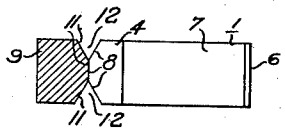


Fig. 5

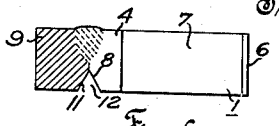


Fig. 6

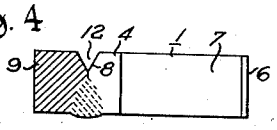


Fig. 7

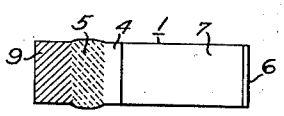


Fig. 8

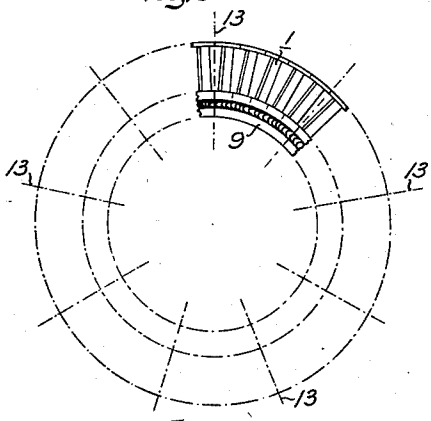


Fig. 9

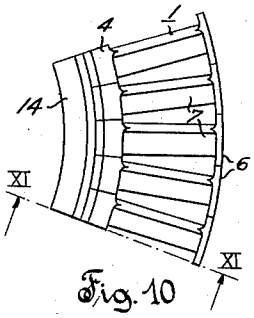


Fig. 10

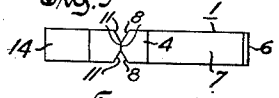


Fig. 11

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SEGMENTAL BLADING

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3 Claims. (Cl. 29—156.8)

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This invention relates generally to the blading of rotor and stator elements of machines, such for example as elastic fluid turbines, and more particularly to the formation of bladed segments having foundation parts adapted to be attached to the selected machine element in end-abutting, row forming relation.

In this connection, the practices heretofore most commonly employed have been to either position blade sections cut from rolled stock, or otherwise formed, in a suitable mold and integrally cast a base or foundation part thereto or to position such blade sections with spacing pieces inserted between the root portions thereof against a rotor disk or ring segment and weld both the exposed base ends of the blade sections and the bottom surfaces of the spacing pieces to the opposed surface of the rotor disk or ring segment. Still another practice more recently employed has been to position blades having enlarged, relatively massive root portions in end-abutting, row forming relation against the periphery of a rotor disk and weld the bottom surface of the root portions to the opposed surface of the rotor disk.

However, the first mentioned practice has not been entirely satisfactory, particularly with respect to high speed, high temperature machines necessitating the use of nickel-chrome blading, in that the quantity of molten metal necessary to form a cast-on base or foundation part heats the nickel-chrome blade sections sufficiently to produce a detrimental degree of grain growth in such sections and thereby a weakening of same, in that when a cast-on base or foundation part is made of steel, it is difficult to machine due to the formation of a very tough and hard enveloping crust, and in that when the cast-on base or foundation part is made of some machineable composition having a coefficient of expansion substantially equal to that of steel, for example a composition consisting of nickel and copper, blow-holes are likely to occur thereby ruining the bladed segment.

The second mentioned practice is also objectional in some respects in that the time and skill required to make, assemble and weld the separate spacing pieces and blade sections to the opposed peripheral surface of a rotor disk or to the opposed surface of a ring segment necessarily renders the cost of such a construction relatively high, and in that it is difficult and sometimes impossible to effect a satisfactory bond between the blade sections and spacing pieces and between the blade sections, spacing pieces and the opposed surface of the disk or

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ring segment, while the last mentioned practice, although entirely satisfactory for the construction of small, single stage turbines, has not proven practical for turbines having two or more stages in that the sides of the blades in adjacent, axially spaced blade rows cannot be satisfactorily welded in the limited space available, and in that even if the rotor is an assembled structure, i. e. made up of two or more detachably united disks to which the blades are welded, the replacement of a part or all of the blades on any disk necessitates the costly procedure of disassembling the rotor. In addition, the last mentioned procedure has not proven entirely satisfactory for large single stage turbines in that the formation of the necessarily large weld bond, i. e. large in both radial extent and circumferential length, results in an unequal heating and warping of the rotor disk.

It is therefore an object of this invention to provide a method of forming bladed segments which is relatively simple and inexpensive to practice and which produces segments that are entirely satisfactory both with respect to strength and machineability.

Another object of this invention is to provide a practical method of forming bladed segments having a readily machineable foundation part and blades made of a material which is difficult if not impossible to machine other than by a grinding operation.

Another object of this invention is to provide a practical method of forming bladed segments which permits fusibly uniting nickel-chrome blades and blades of similar composition insofar as heat-produced grain growth is concerned to a foundation part without effecting a detrimental degree of grain growth and thereby a weakening of the blades.

Still another object of this invention is to provide a practical method of forming bladed segments having a foundation part of which the portion to be shaped for engagement with a blade-structure-supporting portion of a rotor or stator element consists of fusibly united, concentric layers of the same or different readily machineable materials.

The construction and the nature of apparatus embodying the invention will become readily apparent as the disclosure progresses and more particularly emphasizes the significance of the aforementioned objects and other features considered of special importance. And accordingly the invention may be considered as consisting of the various methods, combinations of parts, and

details of construction as is more fully set forth in the following description and claims, reference being had to the accompanying drawing, in which:

Fig. 1 illustrates a completed bladed segment embodying the invention;

Fig. 2 is a section through a blade taken on line II—II of Fig. 1;

Fig. 3 is a view taken on line III—III of Fig. 1;

Fig. 4 illustrates a group of blades positioned with their enlarged base portions disposed in end-abutting, blade-spacing-relation against the opposed peripheral surface of a base or foundation ring part;

Fig. 5 is a view taken on line V—V of Fig. 4;

Fig. 6 is a view similar to Fig. 5 showing the next step in the procedure of fusibly uniting the blades and base part;

Fig. 7 is a view showing the partially completed assembly of Fig. 6 inverted preparatory to completing fusibly uniting the blades and base part;

Fig. 8 is a view similar to Fig. 7 showing the blades and base part completely fusibly united;

Fig. 9 is a plan view of a completed ring assembly machined to final dimensions and cut into segments such as is shown in Fig. 1;

Fig. 10 is a view similar to Fig. 4 showing the blades in position against a segment foundation part; and

Fig. 11 is a view taken on line XI—XI of Fig. 10.

Referring to Figs. 1, 2 and 3 of the drawing, it is seen that a completed bladed segment constructed in accordance with this invention comprises a plurality of blades 1 terminating in a relatively massive foundation part 2 machined or otherwise shaped to provide a cross-sectional configuration complementary to that presented by the portion of a member to which the segments are to be secured, and that the massive foundation part 2 is composed of a base member 3, the end-abutted enlarged, relatively massive root portions 4 of blades 1, and an interposed weld metal bond 5 approximately coextensive in length and width with the opposed surfaces presented by the bottom of surfaces of root portions 4 and by base member 3. If desired, the blades 1 may also be provided with integral shroud portions 6 disposed in end-abutting relation as herein illustrated.

Referring to Figs. 4–9, inclusive, it is seen that bladed segments conforming with that shown in Fig. 1 may be constructed by providing blades 1 each having an enlarged, relatively massive root portion 44 adapted to end-abut the root portion of the next adjacent blade when the blades are assembled in a row to thereby position the blades with their passage defining surfaces or faces 7 disposed in correctly spaced relation and with their root portions 4 presenting a substantially continuous base surface 8, by providing a continuous base ring 9 having an outer peripheral surface 11 which may conform to the base surface 8 presented by the root portions 4 of blades 1, by assembling and retaining the blades 1 and ring 9 in the relation shown in Figs. 4 and 5, i. e. with the substantially continuous base surface 8 disposed in contiguous or radially opposed, gap forming relation with respect to the conforming outer peripheral surface 11 on ring 9 with one of the oppositely facing grooves 12 disposed in upwardly opening relation as best shown in Fig. 5, and then fusibly depositing metal between the opposed surfaces to form an interposed weld metal bond 5 which is approximately coextensive in length and width with the surfaces 8 and 11 as indicated in Figs. 8 and 9.

In this connection, the weld metal is preferably fusibly deposited in two steps as indicated in Figs. 6 and 7, i. e. the upwardly opening one of the grooves 12 is first filled with metal whereupon the assembly is inverted and the procedure repeated, the weld metal fusing with the adjacent portions of the blade roots 4 and with the adjacent portion of the ring 9 to provide an interposed coextensive bond of the type best shown in Fig. 8. The filling of each groove 12 with weld metal as herein indicated may be performed in any desired manner, but is preferably accomplished by a continuous operation with a flux submerged electric arc in accordance with the procedure disclosed in U. S. patent, L. T. Jones et al., 2,043,960. Although it is preferable in this connection to bevel or otherwise shape the opposed surfaces 8 and 11 to provide flux retaining grooves therebetween, for example the grooves 12, an interposed weld bond of the type herein indicated can be formed either with or without grooves, and if grooves are employed, irrespective of their side wall configuration. It is preferable to use a non-air-hardening weld metal having a coefficient of expansion similar to that of the blade material and to that of the base ring 9.

Upon completing the welding together of the blades 1 and ring 9 as indicated in Figs. 7 and 8, the completed assembly may be first machined to remove any excess weld metal and to shape the foundation part for complementary engagement with a blade structure-supporting portion of the member or element to which the completed, bladed segments are to be attached, and then cut into a desired number of segments as indicated by dot and dash lines 13 and the ends of the segments further machined to provide suitable end-abutting radial surfaces. If desired, the welded-ring assembly may be cut into a selected number of segments before performing the previously mentioned machining operations and the individual segments then machined to final dimensions either separately or in groups as preferred. Whether the ring assembly is made into segments by performing the cutting and machining operations in the sequences just described or in some other sequence is immaterial insofar as this invention is concerned and a further description of such operations is believed unnecessary. However, it may be well to point out that the completed ring assembly and the segments made therefrom are normalized or otherwise heat treated during the formative procedures heretofore described as required in order to preserve or obtain desired physical properties.

In this connection, the continued development of blade materials capable of withstanding increasingly higher operating temperatures and pressures coupled with the fact that although the more recently developed materials, for example alloys containing nickel, chromium and/or cobalt, have improved stress, corrosion and erosion resisting properties at high temperatures, their initial cost is relatively high and in addition some of them are difficult if not impossible to machine other than by a grinding operation. Consequently, the procedure hereinbefore described is of particular advantage in that the blade proper may be of a material best suited to withstand high operating temperatures and pressures whereas the major portion of the foundation part, i. e. the part consisting of the base member 3 and

the bond of weld metal 5, may be of a less expensive, readily machineable material thus enabling the foundation part to be machined to a desired configuration as indicated in Figs. 1 and 2 without cutting into the blade material.

In addition, the formation of a relatively massive, readily machineable foundation part can be readily accomplished as hereinbefore described without heating the blade portion of reduced section, i. e. the radially extending portion presenting fluid confining side surfaces 7, sufficiently to produce a detrimental degree of grain growth in such sections and a weakening of same. This improved result is attributable to one or more of the following features: (*a*) the use of blades having enlarged, relatively massive root portions 4 (note Fig. 3), (*b*) the relatively small amount of heat imparted to the blade portions of reduced section in producing a weld bond 5 between the root portion 4 and base member 3 as compared with that imparted to the blade portions of reduced section in producing a cast-on foundation part, and (*c*) the fact that in fusibly depositing weld metal between the contiguous opposed surface portions of blade roots 4 and base member 9, the assembly is in fact locally heated and substantially free to dissipate heat by radiation and convection whereas the production of a cast-on foundation part necessitates embedding the blade portions of reduced section in molding sand or otherwise covering same in a manner effective to accumulate heat therein. Moreover, the procedure of successively welding opposite sides of the assembly (note Figs. 5 and 6) further localizes heat input to the base ends of the blades and to the peripheral blade mounting portion of the base member and necessarily reduces the rate of heat input and thereby the maximum temperature to which the blade portions of reduced section become heated. However, the rate of heat dissipation afforded by the use of blades having enlarged, relatively massive base portions and by an assembly such as that indicated in Fig. 4 is generally sufficient to prevent heating the reduced portions of the blades to a detrimental degree irrespective of whether opposite sides of the assembly are locally heated and welded simultaneously or successively.

Referring to Figs. 10 and 11 in which like numerals are used to designate the same or corresponding parts, it is seen that a bladed segment conforming with that shown in Fig. 1 may also be constructed by using a ring segment 14 rather than a complete ring 9 and assembling, retaining and fusibly uniting the contiguous opposed surfaces 8 and 11 of the blades 1 and ring segment 14, respectively, in the same manner as disclosed in connection with the construction illustrated by Figs. 4–9, inclusive. Upon completing one or more of the segments to this extent, the segments may be then machined to final dimensions either separately or in groups and normalized or otherwise heat treated as hereinbefore specified. This modified construction also affords all of the advantages particularly pointed out in connection with the disclosure relating to Figs. 4–9, inclusive.

The invention is applicable to the formation of bladed segments for stator elements as well as for rotor elements, and it should therefore be understood that it is not intended to limit the invention to the exact procedures herein disclosed for purposes of illustration as various modifications within the scope of the appended claims may occur to persons skilled in the art.

It is claimed and desired to secure by Letters Patent:

1. The method of making a bladed rotor or stator element having a plurality of sector shaped bladed structures individually detachably mounted thereon, each bladed structure having a foundation part adapted for individual detachable mounting on said rotor or stator element, comprising, providing blades each having an enlarged integral root portion presenting oppositely facing surfaces adapted to abut a like surface on the root portion of the next adjacent blade to thereby position the blades with their passage defining faces disposed in correctly spaced relation, said blades being of a material which is difficult if not impossible to machine, when unheated, other than by a grinding operation, positioning said blades in row forming relation with the oppositely facing surfaces of their root portions disposed in abutting engagement and with the base ends of said root portions presenting a circular approximately continuous base surface, providing a base member of ring form for forming a portion of said foundation part, said base member having a circular peripheral blade mounting portion approximately equal in width and diameter to said base surface, said base member being of material readily machineable when unheated, and positioning said base member with its said peripheral blade mounting portion disposed in opposed coextensive relation with respect to said base surface, said root portions being sufficiently enlarged so that when heat sufficient to fuse the material thereof is locally applied to respective base ends the resultant temperature rise of respective blades will be insufficient to detrimentally affect respective blades, fusibly uniting said blades and base member by a procedure which localizes the application of heat to said base ends and to the peripheral blade mounting portion of said base member and which provides an interposed bond of fused material, readily machineable when unheated, coextensive with and uniting all of the blades by substantially the entire base ends of their respective root portions collectively with substantially the entire peripheral blade mounting portion of said base member, and cutting the bladed structure comprising the base member and blades welded thereto into a plurality of bladed sectors, each sector comprising a plurality of blades.

2. The method of making a bladed rotor or stator element having a plurality of sector shaped bladed structures individually detachably mounted thereon, each bladed structure having a foundation part adapted for individual detachable mounting on said rotor or stator element, comprising, providing blades each having an enenlarged integral root portion presenting oppositely facing surfaces adapted to abut a like surface on the root portion of the next adjacent blade to thereby position the blades with their passage defining faces disposed in correctly spaced relation, said blades being of a material which is difficult if not impossible to machine, when unheated, other than by a grinding operation, positioning said blades in row forming relation with the oppositely facing surfaces of their root portions disposed in abutting engagement and with the base ends of said root portions presenting a circular approximately continuous base surface, providing a base member of ring form for forming a portion of said foundation part, said base member having a circular peripheral blade mounting portion approximately equal in width and diameter to said base surface, said base member being of material readily machin-

able when unheated, and positioning said base member with its peripheral blade mounting portion disposed in opposed coextensive relation with respect to said base surface, said root portions being sufficiently enlarged so that when heat sufficient to fuse the material thereof is locally applied to respective base ends the resultant temperature rise of respective blades will be insufficient to detrimentally affect respective blades, fusibly uniting said blades and base member by a procedure which localizes the application of heat to said base ends and to the peripheral blade mounting portion of said base member and which provides an interposed bond of fused material, readily machinable when unheated, coextensive with and uniting all of the blades by substantially the entire base ends of their respective root portions collectively with substantially the entire peripheral blade mounting portion of said base member, machining said bond and base member to provide at least one groove extending circumferentially of said base member for complementary engagement with and detachable mounting on a blade structure supporting portion of the rotor or stator element, and cutting the bladed structure comprising the base member and blades welded thereto into a plurality of bladed sectors, each sector comprising a plurality of blades, so that each bladed sector is individually detachably mountable on a rotor or stator element.

3. The method of making a bladed rotor or stator element having a plurality of sector shaped bladed structures individually detachably mounted thereon, comprising: providing blades of a material which is difficult if not impossible to machine when unheated, other than by a grinding operation; positioning said blades in row forming relation with oppositely facing surfaces of root portions of said blades disposed in abutting engagement and with base ends of said blades presenting a circular approximately continuous base surface; providing a base member having a peripheral blade mounting portion approximately equal in width, curvature and length of curvature to said base surface, said base member being of material readily machinable when unheated; positioning said base member with its said peripheral blade mounting portion disposed in opposed coextensive adjacent relation to said base surface; fusibly uniting said blades and base member with an interposed bond of fused material, readily machinable when unheated, machining said bond and base member to provide at least one groove extending circumferentially of said base member for complementary engagement with and detachable mounting on a blade-structure-supporting portion of the rotor or stator element; and cutting said base member and blades united thereto into a plurality of bladed sectors, each sector comprising a plurality of blades.

WILLIAM C. JOHNSON.

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