METHOD OF FORMING BLADE ROOTS

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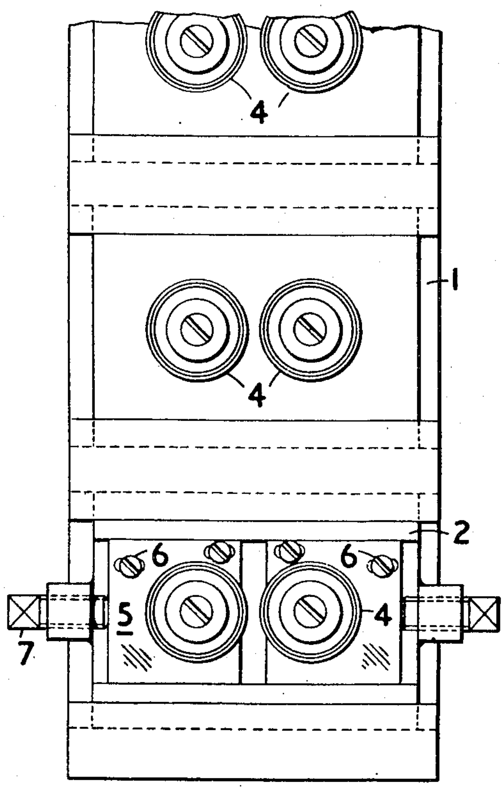

FIG. 1

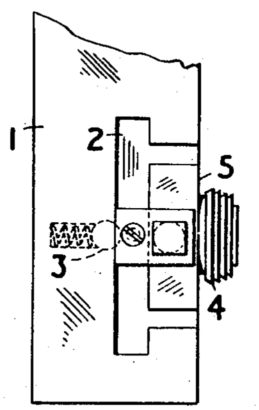

FIG. 3

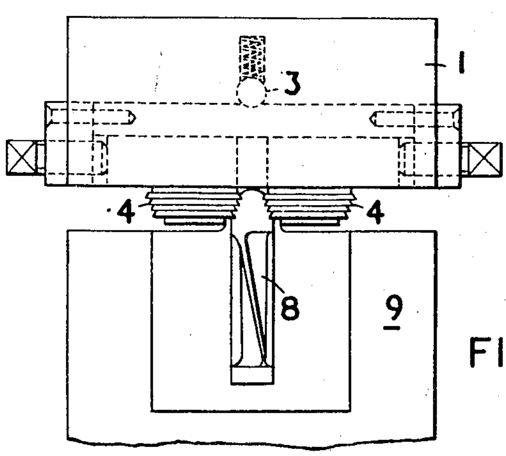

FIG. 2

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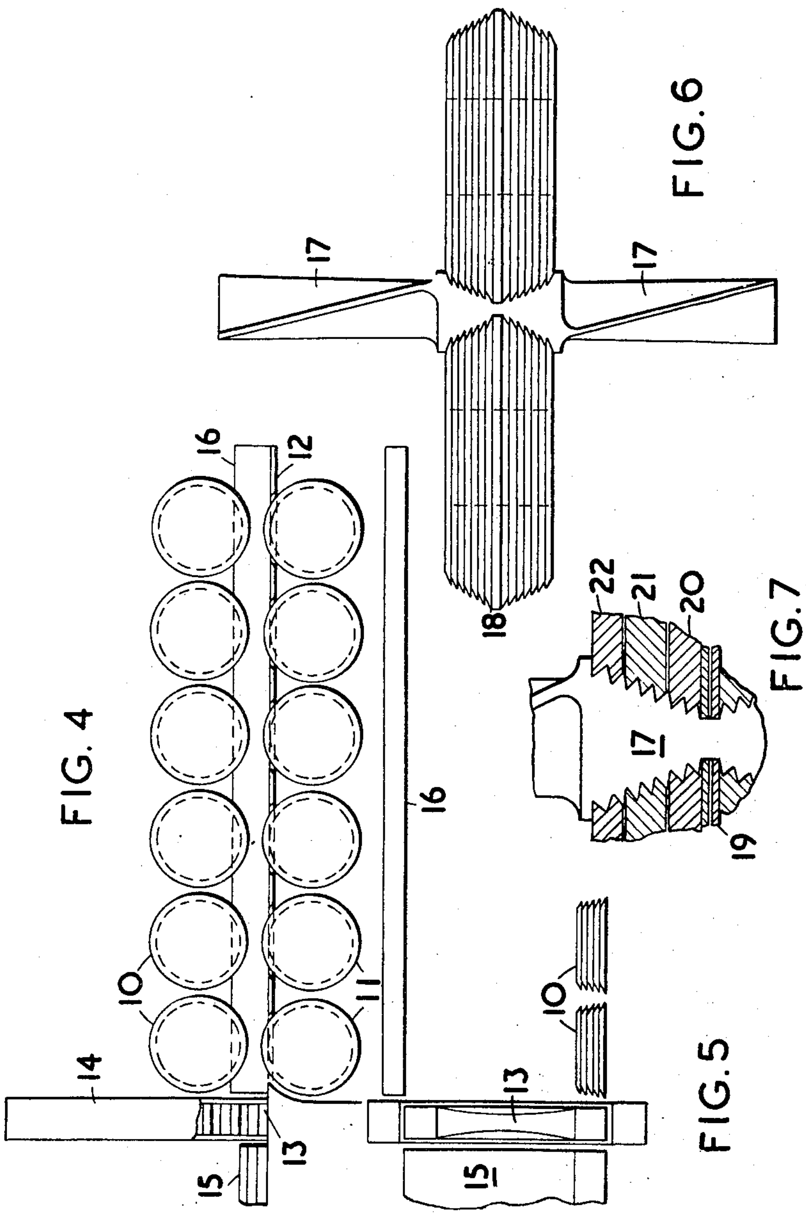

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METHOD OF FORMING BLADE ROOTS

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3 Claims. (Cl. 29—156.8)

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This invention relates to an improved method for forming the root or anchor portion of the blades used in bladed fluid-flow machines such as turbines and compressors, and relates particularly to blades of the type which are formed with a profiled root adapted to be secured in a socket (hereinafter referred to as "blades of the type described").

The invention is mainly of interest in connection with the production of blades which are subjected in use to high temperatures and stresses, and which therefore require to be made of specially developed steels or alloys, such as nickel-chrome alloys, which may be difficult and expensive to machine. Examples of such blades are the turbine rotor blades of gas turbine machines, and in a lesser degree the compressor rotor blades (in cases where bladed compressors of the axial flow type are used).

One known method of securing the blades to the turbine rotor disc of a gas turbine is to provide the periphery of the rotor disc with serrated slots extending in a generally radial direction, complementary serrations being formed on the blade roots so that they can be pressed into the slots and secured, for instance by peening. Where the serrated blade root, and the corresponding slot, are tapered, such a method of blade mounting is generally known in the art (from the profile of the blade root) as the "fir-tree" mounting, and it will be hereinafter designated by this term. At present "fir-tree" mountings are in wide use.

"Fir-tree" roots have hitherto been usually made by a machining operation, such as broaching, and one object of the present invention is to provide an alternative method of making such roots which eliminates or reduces machining operations, thus cheapening production, and which, at least in the case of some materials, also has a beneficial effect on the material treated.

Broadly the invention provides, for blades of the type described, the method of forming the root contour wholly or partly by means of pressure-working.

By "pressure-working" is meant a rolling, swaging, stamping, coining or similar operation.

The pressure working may most advantageously comprise a rolling operation, which will usually be cold, but may be hot if the nature of the material which is being worked requires it. The rolls may be of any suitable material, such as hardened steel or tungsten carbide.

Cold pressure working provides an improved surface finish for most of the metallic materials

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likely to be useful for the turbine blades of gas turbine machines, and may have a beneficial effect in other respects; for example, alloys of the 18 chromium 8 nickel type can have their creep limit raised by cold work (see Zschokke, Brown Boveri Review 1946, v. 33, pp. 227–233). Other highly alloyed steels are also improved in the same respect by cold work (see Cornelius, "Metallwirtschaft," 1939, v. 18 pp. 399–403, and pp. 419–421). The degree of such improvement does however, depend on the proximity of the operating temperature of the blade root to the re-crystallisation temperature. With the general run of turbine rotor disc rim temperatures the difference between the operating temperature and the re-crystallisation temperature is such that substantial improvement results.

Some alloys, intended to operate at lower temperatures, such as aluminum alloys, bronzes, and stainless steels, for compressor blades, lose a portion of their highly creep-resisting properties when cold worked. With such alloys, or where the operating temperature is near to re-crystallisation temperature, it is preferable to subject at least the root of the blade (after pressure working) to re-heat treatment (which can often be done by an induction process), and thereafter to remove the oxidised surface by mechanical or electrolytic means.

For the sake of example some practical methods according to the invention of rolling the "fir-tree" roots of turbine blades will now be described with reference to the accompanying diagrammatic drawings, in which:

Figs. 1–3 show the essential parts of a rolling machine in which the work is held stationary and the rolls are moved linearly over the work. Fig. 1 is a front elevation of the movable ram carrying the rolls, Fig. 2 is a transverse section through the ram, showing the stationary table in which the blades are fixed, and Fig. 3 is a side elevation of the ram.

Fig. 4 is a side elevation, and Fig. 5 is a fragmentary plan, of an alternative rolling machine in which the blades are fed linearly through the rolls.

Figs. 6 and 7 are detail views of modified types of roll.

Referring to Figs. 1–3, the machine there shown comprises in essentials a vertically movable ram **1**, in which three slides **2** are mounted for horizontal sliding movement. Each slide is resiliently biassed to a central position by a spring-pressed ball or plunger device **3**, and the slide can move against such spring pressure in order to accommodate any inaccuracies in the positioning of the work. The slides carry pairs of spaced freely rotatable rolls 4, each roll being mounted on an adaptor 5 capable of being secured to the slide in various positions by means of bolts such as 6 passing through slotted holes in the adaptor. The adjustment of the adaptors 5, to set the rolls for different centre-to-centre distances, is effected by end screws 7 bearing against the adaptors.

A series of partly formed blades 8 are secured, vertically aligned on a vertical table 9, with the roots protruding as shown, in position to cooperate with the various pairs of rolls provided on the ram 1. In operation, the three pairs of rolls are set to progressively smaller centre-to-centre distances, and when the ram 1 is caused to descend the pairs of rolls pass in succession over the blade roots and progressively form the "fir-tree" serrations.

The machine may be modified in obvious ways. For instance, the rolls could be mounted on the fixed table and the blades on the movable ram; and the ram, whether it carries rolls or blades, could be disposed for horizontal movement. However, the particular arrangement shown in Figs. 1–3 is convenient, since it represents an adaptation of a standard type of broaching machine used for the conventional method of making "fir-tree" roots.

In the machine shown in Figs. 4–5 a series of pairs of freely rotatable rolls 10, 11, are mounted above and below a vertically adjustable apertured platen 12 over which blades 13 from a magazine 14 are horizontally fed between the rolls by a ram 15. Here again the roots are progressively rolled to the required contour. An end guide 16 takes the end thrust of the blades during rolling.

The ram 15 may be constructed and arranged to have a sufficiently long stroke to pass between the whole series of rolls, or alternatively its stroke may be shorter. In the latter case the machine may be cleared after working by passing through the rolls dummy blade blanks, which may be resilient.

Fig. 6 illustrates diagrammatically a method of simultaneously rolling fir-tree roots on two blades 17 interconnected at the roots, so that the end thrust of the blades during rolling is balanced. The double-sided rolls each have a central locating rib 18, and may be solid (as shown in Fig. 6), or built up of a number of disc members each independently freely rotatable, such as 19, 20, 21, 22 (Fig. 7).

The construction shown in Fig. 7 may if desired be applied to the rolls in the machines described with reference to Figs. 1–3 and 4–5.

The rolls and the work will probably require to be flooded with oil during operations; and the rolling process may be further facilitated by previously plating the blade roots with a friction-reducing material, such as cadmium or zinc.

Although the invention is primarily useful for making serrated blade roots, it may also be applied to forming roots of other contours, such as a bulbed contour.

I claim:

1. A method of forming root portions of a plurality of blades for turbines and similarly bladed fluid-flow machines, comprising rigidly securing said plurality of blades with respect to one another with root ends aligned for movement in a direction normal to the length of the blades, moving said plurality of blades between a plurality of pairs of spaced similar contour-forming rollers located at spaced stations along the line of movement of said blade roots, said pairs of rollers having smaller spacing between successive pairs, whereby the plurality of blade roots are progressively reduced to contour as they pass between successive decreased spaces between said rollers.

2. A method of forming root portions of a plurality of blades for fluid turbines and the like machines, comprising rigidly securing a plurality of blades aligned one parallel with respect to the others, with the root ends extending in the same direction, spacing a plurality of pairs of contour-forming rollers aligned similarly to the blades at spaced intervals corresponding to the location of the blades, in which the spacing between the pairs of rollers is decreased between successive pairs, placing said plurality of blades in alignment with said plurality of rollers and moving said pairs of rollers relative to said blade roots to progressively and successively reduce the plurality of blade roots to the desired contour.

3. A method of forming root portions of a plurality of blades for fluid turbines and the like machines, comprising rigidly securing a plurality of blades aligned one parallel with respect to the others, with the root ends extending in the same direction, spacing a plurality of pairs of contour-forming rollers aligned similarly to the blades at spaced intervals corresponding to the location of the blades, in which the spacing between the pairs of rollers is decreased between successive pairs, placing said plurality of blades in alignment with said plurality of rollers and effecting relative motion therebetween, and inserting said blade roots into the path of motion of said plurality of pairs of rollers to progressively and successively reduce the plurality of blade roots to the desired contour.

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