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TURBINE BLADE AND METHOD OF MAKING THE SAME

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Fig. 1

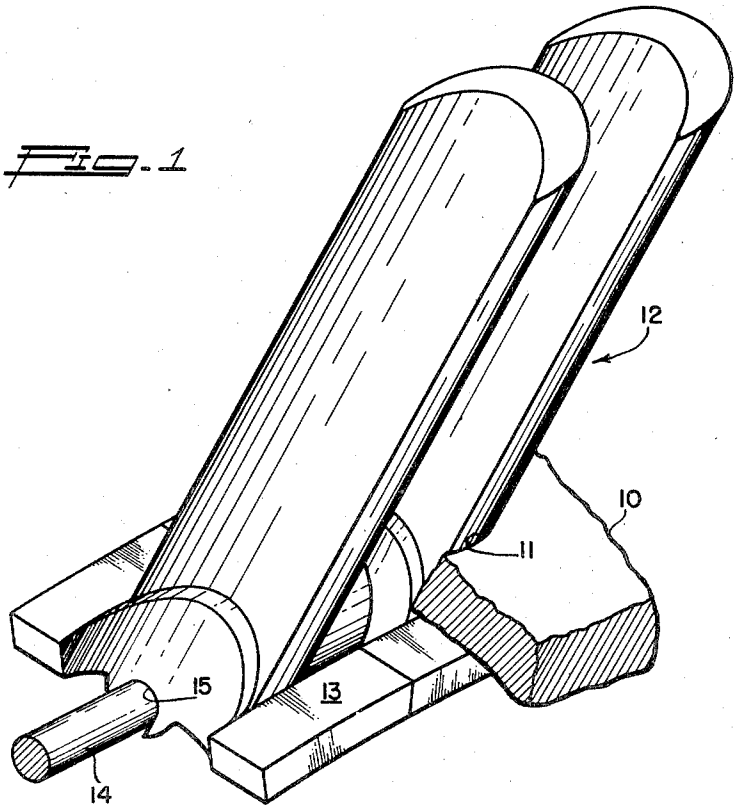
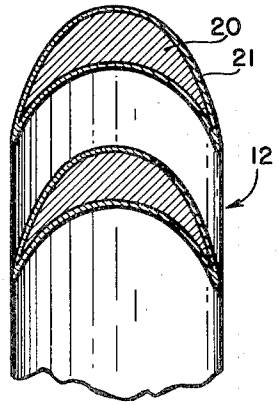


Fig. 2



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TURBINE BLADE AND METHOD OF MAKING THE SAME

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1 Claim. (Cl. 253—77)

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This invention relates to turbine elements, and relates more particularly to buckets or blades for gas turbines and to methods for making the same.

This application is a continuation-in-part of application, Serial Number 433,599, entitled "Aircraft Powerplant" filed March 6, 1942. In that application I have disclosed a high temperature gas turbine embodying means for cooling the turbine wheel and the roots of the turbine blades. This cooling of the turbine wheel and the blade roots enables the employment of considerably higher turbine gas temperatures than would otherwise be possible, with resultant improved turbine efficiency. The gas temperatures may be safely elevated still further, while retaining the cooling arrangement, if the turbine blades or buckets are constructed to have a yield point at elevated temperatures higher than the yield points of the usual steel alloys at such temperatures.

It is therefore a general object of the invention to provide a gas turbine bucket or blade capable of successfully withstanding exceedingly high operating gas temperatures, and to provide a simple effective and commercially practical method for making such blades or buckets.

It is another object of the invention to provide blades or buckets for use in gas turbines characterized by bodies or cores of material having a yield point, at elevated temperatures, much higher than the yield point of most steel alloys at comparable temperatures.

It is another object of the invention to provide gas turbine buckets of the character referred to in which the high strength cores or bucket bodies are protected by plating or protective coverings of a hard dense metal that is chemically inactive and resistant to abrasion and erosion. The buckets of the invention shielded by these protective coatings are capable of operating continuously at temperatures in the neighborhood of 2000° Fahrenheit without thermal, corrosion or erosion difficulties.

It is another object of the invention to provide a method for making gas turbine buckets, of the character above referred to, which involves the employment of a selected powdered metal, or mixture of selected powdered metals as the material of the bucket body or core, and in which the powdered metal is subjected to a series of forming and treatment operations assuring the formation of a dense, substantially homogeneous body of metal of great physical strength and having a high yield point at elevated temperatures.

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It is a further object of the invention to provide a method of the character referred to in which the protective coating is uniformly alloyed and bonded with the metal of the core and then shaped and sized in suitable precision dies to give the bucket its final required shape and dimensions. The material of the protective coating is readily shaped in the proper dies thus providing for final forming of the buckets to the exact required shape and dimensions so that shrinkage and minor distortion of the core are remedied or compensated for.

Other objectives and features of the invention will become apparent from the following description of a typical preferred bucket, and the method of the invention throughout which description reference will be had to the accompanying drawings in which:

Figure 1 is a perspective view of a portion of a turbine rotor illustrating two adjacent buckets; and,

Figure 2 is a transverse sectional view of the buckets.

The method of the present invention may be practiced in the manufacture of buckets or blading for use in turbines and like machines varying considerably in character, proportions and intended purpose. Furthermore, the buckets or blades of the invention may be designed for use either as the impeller or stator blading of the turbo machines, and may vary materially in configuration. Accordingly, it is to be understood that the invention is not to be construed as limited or restricted to the specific type of bucket illustrated in the accompanying drawings or to the exact procedure described in producing the same.

In the drawing I have shown a portion of a turbine rotor or shell 10 having broached openings 11. The blades or buckets 12 are inserted into the openings 11 from the interior of the shell. The buckets have a light pressed fit in the openings, and have root flanges 13 which are held firmly in place against the shell by centrifugal force during operation of the turbine. A ring 14 engages in grooves 15 in the ends of the buckets to hold the flanges 13 seated firmly in place at all times. The particular buckets 12 shown in the drawings are substantially crescent shaped in transverse cross-section and are of uniform cross-sectional configuration throughout their lengths, it being understood that insofar as the present invention is concerned, the buckets may be of any selected or required configuration.

Each blade or bucket 12 includes a body or core

20 and a protective plating or covering 21. The core 20 is the principal element or portion of the bucket, and in accordance with the invention, is formed of a dense high strength, high melting point metal. The core 20 may be formed of a metal of the group comprising iridium, molybdenum, tungsten or tantalum or a mixture of two or more of such metals. In practice I usually prefer to construct the core 20 of tantalum which has a melting point of about 5160° Fahrenheit, and which has a high yield strength at elevated temperatures. As will be later described in connection with the method of the invention, the core 20 is preferably formed of a highly compressed mass of metal powder sintered to constitute a compact, essentially homogeneous body of great density and high strength.

The protective coating or layer 21, is composed of a metal resistant to erosion and corrosion, that is hard and dense, and that has a relatively high melting point. It is contemplated that the protective coating 21 may be composed of chromium, cobalt, nickel, manganese, iron or a mixture or alloy of such metals. It has been found desirable to form the protective coating of chromium. Chromium effectively bonds and alloys with the metal of the core 20, is chemically inactive and is resistant to abrasion and corrosion. The plating or coating 21, preferably covers the entire surface of the core 20, or at least, all surfaces of the bucket subject to abrasion and high temperature conditions.

I will now proceed with a description of the method for forming the buckets described above. The first step of the method is the molding of the core 20. A suitable quantity of the selected metal powder, such as tantalum powder or tantalum powder with a small portion of a suitable binding metal or metals in powdered form, is hydraulically molded to the approximate shape of the bucket. It is preferred to hydraulically mold the metal powder at high pressure to a form that is slightly over-size and the approximate shape of the final bucket. This body of molded metal powder is then sintered in an induction furnace, or by other appropriate sintering means, at temperature of about 4000° Fahrenheit. The sintering is performed in an inert atmosphere such as nitrogen, helium or argon from which oxygen is carefully excluded, or preferably in a vacuum. During the sintering operation the molded blank or core 20 shrinks with the accompanying consolidation and may be somewhat under-size as a result of the sintering operation. The sintering and consolidation convert the molded core into a substantially homogeneous piece of metal of high physical strength.

The next step or operation of the method is the plating of the core 20. The core 20 cannot be used in its molded and sintered form because it may not accurately conform to the required shape and dimensions and because it is subject to attack or corrosion by the combustion gases of the high temperature turbine, or the like. In accordance with the present invention, the sintered, molded powdered metal core is electroplated with chromium, or other above mentioned plating metal, sufficiently thick to assure both full protection of the core and to build the bucket up to over-size dimensions. The resultant plated bucket is then heated to the forging temperature

of the chromium, or other selected metal of the protective sheath 21, and is preferably maintained at that temperature for a sufficient period of time to insure effective diffusion and alloying of the core and sheath metals and thus bring about a high degree of bonding between the core 20 and sheath 21.

The final step of the method is the die forming of the plated bucket. In accordance with the invention, the plated bucket is sized in dies of the exact shape and dimensions of the finished bucket, while heated to the forging pressure of the sheath or plating metal. This final shaping or sizing of the bucket avoids the necessity for any subsequent machining or shaping and upon completion of the die-sizing operation the bucket 12 is ready for installation in the rotor or turbine wheel 10. The accurately shaped and sized coating 21, when formed of chromium, has a melting point of 2940° Fahrenheit, is dense, hard and chemically inactive. The sheath or coating 21 is also resistant to abrasion and erosion. Thus the chromium protective coating 21 forms an effective sheath for the physically stronger core 20 preventing erosion, abrasion and corrosion of the relatively chemically active core 20.

It is to be understood that the invention is not to be regarded as limited to the express procedure or materials set forth above, these details being given by way of illustration and only to aid in making the invention more clear. I do not regard such specific details as essential to the invention, except insofar as they are expressed by way of limitation in the appended claim in which it is my invention to claim all novelty inherent in the invention as broadly as is permissible in view of the prior art.

I claim:

A high temperature gas turbine blade comprising a root portion for anchoring the blade and a blade portion to be acted upon by the high temperature turbine actuating gases, said portions including a common core of molded and sintered powdered tantalum, and a coating of chromium electroplated directly on the core and hot forged to size, said coating covering those surfaces of the core subject to abrasion and high temperature conditions.

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