Nov. 1, 1960 R. G. FRANK 2,958,505

TURBINE BUCKET BLADES

Filed Nov. 20, 1958 2 Sheets-Sheet 1

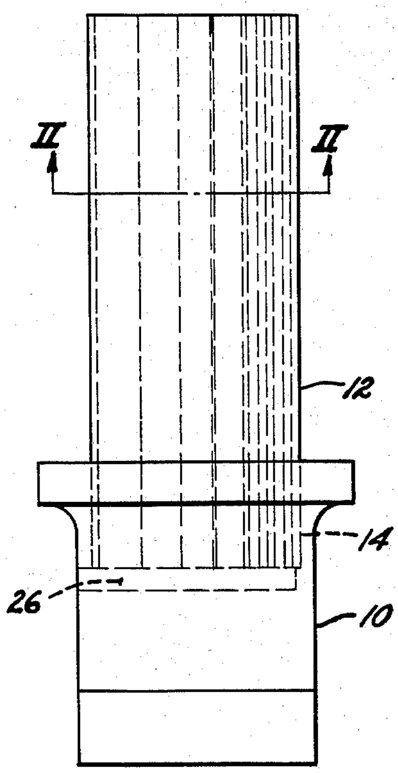

Fig. 1

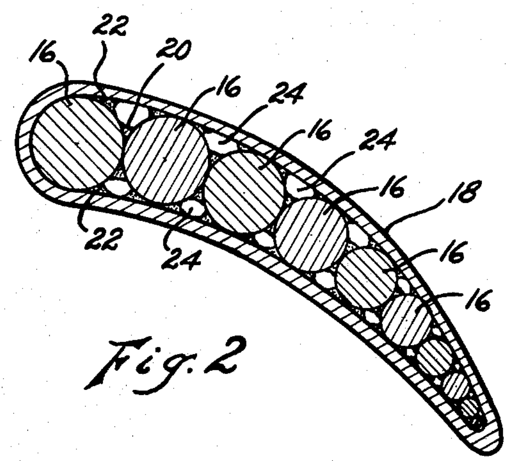

Fig. 2

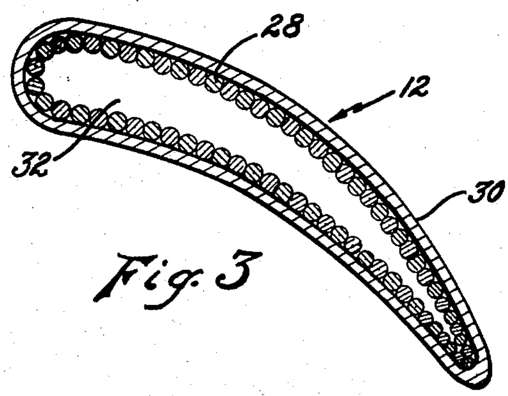

Fig. 3

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Nov. 1, 1960 R. G. FRANK 2,958,505

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Filed Nov. 20, 1958 2 Sheets-Sheet 2

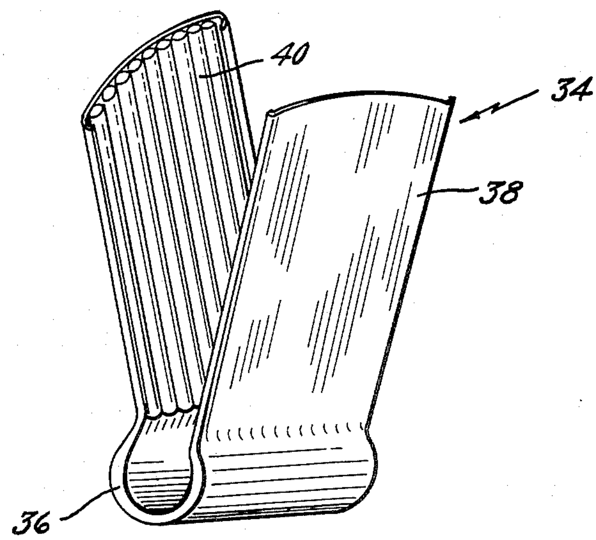

Fig. 4

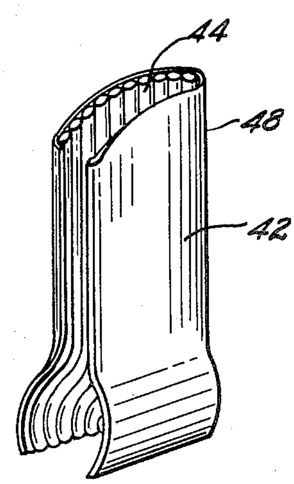

Fig. 6

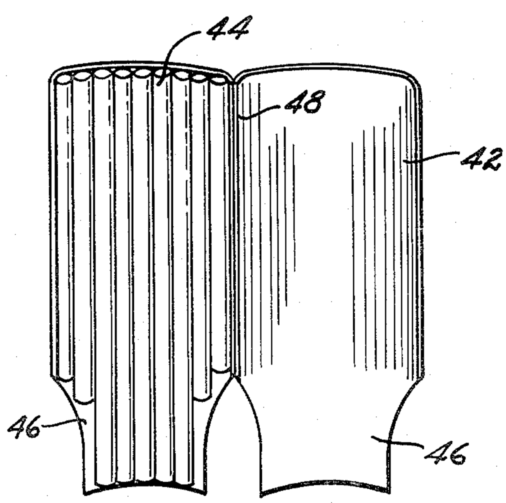

Fig. 5

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1

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TURBINE BUCKET BLADES

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2 Claims. (Cl. 253—39.15)

The present invention relates generally to turbine blades or buckets for use under high temperature conditions, and as illustrated herein, relates more particularly to turbine blades or buckets having cooling passages therein.

The high temperatures incident to the combustion of jet and rocket fuels has made it necessary to form turbine blades from metals or other materials which are substantially free from oxidation. However, new designs in reaction motors have resulted in highly increased inlet temperatures which are destructive of previously known turbine blades. Under earlier conditions the use of molybdenum and molybdenum alloys gave satisfactory results and destruction of the surfaces of the turbine blade due to high temperature oxidation was not a problem. However, gas temperatures may now range from about 2000° F. to about 2600° F. and solid molybdenum, molybdenum alloys and ceramic coated molybednum and molybdenum alloys corrode to such an extent that virtual destruction of the turbine blades may result.

It has been discovered, however, that hollow air cooled blades fabricated from conventional materials may be used in aircraft jet turbines. The strength of these blades or buckets is limited because of the inherent low strength of the materials of which the buckets are formed. It was found, however, that if the blades were fabricated from molybdenum wire clad or plated with a material highly resistant to oxidation would have sufficient strength, be of light weight and could be readily fabricated while still protecting the blades from oxidation at temperatures ranging from about 2000° F. to about 2600° F.

One object of the present invention, accordingly, is to provide turbine blades which are oxidation resistant at relatively high combustion temperatures. To this end and as illustrated, the invention contemplates the use of molybdenum wire clad or plated with an oxidation resistant material and encased in a sheath of oxidation resistant material.

With the above and other objects in view the invention will now be described with particular reference to the accompanying drawings in which:

Fig. 1 is a view in elevation of one form of turbine bucket embodying the present invention;

Fig. 2 is a view in section taken along the lines II—II of Fig. 1;

Fig. 3 is a view in section similar to that shown in Fig. 2 but illustrating another embodiment of the invention;

Fig. 4 illustrates another embodiment of the invention but before the parts of the sheet are secured together at their leading and trailing edges;

Fig. 5 illustrates another form of the invention with the sheath in the flat; and

Fig. 6 is a view of the construction shown in Fig. 5 before the leading edges of the turbine bucket are welded together.

The purpose of the present invention is to provide air-cooled turbine buckets which are able to withstand the high temperatures and high strains incident to the use of modern fuels in turbojet engines. Molybdenum wire or

2

wires fabricated from tungsten, columbium, or nickel base alloys could be used so long as the intended operating temperature remains below the recrystallization temperature of the material.

The present invention contemplates the use of high strength-high temperature wire as a supporting frame having sufficient strength to withstand the high strains to which the buckets are subjected during use. Preferably molybdenum wire is used but any of the wire materials referred to just above will be satisfactory.

The construction shown in Fig. 1 comprises a root portion **10** and a bucket or airfoil section **12**. The root portion **10** is of usual shape and construction and need not be described in further detail herein. The airfoil section **12** is seated in a suitable shaped recess **14** in the root portion **10** and in which the completed airfoil is suitably brazed or welded. The airfoil section **12**, as illustrated in Fig. 2, is composed of a plurality of rods or wires **16** of varying size which are coated with a suitable brazing alloy. The coated wires **16** are arranged parallel and contiguous to each other along the lateral center line of the blade and are assembled within a suitable sheath **18** formed preferably of chromium plate.

The shield **18** and the wires **16** assembled therewith are placed in an autoclave to fuse the brazing alloy to secure the wires **16** to each other and to the sheath **18** as shown at **20** and **22**, respectively, in Fig. 2. It is to be noted that only sufficient brazing alloy is used to permit the parts to be secured together without entirely filling the space between adjacent wires **16** and the sheath **18**. Thus, a plurality of spaces **24** are provided which extend the entire length of the turbine buckets **12** and through which cooling air may be forced. It was previously stated that the root portion **10** was provided with a suitable shaped recess **14** in which the base portion of the airfoil section **12** is secured either by brazing or welding. There is provided an air duct **26** through which cooling air may be drawn and passed through the cooling passages **24**.

The invention, however, is not limited to the modification shown in Fig. 2 since the central portion of the bucket **12** may be hollow and provided with an internal lining formed of wires **28** which are substantially uniform in diameter and are so closely spaced that they are substantially in contact with each other. The wires **28** are coated with a suitable brazing or welding alloy. The wires **28** are assembled and supported in a suitable jig or fixture to form an airfoil section such as shown in Fig. 3. The shaped wire section has placed thereover a suitable sheath **30** which fits closely against the wires **28**. The assembled wires **28** and sheath **30**, together with jig with which they are supported are placed in an autoclave to permit the brazing or welding alloy to be fused to secure the wires **28** to each other and to the inner surface of the chromium coated sheath **30**. After the brazing or welding operation has been completed the assembly is removed from the jig and surplus lengths of wire are trimmed at the top and bottom end portions of the sheath **30**.

The bucket **12**, as constructed above, is then placed in a recess **14** and suitably secured in place by brazing or welding. The bucket **12** shown in Fig. 3 has a hollow interior portion **32** which communicates with the air duct **26** through which suitable air or other fluid may be passed to maintain the temperature of the bucket **12** substantially below the high temperature of the inlet gases of the axial flow turbine.

There are shown in Figs. 4, 5 and 6 two other forms of the invention, which, however, when assembled display a cross-sectional area similar to the one shown in Fig. 3. In the modification shown in Fig. 4, a sheath **34** is shaped to form a root section **36** and a bucket section **38**. The bucket or airfoil section **38** is coated with a suitable brazing or welding alloy and high strength molybdenum or other high temperature alloy wires are suitably brazed or secured to the inner surface of at least one side of the sheath **38**. Preferably, both sides of the sheath **38** are provided with closely spaced wires **40** which are arranged in an airfoil section substantially similar to that shown in Fig. 3. It is to be noted that the airfoil section itself is of substantial thickness at the root section **36** and tapers from the root section toward the outer end of the blade or airfoil section **38**. After the wire **40** has been secured in position the assembled bucket is placed in a suitable jig or fixture and maintained in shaped position to permit the leading and following edges of the airfoil section to be secured together by suitable brazing or welding.

As illustrated, the construction shown in Fig. 4 has a root section which differs from that shown in Fig. 1, but it is apparent that the hub of the turbine wheel may be suitably shaped to receive the substantially cylindrical root portion shown in Fig. 4.

The construction shown in Fig. 5 is somewhat similar to the construction shown in Fig. 4, except that the portions of the sheath **42** are formed in one section and in side by side relation so that the right hand portion of the sheath **42** may be folded over the left hand portion of the sheath **42** and suitably shaped to form an airfoil turbine bucket section.

The modification shown in Fig. 5 is provided with a series of wires **44** which are coated with suitable alloy and secured to the sheath **42** in the same manner that the wires **40** are secured to the sheath **38**, except that the wires extend from the top to the bottom of the sheath and thus extend into the root section **46** as shown in Figs. 5 and 6. Here again, it may be necessary only to provide one side of the sheath with wires. However, preferably both sides of the sheath are provided with wires so that the airfoil section is similar to the construction shown in Fig. 3, rather than to the construction shown in Fig. 2, which would be the case when only one side of the sheath **42** was provided with wires. After the sheath **42** has been provided with properly positioned wires it is folded along the line **48** which may form either the leading or following edge of the bucket blade and is then placed in a suitable jig or die to bring the other longitudinal edges of the

bucket close together to permit them to be secured by suitable brazing or welding to form a turbine bucket having the airfoil contours as shown in Fig. 3. At the same time the root section **46** is curved inwardly at the lower end to form a root portion for securing the bucket to a suitable hub.

Having thus described my invention what I claim as new and desire to secure by Letters Patent of the United States is:

1. A fabricated blade for an axial flow rotor comprising a hollow metal sheath of airfoil cross section, a series of round metal rods within said sheath arranged contiguously with their centers along the chord of said airfoil, said rods being of diameters to substantially fill said sheath, and means to secure said rods to each other and to said sheath at their points of contact thereby allowing voids at the interstices between adjacent rods and said sheath.

2. A fabricated blade of airfoil cross section comprising a hollow metallic sheath of said airfoil cross section, a reinforcing section, said reinforcing section comprising a series of contiguous, round metal rods arranged within said sheath with their centers along the chord of said airfoil cross section, the end rods in said sheath being in intimate contact with said sheath and one adjacent rod, the remainder of said rods being in intimate contact with adjacent rods and with opposite surfaces of said hollow metallic sheath, and means for securing said rods and said sheath together to allow voids at the interstices between the rods and said sheath.

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