May 19, 1953 K. M. BARTLETT ET AL 2,638,663

METHOD OF MAKING TURBINE BLADES

Filed Oct. 23, 1948

Fig. 1

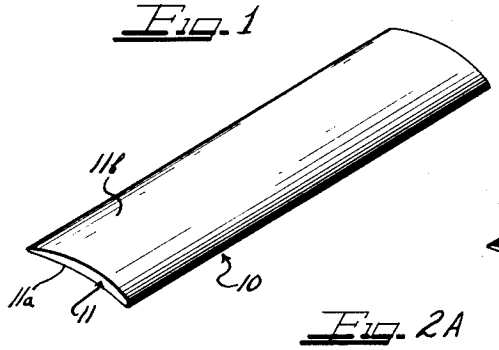


Fig. 2

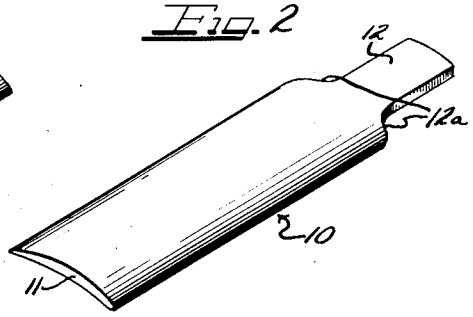


Fig. 2A

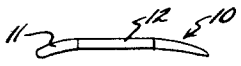


Fig. 3

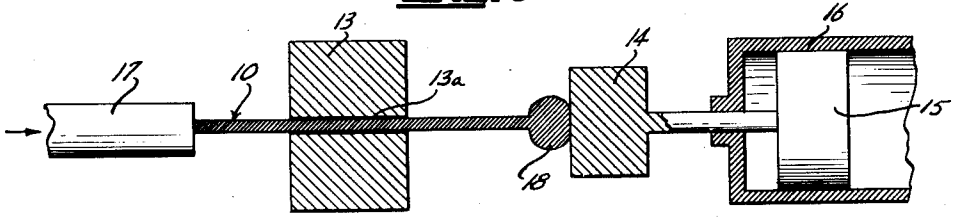


Fig. 4

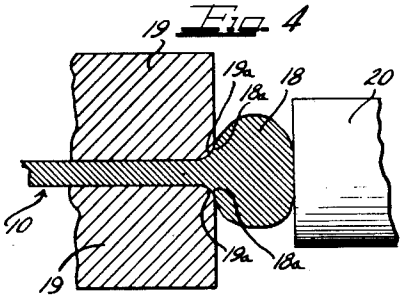


Fig. 5

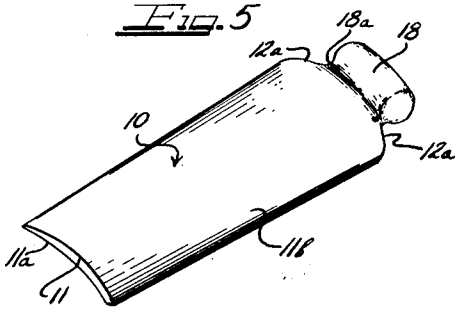


Fig. 6

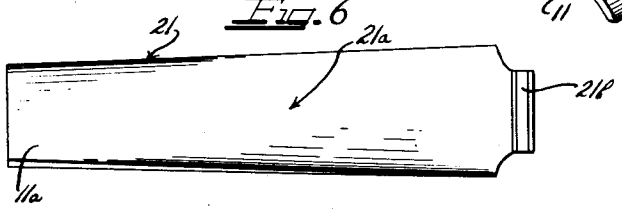
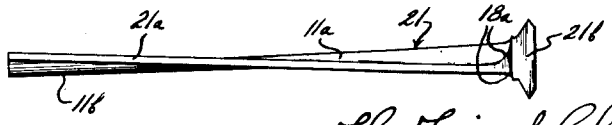


Fig. 7



Inventors
Kenneth M. Bartlett
Nicholas J. Connavino

by The Firm of Charlesworth Atty.

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METHOD OF MAKING TURBINE BLADES

Kenneth M. Bartlett and Nicholas J. Connavino, South Euclid, Ohio, assignors to Thompson Products, Inc., Cleveland, Ohio, a corporation of Ohio

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2 Claims. (Cl. 29—156.8)

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This invention deals with the production of blades for turbines and compressors of steam turbine or gas turbine engines such as turbo-jet engines and jet-propulsion engines.

Specifically the invention relates to the production of turbine and compressor blades from bar stock having a cross-sectional contour in the shape of an air foil, the stock being formed at one end into a butt or root designed for attachment to a rotor hub or stator ring.

It is an object of this invention to provide a method whereby turbine and compressor blades may be formed from bar stock.

Another object of this invention is to provide a method whereby the tip of a piece of bar stock may be gathered into the form of a butt or root for attachment to a turbine engine part.

A further object of this invention is to provide a method whereby elongated bar stock may be given an air foil cross-sectional contour, cut into blade lengths, upset at one end to form an anchoring root, and cambered into the proper shape to act as a turbine or compressor blade.

Other and further objects of the invention will be apparent to those skilled in the art from the following detailed description of the annexed sheet of drawings which, by way of preferred example only, illustrate one embodiment of the invention.

On the drawings:

Figure 1 is a perspective view of a piece of bar stock with a cross-sectional contour in the shape of an air foil;

Figure 2 is a perspective view of a section of bar stock similar to Figure 1 except that the sides have been cut away from one end to leave a reduced width tang;

Figure 2A is an end view showing how the tang can be flattened if desired.

Figure 3 is a view, partially in cross-section, of an electric upsetting machine forming an upset head from the tang end of the member shown in Figure 1;

Figure 4 is an enlarged fragmentary view, partially in cross-section, showing a die shaping of a fillet portion on the upset head formed on the member;

Figure 5 is a perspective view showing the shape of the upset member after the end thereof has been die shaped into a compact mass;

Figure 6 is a top plan view showing the member of Figure 5 after machining operations on the root have been completed; and

Figure 7 is a side elevational view showing the twisted blade portion of the member formed according to the invention to give a desired camber to the vane portion of the member.

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As shown on the drawings:

In Figure 1, a cut length of bar stock 10 has a transverse air foil contour 11 with a concave face 11*a* and a convex face 11*b*. Elongated bar stock of rectangular cross-section may be shaped to form such an air foil, by rolling, forging, machining etc., and pieces 10 of desired length are conveniently cut therefrom.

In order that the stock may serve as a turbine or compressor blade it is necessary to twist the blade portion to provide the proper camber for the anticipated operating conditions. It is also necessary to provide an enlarged root or butt on one end of the blade for anchoring the blade to a stator or rotor. Since considerable stress is applied to the blade at the hub portion thereof, a strong anchor must be provided.

According to this invention, the first step in forming a butt is to cut away the leading and trailing edges of the airfoil at one end of the stock in order to provide a tang 12 of reduced width. This tang 12 has tapered shoulders 12*a* with rounded ends merging into the longitudinal sides of the air foil and tang. If desired, the tang 12 can be flattened, as shown in Figure 2A, to a uniform thickness. This reduced width tang portion and shoulder arrangement forms a section which can be headed and shaped to form a desired root shape and fillet between the root and vane portions of the blade.

After the tang 12 has been cut, the stock is placed in an electrode 13 (Figure 3) of an electric upsetting machine with the tang portion thereof extending toward an electrode 14. The electrode 13 has a contoured aperture 13*a* shaped to slidably contact the airfoil shape of the bar-stock 10. If desired, the electrode can be in two sections with a bottom section having a top contour to fit the face 11*a* or 11*b* of the piece 10, and a top section having a bottom face shaped to fit the opposite face of the piece. The electrode 14 is carried by a piston 15 which is slidable in a cylinder 16. Fluid in the cylinder 16 will be relieved whenever axial pressure on the electrode 14 exceeds a predetermined amount so that the electrode will not be overloaded. A pusher 17 acts on the bar piece 10 to slide it through the electrode 13 to force the tang end 12 against the electrode 14.

The electrodes 13 and 14 are in a low voltage, high amperage electric circuit which is closed when the piece 10 is in the electrode 13 and the tang 12 contacts the electrode 14. The electric

current then heats that portion of the piece 10 between the electrodes, and since the tang 12 is of reduced area it will be quickly heated to a plastic state or to a suitable forging temperature. The pusher 17 advances the piece through the electrode 13 toward the electrode 14 at a rate that is correlated with the electric power imput until a head 18 of desired size is upset from the tang 12.

Since, in the illustrated upsetting operation of Figure 3, the blending of the head 18 into the airfoil contour of the piece 10 is through free bend fillets along the length of the head 18 between the head and each face 11a or 11b, it is desirable to control the contour of the fillets by a coining operation shown in Figure 4 in order to obtain the most efficient reinforcement contour which will not interfere with the efficiency of the airfoil. Thus while the head 18 is still in a heated forgeable state, the piece 10 is placed in coining dies 19, 19 having rounded active faces 19a, 19a for receiving the fillet portion of the head 18. A plunger 20 then presses the head 18 toward the dies to conform fillet contours 18a in conformity with the shape of the die faces 19a. These fillets 18a blend the head into the airfoil section so that no sharp edges or cracks will develop. In addition, sufficient reinforcing metal is provided at these points to insure a smooth blending of the concavo-convex airfoil with the thickened cylindrical head 18.

If desired, the coining of Figure 4 can be carried out on the upsetting machine of Figure 3 by forming the faces 19a on the electrode 13.

As shown in Figure 5, the upset and coined piece 10 has its original airfoil 11 for the major portion of its length, and an integral thickened cylindrical head 18 of reduced width is blended into one end of the airfoil section by contoured fillets 18a. The ends of the head 18 are joined with the leading and trailing ends of the airfoil section by the tapered shoulders 12a. The reduced width tang 12 affords sufficient metal to form the head without utilizing thin metal sections which will fold up or collapse like an accordion when upset.

The upsetting of a flattened or uniformly thick tang 12, shown in Figure 2A, gives better control of the head shape, but this flattening step is not always necessary.

A finished blade 21, shown in Figures 6 and 7, is formed from the headed piece 16 of Figure 5 by coining the airfoil body 11 of the piece along its length to form a twisted vane portion 21a having the original concave face 11a and convex face 11b. This twist provides the desired camber or pitch in the vane 21a. The head 18 is machined to form the finished root or butt 21b for the blade. As shown in Figure 7, the fillets 18a blend the root 21b into the vane 21a and strengthen the blade at a point which in use is subjected to great stresses.

From the above descriptions it should be clear that the invention provides blades for turbine engines and the like from inexpensive contoured bar stock by inexpensive trimming, upsetting, and coining operations.

We claim as our invention:

1. The method of producing a blade for turbines and the like which comprises, providing elongated bar stock having a thick longitudinal central portion, thin longitudinal leading and trailing elges, a concave front face and a convex back face, cutting said bar stock into pieces of slightly greater length than the length of the desired blade, trimming off the leading and trailing longitudinal edges of one end of the thus cut length along concave paths from said edges to the thick central portion and thence along lines parallel with said edges to produce a generally rectangular tang on said one end of reduced width composed only of the thick central portion of the bar stock and merging into said leading and trailing longitudinal edges along smoothly rounded edges, flattening said tang to form a section of uniform thickness, heating the tang to forging temperature, upsetting the heated tang to reduce the longitudinal length thereof while increasing the thickness thereof to form a head blended into the concave and convex faces through free bend fillets along the juncture of said head and faces, and coining said fillets into rounded concave shapes which will not interfere with the airfoil efficiency of said faces to provide an anchoring root portion of less width and greater thickness than the bar stock and blended into both the faces and the edges of the bar stock along smooth rounded concave surfaces.

2. In the method of producing a blade for turbines and the like from bar stock having a thick longitudinal central portion, thin longitudinal leading and trailing edges, a concave front face and a convex back face, the steps which comprise trimming off the leading and trailing longitudinal edges at one end of the bar stock along concave paths from said edges to the thick longitudinal central portion of the bar stock and thence along lines parallel with said edges thereby producing a generally rectangular tang on said end of reduced width composed only of the thick central portion of the bar stock and merging into said leading and trailing longitudinal edges along smooth rounded edges, flattening said tang to form a section of uniform thickness, heating the tang to forging temperatures, upsetting the heated tang to reduce the longitudinal length thereof while increasing the thickness thereof to form a head blended into the concave and convex faces through free bend fillets along the juncture of said head and faces and blended into the leading and trailing edges along tapered shoulders formed from the concave trimmed portions, coining the free bend fillets into rounded concave shapes merging into the concave front face and convex back face of the bar stock, and machining the thus formed coined head to provide an anchoring root for the blade having less width and greater thickness than the bar stock and blended into both the faces and the edges of the bar stock along smooth surfaces free from folds.

KENNETH M. BARTLETT.
NICHOLAS J. CONNAVINO.

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