

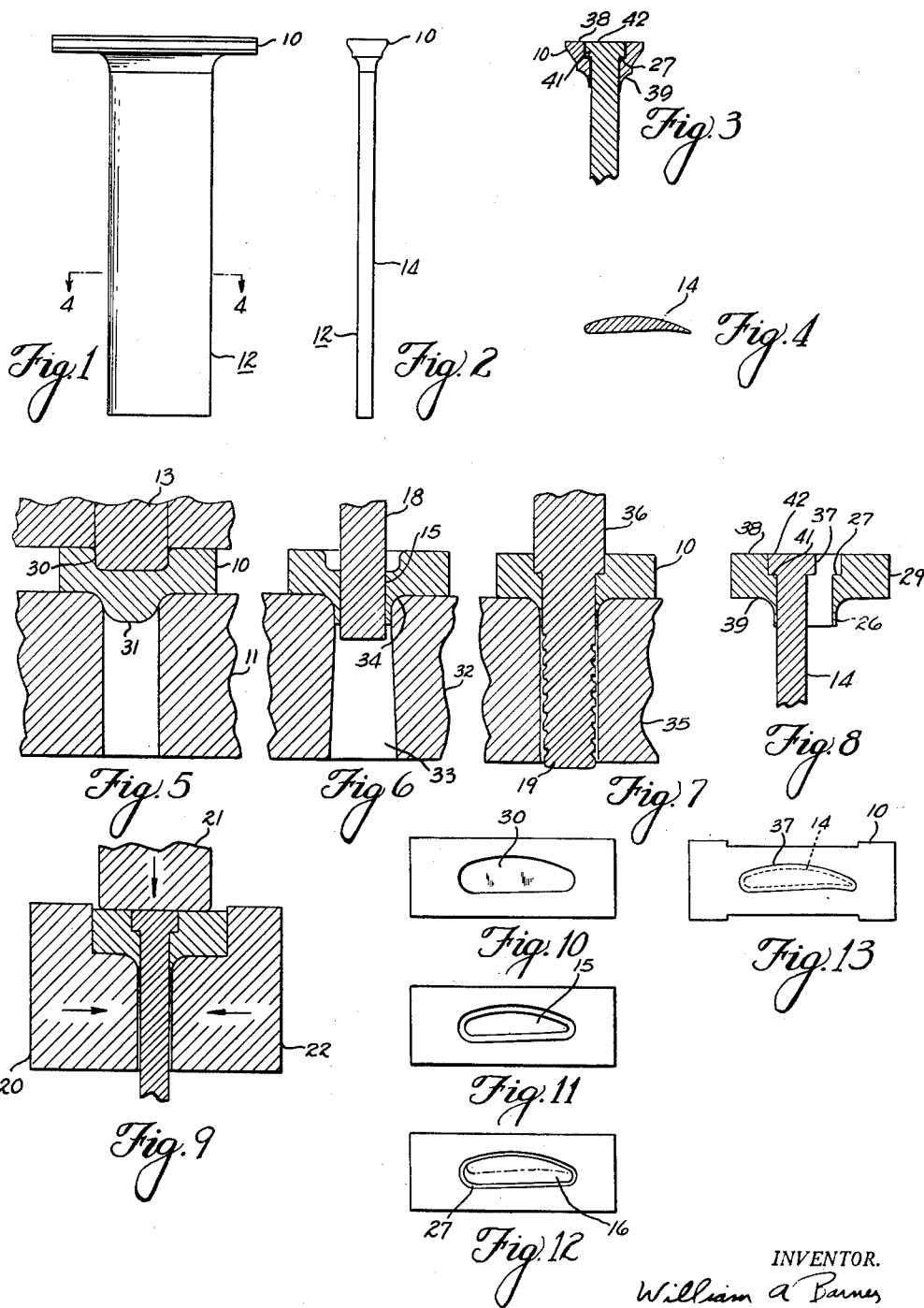
March 30, 1954

W. A. BARNES

2,673,709

COMPOUNDED AIRFOIL BLADE STRUCTURE AND METHOD OF MAKING SAME

Filed Dec. 28, 1949



INVENTOR.

William A Barnes
BY Woodling and Root
attys

UNITED STATES PATENT OFFICE

2,673,709

COMPOUNDED AIRFOIL BLADE STRUCTURE
AND METHOD OF MAKING SAMEWilliam A. Barnes, Utica, N. Y., assignor to Utica
Drop Forge & Tool Corporation, a corporation
of New York

Application December 28, 1949, Serial No. 135,477

3 Claims. (Cl. 253—77)

1

This invention relates generally to rotatable blade structures, and relates specifically to turbine, rotary compression, and similar blades used in series and banks.

As well known by those skilled in turbine and similar work, integrally formed blades, either forged or machined, are prohibitively expensive. Accordingly, many attempts have been made to fabricate blades from forged or precision-rolled blade stock and dovetail base pieces. Prior to this invention, such fabricated blades were formed by many diverse ways, but were very expensive and undependable. High centrifugal force in modern machines causes failures in pieces fabricated by prior methods.

An object of this invention is to provide a fabricated blade for turbines, rotary compressors, and similar gas machines.

Another object of this invention is to provide an improved method of holding a blade and a dovetail for brazing.

A further object of this invention is to provide an improved blade structure having a solid metal dovetail base and a blade united by extremely tight physical contact and by brazing.

A still further object of this invention is to interlock a dovetail base and a dovetail blade to resist separation by centrifugal force.

Yet another object of this invention is to distribute stresses in a compounded blade.

Other objects and a fuller understanding of this invention may be had by referring to the following description and claims, taken in conjunction with the accompanying drawing, in which:

Figure 1 is a side view of a blade incorporating the principles of this invention;

Figure 2 is an edge view of a blade incorporating the principles of this invention;

Figure 3 is a lateral sectional view through the dovetail and airfoil juncture of the blade of Figure 1;

Figure 4 is a cross-sectional view along line 4—4 of Figure 1 illustrating the airfoil form of the blade;

Figure 5 illustrates the first, or dimpling step in the process of this invention to produce an improved juncture between blade and base;

Figure 6 illustrates the second step which is the piercing step;

Figure 7 illustrates the third step, which is a broaching step and shoulder-forming step combined;

Figure 8 is a lateral sectional view through the pierced dovetail, with the airfoil blade in posi-

2

tion within the pierced opening of the dovetail base;

Figure 9 illustrates the principle employed in this invention to physically join the dovetail base and the airfoil blade;

Figure 10 is a top view of the dovetail base after the dimpling step of Figure 5;

Figure 11 is a top view of the dovetail base after the piercing step of Figure 6;

Figure 12 is a top view of the dovetail base after the broaching step of Figure 7, with a phantom cross section of the airfoil blade sketched within the opening to illustrate the comparative size of the opening with the size of the airfoil blade; and

Figure 13 is a top view of the dovetail base after the compression step of Figure 9.

This invention is applicable to all blade structures subject to centrifugal force.

The preferred practice of this invention is carried out by providing a suitable dovetail base blank 10. The blank 10 is dimensioned to be suitably secured upon the rotatable hub or drive of a turbine, compressor, or other machines upon which the finished blades 12 are to be employed. In the illustrated embodiment, the base blank 10 is a rectangular slab.

An airfoil blade 14 is provided having a suitable cross-sectional outline, and longitudinal taper, for the particular service requirement of the finished blade 12. Many airfoil blades are tapered in thickness from dovetail to tip and have slight changes of cross section. The airfoil blades may be provided with the proper cross section and tapers by running the parts through hardened steel contoured rolls which compress the metal where needed and give the desired tapering, contouring and reshaping.

Referring to Figure 4 of the drawing, it may be seen that the airfoil blade 14 has sharp small radii on the leading and trailing edges. The entire blade is comparatively thin, and the leading end trailing radii are quite sharp. All of the illustrations in the drawings are full size, and therefore Figure 4 illustrates exactly the shape of the blade and small radii. Making a fabricated blade structure by mounting a blade as illustrated in Figure 4 within a base member to hold the blade becomes very expensive and tedious if an opening the exact size and shape of the cross section as illustrated in Figure 4 is attempted. On the other hand, a larger opening may be produced in a plurality of dovetail base members in mass production by punching, provided that the punch edges are of sufficiently

3

large radii to prevent punch breakdown. Such large opening radii, however, do not conform to the desired shape of the airfoil blade 14.

It has been discovered that an opening 16 having the general outline shape of the cross section of blade 14, but having a cross-sectional area larger than the cross-sectional area of the blade 14, and having greater leading and trailing radii, may be provided, and thereafter the blade 14 may be inserted into the opening 16 as shown in Figure 8 of the drawing. Finally, the preliminarily assembled blade and dovetail are united by compressing the dovetail 10 laterally with respect to said opening 16 until the opening 16 is closed tightly into contact with said blade, as shown in Figure 13.

In actual use of blades constructed by the foregoing method, it has been found that although such blades are quite satisfactory in many instances, there are numerous types of rotary compressors and turbines which rotate at extremely high rotational speeds and therefore cause an extreme centrifugal force tending to pull the blade 14 out of the dovetail base 10. Furthermore, in many uses, vibrations are encountered which set up a stress riser at any large angular junction between surfaces.

The improved method of constructing the dovetail base and method of uniting the airfoil blade with the improved base, constituting the basis of this invention, was discovered and has been proven to be the solution to the foregoing problems.

The principles employed to produce the improved dovetail base of this invention are illustrated in the steps shown in Figures 5, 6 and 7, and in Figures 10, 11 and 12. The blank 10 is placed upon a suitable die 11 and indented by a dimpling punch 13. The punch 13 does not pierce or cut the material of the blank 10, but rather produces an indenture 30 on one side of the blank 10 and a protrusion 31 on the opposite side thereof.

After the indenture and protrusion 30 and 31 have been formed, a piercing punch 18 is forced through the blank 10 substantially centrally of the indenture 30 and protrusion 31, and thereby provides a small opening 15. A die 32 having an opening 33 therein is provided with a shoulder area 34 at the top thereof formed substantially to the curvature desired between the body of the dovetail base and the desired fillet thereon. The punch 18 is considerably smaller than the width of the shoulder 34 across the opening 33, and therefore the metal of the protrusion 31 which is not removed by the punching action of the punch 18 will be further curved toward the form of the desired finished fillet. The remaining metal of the protrusion 31, however, is allowed to remain considerably thicker than the desired thickness of the finished fillet, because it has been found that if the shoulder area 34 on the die 32 were formed to a sharp end, rather than the blunt end illustrated in Figure 6, the punch 18 would drag the metal to a ragged sharp edge.

After the small opening 15 has been provided by the punch 18, and the outside surface of the protrusion 31 has been further molded against shoulder area 34 on the die 32, the blank 10 is removed to a die 35, and a broach 19 is passed therethrough to enlarge the small opening 15 to the finished size to produce the opening 16 illustrated best in Figure 12. The indenture or impression 30, as formed by the punch

4

13, is usually rather rounded instead of square, and therefore at some step between the indenting step of Figure 5 and the production of the finished dovetail base, it is preferably to square the shoulder. Accordingly, the broach 19 is illustrated as being combined with an enlarged punch portion 35 which operates after the broach 19 has passed through the opening. It is understood, of course, that the shoulder squaring step could be combined with punch 13 if desired, or carried out entirely separately.

After the blank 10 has been indented and dimpled, pierced, shouldered, and broached as heretofore described, a finished dovetail base member 29 is produced substantially as illustrated in Figure 8, with an opening therethrough from one face 38 to another face 39 internally of the base member and preserving the grain structure of the base member unbroken surrounding the opening, the form of the opening comprising a stepped opening with a shoulder 27 therein, and the preferred embodiment of the invention. The invention resides principally in the lateral coining of the base upon the blade and the additional provision of mechanically interfering surfaces to aid in the resistance to centrifugal force. It has been discovered after producing the improved dovetail base 29 by the described and illustrated method, that a superior fillet 26 resulted from this process than was originally anticipated. It was found that the natural grain structure of the blank 10 was curved during the dimpling step of Figure 5, and was further carried in the angular direction of the fillet by the punching step of Figure 6. The resulting finished product therefore has a continuous grain structure extending from the body of the dovetail base 29 into the fillet 26, resulting in a fillet of superior strength and durability than could be produced by machining methods which would cut across the grain structure and leave weak and unsupported grains in the fillet 26.

The punch 36 produces a uniform square shoulder 27 in the opening 16. It has been found that the dovetail blade 14 may be provided with a head portion 37 by hammering, upsetting, or similar metal-forming operations. The head 37, like the regular cross-sectional area of the blade 14, is considerably smaller than the area of the opening 16, and has a diverging form similar to the opening 15 with a shoulder 41 thereon. Preferably, the top 42 of blade 14 is flush with the face 38.

To effect final assembly, the blade 14 is placed within the opening 16, with the head 37 thereof positioned within the stepped portion of the opening 16 substantially as illustrated in Figure 8. Thereafter the preliminarily assembled pieces are united by compressing the dovetail base 29 laterally with respect to said opening 16 until the opening 16 is closed tightly into contact with said blade. In Figure 9, two laterally moving dies 20 and 22, and a vertically moving punch 21, are shown moving against the dovetail base to compress it into tight fit with the blade. It is of course possible to use any suitable type of apparatus to compress the dovetail base 29, such, for example, as a press upsetter, or hammer to apply one or repeated blows. The Figure 9 illustrates diagrammatically one possible method for the purpose of setting forth the principles of the invention.

Compression of the dovetail 29 upon the blade 14 results in a strong physical union between

5

the parts to produce the unit blade shown in Figure 1.

In addition to physical grip-holding as heretofore explained, it is advantageous to braze the union for further strength and stress dampening. Brazing may be accomplished on the united pieces, when joined as set forth herein, with no special jigs or fixtures, in spite of the high lubricating action of liquid brazing material. Although it may seem that the tight physical union provided by the compression of dovetail 29 upon blade 14 would not permit flowing of brazing material between the parts, it has been found that the brazing material will feed into the union by capillary action. However, a preformed brazing sleeve may be placed over the end of the blade before compression of the base dovetail, and will therefore be correctly positioned for brazing.

After the parts are assembled, the blade may be further processed in any manner to adapt the blade for service.

Although the invention has been described in its preferred form with a certain degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and the scope of the invention as hereinafter claimed.

What is claimed is:

1. A blade structure comprising, a metal dovetail base member having a stepped opening there-through, a protruding fillet portion surrounding said opening on one side of said base member, the grain structure of said base member flowing from the body of said base member into said fillet portion, an airfoil blade having a head portion, said base member being compressed upon said blade with said head portion of the blade registering with said stepped opening through the base.

2. The method of securing an airfoil blade in a base comprising the steps of, providing a blade member having side edge radii, providing a slab base member, indenting a pattern into one side of said slab having an outline similar to the entire cross-sectional outline of said blade including side edges, permitting the material displaced by said indenture to protrude from the opposite side of said slab as a protrusion, thereafter forming an opening through said protrusion substantially within the outline of said protrusion, said opening having an outline similar

6

to the entire cross-sectional outline of said blade including side edges, every lateral dimension of said opening being at least as large as the corresponding lateral dimension of said blade, the cross-sectional area of said opening being larger than the cross-sectional area of said blade, the cross-sectional area of said opening being smaller than the cross-sectional area of said indenture, the outer surface of said protrusion and the wall surface of said opening defining a blunt edge, the bottom of said indenture and the edge of said opening thereby defining a stepped shoulder, removing a portion of material from the inside surface of said opening to reduce said blunt edge to a sharp edge, producing a solid head on one end of said blade having a shoulder between the head and the blade corresponding to the said stepped shoulder in the base member, said head having a cross-sectional area and configuration smaller than said indenture in the base member, thereafter placing the head portion of the blade in said indenture with the blade extending through said opening, and finally compressing said base member in a lateral direction with respect to said indenture and opening until the base member is tightly closed and bonded upon said blade member and head thereof.

3. A blade structure comprising, a blade member having a head portion and a blade portion integrally formed, said head portion of said blade having a larger cross-sectional outline than the cross-sectional outline of the blade portion at the juncture between the head and blade portions, a dovetail base member having side walls with the grain structure unbroken, said walls defining an opening with an outline similar to the cross-sectional form of said head portion, said base member being compressed laterally upon said head portion into a mutually interlocked structure wherein the opening in said base member is closed down upon the head portion.

WILLIAM A. BARNES.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
297,242	Emerson	Apr. 22, 1884
1,932,278	Lacey	Oct. 4, 1933
1,947,347	Lorenzen	Feb. 13, 1934
2,264,897	Becker et al.	Dec. 2, 1941
2,291,803	Grotnes	Aug. 4, 1942
2,347,034	Doran	Apr. 18, 1944
2,350,125	Dahlstrand	May 30, 1944