March 25, 1930. J. L. RAY 1,751,758

METHOD OF MAKING TURBINE BLADES

Filed Aug. 1, 1928

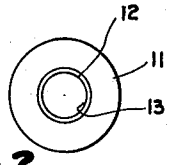


Fig. 2.



Fig. 4.

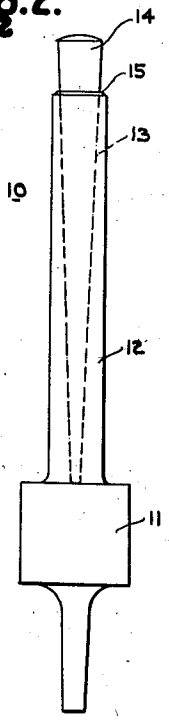


Fig. 1.

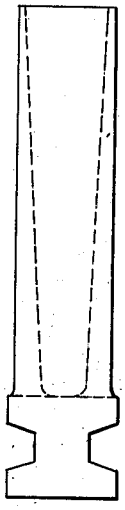


Fig. 3.

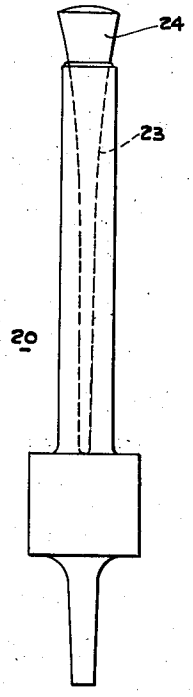


Fig. 5.

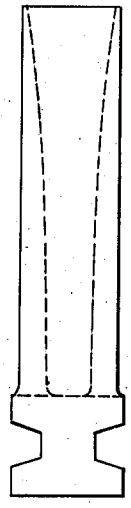


Fig. 6.

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UNITED STATES PATENT OFFICE

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METHOD OF MAKING TURBINE BLADES

Application filed August 1, 1928. Serial No. 296,853.

My invention relates to elastic fluid turbines, and more particularly to the blading thereof, and it has for an object to improve the efficiency of apparatus of this character.

Hollow turbine blades possess advantages which make their use highly desirable, especially where blades of the larger sizes are used, such, for example, as for the low-pressure blading. The hollow construction reduces the weight and, consequently, the centrifugal forces and the stresses resulting therefrom and, at the same time, a hollow blade is well adapted to withstand the various bending stresses. It will also be clear that these advantages are possessed in the greatest measure by a hollow blade having a decreasing cross-sectional area from the base, or root portion to the tip thereof. As the stresses increase from the tip toward the root, it is possible to give a blade a variable section and thus, to decrease the total centrifugal force acting on a blade and hence, to provide for a lighter rotor construction.

While the advantages of a hollow blade are generally appreciated, there are difficulties in the way of manufacture thereof, particularly in the making of forged or rolled blades, for it will be clear that, due to the peculiar shape of a blade, it would be practically impossible to form a hole of this shape after the blade had been forged or rolled, much less to form a tapered hole.

It is a more particular object of this invention, therefore, to provide a turbine blade of a hollow construction, and having a variable cross-sectional area, which may also be readily manufactured by forging, rolling or other manufacturing operations.

This and other objects are effected by my invention, as will be apparent from the following description and claims taken in connection with the accompanying drawings, forming a part of this application, in which:

Fig. 1 is an elevation of a blank from which a blade may be rolled or forged;

Fig. 2 is a plan view of the blank shown in Fig. 1;

Fig. 3 is an elevation of the blank shown in Fig. 1 after the forging or rolling operation has been completed;

Fig. 4 is a plan of Fig. 3; and,

Figs. 5 and 6 are elevational views of a partially formed blank and of a completed blade respectively, showing a modified form of my invention.

According to my invention, a blank from which the blade is made is prepared so that the blade-forming portion is substantially cylindrical and a round, tapered hole is then reamed lengthwise through the blade from the tip toward the base thereof so as to provide an increasing cross-sectional area from the tip to the base of the blade. A filling piece is then inserted into this hole and is secured therein against accidental displacement in some approved manner and the blade is then either forged, or rolled into its final form, after which the filling piece is removed. In this way, the blade is formed by simple operations and, at the same time, the filling piece assures that the surfaces of the blade will be definite and well-formed and that the hollow construction will also have the proper shape to give maximum efficiency.

Referring to the drawing, I show a blank indicated generally at 10, from which a blade may be formed. This blank comprises a root forming portion 11 and a blade forming portion 12, the latter being, preferably, substantially cylindrical as shown by Figs. 1 and 2 and, while the root forming portion 11 may be of any desired shape it also is, preferably, cylindrical as shown by these views.

In order to provide for the hollow construction of the blade, I form a hole which extends from the tip through the blade forming portion 12 towards the base, or the root forming portion 11, and, in order to facilitate the manufacture, this hole is, preferably, round and is reamed out to provide the tapered hole 13 as shown in Fig. 1. A filling piece, such as the round, tapered pin 14, is then fitted into this hole and is secured against accidental displacement in any approved manner, preferably, by means of a tack weld 15, as shown.

The blade forming portion 12 is then reduced in the desired manner, either by rolling, pressing, or other forging operations to the final form desired for the blade, and

after the reducing operation is completed the tack weld 15 is broken and the filling piece 14 is removed.

It will be observed that in reducing the blade, as by a forging operation, with the filling piece 14 in place, the cylindrical portion 12 of the blank as well as the pin 14 will undergo a change in shape so that the hole extending from the tip towards the base of the blade will have a shape similar to the outer contour of the blade.

In order to facilitate the removal of the tapered pin 14 after the blade forming operations have been completed, the blade may be quenched in some suitable medium, such as oil. The quenching will serve to cool the blade portion 12 and the resultant shrinkage thereof will compress the pin, which latter, being practically out of contact with the cooling medium, will remain in a hot, semi-plastic condition while the shrinkage of the blade 12 occurs. The shrinkage of the blade will, therefore, compress the pin so that when it finally cools it will be smaller and will tend to shrink away from the hole and hence, may be easily removed. While this method of removing the filling piece 14 greatly facilitates its removal, it will be obvious that my invention may be practiced by merely pulling out the pin 14 after the blade and pin have cooled sufficiently to permit this to be done without deforming the blade.

In Fig. 5, I show a modified form of blank 20 in which a hole 23 is reamed out to a curved taper instead of a straight taper as shown in Fig. 1. The filling piece 24 is also formed with a curved taper to fit the hole 23. The blade 20 may then be completed as shown in Fig. 6 by following the same procedure as that previously described with reference to the blade 10. It will be obvious that, in the blade 20, the sectional area is proportioned more precisely in accordance with the variation in intensity of the stresses and hence, a more efficient distribution of material and a reduction in weight is effected without sacrificing any strength.

With either of the blades described, the filling piece (14 or 24) is of any suitable yieldable material, that is, a material which is deformed along with the blade when the latter is forged to the shape of a blade. It may be a steel or iron plug, or it may be made of copper, lead, or like material which may be melted out after the blade is formed. Instead of using a metal filling piece, I may also pack the hole with fire clay and after the blade is formed the clay may be dug out.

In this way, it is possible to form a blade having the desired proportions with the minimum expenditure of time and labor, as no expensive manufacturing operations are required and, at the same time, it is assured that the blade will have the proper cross-sectional area which will vary from the base to the tip thereof.

While I have shown a method of forming a hollow blade of variable cross-sectional area, it will be obvious to those skilled in this art, should it be desired, a hollow blade of uniform cross-sectional area may be formed by my improved method in a similar manner by merely boring a cylindrical hole in the blank and fitting a cylindrical filling piece, instead of the tapered pin 14, into such hole.

While I have shown my invention in two forms, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various other changes and modifications, and I desire, therefore, that only such limitations shall be placed thereupon as are imposed by the prior art or as are specifically set forth in the appended claims.

What I claim is:

1. The method of forming a blade which comprises forming a hole extending from the tip toward the base of the blade forming portion of a blade blank, filling the hole with a yieldable mass, reducing the blank to the form of a blade, and removing the filling from the hole.

2. The method of forming a blade which comprises forming a hole having a curved taper and extending from the tip toward the base of the blade forming portion of a blade blank, filling the hole with a yieldable mass, reducing the blank to the form of a blade, and removing the filling from the hole.

3. The method of forming a turbine blade which comprises forming a tapered hole extending from the tip towards the base of the blade forming portion of a blade blank, fitting a filling piece of yieldable material into the tapered hole, reducing the blade forming portion of the blank to the form of a blade, at the same time deforming the filling piece similarly to the blade, and removing the filling piece from the tapered hole.

4. The method of forming a turbine blade which comprises forming a tapered hole extending from the tip towards the base of a blade blank, fitting a filling piece of yieldable material into said hole, securing the filling piece against accidental displacement, reducing the blank to the form of a blade, at the same time deforming the filling piece similarly to the blade, and removing the filling piece.

5. The method of forming a turbine blade which comprises providing a blade blank having a substantially cylindrical blade forming portion, forming a substantially round hole in the blade forming portion of the blank from the tip to the base thereof, fitting a filling piece of yieldable material into said hole, reducing the blank to the form of a blade, at the same time deforming the filling piece similarly to the blade, and removing the filling piece.

6. The method of making a turbine blade

which comprises forming a hole extending from the tip toward the base of a blade blank, fitting a filling piece into the hole, heating the blank and filling piece, reducing the blank to form a blade, causing the blank to cool more rapidly than the filling piece so that the resultant shrinkage of the blank will reduce the size of the filling piece for facilitating the removal of the filling piece.

7. The method of forming a turbine blade which comprises forming a hole extending from the tip toward the base of a blank, fitting a filling piece into the hole, heating the blank and filling piece, reducing the blank to form a blade, quenching the blank in a cooling medium, and removing the filling piece after the latter has cooled.

In testimony whereof, I have hereunto subscribed my name this 20th day of July, 1928.

JAMES L. RAY.