

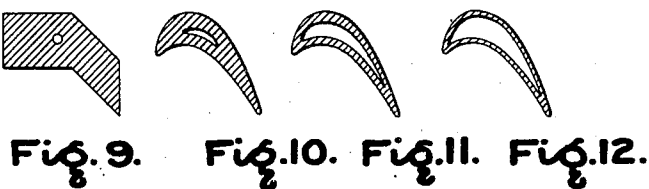
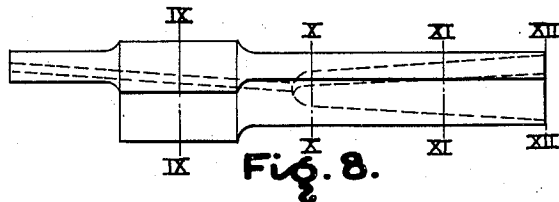
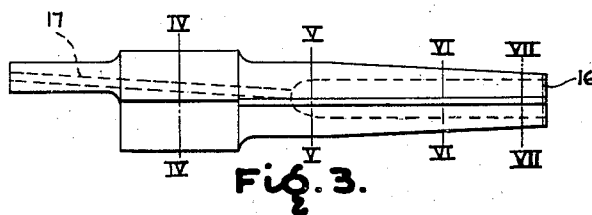
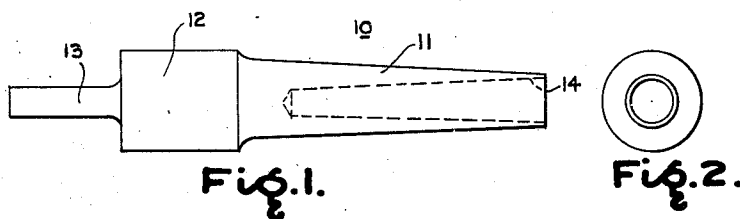
Feb. 25, 1930.

J. L. RAY

1,748,364

METHOD OF MAKING TURBINE BLADES

Filed Oct. 9, 1928



WITNESSES:

C. Lutz

INVENTOR

J. L. Ray

BY

A. B. Reavis
ATTORNEY

UNITED STATES PATENT OFFICE

JAMES L. RAY, OF SWARTHMORE, PENNSYLVANIA, ASSIGNOR TO WESTINGHOUSE
ELECTRIC & MANUFACTURING COMPANY, A CORPORATION OF PENNSYLVANIA

METHOD OF MAKING TURBINE BLADES

Application filed October 9, 1928. Serial No. 311,323.

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.

In turbine blades of a tapered, hollow construction, the metal is more efficiently disposed with respect to the neutral axes and the requisite strength may thus be obtained with minimum weight. Inasmuch as the centrifugal forces, and the stresses resulting therefrom, are directly proportional to, and vary directly as the weight, it becomes important, particularly with the larger blades, such as the low pressure reaction blades, to reduce the weight as much as possible in order to keep the centrifugal stresses within permissible limits. By decreasing the weight of the blades, it is possible to use a rotor of relatively light construction and thus, to generally reduce the weight, as well as the cost, of a turbine and hence, to improve the construction of apparatus of this character. While these advantages may be gained by using hollow blades, of variable cross-section, proportioned to have the proper strength at each transverse section, the manufacture of such blades has, therefore, been quite expensive and tedious work.

It is a more particular object of this invention therefore, to provide a simple and inexpensive method by which turbine blades of the tapered, hollow type of construction may be made with a high degree of accuracy.

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 blade blank;

Fig. 2 is an end view of Fig. 1;

Fig. 3 is a view of the blank shown in Fig. 1 after some of the manufacturing operations have been completed;

Figs. 4, 5, 6 and 7 are sections on the lines IV—IV, V—V, VI—VI and VII—VII, respectively, of Fig. 3;

Fig. 8 is an elevation of the completed blade; and,

Figs. 9, 10, 11 and 12 are sections on

the lines IX—IX, X—X, XI—XI and XII—XII, respectively, of Fig. 8.

In accordance with my improved method, the blade-forming portion of a blade blank, which may be cylindrical, is hollowed out by some simple method, as by boring, and the root-forming portion and the base of the blade are forged to substantially their finished form; while the remainder, or outermost portion of the blade is flattened out to a shape which approximates its finished form but which is somewhat smaller. The blade blank is then placed in a finishing die and the hollow portion is expanded by fluid pressure until the blade properly fills the die. In this way, a blade may be made of a tapered, hollow construction which is properly proportioned at its various transverse sections to have the requisite strength and, at the same time, this procedure is relatively inexpensive and easy to carry out, as no difficult machining, or forging operations are required.

In the drawing, the blade blank is indicated generally at 10, in Fig. 1, and this blank may conveniently be cylindrical, as shown, and may consist of a blade-forming portion 11, and a root-forming portion 12 and a suitable extension, or tong hold 13 may project from the root-forming portion 12. In preparing this blank, the blade-forming portion 11 is hollowed out in any approved manner, as by boring as indicated at 14, to provide a hollow blade section. The taper is secured either by turning the outside of the blade-forming portion to the proper taper, or by taper boring of this portion, or by both of these operations, as shown.

The blade is next forged to the form shown in Fig. 3, wherein it will be noted (Figs. 4 and 5) that the root-forming portion as well as the base of the blade is forged to the finished form, while as will be apparent from Figs. 6 and 7, the thin cylindrical outer portion is closed down and bent to a shape which approximates the shape of the finished blade but which is of smaller cross section than the finished form, so that this latter portion may be easily inserted in a finishing die. The inlet and outlet edges are also worked down

thin and somewhat sharp, either by forging, or machining.

At the tip of the blade, the hollow interior is sealed shut in some approved manner, as by means of the weld indicated at 16, and a hole 17 is bored longitudinally through the root portion and, preferably, through the tongue hold to provide a passage through which fluid may pass into the hollow interior of the blade. The blade is then placed in a finishing die and the partially formed portion is expanded to fill the die by fluid pressure acting through the passage 17. In this way, the blade is accurately formed to the proper proportions and of variable cross section, as shown in Figs. 8 to 12. It will be apparent that by using fluid pressure to expand the unfinished portions of the blade, practically any amount of pressure may be provided and thus, it is possible to expand the blade while cold and also to properly regulate the expanding force so that the metal may be gradually expanded and thus, to avoid rupture of the expanded portion and to assure that the blade will take the shape of the die.

While I prefer to make this blade by applying fluid pressure through the root portion to the interior of the blade, it will be obvious that the passage 17 as well as the weld 16 may be omitted, if desired, and that fluid pressure may then be applied from the open end, or tip of the blade.

While I have shown my invention in but one form, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various changes and modifications without departing from the spirit thereof, 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 making a turbine blade which comprises boring the blade-forming portion of a blade blank from the tip toward the base thereof to provide a hollow blade section, forging the root to substantially its finished form and closing down the hollow blade section to a shape which approximates the shape of the finished blade but which is of smaller cross section than the finished blade, holding the blank in a die and using fluid pressure to expand the blade section to cause the latter to fill the die.

2. The method of making a turbine blade which comprises forming the blade portion of a blade blank into a substantially cylindrical shape, boring the blade portion from the tip toward the base thereof to provide a hollow cylindrical blade section, tapering the blade section, forging the root of the blade to substantially finished form and closing down the cylindrical blade section to a shape which approximates the shape of the finished blade but which is of smaller cross section than the

finished blade, holding the blank in a finishing die and applying fluid pressure to the interior of the blade section to expand the latter until it properly fills the die.

3. The method of making a turbine blade which comprises boring the blade portion of a blade blank from the tip toward the base thereof to provide a hollow blade section, forging the root and the base of the blade to substantially finished form, closing down and bending the remainder of the hollow blade section to a shape which approximates the shape of the finished blade but which is of smaller cross section than the finished blade, working down the inlet and outlet edge portions until they are relatively thin, holding the blank in a finishing die and applying fluid pressure to the interior of the blade section to expand the latter until it properly fills the die.

4. The method of making a turbine blade which comprises boring the blade portion of a blade blank from the tip toward the base thereof to provide a hollow blade section, tapering the outside of the hollow blade section, forging the root and the base of the blade section to substantially finished form, closing down and bending the remainder of the blade section to a shape which approximates the shape of the finished blade but which is of smaller cross section than the finished blade, holding the blade in a finishing die and applying fluid pressure to the interior of the blade section until the latter is sufficiently expanded to properly fill the die.

5. The method of making a turbine blade which comprises boring the blade portion of a blade blank from the tip toward the base thereof to provide a hollow blade section, tapering the inside of the hollow blade section, forging the root and the base of the blade section to substantially finished form, closing down and bending the remainder of the blade section to a shape which approximates the shape of the finished blade but which is of smaller cross section than the finished blade, holding the blade in a finishing die and applying fluid pressure to the interior of the blade section until the latter is sufficiently expanded to properly fill the die.

6. The method of making a turbine blade which comprises boring the blade portion of a blade blank from the tip toward the base thereof to provide a hollow blade section, tapering the outside and inside of the hollow blade section, forging the root and the base of the blade section to a shape which approximates the shape of the finished blade but which is of smaller cross section than the finished blade, holding the blade in a finishing die and applying fluid pressure to the interior of the blade section until the latter is sufficiently expanded to properly fill the die.

7. The method of making a turbine blade which comprises boring the blade portion of

a blade blank from the tip toward the base thereof to provide a hollow blade section, tapering the hollow blade section from the base toward the tip thereof, forging the root and the base of the blade to substantially finished form, closing down and bending the remainder of the hollow blade section to a shape which approximates the shape of the finished blade but which is of smaller cross section than the finished blade, working down the inlet and outlet edge portions until they are relatively thin, holding the blank in a finishing die and applying fluid pressure to the interior of the blade section to expand the latter until it properly fills the die.

8. The method of making a turbine blade which comprises boring the blade portion of a blade blank from the tip toward the base thereof to provide a hollow blade section, forging the root to substantially finished form, closing down and bending the hollow blade section to a shape which approximates the shape of the finished blade but which is of smaller cross section than the finished blade, sealing shut the hollow interior of the blade at the tip thereof, forming a passage through the root to the interior of the hollow blade section, holding the blade in a finishing die and applying fluid pressure through said passage to the interior of the hollow blade section until the latter properly fills the die.

9. The method of making a turbine blade which comprises boring the blade portion of a blade blank from the tip toward the base thereof to provide a hollow blade section, tapering the hollow blade section from the base toward the tip, forging the root and the base of the blade substantially finished form, closing down and bending the remainder of the hollow blade section to a shape which approximates the shape of the finished blade but which is of smaller cross section than the finished blade, sealing shut the hollow interior of the blade at the tip thereof, forming a passage through the root to the hollow interior of the blade section, holding the blade in a die and applying fluid pressure through said passage to the interior of the hollow blade section until the latter is sufficiently expanded to properly fill the die.

In testimony whereof, I have hereunto subscribed my name this 2nd day of October, 1928.

JAMES L. RAY.