Inventor:
Abram M. Reynolds,
by Harry C. Shubert
His Attorney.
Inventor:
Abram M. Reynolds,
by Harry E. Sunley
His Attorney.
METHOD OF MAKING ELASTIC FLUID TURBINE BUCKETS

Abram M. Reynolds, Schenectady, N. Y., assignor to General Electric Company, a corporation of New York

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This invention relates to elastic fluid turbine buckets and more particularly to methods for manufacturing removable bucket units for turbines of the axial flow type.

In axial flow elastic fluid turbines designed for high admission pressures, for example, of the order of 1200 pounds per square inch and above, and correspondingly high initial temperatures, it is required that the buckets, particularly in the high pressure stages, be of an extremely strong and rigid construction. One way of suitable bucket arrangement consists of a plurality of bucket units each having a base portion, a plurality of blades and a heavy cover portion all machined from a single piece of forged steel. The base of such bucket units may be provided with a dovetail slot for removably positioning the units onto the rotor rim. The manufacture of such bucket units from solid blocks of metal is exceedingly difficult in that accurately finished transverse passages of arcuate cross-sectional shape must be formed through the block defining the elastic fluid channels between the adjacent blade portions.

It is an object of this invention to provide a new and improved method of manufacturing elastic fluid turbine bucket units comprising a base portion, a plurality of blades and a cover portion out of a solid piece of metal by which the method the bucket blades can be readily formed with great accuracy while the strength of the finished unit is such as will withstand the most severe of operating conditions in the turbine.

For a consideration of what I believe to be novel and my invention, attention is directed to the following description and the claims appended thereto taken in connection with the accompanying drawings.

Referring to the drawings, Fig. 1 illustrates a metal blank from which a bucket unit may be formed; Figs. 2 to 7, inclusive, are views illustrating various steps in the manufacture of bucket units according to my invention; Fig. 8 is a view in perspective illustrating the finished turbine bucket unit; and Figs. 9 and 10 are cross-sectional views of a blank illustrating steps in the manufacture of the bucket unit according to a modification of the invention.

In the manufacture of turbine bucket units having a plurality of blades, from a single solid block of metal or blank, considerable difficulty is experienced in accurately forming the concave and convex surfaces defining adjacent blade walls in the central portion of the block. This difficulty is primarily due to the particular configuration of the passage which must be formed through the blank from side to side, it being of irregular arcuate shape, and sufficient clearances do not exist so that cutting tools of sufficient rigidity can be passed into the cavity from either side for removing metal therefrom in a satisfactory manner. In the formation of the passage, the region of comparative inaccessibility in the central portion of the blank is relatively small and in accordance with my invention, a portion of the metal is removed therefrom through a relatively small opening drilled through either end of the blank between, and parallel with, the portions forming the blades.

In Fig. 1 is shown a solid block of metal or blank preferably of forged steel of a suitable alloy, the outer surfaces thereof having been rough machined or squared to some suitable preliminary shape such as that indicated. The position of the blades to be formed in the blank may be determined, as indicated in Fig. 2, by the layout of the blade ends 11 and 12 traced on the upper surface of the blank defining the substantially arcuate passage 13 therebetween. A hole 14 is then drilled through the upper surface of the blank in the portion to be removed for the formation of the passage between the adjacent blades. The hole is drilled parallel with the blades and downwardly to a depth substantially equal to the lower boundary of the passage as shown more clearly in Fig. 3. The hole is preferably centrally located as regards the passage, midway between the opposite sides of the blank, the diameter of the bore being substantially equal to the desired width of the passage between the adjacent blades 11 and 12. The formation of the passage is then continued from the opposite sides of the blank by end milling operations substantially as indicated in Fig. 4. Cuts 15 and 16 may first be taken along the tangents 17 and 18 defining the sides of the blade portion 12, these cuts to be followed by milling through as indicated at 19 and 20 into the bore 14. After the rough milling operations are completed, the passage may then be finished from the sides of the blank by tools suitably designed for removing the necessary metal to form the concave and convex surfaces of the blade portions 11 and 12, respectively, substantially as indicated in the cross-sectional view, Fig. 5. Fig. 6 is a perspective view illustrating the blank at this stage of manufacture showing a passage 13 provided therethrough, defining the elastic fluid channel between two adjacent bucket surfaces.

After the passage 13 has been completed, the 55
upper end of the hole 14 may be closed in any suitable manner to provide a tight cover for the bucket unit. As indicated in the cross-sectional view, Fig. 7, a close fitting plug 21 may be welded therein as at 21'.

Once the passage through the blank is finished, the remaining steps to be performed present no particular difficulties and may be carried out by any worker skilled in the art since the remaining surplus of metal need be removed only from the outer surfaces of the blank. Such steps include the milling of the outer convex and concave sides of the blade portions 11 and 12, respectively, the milling of the dovetail slot 23 in the base of the unit, the finishing of the cover portion 25, the milling of the unit profile to the proper taper and the fitting of the unit to the wheel. The finished bucket unit is shown in Fig. 7.

As a preferred method of construction, the central hole may be drilled upwardly through the base portion of the blank rather than through the cover portion. As shown in the cross-sectional view, Fig. 9, the hole 25 between the two blade portions may be drilled upwardly through the base portion, the cover portion being provided therein, to the upper limit of the passage adjacent the cover. Either before or after the formation of the passage between the blade portions has been completed in a manner similar to that previously described, the lower end of the hole 25 may be closed by means of a plug 26. The sides of the plug 26 are slightly tapered so that it may be driven tightly into the correspondingly tapered portion at the lower end of the hole as illustrated in Fig. 10. The plug 26 may be further held in place by forging or pinning the edges of the hole as indicated at 27. During the operation of the bucket unit in the turbine, the centrifugal force acting upon the plug will tend to move it in the direction of the outer end of the bucket unit and, due to the taper thereof, will be held tightly in the position indicated.

From another viewpoint, my method of manufacturing bucket units comprises the step of making a blank, (as shown in Fig. 1) which blank has outer and intermediate portions which upon subsequent machining form the cover of the bucket unit. A dead-end bore is formed through central parts of one of the outer portions and through the intermediate portion. The diameter of the bore is about equal to the width of the central part of the passage or the corresponding distance between two buckets to be formed. Also, the bore leaves material connecting the ends of two buckets to be produced to form a cover integral with such buckets. In one instance, as shown in Fig. 3, this dead-end bore is formed through the upper and intermediate portions, and in another instance, as illustrated in Fig. 9, the dead-end bore 15 is formed through the lower and intermediate portions. After the drilling of the bore, material is removed from opposite sides of the intermediate portion only to form channels or spaces which together with the bore define a bucket passage transverse through the blank. Thereupon the lower portion may be dovetailed, that is, machined to form a dovetail for connection to a corresponding dovetail of a bucket wheel disk. The intermediate portion is machined to define bucket blades and the upper portion is finished to define a cover integral with the blades. The free end of the bore is closed or plugged.

Though the method of manufacture is applied herein to the manufacture of bucket units having but a pair of blades integrally united with base and cover portions, it is obvious that the methods herein described are equally applicable in the manufacture of bucket units having any greater number of blades. It is also understood that the dovetail type of fastening arrangement shown in the drawings is merely illustrative of any suitable method of uniting the bucket units upon the turbine rotor rim.

Having described the principle of operation of my invention together with the apparatus which I now consider to represent the best embodiment thereof, I desire to have it understood that the apparatus shown is only illustrative and that the invention may be carried out by other means.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. The method of manufacturing a bucket unit for an axial flow elastic fluid turbine from a substantially homogeneous metal blank, said unit comprising a cover portion, a plurality of blades and a base portion integrally united together, said base portion having a dovetail slot therein for removably attaching said unit to an elastic fluid turbine, the method comprising the forming of a dovetail slot in the base portion of the blank, the forming of a passage transversely of said blank to define adjacent blade surfaces therein, said passage being formed in part by a hole drilled from said dovetail slot into the blank parallel with and between adjacent blade surfaces to be defined by said passage, removing the remainder of the metal necessary to complete the formation of said passage through openings in the opposite side walls of said blank leaving the cover portion substantially intact, closing the hole in the base portion, and machining the outer surfaces of said blank to complete said bucket unit.

2. The method of manufacturing a bucket unit for an axial flow elastic fluid turbine from a substantially homogeneous metal blank, said unit comprising a cover portion, a base portion and a pair of spaced apart blades extending therebetween and integrally united therewith, said base portion having a dovetail slot for removably attaching said unit to a base, blades of said blank being formed by drilling said dovetail slot, said method comprising the cutting of a slot forming a part of a dovetail in the base of said blank, forming a passage transversely of said blank to define the adjacent blade surfaces therein leaving the cover portion integral with the upper ends of said blade portions, said passage being formed in part by a hole drilled into the central portion of said blank from the slot in the base portion, said hole extending parallel with and between adjacent blade surfaces to be defined by said passage, cutting away the remainder of the metal necessary to complete said passage through openings in the opposite side walls of said blank, fitting a tapered plug into the lower end of said hole so that it will be held substantially in position in said base portion by centrifugal force, it is objectional of this bucket unit, and machining the outer surfaces of said cover portion, blade portions and base portions to complete the formation of the bucket unit.

3. The method of manufacturing a bucket unit having a pair of blades and a cover portion integral therewith which comprises the steps of producing a blank of material having outer and intermediate portions, forming a dead-end bore through central parts of one of the outer portions and through the intermediate portion, the
bore being of a diameter about equal to the central distance between two buckets to be produced and leaving material connecting the ends of such buckets to form a cover integral therewith, and machining passages from opposite sides of the intermediate portion towards the bore without removing said material to form a bucket passage.

4. The method of manufacturing a bucket unit having two blades and a cover integral therewith which comprises the steps of making a blank having outer and intermediate portions, forming a dead-end bore through one of the outer portions and through the intermediate portion, the bore having a diameter about equal to the corresponding distance between two bucket blades to be produced, removing material from opposite sides of the intermediate portion only towards the bore to form a passage transverse through the intermediate portion, machining the lower portion to form a dovetail, closing the free end of the bore, and machining the upper portion to form a cover.

5. The method of manufacturing a bucket unit having two buckets and a cover integral therewith which comprises the steps of making a blank having outer and intermediate portions, forming a dead-end bore through one of the outer portions and through the intermediate portion, the bore being formed in central parts of such outer and intermediate portions and having a diameter about equal to the central distance between two buckets to be produced, removing material from opposite sides of the intermediate portion only towards the bore to form a passage transverse through the intermediate portion, machining the intermediate portion to form bucket blades, and plugging the free end of the bore.

ABRAM M. REYNOLDS.