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V. BENDIX

1,996,850

METHOD OF MAKING PROPELLER BLADES

Filed Sept. 22, 1930

Fig. 1.

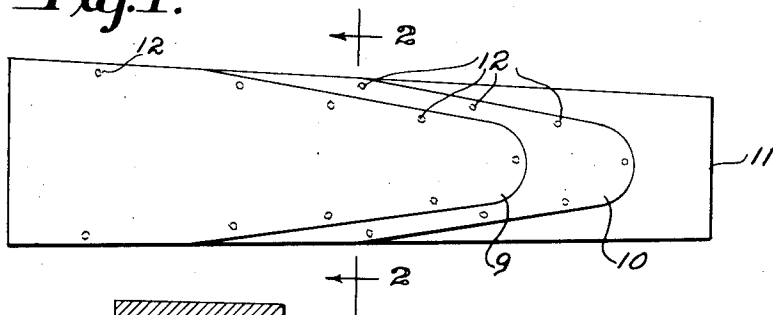


Fig. 2.

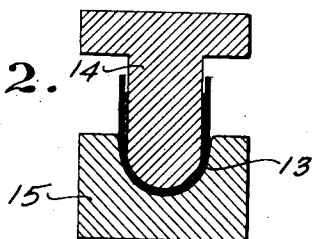


Fig. 3.

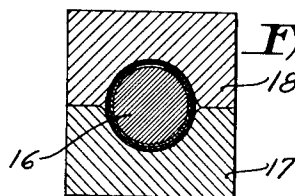


Fig. 4.

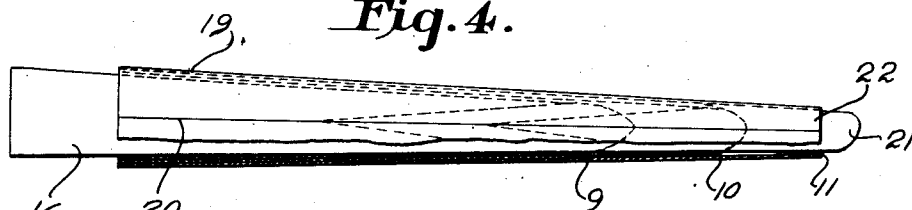


Fig. 5.

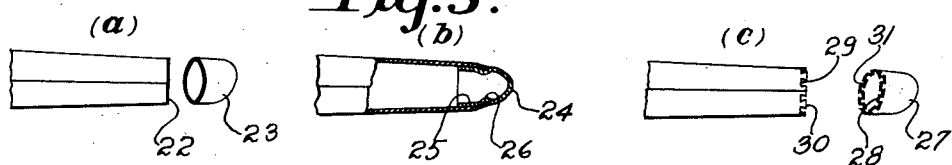


Fig. 6.

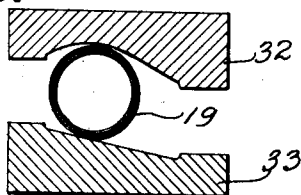


Fig. 7.

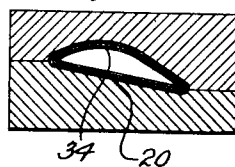
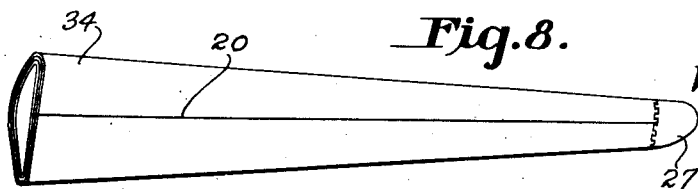


Fig. 8.



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METHOD OF MAKING PROPELLER BLADES

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16 Claims. (Cl. 29—156.8)

The present invention relates to propellers, and more particularly to hollow metal propeller blades and a method of making them.

Heretofore it has been the usual practice to make hollow metal propeller blades from seamless drawn tubing which is costly, and the method of making the blades from such tubing requires various expensive operations, such as accurately machining the hollow tubing to obtain the desired taper and longitudinal variation and cross-sectional variation in the thickness of the blade from root to tip in order to produce a blade structure having the required strength and air-foil section. After the machining operations, the tapered end of the hollow tube is generally closed up by spinning the metal of the tube prior to the final die-forming operation to produce the finished blade. This also requires accurate and precise manipulation and measurement, which add to the cost of the method.

It is, therefore, one of the objects of the present invention to provide a novel and improved method of making hollow metal propeller blades, which is simple, inexpensive, and capable of producing a high-grade product.

Another object of the invention is to provide a novel and efficient method of producing a hollow propeller from one or more sheets of metal, whereby a blade of the desired strength with light weight and low cost is obtained.

Another object is to provide a novel method of making hollow metal propeller blades, in which the metal is entirely protected against buckling, cracking, folding, or other distortions during the forming operation.

A further object is to provide a novel and economical method of manufacturing hollow metal propeller blades, which insures the proper distribution of metal and the required accuracy of shape without impairing the fibre strength of the metal.

A still further object is to provide a novel method of making hollow metal propeller blades whereby a separate tip is provided for the blade which may be easily and quickly secured to and made an integral part of the blade, while the latter is in tubular form.

Still another object is to provide an improved method of making hollow metal propellers from one or more sheets of metal and involving the use of internal pressure in the final formation of the finished blade to prevent distortion of the metal.

A still further object is to provide a novel improved construction of a hollow metal propeller

blade, which is inexpensive to manufacture and capable of withstanding the centrifugal forces produced in the propeller when the latter is in operation.

Other objects and advantages of the invention will appear more fully hereinafter from the following detailed description taken with the accompanying drawing. Although certain steps used in the method of manufacturing propeller blades in accordance with the present invention are illustrated diagrammatically in the drawing, it is to be expressly understood that the drawing is for the purpose of illustration only, and is not to be construed as a definition of the limits of the invention, reference being had for this purpose to the appended claims.

In the drawing, wherein like reference characters refer to like parts throughout the several views,

Fig. 1 is a plan view showing one arrangement of sheets of metal, prior to the shaping operation, which may be employed in accordance with the present invention;

Fig. 2 is a cross-section taken on line 2—2 of Fig. 1, illustrating one first step which may be used in shaping the sheets into a tube;

Fig. 3 is a cross-sectional view of a form of die which may be used in the final step of forming the hollow tube;

Fig. 4 is a plan view showing the tube supported on a mandrel for the welding operation before attaching the cap or tip to the small end of the tube;

Fig. 5 illustrates three ways in which the small end of the tube may be closed;

Figs. 6 and 7 are cross-sectional views illustrating a forming operation for producing the desired air-foil section in the finished blade; and

Fig. 8 is a plan view of a portion of the finished blade.

Referring now to the drawing, the present method of manufacture of hollow metal propeller blades utilizes one or more layers of sheet metal 9, 10, and 11, such as sheet steel, for example. The metal sheet or sheets may have any configuration, but preferably, the outer sheet 11 is trapezoidal, two opposite sides of which are equal to the length of the tube to be formed and the other two opposite sides are equal to the circumference of the large and small ends of the tapered tube, respectively. The remaining sheets, when used, may be cut to a taper, as indicated in Fig. 1, the tapered portions consecutively decreasing in width to provide a variation in the cross-sectional thickness of the wall of the blade

and are arranged in overlapping relation to provide a longitudinal variation in thickness from the root to the tip of the blade, thereby affording the required strength with light weight. It is of course obvious that only one sheet may be used if desired, which may be of a uniform thickness or of varying thickness.

When more than one sheet is used the sheets may be spot welded at various points along their edges, if desired, as indicated at 12, to hold the sheets together in intimate contact during the shaping operation to form the hollow tube.

The sheets are now bent to form a curved surface 13, preferably by pressing them between bending dies 14 and 15 as indicated in Fig. 2, and then placing the curved workpiece 13 on a mandrel 16 with the open end thereof extending upwardly, and forming the piece into a tapered tube in a pair of forming dies 17 and 18, as indicated in Fig. 3. Although the forming of the tube has been illustrated as being performed in dies it may be accomplished by rolling the sheets between suitable rollers in a manner well-known in the art of making, shaping and treating of steel and in sheet-metal work.

In Fig. 4 is shown the formed tapered tube 19 with a portion thereof broken away to indicate the position of the sheets 9, 10, and 11 to produce the longitudinally decreasing thickness of the wall of the tube. The edges 20 of the outer sheet 11 are caused to come together in abutting relation as indicated, or may slightly overlap. These edges are then welded to form a longitudinal seam to complete the hollow tube. The mandrel 16 is provided with a curved tip 21, the contour of which may correspond to the shape of a metal cap, which is adapted to be secured to the smaller end 22 of the tube to close the latter.

In Fig. 5 are shown three forms, (a), (b), and (c), of caps which may be employed for closing the end of the tube. As illustrated at (a), a tip 23 is placed on the end 21 of the mandrel adjacent the end 22 of the tube and then butt welded to form an integral structure therewith. The cap or tip 23 may be of the same material as the tube, or of different material if desired.

In the form (b) a cap 24 is provided having a tapered section 25 the open end of which is of slightly larger diameter than the end 22 of the tube, and which has an annular groove or depression 26. The cap 24 is inserted into the large end of the tube and is moved therealong until the annular depression 26 is in the plane of the end 22 of the tube and said end is then crimped so that it fills the groove 26. The crimped parts are now preferably welded so that a smooth curved surface is formed.

In the form (c) the cap 27 and the end 22 of the tube are dove-tailed to form projections 28 and 30 and recesses 29 and 31. The cap may be secured to the tube by bending the projections 28 or 30 radially outward, uniting the two members and then forcing the bent projections inwardly so that the projections 28 on the cap fall within the tapered recesses 29 of the tube and the projections 30 on the tube fall within the recesses 31 of the cap. The dove-tailed joint thus produced is then welded and finished off to form a smooth integral surface. The dove-tailed cap provides a particularly strong structure which is capable of withstanding centrifugal forces produced in the propeller blade when the latter is in operation.

The closed tube is removed from the mandrel and if it is desired to work the tube hot the tube

is heated to a sufficiently high temperature to render the metal readily deformable, and a fluid pressure medium, such as compressed air or any other suitable pressure medium, is introduced into the hollow tube which is then placed in a heavy, two-part metal moulding die 32-33, the interior cavity of which has the precise shape of the ultimate propeller blade to be produced. It is preferable that the tube be placed in the die in such a way that the welded seam 20 shall fall on the flat face of the finished blade. The two parts 32-33 are brought together, as indicated in Fig. 7, by suitable pressure apparatus, to form the finished blade 34 having the desired air-foil section.

When using sheets of metal which may be worked cold, such as aluminum alloys or ordinary steel, heavy oil may be used as a shape-retaining medium on the inside of the tube, but, when using alloyed steel for example, forming in the die 32-33 may preferably be done while the metal is hot, in which case compressed air is preferably employed. It may also be desirable, when certain metals are used, to submit the tube to a preliminary rolling or shaping operation so that the blade will initially assume a shape of less curvature than the finished product. This may be done in any suitable manner well known in the metal working art.

It will be noted that when a plurality of sheets are used and arranged as illustrated in Fig. 1, the finished product will be a laminated hollow metal propeller blade having the required wall thickness and the desired air-foil section, although, as hereinbefore stated, one sheet of metal may be used and shaped into a hollow tube in accordance with the above method and then formed into the finished blade.

It will be evident from the foregoing description that the present invention provides a novel and improved construction of a hollow metal propeller blade which may or may not be laminated, and a simple, inexpensive method of producing such propeller blades from sheets of metal. The blades are formed by a new method which includes the use of internal fluid pressure, with the result that the blade surface is not only accurately shaped but also, the metal of the blade is fully protected against folding, buckling, or other distortions. Although certain steps and materials used in the method of making metal propeller blades in accordance with the present invention have been illustrated and described in detail, it will be apparent that the invention is capable of embodiment in various forms, any of which will now occur to those skilled in the art, without departing from the scope of the invention. Reference is therefore to be had to the appended claims for a definition of the limits of the invention.

What is claimed is:

1. The method of making hollow propeller blades, which comprises arranging a plurality of sheets of metal in overlapping relation whereby the total thickness is varied from one end to the other, cutting certain of said sheets to form tapered ends to form a cross-section varying in thickness when said sheets are shaped into a tube, spot-welding said sheets at various points along their edges to hold them together, shaping said sheets to form a curved surface, placing the curved work-piece thus formed on a mandrel and pressing it in dies while supported thereon to produce a hollow tube having a longitudinal overlapping portion, welding said overlapping

portion to form a seam, providing a separate cap for the tube, welding said cap to the tube to close the latter, heating said tube to a sufficiently high temperature to render the metal readily deformable, filling the tube with a fluid medium under pressure, and forming said tube to the required shape of the finished blade while hot by pressing it in dies while under the internal pressure of said fluid to prevent distortion of the metal.

2. The method of making laminated hollow propeller blades, which comprises arranging a plurality of sheets of metal in overlapping relation whereby the total thickness is varied from one end to the other, securing said sheets together at various points along their edges to hold them in intimate contact, shaping said sheets to form a curved surface, placing the curved work-piece thus formed on a mandrel, pressing said work-piece in dies while supported on said mandrel to produce a hollow tube having a longitudinal overlapping portion, welding said overlapping portion to form a seam, providing a separate metallic cap having a predetermined shape and thickness for said tube, welding said cap to the tube to close the latter and provide a tip for the finished blade, heating said tube to sufficiently high temperature to render the metal readily deformable, filling the tube with a fluid medium under pressure, and forming said tube to the required shape of the finished blade while hot by pressing it in dies while under the internal pressure of said fluid to prevent distortion of the metal.

3. The method of making hollow propeller blades, which comprises shaping one or more layers of sheets of metal to form a hollow tapered tube having longitudinal abutting portions, welding said abutting portion to form a seam, providing a separate metallic cap for said tube, securing said cap to the tube to close the latter and provide a tip for the finished blade, filling said tube with a fluid medium under pressure, and forming said tube to the required shape of the finished blade by pressing it in dies while under the internal pressure of said fluid to prevent distortion of the metal.

4. The method of making laminated hollow propeller blades, which comprises arranging a plurality of sheets of metal in overlapping relation whereby the total thickness thereof is varied from one end to the other, shaping said sheets to form a curved surface, placing the curved work-piece on a mandrel, pressing said work-piece in dies while supported on said mandrel to produce a hollow tube having a longitudinal overlapping portion, welding said overlapping portion to form a seam, providing a separate cap for the tube, welding said cap to the tube to close the latter and to provide an integral tip for the finished blade, filling the tube with a fluid medium under pressure, and forming said tube to the required shape of the finished blade while under the internal pressure of said fluid to prevent distortion of the metal.

5. The method of making hollow propeller blades, which comprises shaping one or more layers of sheets of metal to form a hollow tapered tube, providing a separate cap for said tube, securing said cap to the tube to close the latter, and forming the closed tube to the required shape of the blade by pressing it in dies while subjecting it to internal fluid pressure to prevent distortion of the metal.

6. The method of making hollow propeller blades, which comprises shaping one or more

layers of sheets of metal into a hollow tapered tube, providing a separate cap for said tube, securing said cap to the tube to provide a closed tip for the latter, heating the closed tube to a sufficiently high temperature to render the metal readily deformable, filling said tube with a fluid medium under pressure, and forming said tube to the required shape of the finished blade by pressing it in dies while under the internal pressure of said fluid to prevent distortion of the metal.

7. The method of making hollow propeller blades, which comprises shaping one or more layers of sheets of metal into a hollow tapered tube having longitudinal overlapping portions, welding said overlapping portions to form a seam, providing a separate cap for said tube, inserting said cap into the large end of the tube and moving said cap therealong until it projects from the small end of the tube to close the latter, crimping the end of said tube around said tip to produce a snug fit, welding the said crimped portion to form an integral structure, heating said tube to a sufficiently high temperature to render the metal readily deformable, and forming the closed tube to the required shape by pressing it in dies while subjecting it to internal fluid pressure.

8. The method of making hollow propeller blades, which comprises shaping one or more layers of sheets of metal into a hollow tapered tube having longitudinal overlapping portions, welding said overlapping portions to form a seam, providing a separate cap for said tube, inserting said cap into the large end of the tube and moving said cap therealong until it projects from the small end of the tube to close the latter, crimping the end of said tube around said tip to produce a snug fit, welding the said crimped portion to form an integral structure, heating said tube to a sufficiently high temperature to render the metal readily deformable, filling the tube with a fluid medium under pressure, and forming said tube to the required shape of the finished blade while hot by pressing it in dies while under the internal pressure of said fluid to prevent distortion of the metal.

9. The method of making hollow propeller blades, which comprises arranging a plurality of sheets of metal in overlapping relation to vary the total thickness thereof from one end to the other, cutting certain of said sheets to form consecutively decreasing tapered ends whereby a cross-section of varied thickness is produced when said sheets are shaped into a tube, spot-welding said sheets at various points along their edges to hold said sheets together, shaping said sheets to form a curved surface, placing the curved work-piece thus formed on a mandrel and pressing it in dies while supported thereon to produce a hollow tube having a longitudinal overlapping portion, welding said overlapping portion to form a seam, providing a separate cap for the tube, dove-tailing the small end of the tube and the open end of the cap whereby the finished structure is strengthened to withstand the centrifugal forces produced when the propeller is in operation, securing the cap to the tube so that the dove-tailed portions fit one within the other to close said tube, welding said dove-tailed portions to form an integral piece, heating said closed tube to a sufficiently high temperature to render the metal readily deformable, filling the tube with a fluid medium under pressure, placing the heated tube in forming dies so that the longitudinal seam shall fall upon the flat face of the blade, and pressing said tube to the required shape of the finished blade while under

the internal pressure of said fluid to prevent distortion of the metal.

10. The method of making hollow propeller blades, which comprises arranging a plurality of sheets of metal in overlapping relation to vary the total thickness thereof from one end to the other, cutting certain of said sheets to form consecutively decreasing tapered ends whereby a cross-section of varying thickness is produced when said sheets are shaped into a tube, spot-welding said sheets at various points along their edges to hold said sheets together, shaping said sheets to form a curved surface, placing the curved work-piece thus formed on a mandrel and pressing it in dies while supported thereon to produce a hollow tube having a longitudinal overlapping portion, welding said overlapping portion to form a seam, providing a separate cap for the tube, butt-welding said cap to the tube to close the latter, heating said tube to a sufficiently high temperature to render the metal readily deformable, filling the tube with a fluid medium under pressure, placing the heated tube in forming dies so that the longitudinal seam shall fall on the flat face of the finished blade, and pressing said tube in said dies to the required shape of the finished blade while under the internal pressure of said fluid to prevent distortion of the metal.

11. The method of making hollow propeller blades, which comprises arranging a plurality of sheets of metal in overlapping relation to vary the total thickness of said sheets from one end to the other, cutting certain of said sheets to form consecutively decreasing tapered portions whereby a cross-section of varied thickness is produced when said sheets are shaped into a tube, shaping said sheets to form a curved surface, placing the curved work-piece thus formed on a mandrel and pressing it in dies while supported thereon to produce a hollow tube having a longitudinal overlapping portion, welding said overlapping portion to form a seam, providing a separate cap for the tube, dove-tailing the small end of the tube and the open end of the cap whereby the finished structure is strengthened to withstand the centrifugal forces produced when the propeller is in operation, securing said cap to the tube so that the dove-tailed portions fit one within the other to close the tube, welding said dove-tailed portions, heating said closed tube to a sufficiently high temperature to render the metal readily deformable, filling the tube with a fluid medium under pressure, and forming said tube to the required shape of the finished propeller blade while hot by pressing it in dies while under the internal pressure of said fluid to prevent distortion of the metal.

12. The method of making hollow propeller blades, which comprises shaping one or more layers of sheets of metal into a hollow tapered tube having longitudinal overlapping portions, welding said overlapping portions to form a seam, providing a separate cap for said tube, dove-tailing the small end of the tube and the open end of the cap, attaching the cap to said tube so that the

dove-tailed portions fit one within the other whereby the structure is strengthened to withstand centrifugal forces produced when the propeller is in operation, welding the dove-tailed portion, heating said tube to a sufficiently high temperature to render the metal readily deformable, filling the tube with a fluid medium under pressure, and forming said tube to the shape of the finished blade while hot by pressing it in dies while under the internal pressure of said fluid to prevent distortion of the metal.

13. The method of making hollow propeller blades, which comprises shaping one or more layers of sheets of metal into a hollow tapered tube having longitudinal overlapping portions, welding said overlapping portions to form a seam, providing a separate cap for said tube, dove-tailing the small end of the tube and the open end of the cap, attaching the cap to said tube so that the dove-tailed portions fit one within the other whereby the structure is strengthened to withstand centrifugal forces produced when the propeller is in operation, welding the dove-tailed portion, and forming the closed tube to the required shape by pressing it in dies while subjecting it to internal fluid pressure to prevent distortion of the metal.

14. The method of making hollow propeller blades, which comprises shaping a plurality of layers of sheets of metal into a hollow tapered tube, closing one end of said tube, and thereafter forming the tube to the required shape of the blade by pressing said tube in dies while subjecting it to internal fluid pressure to prevent distortion of the metal.

15. The method of making hollow propeller blades, which comprises shaping a plurality of layers of sheets of metal to form a hollow tapered tube having a longitudinal overlapping portion, welding said overlapping portion to form a seam, closing the small end of said tube, and thereafter forming the tube to the required shape of the blade by pressing said tube in dies while subjecting it to internal fluid pressure to prevent distortion of the metal.

16. The method of making hollow propeller blades, which comprises shaping one or more layers of sheet metal into a hollow tapered tube having a longitudinal portion adapted to be welded, welding said portion to form a seam, providing a separate cap for said tube, cutting the small end of the tube and the open end of the cap to form projections and recesses thereon, bending the projections outwardly on one of said members, attaching the cap to the tube and forcing the bent projections inwardly so that the projections of each fall within the recesses of the other, whereby the structure is strengthened to withstand centrifugal forces produced when the propeller is in operation, welding the joint thus produced to close the tube, and forming the closed tube to the required shape by pressing it in dies while subjecting it to internal fluid pressure to prevent distortion of the metal.

VINCENT BENDIX.