Aug. 31, 1943. G. T. LAMPTON 2,328,348

MANUFACTURE OF PROPELLER BLADES

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Fig. 1

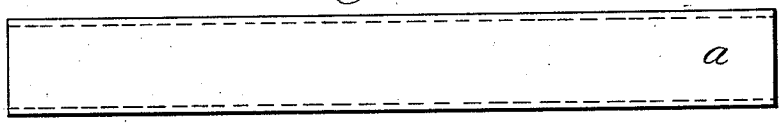


Fig. 2

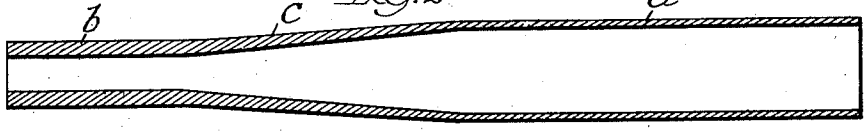


Fig. 3

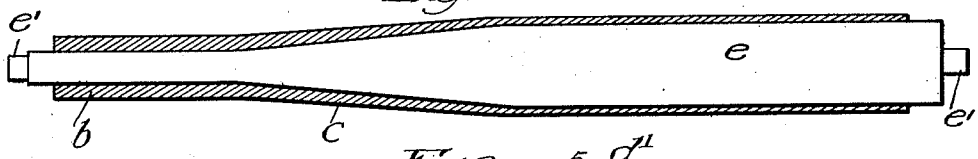


Fig. 4

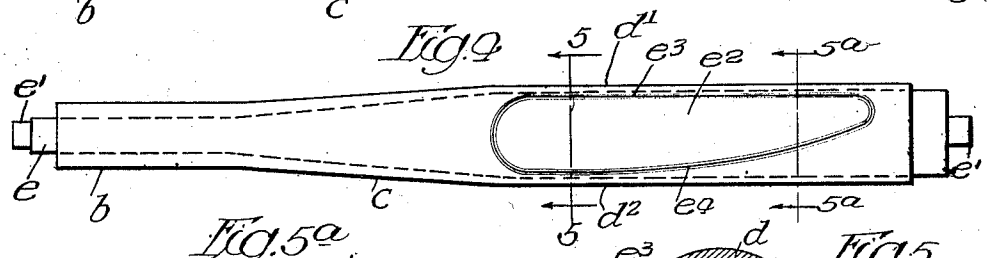


Fig. 5a

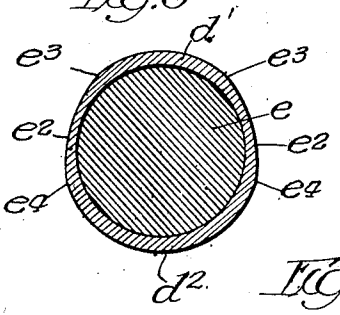


Fig. 5

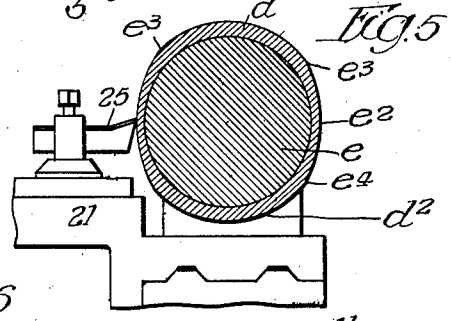


Fig. 6

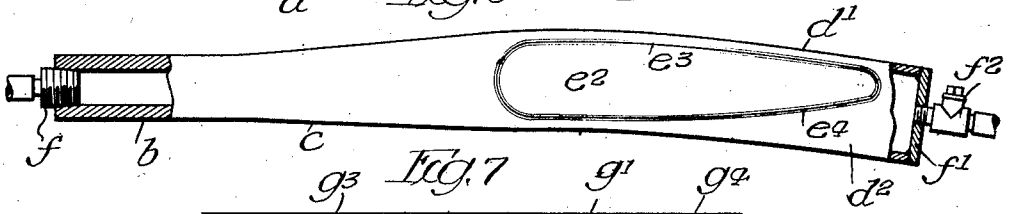
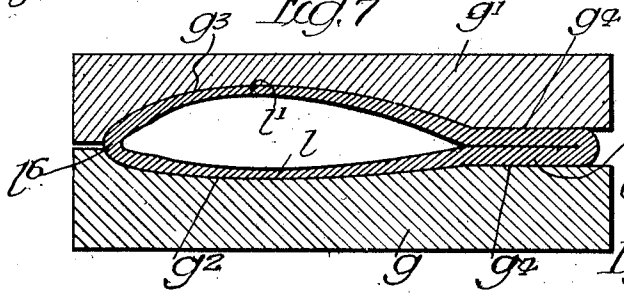


Fig. 7



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Aug. 31, 1943. G. T. LAMPTON 2,328,348

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Fig. 8

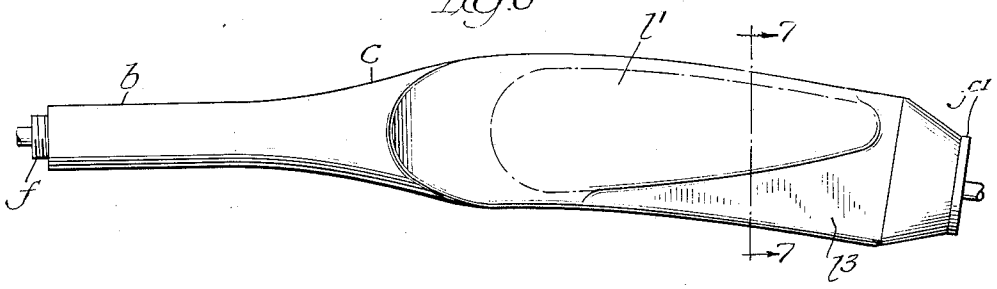


Fig. 9

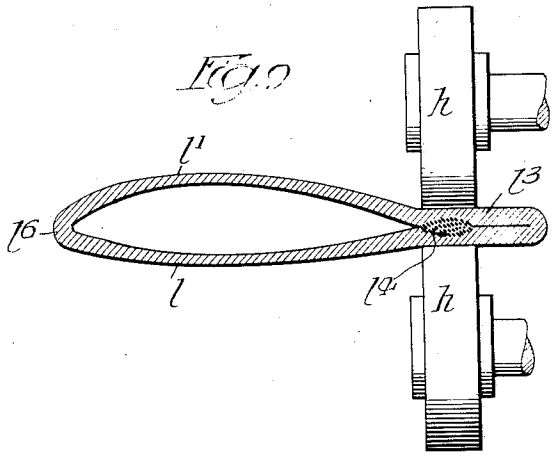


Fig. 10

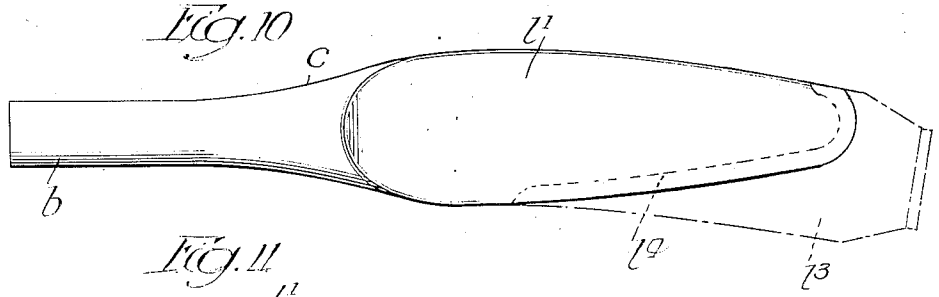


Fig. 11

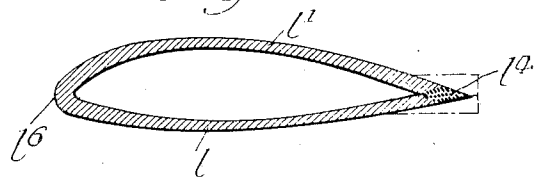
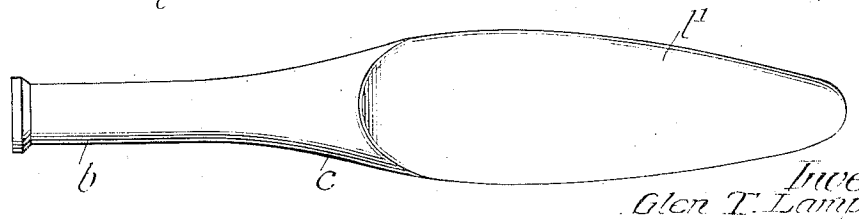


Fig. 12



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Patented Aug. 31, 1943

2,328,348

UNITED STATES PATENT OFFICE

2,328,348

MANUFACTURE OF PROPELLER BLADES

Glen T. Lampton, Williamsport, Pa., assignor, by mesne assignments, to The Aviation Corporation, New York, N. Y., a corporation of Delaware

Application June 12, 1939, Serial No. 278,740

4 Claims. (Cl. 29—156.8)

The invention relates to the manufacture of hollow metal propeller blades for aircraft from tubular steel blanks.

One object of the invention is to improve the manufacture of hollow steel propeller blades by removing zones of metal from the outer face of the tubular blank to vary the wall-thickness as desired in the face-sections of the blade before bending the tubular blank longitudinally on a curve conforming substantially to the longitudinal curvature of the leading edge desired.

Another object of the invention is to provide a curve for such blades in which the longitudinal bending of the tubular blank conformably to the longitudinal curvature of the leading edge desired, is made along a longitudinal zone of the blank of substantially full wall thickness and between the relieved zones.

Another object of the invention is to provide a method for making such blades in which the shaping of the tubular blank into face-sections of airfoil cross-sectional shape with a seamless leading edge is simultaneously performed with the flattening of the blank along the margin which is used in forming the trailing edge of the blade.

Another object of the invention is to provide a method in which the tubular blank is bent longitudinally while subjected to internal pressure to produce a uniform or symmetrical bending of the blank.

Another object of the invention is to provide an improved method of making blades from hollow tubular blanks in which the flattened portions of the blank along one margin are autogenously joined for producing the trailing edge before the blank is trimmed to remove the excess flattened portions of the blank.

Other objects of the invention will appear from the following detailed description.

The invention consists in the several novel features which are hereinafter set forth and are more particularly defined by claims at the conclusion hereof.

In the drawings: Fig. 1 is a side elevation of the tubular blank used in making the propeller blade. Fig. 2 is a longitudinal section of the tubular blank after it has been upset and swaged to form a shank for the blade. Fig. 3 is a side elevation of the arbor onto which the tubular blank is shrunk, the blank being shown in section thereon. Fig. 4 is a side elevation of the blank on the arbor after the blank has been machined to vary the wall-thickness of different portions of the blank used in forming the pressure and suction faces. Fig. 5 is a section through the arbor on line 5—5 of Fig. 4 in a lathe for cutting portions from the wall of the tubular blank. Fig. 5ª is a section on line 5ª—5ª of Fig. 4. Fig. 6 is a side elevation of the blank after it has been bent so that one side of the blank will be curved longitudinally to substantially conform to the curvature desired on the leading edge of the blank. Fig. 7 is a section showing the tubular blank after it has been bent longitudinally and between dies for forming pressure and suction faces integrally connected at the leading edge and flattened at the opposite edge, the section being taken through the blank on line 7—7 of Fig. 8. Fig. 8 is an elevation of the blank after it has been shaped to form the suction and leading faces, as illustrated in Fig. 7. Fig. 9 is a transverse section of the blank illustrating the welding step in forming the trailing edge of the blank. Fig. 10 is a plan of the blank after it has been trimmed to provide the desired longitudinal curvature at the trailing edge and the desired curvature at the tip. Fig. 11 is a transverse section of the finished blade after the trailing edge has been finished. Fig. 12 is a plan of the finished blade.

The invention is exemplified by the manufacture of a blade from a tubular blank *a* of requisite length having a commercially uniform wall-thickness at least as great as the wall-thickness desired in the leading and trailing edge portions of the finished blade. One end of the blank is swaged and upset to form a shank portion *b* and a tapering portion *c* joining the shank portion and the cylindrical section *d* of which the pressure and suction faces of the blade are shaped.

A solid arbor or core *e* is provided for insertion into the blank after the latter has been shaped to form shank *b*, tapering portion *c* and section *d*. The contour of the periphery of the arbor corresponds to the contour desired for the inner periphery of the blank while it is being shaped and its area is at least slightly greater than that of the normal area of the internal periphery of the blank so that when the blank is shrunk onto the arbor the inner periphery of the blank will be formed accurately to the arbor and the blank will be rigidly secured thereon. The arbor *e* is provided with studs e^1 for centering it in a suitable lathe used for machining zones of metal from the outer face of the section *d* of the blank to produce reduced wall-thickness where desired according to the stresses to which the different portions of the blade are subjected in use.

Before the blank is shrunk on the arbor it is heated to a sufficiently high temperature so that

the expansion of the blank will exceed the limits of its inaccuracy or irregularity and permit the arbor to be inserted and positioned in the blank without interference. In this heating of the blank the temperature is controlled so that when the blank shrinks onto the arbor or cools at relatively low temperature, it will not expand abruptly away from the arbor and lose its previous tight fit thereon when both the blank and the arbor are subsequently brought to normal temperature.

The steel alloys which are suitable for the fabrication of propeller blades are limited to those having carbon contents less than 85% at which the eutectoid of iron and carbon exists. A blank of a steel alloy in the range of .38% carbon is an example of suitable metal for the manufacture of blades. The critical temperatures and the shrinking and expansion of the blank are more fully set forth in the application filed by me April 13, 1939, Serial No. 267,548.

When the blank has been thus shrunk and is tightly fitted and shaped around the arbor, the arbor with the blank thereon is placed in a lathe 21 for machining the external surface of the blank and relieving oppositely disposed zones e^2 on the blank section d to produce reduced wall-thickness in the portions of the blank used to form the suction and pressure faces of airfoil cross-sectional contour between the leading and trailing edges. This machining may be done with a cutting tool 25 for milling portions of the blank during the rotation of the arbor and blank and in practice is automatically controlled in any manner well understood in the art, to cut away predetermined zones of the desired contour and of varying depth from the blank in the portions of the blank used to form the blade-faces, leaving the portions used for forming the trailing and leading edges of substantially full wall-thickness. In this operation the relieved zones e^2 are terminated along straight lines e^3 at one of their sides and along curved lines e^4 converging toward the tip at their other sides, and zones d^1 and d^2 of full wall-thickness are left between the relieved zones.

After the blank has been thus machined the arbor with the blank thereon is removed from the lathe and the blank is heated to a sufficiently high degree so it will expand and permit the arbor to be easily withdrawn from the machined blank. This heating may be done when the blank has been placed into a cylindrical chamber by delivering a blast of hot gas in the chamber around and outside of the blank. After the blank has been removed from the arbor, it will shrink so that its internal periphery will conform to the outer periphery of the arbor and be provided with the desired accurate variations in wall-thickness.

Next a fitting f is hydrogen-brazed into the shrunk end of the blank and a closure-plate f^1 is welded to the outer end of the blank so that internal hydraulic pressure can be applied to the blank during the succeeding longitudinal bending step. Fluid under pressure is delivered into the blank through fitting f and escapes under a predetermined pressure through an automatic pressure-controlled valve f^2 to maintain the desired internal pressure in the blank. While the blank is heated and expanding pressure is maintained therein, section d of the tubular blank will be bent or worked longitudinally between suitable dies or formers so that the outer curve of the bend will conform substantially to the curvature desired in the leading edge of the propeller blade, as illustrated in Fig. 6. This bend is made so that the zone d^1 of full wall-thickness between relieved zones e^2 will extend longitudinally at the outer side of the bent tube in conformity with the longitudinal curvature desired in the leading edge of the blade, so that zone d^2 of full wall-thickness used in the trailing edge of the blade will be disposed along the inner curve of the bend; and the relieved zones e^2 will be disposed in the intermediate portions of the blank used in forming the airfoil faces of the blade.

Next, the tubular blank is shaped in a press comprising dies g, g^1, to simultaneously form suction face l^1 and pressure face l with a seamless leading edge l^6 and flat portions l^3 for use in producing the trailing edge. The die g is provided with a cavity g^2 conforming to the contour desired for the pressure face l of the blade and die g^1 is provided with a cavity g^3 conforming to the contour desired for the suction face l^1 of the blade. These cavities are also shaped so that they will bend transversely the portion d^1 of full wall-thickness between the sides e^3 of relieved zones e^2 into a seamless curved leading edge l^6 between the airfoil faces l, l^1. These dies are also provided with faces g^4 for flattening the marginal portions l^3 of the blank and its outer end into abutting relation outside of the curved margins e^4 of the relieved zones e^2. The blank is heated to a suitable temperature during this shaping operation and while predetermined hydraulic pressure is maintained in the tubular blank. This shaping operation will impart to the blank the cross-sectional shape illustrated in Figs. 7 and 8. The hydraulic internal pressure maintained in the blank will cause the outer faces of the face-sections of the tubular blank to conform to the cavities g^2, g^3 in dies g, g^1, respectively, so that their outer faces will be symmetrical and the irregularities resulting from relieving the zones e^2 from the tubular blank will be transferred to the inner faces thereof.

The inner margins of the flattened portions l^3 of the blank are then passed between resistance welding rolls h, as illustrated in Fig. 9 to autogenously weld together the inner faces of said flattened portions for a trailing edge conformably to and outside of the curved margins e^4 of the relieved zones e^2. The zone of weld is indicated at l^4 in Fig. 10. The welding rolls are subjected to pressure and autogenously unite the flattened portions by resistance-welding along the curved margins of relieved zones e^2 and around the tip of the blade. The weld is made between zones d^2 of greater wall-thickness. The weld is also made inwardly of the fold which joins the flat portions l^3 of the blank. An important resultant advantage of welding the flattened portions together before their connected portions are trimmed from the blank, and inwardly of the fold, is that arcing between the welding rolls, which is likely to burn the metal, is prevented.

Next, the blank is cut or sawed off through the flattened portions l^3 conformably to the curvature of the trailing edge and tip desired, as illustrated in Fig. 10, to completely sever from the shaped blank the unnecessary flat portions to locate the center of pressure at all sections of the blade substantially coincident with the longitudinal center of the blade for maximum blade

efficiency. The closure-plate f^1 which is welded to the outer end of the blank is cut off with the trim.

Next the trailing edges of the face-sections are finished to conform to the cross-sectional airfoil shape of the faces l, l^1, as illustrated in Fig. 11. The entire blade is then polished and finished to provide smooth faces and edges. The finished blade is then nitrided to give the metal the desired hardness after wear and strength.

The invention exemplifies a method of making hollow steel propeller blades from tubular blanks in which the face-sections of the blank are simultaneously shaped to airfoil contour and the marginal portions are flattened for forming the trailing edge of the blade, which avoids the necessity of repeatedly heating the blank when these steps are successively performed.

The invention also exemplifies a method in which the welding for the trailing edge is performed before the blank is trimmed to remove the fold along the margin used for forming the trailing edge and this makes it possible to join the flattened portions by resistance-welding without arcing between the welding rolls which may result in burning the metal.

The invention is not to be understood as restricted to the details set forth, since these may be modified within the scope of the appended claims, without departing from the spirit and scope of the invention.

Having thus described the invention, what I claim as new and desire to secure by Letters Patent is:

1. That improvement in the manufacture of hollow propeller blades from a tubular steel blank which comprises shaping one end portion of the blank to form a shank, axially bending the other portion of the blank while it is tubular so that the outer side of the bend will be curved to conform substantially to the longitudinal curvature of the leading edge desired, pressing the curved tubular portion into face-sections of cross-sectional airfoil contour with a seamless leading edge along the outer side of the bend, flattening the opposite side portion of the blank upon itself along a line conforming to the trailing edge desired to form two layers with a connecting fold between them, welding together the two layers by current flowing between electrodes and across the layers inwardly of the fold and along the line of the trailing edge desired, trimming off the layers and the fold outwardly of the weld, and shaping the margin of the welded layers to conform to the airfoil faces.

2. That improvement in the manufacture of hollow propeller blades from a tubular steel blank which comprises shaping one end portion of the blank to form a shank, axially bending the other portion of the blank while it is tubular so that the outer side of the bend will be curved to conform substantially to the longitudinal curvature of the leading edge desired, pressing the curved tubular portion into face-sections of cross-sectional airfoil contour with a seamless leading edge along the outer side of the bend while the blank is subjected to internal fluid pressure and flattening, silultaneously with said pressing, the opposite side portion of the blank upon itself along a line conforming to the trailing edge desired to form two layers with a connecting fold between them, welding together the two layers by current flowing between electrodes and across the two layers inwardly of the fold and along the line of the trailing edge desired, trimming off the layers and the fold outwardly of the zone of the weld, and shaping the margin of the welded layers to conform to the airfoil faces.

3. That improvement in the manufacture of hollow propeller blades from a tubular steel blank which comprises shaping one end portion of the blank to form a shank, closing the blank so it will hold fluid under pressure, axially bending, while the blank is subjected to internal fluid pressure, the other portion of the blank while it is tubular so that the outer side of the bend will be curved to conform substantially to the longitudinal curvature of the leading edge desired, pressing the curved tubular portion into face-sections of cross-sectional airfoil contour with a seamless leading edge along the outer side of the bend while the blank is subjected to internal fluid pressure, flattening the opposite side portion of the blank upon itself along a line conforming to the trailing edge desired to form two layers with a connecting fold between them, welding together the two layers by current flowing between electrodes and across the layers inwardly of the fold and along the line of the trailing edge desired, trimming off the layers and fold outwardly of the weld and shaping the margin of the welded layers to conform to the airfoil faces.

4. That improvement in the manufacture of hollow propeller blades from a tubular steel blank which comprises shaping one end portion of the blank to form a shank, cutting away zones of metal of blade face profile from opposite sides of the other portion of the blank while it is tubular to vary the wall thickness in the finished blade and leaving zones of greater thickness between the cut-away zones for use in the leading and trailing edges, axially bending said other portion of the blank while it is tubular so that the outer side of the bend with a zone of greater thickness will be curved to conform substantially to the longitudinal curvature of the leading edge desired, pressing the curved tubular portion into face-sections of cross-sectional airfoil contour with a seamless leading edge of greater thickness along the outer side of the bend, flattening the other zone of greater thickness on the opposite side portion of the blank upon itself along a line conforming to the trailing edge desired to form two layers, welding together the two layers along the line of the trailing edge desired, trimming off the layers outwardly of the zone of the weld, and shaping the margin of the welded layers to conform to the airfoil faces.

GLEN T. LAMPTON.