June 16, 1936. A. A. HANDLER 2,044,294

PROPELLER

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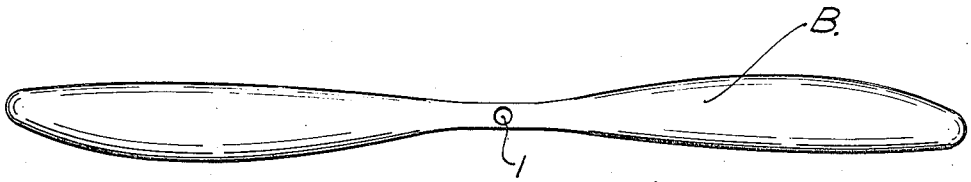


Fig. 2

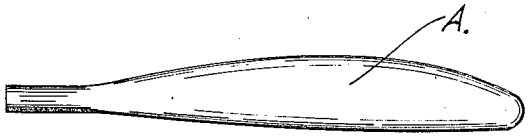


Fig. 1

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PROPELLER

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18 Claims. (Cl. 170—159)

This invention relates to the art of propellers and involves primarily the provision of metallic propellers having novel qualities and properties.

Heretofore propeller manufacturing operations ordinarily included, as an essential step, the working of either an ingot or billet into the general shape of a propeller by hammer forging. This metal working method provides a product which is inherently characterized by certain undesirable features. The working comprises a series of impact blows which affect the metal being worked in two distinctive ways. The metal directly beneath the hammer is compressed and spread out to some extent while the metal at the edges of the hammer is sheared. At the shear line edges or ridges are formed which must be worked down into the remainder of the metal by subsequent forging operations but the elimination of the ridges does not entirely obviate the effect of their presence. A study of the flow lines in the finished product will make this apparent. A flow line in a wrought metal bears a certain relation to fiber in wood and the term "fiber" has come into quite common usage in the wrought metal field. It has been defined as a condition of parallelism of lines or structural details and may frequently be found in any wrought metal. On visual examination it may show itself through undissolved constituents, segregations, or non-metallic inclusions. Grains may quite often be found to be elongated in the direction of the fiber, and the fiber will parallel the direction of the previous working.

Fiber, or flow lines, as I have mentioned, may sometimes be visible to the unaided eye when a specimen of wrought metal is deeply etched, or may be apparent only on microscopic examination. Going even further certain types of flow lines caused by preferred orientations of crystal axes are only distinguishable by X-ray analyses.

As above mentioned, the flow lines formed at the edges of the hammer dies may subsequently be worked into the product in irregular and undesirable configurations. Some of the lines terminate at the surface of the metal which condition tends to weaken the final product. Moreover, the flow lines created under the hammering action take no definite order or arrangement. Hence, there is no uniformity or constancy in products turned out in accordance with the prior methods. Any further working of the metal in the form of propeller shaping operations does not affect the flow lines to any appreciable extent nor obviate the undesirable features noted.

A laminated structure is sometimes evident as a part of the flow line arrangement and is of the same disorderly nature as the latter. These laminations also appear at the surface of the metal, and, as in the case of the flow lines make the product undesirable. The presence of the laminated structure is attributed to the presence of voids, dross, impurities, uncombined constituents of the alloy, and the like, which are always present, to at least some small degree, in the metal or alloy from which the propeller is made and which are flattened out by the hammering action to form the laminations.

At times the hammering out of the metal results in the concentration or localization of these voids, etc. transversely across the propeller and when the localized voids and the like occur at or near the surface of the metal, blistering of the latter results. In any event the localization of these defective features across the propeller is to be avoided to as great an extent as is feasible.

The hammer forging also creates a grain structure characterized by irregularly sized grains. Where the metal is unevenly or irregularly worked by the hammering, the change in grain size in the propeller is irregular and non-uniform throughout and areas of fine and coarse grains occur at various points in the propeller, the coarse grains at times occurring in wavelike bands extending transversely across the blade, thus causing areas or planes of weakness. These bands of coarse grains arise during the heat treatment of the articles due to grain size contrasts. In the initial working of the billet or ingot by the forging hammer, the metal is worked substantially uniformly throughout small individual areas, and non-uniformly in consecutive areas, creating relatively sharp lines of demarcation between portions of the metal which have been subjected to different degrees of working. Since the size of the grains in the metal is dependent upon the amount of working to which it has been subject, a greater amount of working producing smaller grains, the resulting product contains a series of lines at which different sized grains are in juxtaposition.

When the shaping of the forged articles has been completed the articles are subjected to heat treatment to increase the hardness and tensile strength and to generally improve the physical characteristics of the metal. During the heat treatment, a phenomenon known as "grain growth" tends to take place, since the thermal stability of the metal would be increased by an increase in grain size. Where adjacent grains are uniform in size and similar in other respects,

there is a balanced condition with no opportunity for grain growth, since the grains all possess equal powers of orientation. Where grains of different sizes are in juxtaposition, however, the larger grains tend to assimilate, and to grow at the expense of the smaller grains. The greater the contrast in size of adjacent grains, the greater is the growth of the larger grains. Accordingly, in the forged structure previously described, the lines of demarcation between the areas which have been worked to different degrees constitute lines of relatively great grain size contrast resulting in excessive localized grain growth which greatly weakens the structure.

As an ingot begins to be worked down from the cast condition, and as its cross-sectional area decreases there will become apparent a refinement in the grain structure which will be proportional to the reduction of area. A microscopic examination, or even visual observation, will show that the metal is losing the indicia of the cast condition and is assuming the characteristics of wrought metal. The process is a gradual and progressive one.

With the foregoing factors in mind, this invention has as an object the provision of metallic propeller products in which the flow lines conform in direction to the contour of the propeller. Any laminations which may occur as a part of the flow line arrangement will of course take the direction of the latter, to wit, lengthwise of the propeller. When the laminations are so disposed any detrimental effects are largely nullified, at least so far as the stresses encountered in propeller service are concerned. It is also an object of this invention that the size of the grains of the metal or alloy constituting the propeller shall vary in a uniformly progressive manner throughout the propeller in accordance with the thickness of the latter and the amount of working received by the metal to reduce grain size contrast and decrease grain growth to a minimum. The instant invention also contemplates the substantial elimination of blistering of the metal and the localization of voids across the propeller.

The present invention also involves the proposition of providing double bladed as well as single bladed propellers in accordance with the above precepts. For a full and more complete understanding of the invention, reference may be had to the following description, and accompanying drawing, wherein:

Figure 1 is a plan view of a single bladed propeller made in accordance with this invention, and,

Figure 2 is a showing similar to Figure 1, but of a double bladed article.

By way of setting out a preferred specific embodiment of the invention a propeller that is designed for aeronautical purposes and made from an aluminum base alloy containing approximately ninety-four per cent aluminum, four and five-tenths per cent copper, seventy-five hundredths per cent manganese, and seventy-five hundredths per cent silicon, is herein described. It is to be clearly understood, however, that not only could other aluminum base alloys be employed with satisfactory results, but also the magnesium base alloys, as these alloys exhibit substantially the same properties and qualities as do the aluminum base alloys and are therefore particularly adapted for aircraft purposes. As other materials which may be availed of for propeller manufacture I note iron and steel, copper, and in alloy form such as brass and bronze, and nickel in combined form such as Monel metal. Emphasis is also placed on the fact that while propellers that are designed for operation in gaseous fluids are made the subject hereof, propellers intended for operation in other fluids such as water may be made within the purview of this invention.

Briefly describing a process which may be availed of to produce propellers having the desired properties, a billet or ingot of the aluminum base alloy is worked out into the general shape of a propeller by rolling out operations effected by forging rolls, which operate on the alloy while the latter is in a heated condition. The rolling out operations include one or more passes through the forging rolls depending on the extent of change required in the shape of the billet, and the apparatus employed. After the rolling the partially fashioned article is again heated and further shaped by operations which are hereinafter referred to as forging operations. The latter may include forging by dies, pressing, or other metal working operations involving the application of a deforming force under pressure. Subsequent to the rolling and forging operations the propeller is further subjected to processes including cleaning, sizing, and trimming. The article is then heat treated and finally finished by operations including polishing and trimming. Preferably the present propeller is produced in accordance with the method disclosed and claimed in my co-pending application Serial No. 387,017, filed August 19, 1929.

A single propeller blade, made as above set forth is shown in Figure 1 and designated A. This propeller has a grain structure that is defined by flow lines that conform in direction to the contour of the propeller. Such a flow line arrangement renders the propeller particularly resistant to the stresses encountered in service. As the flow lines assume a certain definite directional tendency a uniformity in products is obtained which is a feature of commercial importance.

Any laminations which may occur in the metal or alloy will constitute a part of the flow line arrangement and therefore take the order of the latter. Under this condition they are usually harmless as far as the stresses of propeller service are concerned. The product is consequently free from blisters or localized voids extending transversely across the blade.

The grain structure is characterized by the substantial absence of coarse grains and the fine grains vary in size in a uniformly progressive manner throughout the propeller in accordance with the thickness of the latter.

A double bladed propeller provided hereby is shown in Figure 2 and designated B. This propeller B is provided with a hub opening 1. The double bladed article is made in substantially the same way as the single blade, the billet being rolled from the hub portion outwardly towards the tips. The metal, of course, assumes the same properties and qualities as does the single blade.

What I claim is:

1. A metallic propeller consisting of a piece of metal in propeller shape and having flow lines conforming in direction to the contour of the propeller.

2. A propeller of the class described consisting of a piece of metal in propeller shape and having a grain structure in which the grains vary in size in a uniformly progressive manner.

3. A metallic propeller consisting of a piece of

metal in propeller form and having flow lines conforming in direction to the contour of the propeller, the flow lines including any laminations which may occur in the metal.

4. A propeller of the class described consisting of a piece of metal in propeller shape and having a grain structure in which the grains vary in size in a uniformly progressive manner, and in which the grains occur in flow lines conforming in direction to the contour of the metal.

5. A metallic propeller consisting of a piece of an aluminum base alloy in propeller shape and having flow lines conforming in direction to the contour of the propeller.

6. A propeller of the class described consisting of a piece of an aluminum base alloy in propeller shape and having a grain structure in which the grains vary in size in a uniformly progressive manner.

7. A propeller of the class described, comprising, in combination, integral hub and blade portions of a light metal base alloy, said alloy having flow lines conforming in direction to the contour of the propeller.

8. A double bladed propeller of the class described comprising integral hub and blade portions, said portions being formed from a piece of metal having a regular grain structure, said hub portion being formed with an opening.

9. A metallic screw propeller blade consisting of a single piece of metal, having a wrought metallic structure throughout and having flow lines conforming to the contour of the blade and a cross-sectional area decreasing gradually from the root portion to the tip portion and refined grains decreasing in size gradually with the cross-sectional area with a minimum of grain size contrast.

10. A metallic screw propeller consisting of a single piece of metal in the form of integral hub and blade portions having a wrought metallic structure throughout and having flow lines conforming to the contour of the blade and hub portions.

11. A metallic propeller consisting of a single piece of metal in the form of integral hub and blade portions having a wrought metallic structure throughout and having a refined grain structure with the grains decreasing in size gradually from the hub portion to the tip portion of the blade with a minimum of grain size contrast.

12. A metallic propeller blade consisting of a single piece of aluminum base alloy having a wrought structure throughout and having flow lines extending lengthwise of the blade and including any laminations which may occur in the metal.

13. A metallic propeller blade consisting of a single piece of aluminum base alloy having a wrought structure throughout and having a refined grain structure with the size of the grains decreasing gradually from the hub portion to the tip portion of the blade with a minimum of grain size contrast.

14. A metallic propeller blade consisting of a single piece of metal having a wrought metallic structure throughout and having flow lines extending longitudinally of the blade with any voids, dross or impurities which may occur in the metal arranged longitudinally of the blade and substantially parallel with the flow lines.

15. A double bladed propeller consisting of a piece of metal having a wrought structure throughout formed into a pair of blades and an integral hub portion, the metal of each blade having flow lines extending generally from the hub portion to the tip of the blade.

16. A double bladed propeller consisting of a single piece of aluminum base alloy having a wrought structure throughout and formed into integral hub and blade portions, the metal of the propeller having a refined grain structure and the size of the grains in each blade decreasing gradually with a minimum of grain size contrast from the hub portion to the tip of the blade.

17. A double bladed propeller consisting of a single piece of metal having a wrought metallic structure throughout and formed into integral hub and blade portions, the hub portion being formed with an opening and the metal in the hub and blade portions having flow lines conforming in direction to the contour of the said hub and blade portions.

18. An aeroplane propeller blade consisting of a single piece of light metal alloy wrought in the shape of a hub portion and an integral flattened blade portion decreasing in thickness from the hub to the tip and increasing in width from the hub to an intermediate point and then decreasing in width to the tip, the blade having a wrought metallic structure with flow lines conforming to the contour of the blade and a refined grain structure with the size of the grains decreasing gradually from the hub portion to the tip with a minimum of grain size contrast.

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