

Sept. 6, 1932.

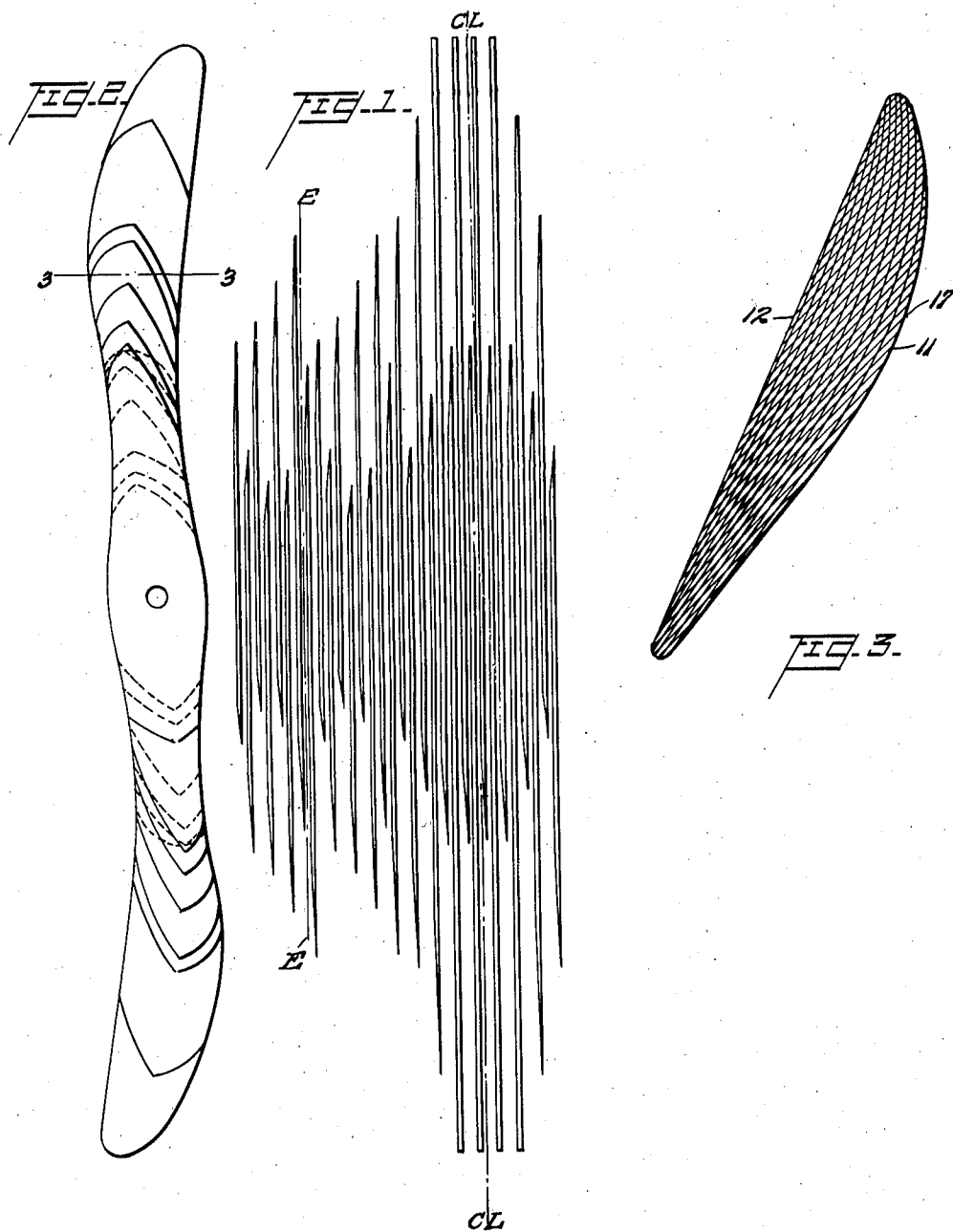
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1,875,597

PROPELLER

Filed Jan. 10, 1929

4 Sheets-Sheet 1



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4 Sheets-Sheet 2

FIG. 5.

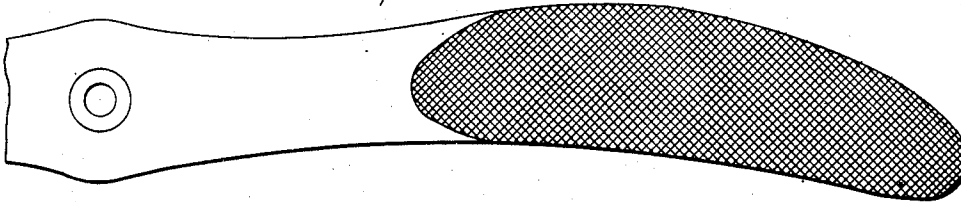


FIG. 8.

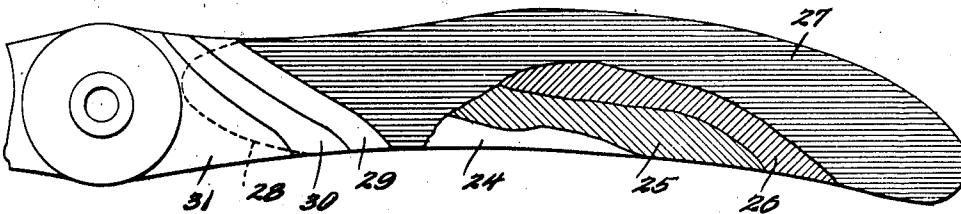
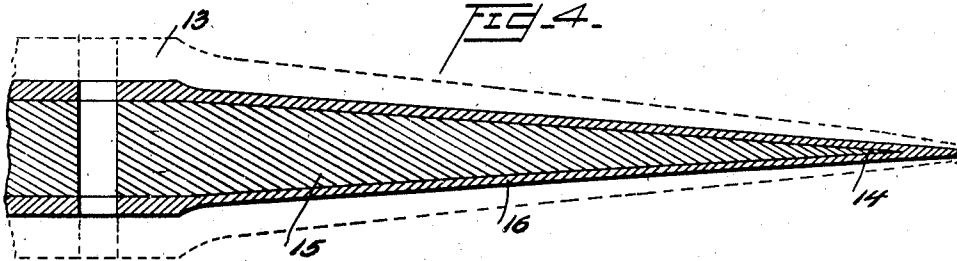


FIG. 4.



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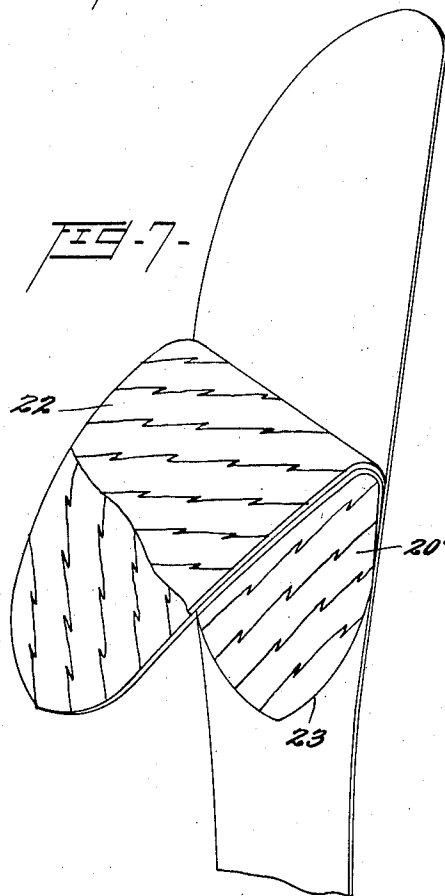
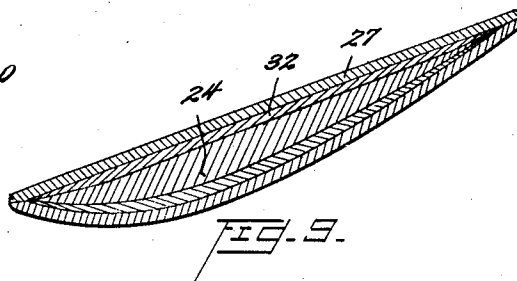
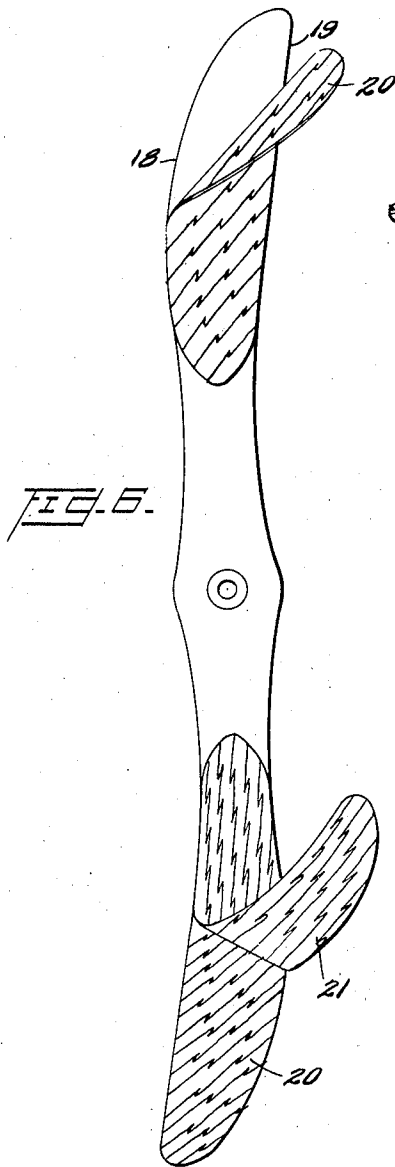
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4 Sheets-Sheet 3



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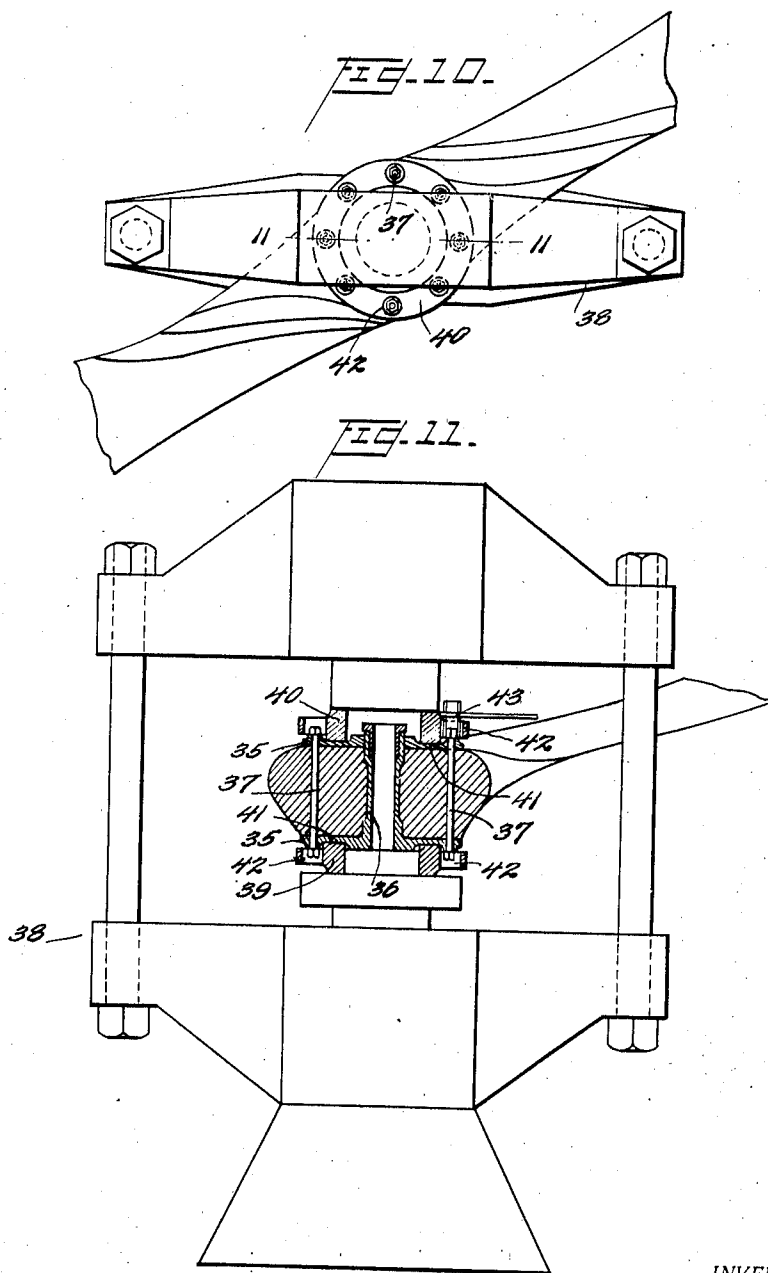
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PROPELLER

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PROPELLER

Application filed January 10, 1929. Serial No. 331,688.

This invention relates to propellers and more particularly to propellers for use on air craft and to methods of making such propellers.

It is a general object of the present invention to provide a novel propeller and a method of making such propeller.

More particularly, the invention, which is susceptible to various embodiments, includes the following features:

A. A method of arranging and building up laminae into a core for a propeller.

B. A method of compressing a propeller formed of fibrous material to form a finished core or finished propeller more highly compressed at points remote from the center than at the central portion.

C. A propeller having a core covered with diagonal reinforcing.

D. A propeller having a core covered with reinforcing material having its maximum strength at an angle less than a right angle to the length of the propeller.

E. The use of reinforcing covering material having greatest tensile strength in two directions, said directions of maximum strength being at an angle to each other and to the longitudinal axis of the propeller core.

F. A propeller having an outer skin to cover joints, add strength to the blade and to provide a smooth outer surface.

G. A propeller having a core and a covering or skin extending near to the hub thereof and a hub forming lamination covering the inner end of said skin.

H. The manner of assembling a propeller and hub plates in which that portion of the propeller between the plates is compressed to such an extent that no further shrinking from natural causes can take place to reduce the thickness of the material between the hub plates.

Other and further features and objects of the invention will be more apparent to those skilled in the art upon a consideration of the accompanying drawings and following specification, wherein are disclosed a number of progressive embodiments of the invention, which are susceptible of combination with each other. It is to be understood, however,

that such changes may be made in the article and method as disclosed as fall within the scope of the appended claims without departing from the spirit of the invention.

In said drawings:

Figure 1 is a side elevation of a group of laminae shown as arranged before gluing together to form a propeller core, the spacing between laminae being exaggerated for purposes of illustration;

Figure 2 is a face view of a core as fully assembled from laminae as shown in Fig. 1;

Figure 3 is a transverse section through one blade taken on the line 3—3 of Fig. 2;

Figure 4 is a side elevation of a propeller in initial and compressed positions, the drawing being simplified for the sake of illustration by leaving out the wind of the blade;

Figure 5 is a face view of a single blade of a propeller showing one manner of applying a double diagonal reinforcing thereto;

Figure 6, in the upper half, shows a completed core having reinforcing thereon and the lower portion of this figure shows an outer skin applied over such reinforcing;

Figure 7 shows a portion of a blade with double diagonal reinforcing;

Figure 8 is a face view of a completed propeller showing the double diagonal reinforcing, an outer skin and additional hub laminae;

Figure 9 is a transverse section through Figs. 6 or 8;

Figure 10 is a plan view of a press having a propeller in position therein; and

Figure 11 is a side elevation of the press with the propeller shown in vertical section on line 11—11 of Fig. 10.

The invention may be said briefly to include: first, a core, both broadly and with certain specific features of construction; second, a reinforcing material covering at least the blade portions of the core, which material is arranged with its direction of greatest fiber strength diagonal to the longitudinal axis of the propeller blades and is used either single or double, and where double is either in separate layers with the axes of greatest fiber strength divergent or has its fibers interwov-

en at divergent angles. The core in this condition or before reinforcing may be compressed in such a manner that it is reduced more in thickness toward the ends of the blades than at the hub. The core, either with
 5 or without but preferably with the reinforcing material, is then covered with an outer skin, the axis of which extends in the direction of the axis of the propeller. This skin
 10 extends well up to the hub where it is overlaid with supplementary laminæ to give the desired hub conformation. This skin may be omitted leaving the blade to consist entirely of the core and the reinforcing cover.
 15 The invention comprises not only the propeller but the method of making the core and assembling the propeller and of applying the hub plates thereto.

The core is preferably composed of thin
 20 laminæ individually tapered at edges and ends as shown in Fig. 1, so that a complete set when pressed in a mould will give blades of airfoil cross-sections without further surface carving. The laminæ are each extend-
 25 ed through and beyond the hub center to give the necessary thickness of hub and adjacent portions. The laminæ are so laid out that the grain of the wood in adjacent layers is crossed at an angle of ten to twenty degrees
 30 to give the core an interlaced fiber construction.

In the construction of cores from laminated material such as wood or other fibrous material, it is desirable that the laminations
 35 be formed and arranged symmetrically about a plane through the center thickness of the propeller and at right angles to the shaft axis. For convenience in manufacture the laminæ are prepared in sets of four.
 40 However, this arrangement, if followed to its logical conclusion, will not give a core of the most desirable form, since as shown in Fig. 3, one side or the working face of each blade is substantially flat, whereas the back
 45 of the airfoil section is curved quite materially. Referring to Fig. 1, it will be seen that the present invention contemplates the assembling of a plurality of blade laminæ extending alternately in opposite directions
 50 beyond the hub for a distance into the opposite blade, thus insuring that the center or hub portion will be thick, since it includes the material of all laminæ and the end portions will be of decreasing thickness since
 55 they include only half of the laminæ and near the ends only portions of a few of them. In Fig. 1 is disclosed a plurality of laminæ of varying lengths and alternately disposed up and down. If they were normally built
 60 up in sets of four about the center line shown in dot and dash lines and indicated by the initials CL, their disposition would be, on each side of the center line, as shown by the section between the center line and the line
 65 marked E so that there would be exact sym-

metry on each side of the center line. However, this would not satisfactorily produce a cross section as shown in Fig. 3 for the center laminations would have sudden changes
 70 in longitudinal curvature. To overcome the trouble those laminæ shown to the left of the line E have been removed from the right-hand side of the group, reversed and placed
 75 as shown so that they build up that portion of the core which will form the back or curved surface of the airfoil section near the hub. The relatively small number of laminæ of less than full length at the right-hand side of the full length laminæ can readily be
 80 compressed into the flat or working face 12 so that when the laminæ are all glued up and pressed they will form a blade of which Fig. 3 is a representative cross section, without
 85 depending upon compression of the material to obtain the desired form. The improved method therefore consists in building up laminæ symmetrically about a center plane in which the length, thickness and other dimensions of the laminæ are properly calculated to give a suitable cross sectional area
 90 to the resulting airfoil and then transposing from one side to the other of the group a sufficient number of these laminæ to give the airfoil of the finished product the desired cross sectional form without sudden changes
 95 of direction of the fibers of any lamination.

Fig. 2 shows clearly the appearance of a completed core after the laminæ arranged as in Fig. 1 have been glued up. This view is
 100 taken looking from the left in Fig. 1. It will be seen that the hub section is not quite complete in that it is not built up to the proper thickness nor to the right shape to receive the hub plates. The material for
 105 building up this portion is applied later, as will be described in connection with a further feature of the invention.

The core as just described may be glued up or otherwise secured together and provided with a cover, for instance of the types
 110 to be described in the latter part of this specification. The purpose of this cover is to reinforce and strengthen the surface and to seal down the edges of the laminæ ends to prevent ravelling and to enhance the appearance of the completed propeller. It is highly desirable that the form of the blades be as fine as possible so that they will slip
 115 through the air with the least possible resistance while yet retaining their true airfoil section. It is also desirable that a substantially thick center portion be provided to enable better attachment to the shaft and to add that necessary stiffness against bending
 120 when the blade is heavily loaded. It is desirable to compress the whole propeller or, in any case, to compress those portions forming and adjacent to the hub sufficiently that there can be no possible shrinkage of the hub
 125
 130

portion away from the engine flanges between which it is clamped.

To attain these various ends the present invention contemplates compressing the assembled propeller, or preferably only the core, in such a manner that the ratio of initial to final thickness is less at the hub than at the ends of the blades and increases along the length of the blade. In other words, the material is compressed less at the hub and in an increasing amount toward the ends of the blades, as clearly shown in Fig. 4, wherein the dotted lines indicate the initial thickness and the solid lines the final or compressed thickness. The blade has been shown for purpose of simplification as being straight rather than provided with the necessary twist or wind to give it the desired pitch. It will be seen that at the hub the portion 13, representing the amount of compression of one side, is less than half the thickness of the finished hub so that the propeller is shown compressed at the hub to a thickness roughly two-thirds of the initial thickness, whereas near the tip, as indicated at 14, the final thickness is roughly one-half of the initial thickness. The core proper is indicated at 15, and at 16 is indicated any suitable form of reinforcing or outer skin covering. It is to be understood that in order to retain the propeller in its compressed form that it may be treated with a suitable cementing material. Compressed wood will not swell up again unless steamed or soaked and the cementing material may well be water-proof to prevent wetting of the wood.

In the upper blade shown in Fig. 6, a core preferably of the type described previously, but of any suitable type, is shown as having applied thereto a reinforcing and protective layer, in this case a lamination of veneer in which the grain runs diagonally to the longitudinal axis of the propeller as clearly shown. The purpose of the diagonal grain is to reinforce the blade and tie the weakest portions thereof to the strongest. Referring to the section shown in Fig. 3, it will be seen that the strongest portion of the blade is along the portion indicated by the reference character 17, that is, near the leading edge which is indicated in Fig. 6 by the reference character 18. The trailing edge, indicated at 19, is quite thin as shown in Fig. 3, and becomes progressively thinner out along the blade so that near or at the tip it is the thinnest portion of the whole blade. It will be noted that the direction of the greatest strength, i. e. the axis of the grain of the reinforcing lamination, extends from this trailing tip 19 toward the thick heavier central section near the leading edge and thus strengthens the blade.

To protect the outer surface of a propeller formed of wood or similar material, it may be found advantageous to apply a layer or

layers of double diagonal reinforcing material which may be stronger than wood and more resistant to abrasion and as shown in Fig. 5 this may well be a wire netting or fabric of about the size say of fly screen, but formed of wire having a higher tensile strength. If the core is to be compressed as shown in Fig. 4, then this fabric may be laid in the molds at the time of compressing so that it is indented into the fibres of the laminae of the core and its upper surface becomes substantially flush with the outer surface of the core. It is held in position by the cementing material previously referred to which will exude between the wires and serve to form a smooth outer surface for the finished propeller which will bind the laminated fabric in position.

This form of construction not only reinforces the outer surface of the blade but gives it added strength against longitudinal stresses as well as transverse stresses. It is a further development of the single layer of diagonal grain. It comprises two layers of divergent diagonal fibres interlaced with each other.

In Fig. 7 is shown a form in which the two layers of diagonally arranged fibers are superposed and secured to both sides of the blade in such a manner that their axes of greatest strength are arranged substantially at right angles to each other, whereby the combined effect of the two layers is to impart not only added transverse strength, but added longitudinal strength to the blade as explained in connection with the interlaced fibers. One of the layers, of course, has the same effect as that indicated at 20 in Fig. 6, and is indicated by the reference character 20', whereas the other, indicated by the reference character 22, while of no particular assistance in connection with tying in the weak portion of the blade to the strongest portion, yet cooperates with the layer 20' to produce the added longitudinal strength desired.

In each of the previously described forms the reinforcing layer stops on easy curves 23 which merge into the surface of the propeller blade at some distance out beyond the hub, for at this point the blade is of sufficient thickness to provide all the desired strength.

As shown in the lower portion of Fig. 6, the blade is reinforced with the diagonally arranged lamination 20 as in the upper portion and this reinforcing is covered with an outer skin 21 preferably a thin veneer in which the grain extends longitudinally of the blade. This outer skin is for the purpose of producing a pleasing finish and further for giving additional strength longitudinally of the blade to resist centrifugal force and to prevent bending of the blade along its length.

In Fig. 8 is shown a blade built up over the core 24 of any suitable form and having

the inner reinforcing layer 25 with the grain arranged as described in connection with the upper portion of Fig. 6 to strengthen the weak edges. Over this is applied the layer 26 with the grain at right angles to that in the layer 25 for the purpose described in connection with Fig. 7 and over this whole assembly is placed the outer skin or covering 27 comprising a lamination having the grain extending longitudinally of the blade. Its upper end reaches substantially to the hub as shown by the dotted lines at 28. It will be remembered that in connection with the description of the core it was pointed out that the center part was not built up to the required thickness and size by the laminæ in the original assembly and for this purpose additional hub section laminæ are applied as shown at 29, 30 and 31 in Fig. 8. These are applied after the skin 27 has been put in position so that they overlap its inner end 28 and insure that this end is firmly tied to the core. These laminæ build up the hub portion to a suitable shape to receive the engine hub plates formed of metal by which the propeller is attached to a shaft.

In Fig. 9 is shown a transverse cross section through the central portion of the blade such as shown in the lower part of Fig. 6 or in Fig. 8, wherein the core is indicated by the reference character 24, the reinforcing material, either of single or double type, by 32 and the outer skin by the reference character 27.

When the propeller is to be compressed as described in connection with Fig. 4, it is first completely assembled including the core, the reinforcing layer or layers and the outer skin and is then subjected to the compressing so that when removed from the mold, which gives it its final size and shape, it is ready for use, for the mold can be of sufficient smoothness to give its outer surface when coated with cement, a suitable final finish.

Hub plates 35 are adapted to be provided on either side of the central hub portion. One of these may conveniently have the central tube 36 integral therewith to project through an opening in the propeller to receive and center the opposite plate as shown. The propeller and the plates are drilled to receive bolts as at 37 to clamp the plates in position. They take a considerable portion of the driving torque and transmit it from the plates to the propeller hub, but some torque is transmitted by the frictional engagement of the plates with the faces of the propeller hub. It is highly desirable that the plates be tightly applied to the faces of the propeller before the nuts are tightened on the bolts and for this purpose in Figs. 10 and 11 the propeller has been shown as arranged between the anvil and plunger of a suitable press 38 with a ring 39 between the bottom hub plate and anvil and a ring 40 between the top hub plate

and the plunger, which rings rest in a circumferential channel 41 in these plates. Each ring-like member is perforated as at 42 for the passage of the bolts 37 and to permit the application of a wrench 43 to the nuts on the bolts. The hub portion is given a suitable compression by means of power applied to the plunger of the press to force the plates tightly against the material of the propeller and to somewhat compress it, after which the nuts on the bolts are tightened and the pressure removed from the hub plates. Much greater pressure can be applied to them than could be applied by tightening the bolts and they can be assured of having a parallel relationship. The bolts, however, easily hold the hub material in compression after it has been set. This compression of the hub between the engine flanges may be applied in addition to the compression given as explained in connection with Figure 4 or may be applied when there is no previous compression of the material of the propeller.

This feature overcomes one of the serious objections to propellers formed of fibrous materials. They have been known to loosen often because of shrinkage of the material or from improperly tightened bolts. If such looseness is not immediately detected and remedied by tightening the bolts, the propeller becomes driven mainly by the pressure of the bolts on the sides of the holes which become rapidly enlarged or elongated. Much vibration may occur and the propeller may become unfit for use or more serious trouble result. By pre-compressing the material, preferably beyond its elastic limit, and then tightening the bolts, it is assured that no further shrinkage will take place and the bolts will remain tight.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. In a propeller, in combination, a core of compressed fibrous material, the density of which differs in various portions so that the ratio of initial to final size is least at the hub.

2. In a propeller, in combination, a core of compressed fibrous material, the density of which differs in various portions so that the ratio of initial to final size is least at the hub, and progressively increases to the tips of the blades.

3. In a propeller, a blade of fibrous material compressed unequally throughout its length.

4. In a propeller, a blade of fibrous material compressed unequally throughout the extent of one of its major dimensions.

5. In a propeller, in combination, a blade having a core of fibrous material compressed unequally throughout its length and a reinforcing covering having its direction of

greatest fiber strength extending diagonally to the axis of the blade.

6. A propeller having a core of fibrous material and wire screen reinforcing the blade surfaces thereof.

7. A propeller having a core composed of compressed fibrous material, cementing material for said core and a layer of metal fabric covering a blade face and embedded in said cementing material.

8. A propeller having a core composed of fibrous material and a sheet of woven metal fabric pressed into the fibers of a surface of said core.

9. In a propeller, in combination, a core having blades and a hub, an outer skin covering the surfaces of the blades, said skin having inner ends near said hub, and a lamination secured to each face of the hub and overlapping the inner ends of said skin.

10. In a propeller, in combination, a core having a hub of less than the desired finished thickness and blades, a layer of material applied to each surface of each blade and extending near to the hub and laminations secured to the faces of the hub to increase its thickness, said laminations extending over the surface of said layers.

11. A propeller having a central portion, a hub plate on each side of said central portion, means passing through the propeller retaining said plates against said central portion, the material of said central portion being precompressed to prevent subsequent shrinkage.

12. The method of preventing loosening of a wood propeller from its hub plates comprising compressing the wood between said plates beyond the elastic limit and then securing the plates together.

13. The method of assembling a propeller and hub structure comprising applying a hub plate to each side of the propeller hub, mounting the assembly in a press, compressing the material of the propeller by pressure on the plates until its thickness is reduced to less than that possible by natural shrinkage and securing the plates together in their compressed position.

14. A core for a two bladed propeller comprising a plurality of preformed laminæ of different sizes, there being four of each size, each set of four down to a certain size being symmetrically disposed about the axis and median plane of the propeller and the remaining sets being all on one side of the median plane.

15. The method of making a propeller core consisting in forming a plurality of sets of laminæ of different sizes, assembling said laminæ with the members of some of the sets symmetrically disposed about the median plane and applying the other sets all to one side of said plane.

16. In a propeller, in combination, a core

formed of laminæ, pre-shaped and tapered to produce substantially the desired airfoil section without carving, said core being compressed after assembly in order to reduce its original section.

17. In a propeller, in combination, a core formed of laminæ adhesively secured together, said laminæ being pre-shaped and tapered to produce a core of substantially the desired airfoil section without carving, said core being compressed after assembly to reduce but still maintain the airfoil section.

18. A propeller formed of compressed, pre-formed and tapered laminæ.

19. The method of making a propeller comprising compressing a core of pre-shaped and tapered laminæ to reduce the cross-sectional area of the blades and produce a fine airfoil section.

20. The method of making a propeller comprising compressing a core of pre-shaped and tapered laminæ to reduce the cross-sectional area of the blades while retaining substantially the original shape of cross section.

In testimony whereof I hereunto affix my signature.

SPENCER HEATH.

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