

June 6, 1944.

G. L. FREEDMAN ET AL

2,350,345

PROPELLER

Filed March 27, 1939

3 Sheets-Sheet 1

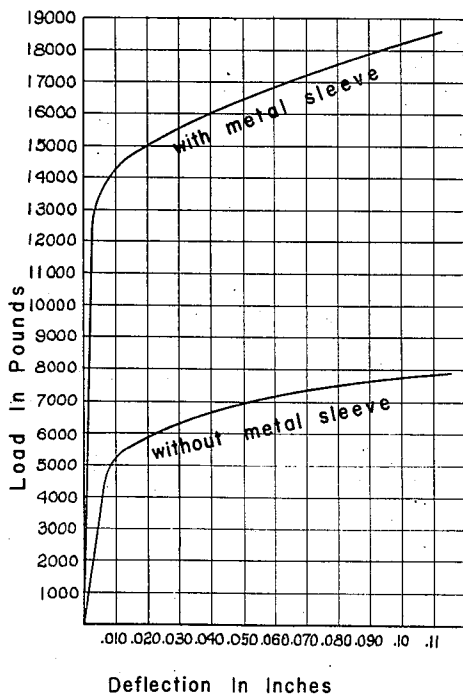
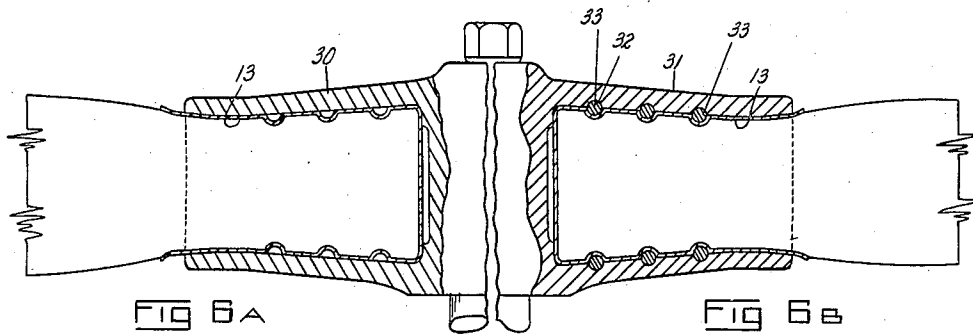


FIG 5

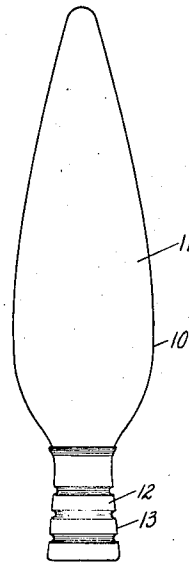


FIG 1

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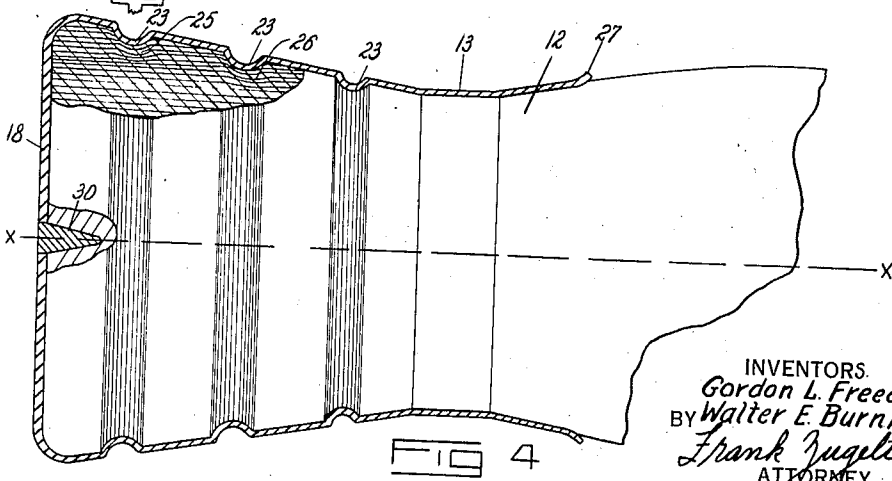
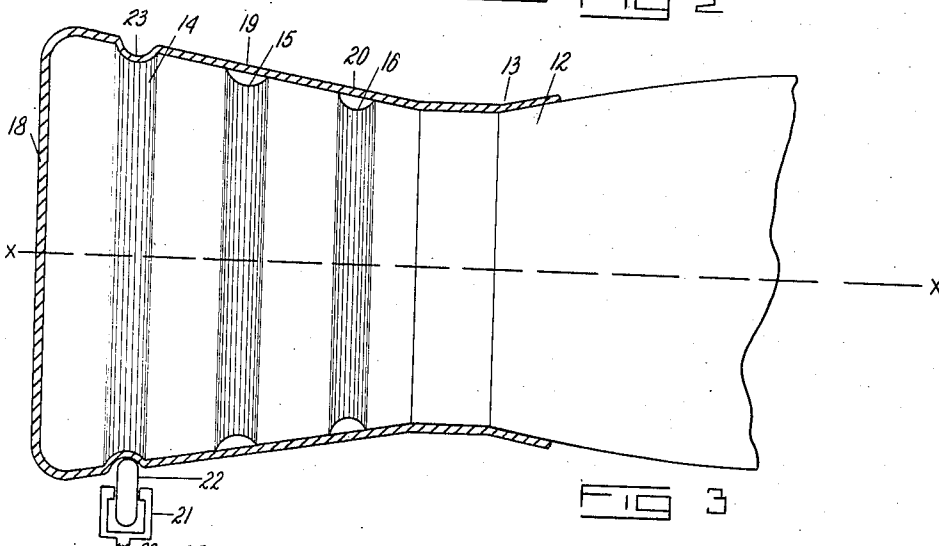
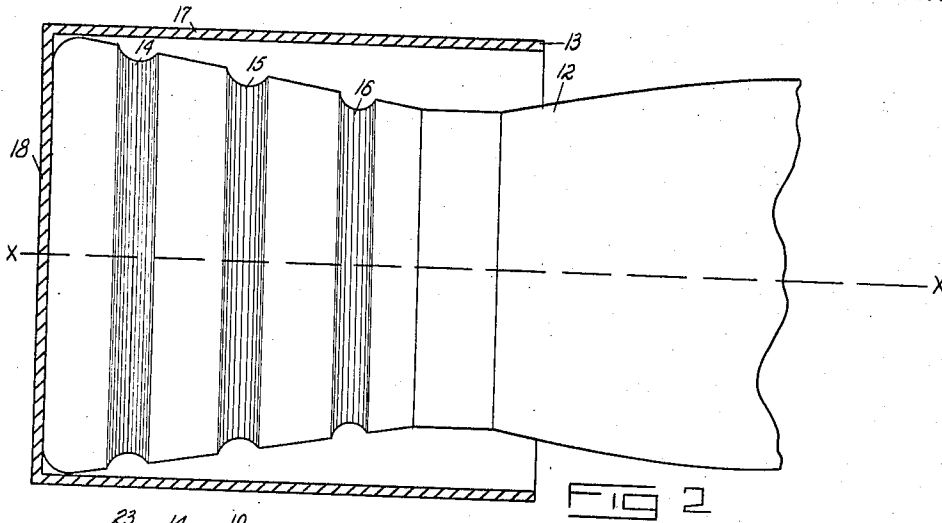
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3 Sheets-Sheet 2



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PROPELLER

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3 Sheets-Sheet 3

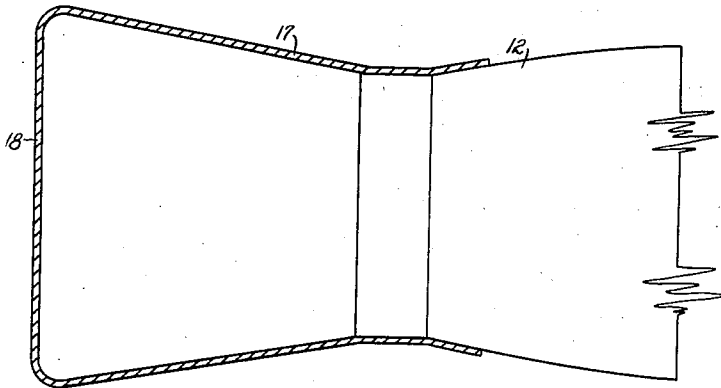


FIG 7

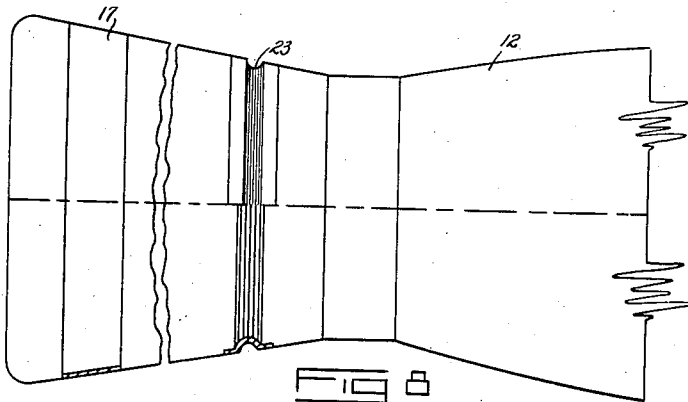


FIG 8

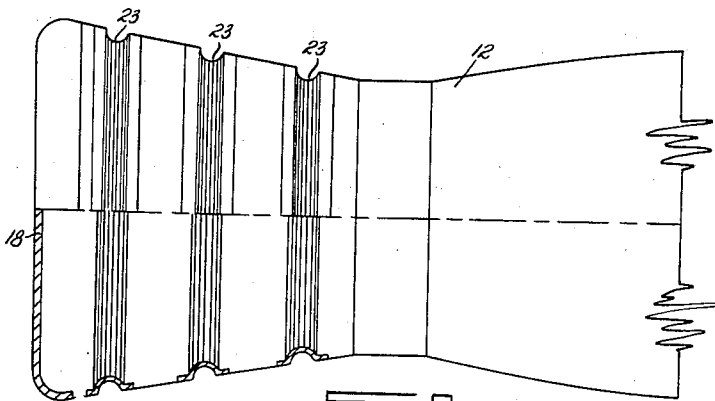


FIG 9

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# UNITED STATES PATENT OFFICE

2,350,345

## PROPELLER

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14 Claims. (Cl. 170—173)

This invention relates to propellers, and more particularly to non-metallic propellers, the shanks of which are encased in a metallic sleeve.

The primary object of the present invention is to provide a metallic sleeve on the shank of a non-metallic propeller to increase the centrifugal force strength of the non-metallic shank.

Another object of the invention is to provide means upon the shank of a non-metallic propeller which will effectively hold said shank within a hub and greatly reduce the blade deflection incident with increased loads.

A further object of the invention is to provide by simple and inexpensive means a method of strengthening the shank portion of a non-metallic propeller.

Still a further object of the invention is to teach a method of securing a metallic sleeve to the shank or butt end of a non-metallic propeller without cutting away or undermining the root of said propeller with radially disposed incisions or anchorage cuts.

As the power and size of aeroplane motors has been increased the need for better and stronger propellers has been keenly felt by the aviation industry. Modern science has produced motors of great horsepower which weigh no more than the older, less powerful motors. With the advent of the powerful, higher speed motors, the stresses and strains placed upon the propeller have likewise increased.

Although weight is an important factor, the aviation industry has been forced to use heavy, expensive metal propellers in preference to the lighter, cheaper, non-metallic propellers. This has been primarily due to the fact that the shank portions of said non-metallic propellers have heretofore been too weak and would fail under load, although the blade portion of said propellers had ample strength.

The present invention teaches how the shank portions of non-metallic propellers may be strengthened whereby all parts and sections of the propeller not only have the same strength, but how to increase the centrifugal force strength of said shank whereby to greatly exceed the centrifugal force strength of the blade portion.

These and other objects are attained by the means described herein and disclosed in the accompanying drawings, in which:

Fig. 1 is a side elevation of a propeller made in accordance with the teachings of the present invention.

Figs. 2 to 4 inclusive, are enlarged detail views, partly in section, of the shank portion of the propeller of Fig. 1, showing various steps followed in practicing the invention.

Fig. 5 is a load-deflection graph showing the comparative deflection of a blade equipped with the present invention as against one not so equipped.

Fig. 6A is a side view of a split hub and blade comprising the invention, having parts broken away for clarity of detail.

Fig. 6B is a view similar to Fig. 6A except that a modified form of hub is shown.

Fig. 7 is a detail view, partly in section, of a modified form of propeller shank with a metallic sleeve swaged thereon.

Fig. 8 is a detail view, partly in section, of a propeller shank provided with a plurality of spaced circumscribing bands or sleeves swaged onto the shank.

Fig. 9 is a detail view, partly in section, of the shank portion of the propeller of Fig. 1, showing a plurality of spaced annular sleeves swaged into the annular grooves in lieu of the one-piece sleeve of Fig. 1.

As shown in Fig. 1, a standard non-metallic propeller 10 comprises blade portion 11 and shank or butt portion 12 is equipped with a metallic sleeve 13 in accordance with the teaching of the present invention.

In practicing the invention, the preferred sequence of steps to be followed is herein set forth:

The shank or butt portion 12 of a non-metallic propeller, preferably of a compressible substance such as wood or the like, is turned down and finished off to proper size for cooperation with a given hub. It is preferable to impregnate said shank with a suitable resinous compound such as a polymerizable phenol formaldehyde as is the custom in the art, to render said shank impervious to moisture.

A shank so prepared and shaped to proper hub size is then provided with one or more annular grooves as 14, 15 and 16, as clearly shown in Fig. 2. The number of grooves in any given shank is dependent upon the size and qualifications of any given blade, and likewise the depth and width of each individual groove is a computed value for each propeller. By way of example, the number of annular grooves for a 40 H. P. adjustable blade comprising alternate laminations of birch and mahogany is three. The number of grooves and relative size thereof should, for proper results, be computed for

each blade so that the shear stresses and crushing stresses will be equal under load. This ratio is familiar to and easily computed by aeronautical engineers.

A one-piece metallic cup 13 comprising a cylindrical side wall 17 closed at one end as at 18 is adapted to be slipped over the prepared non-metallic shank as clearly disclosed in Fig. 2. Highly satisfactory results have been obtained from cups made from deep drawn, low carbon steel, which because of its low carbon content, is particularly adapted and suited to be worked and drawn.

It is highly desirable to dip or otherwise coat grooved shank 12 with a suitable polymeric plastic and/or polymeric adhesive compound such as phenol formaldehyde, before slipping cup 13 in place over shank 12 for reasons hereinafter more fully set forth.

It should be understood that if desired, the shaping of the blade portion 11 may be postponed until after the sleeve swaging operation has been completed, although a sleeve may be easily swaged onto the shank of a completed blade.

The propeller, including cup 13 on shank 12 is then mounted between suitable centers of a turning machine, such as a lathe, whereby said shank is adapted to be rotated about a suitable axis as X-X. The assembly is rotated by any suitable means such as a face plate having suitable power transmitting shank engaging means, not shown.

Cup or sleeve 13 is swaged or compressed, by means of suitable tools, not shown, onto and into intimate contact with the outer perimeter of shank 12 as shown in Fig. 3, so that the metal of cup 13 bridges over the annular grooves, as at 19 and 20. By proper application of pressure via swaging tools, non-metallic shank 12 is compressed somewhat by said metallic sleeve.

The metal bridging over these grooves is then forced into said grooves by means of a suitable tool 21 having a roller 22 of such design as to cause the metal to completely fill said groove as at 23.

The wood fibers beneath and adjacent said grooves are compressed as clearly shown in Fig. 4 at 25 and 26 by this operation. The degree of compression is not arbitrarily determined but should be computed in order that the wood fibers are not crushed or broken during the swaging operation. Broken fibers would destroy the strength of said non-metallic shank. Sleeve 13 is securely anchored to shank 12 by means of said grooves whereby the tendency for said sleeve to be laterally separated from said shank is reduced to a minimum.

Those portions of the sleeve 13 intermediate said annular grooves are then further swaged onto the shank 12 whereby the degree of compression throughout the shank is substantially uniform. However, it may be desirable to reduce the degree of compression near the inner end 27, of sleeve 13, (Fig. 4) so as to reduce the stress at that portion of the blade. This may be accomplished by terminating the end of said sleeve as at 27, externally of said shank, as shown.

The heat generated by the swaging process is usually sufficient to liquefy the phenol formaldehyde impregnating compound whereby said fluid will thoroughly fill every infinitesimal fiber of wood and each and every space between the wood and metal.

After sleeve 13 has been swaged onto shank 12,

the sleeve encased shank may be placed in a suitable heating chamber or retort for inducing substantially complete polymerization of the phenol impregnating compound whereby added strength is given to the wooden shank. This process hardens and likewise positively seals the fibers of the non-metallic portion of the metallic encased shank against moisture whereby said shank is not affected by climatic changes or conditions but is entirely unaffected thereby. This makes it possible and practical to fit propeller shanks more closely to and within hubs since such a metal encased shank will neither expand nor contract due to climatic conditions.

The opening through sleeve end 18 through which the face plate center and suitable power transmitting shank engaging means extended, during the turning operation, may be sealed and closed by any suitable means, such as a plug 30, Fig. 4, adapted to completely fill said openings. If desired, the outer surface of said plug may be soldered to end 18 of said sleeve.

Fig. 5 graphically illustrates how the deflection of identical 40 H. P. adjustable blades, was effected by a metallic shank made in accordance with the teachings of the present invention. Deflection, as here used, is the amount the blades slip out of the hub as the load increases. The so-called "yield point" is not reached until a blade has slipped out of the hub .01 of an inch and then continues to slip out as the load is greatly increased. Calculations and tests indicate that an unsleeved blade would pull out of the hub at about 10,000 pound load, whereas a sleeved blade of identical size, H. P. etc., would withstand a 50,000 pound load. The strength of the sleeved blade over that of the unsleeved blade, is believed to be due to the fact that the shear and crushing stresses of the shanks are greatly increased by reason of impregnation and compressing the wood, as hereinabove set forth.

It should be noted that a propeller having a sleeve encased shank 13 does not require a special hub. As clearly shown in Fig. 6A, hub 30 is of the same type and construction as used for an unsleeved shank of a blade of similar size H. P.

In the modified type of hub 31, disclosed in Fig. 6B, a plurality of annular grooves 32 are provided in alignment with the rings disposed annularly of shank 13 whereby to accommodate suitable snap rings as 33 which cooperate to further anchor said shank within said hub.

If desired, suitable shank groove engaging means such as lugs may be formed integral with the hubs in lieu of the snap rings 33 for increasing the anchorage of said shanks within said hubs.

It should be noted that no appreciable amount of material is removed from the non-metallic shank for the purpose of providing anchorage means between said shank and metallic sleeve, whereby the fibers of the wooden shank remain solid, unbroken and intact whereby the inherent strength thereof is not diminished.

From the foregoing, it is apparent that we have provided a non-metallic propeller having a shank the strength of which is equal to or greater than the blade strength by reason of a metal sleeve being swaged thereon. This permits the use of lighter, less expensive non-metallic blades in all those instances where the shear stress of the blade portion of a given propeller is sufficient for a given installation, but in which instance wooded blades have been rendered useless and unsafe because of shank stress failures

or because the shanks of said wooden blades would pull out from the hubs at comparative low loads.

It should be understood that by reason of the manner in which the annular grooves 14, 15, and 16 are calculated and provided in the non-metallic shank 12, that even a metallic sleeve which is not impressed upon said shank intermediate the grooves, will greatly increase the strength of such a non-metallic shank. Such a metallic sleeve can be secured to shank 12 by compressing and imbedding said sleeve into the grooved portion of said shank.

It should be further understood that the strength of a non-metallic shank may likewise be greatly increased by swaging a metallic sleeve thereon in those instances where annular grooves are not provided circumscribing said non-metallic shank; Fig. 7, said sleeve being secured to said shank by reason of being tightly swaged thereon.

Likewise, the present invention contemplates the use of more than one sleeve on a single shank in lieu of a single sleeve as hereinafter described, as illustrated in Fig. 8. This includes the provision of swaging one or more metallic bands onto a shank at spaced intervals, such as at each annular groove 14, 15 and 16. Likewise, the present invention contemplates the use of a short metallic closed-end sleeve being swaged onto the end of a shank and metallic bands swaged into the shank grooves, as illustrated in Fig. 9.

In the preferred embodiment of our invention, we utilize a sleeve having a closed end 18 formed integral therewith. End 18 acts as a bulkhead to increase the section properties of the shank end which increases the strength thereof. Likewise end plate 18 increases the crushing stresses of said shank end which thereby greatly lessens blade slippage as indicated by the graph, Fig. 5. However, the present invention also contemplates the use of an open ended cylinder which may be swaged into the lateral shank faces, the butt end of which may be sealed after the swaging operation by means of a suitable metallic or non-metallic plate, or such butt end may be left open, although such practice would not be feasible from a practical standpoint.

It is to be understood that various modifications and changes in the structural details of the device may be made, within the scope of the appended claims, without departing from the spirit of the invention.

It has been found by experiment that by swaging the metal sleeve 13 until its outside diameter is the proper size to cooperate with and snugly fit within the hub to which the wooden shank 12 was originally fitted that a satisfactory degree of compression is placed upon said wooden shank. If a more exact degree of compression is required, it may be easily computed by determining the ratios of compressibility of the wooden shank and metallic sleeve and by then determining by what amount the initial diameters would have to be reduced or compressed in order to produce the desired degree of compression.

What is claimed is:

1. The method of providing a metallic sleeve for the shank portion of a non-metallic propeller which comprises the steps of turning and finishing a non-metallic shank, of initially providing one or more individual annular grooves circumferentially of said shank, of introducing a one-piece metallic cup, closed at one end over said

shank, of comprising said cup into intimate contact with said shank throughout substantially its entire length and of further anchoring said cup to said shank by forming grooves in said cup by comprising portions thereof into said shank grooves, whereby the overall centrifugal force strength of said propeller is increased.

2. The method of increasing the centrifugal force strength of a nonmetallic propeller shank which comprises the steps of compressing said nonmetallic shank by swaging thereon a metallic sleeve, the degree of shank compression being reduced adjacent the blade portion of said non-metallic propeller for gradually reducing the stresses at that portion of the nonmetallic shank where said metallic sleeve terminates.

3. The method of providing a metallic sleeve on the shank of a non-metallic propeller which comprises the steps of initially providing an annular groove circumferentially of said shank, of coating said shank with a polymeric impregnating compound, of compressing the non-metallic material comprising said shank by compressing a metallic sleeve into intimate contact with said shank, and of further anchoring said sleeve to said shank by compressing portions of said sleeve into the shank groove, and of then heat treating the compressed, sleeved shank to produce substantially complete polymerization of said impregnating compound whereby the shank is hardened, fixed against subsequent expansion and contraction, and rendered permanently impervious to moisture.

4. The method of providing a metallic sleeve upon the shank of a compressible non-metallic propeller blade which comprises the steps of first turning said shank down to a predetermined size, then introducing an oversized cylindrical metallic sleeve over said shank, then permanently securing said sleeve to said shank by compressing said sleeve into intimate contact with the shank throughout substantially its entire length whereby said shank is reduced to a predetermined size, the degree of reduction in shank size being limited and determined by the ability of the shank to withstand compressive forces without permanent injury.

5. The method of providing a metallic sleeve for the shank of a compressible fibrous non-metallic propeller blade and of simultaneously increasing the centrifugal force strength of the shank, which comprises the steps of turning and finishing the shank, then impregnating said shank with a polymeric impregnating compound, then introducing a metallic sleeve over said impregnated shank, then permanently anchoring said sleeve onto the shank by compressing said sleeve into intimate contact with the shank, said shank being compressed incident to said sleeve anchoring operation, and of then heat treating the sleeved shank for inducing substantially complete polymerization of the impregnating compound, whereby the fibers of the non-metallic shank are hardened, and fixed against subsequent contraction and expansion.

6. The method of hardening the fibers of a compressible non-metallic propeller shank against further distortion after being compressed by a metallic sleeve compressed into intimate contact therewith, which method comprises the step of impregnating the shank with a polymeric impregnating compound prior to being compressed by the sleeve, and of then heat treating the compressed, sleeved shank for inducing substantially complete polymerization of the im-

pregnating compound, whereby the fibers of the shank are hardened against further distortion and sealed against the effects of moisture.

7. A propeller comprising a nonmetallic blade and shank portion, a metallic sleeve encasing and permanently secured to said shank, said sleeve being compressed into intimate contact with the shank throughout substantially its entire length, and wherein the degree of compression is progressively reduced adjacent the blade portion for diminishing the stresses at that portion of said shank where said sleeve terminates.

8. The method of encasing the shank of a non-metallic propeller with a plurality of individual spaced metallic sleeves, which method comprises the steps of turning and finishing the nonmetallic shank, then introducing one or more individual metallic sleeves over said shank, then permanently securing said sleeves to said shank in spaced relationship by individually compressing each of said sleeves throughout substantially their entire length into intimate contact with said shank.

9. The method of hardening the fibers of a compressible nonmetallic propeller blade shank the fibers of which have been first impregnated with a polymerizable compound against further distortion after being compressed by a metallic sleeve mechanically shrunk onto and into intimate contact therewith, which comprises the step of heat treating the compressed sleeved shank for inducing substantially complete polymerization of said compound for hardening the fibers of the nonmetallic shank, and fixing them against subsequent contraction and expansion.

10. A propeller blade comprising a tapered non-metallic shank initially provided with one or more individual annular grooves spaced along its length, a metallic sleeve encasing and permanently engaging said shank, said sleeve being mechanically shrunk onto and into intimate contact with said shank throughout substantially its entire length and into said annular grooves, each of said grooves being so proportioned that the shear stresses and the crushing stresses of said shank will be substantially equal when said shank is under load.

11. A propeller blade including a non-metal-

lic shank and blade portion, said shank tapering outwardly toward its free end, and a one-piece continuous metallic sleeve encasing and permanently secured directly to said shank throughout substantially its entire length, said sleeve being forced into intimate contact with said shank by mechanical pressure exerted on said sleeve inwardly toward the longitudinal axis of said shank.

12. A propeller blade including a non-metallic shank and blade portion, said shank tapering outwardly toward its free end, and a one-piece continuous metallic sleeve encasing and permanently secured directly to said shank throughout substantially its entire length, said sleeve being forced into intimate contact with said shank by mechanical pressure exerted on said sleeve inwardly toward the longitudinal axis of said shank for compressing said shank and for providing the outer face of said sleeve with substantially the same taper which the shank had before being compressed by said sleeve.

13. A propeller comprising a non-metallic blade and shank portion, said shank portion having an annular groove formed in the surface thereof; and a metallic sleeve encasing and permanently secured to said shank portion, said sleeve being compressed into intimate contact with the shank portion throughout substantially its entire length and into the annular groove in said shank portion, and wherein the degree of compression is progressively reduced adjacent the blade portion for diminishing the stresses at that portion of said shank portion where said sleeve terminates.

14. A propeller blade including a non-metallic shank and blade portion, said shank being initially formed with a plurality of individual annular grooves spaced axially along the length thereof; and a plurality of individually spaced metallic sleeves encircling and permanently secured to said shank, each of said sleeves overlying one of said grooves and being forced into intimate contact with its underlying groove by mechanical pressure exerted on said sleeve inwardly toward the longitudinal axis of said shank.

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CERTIFICATE OF CORRECTION.

Patent No. 2,350,345.

June 6, 1944.

GORDON L. FREEDMAN, ET AL.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, second column, lines 1 and 5, claim 1, for the word "comprising" read --compressing--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 22nd day of August, A. D. 1944.

Leslie Frazer

(Seal)

Acting Commissioner of Patents.