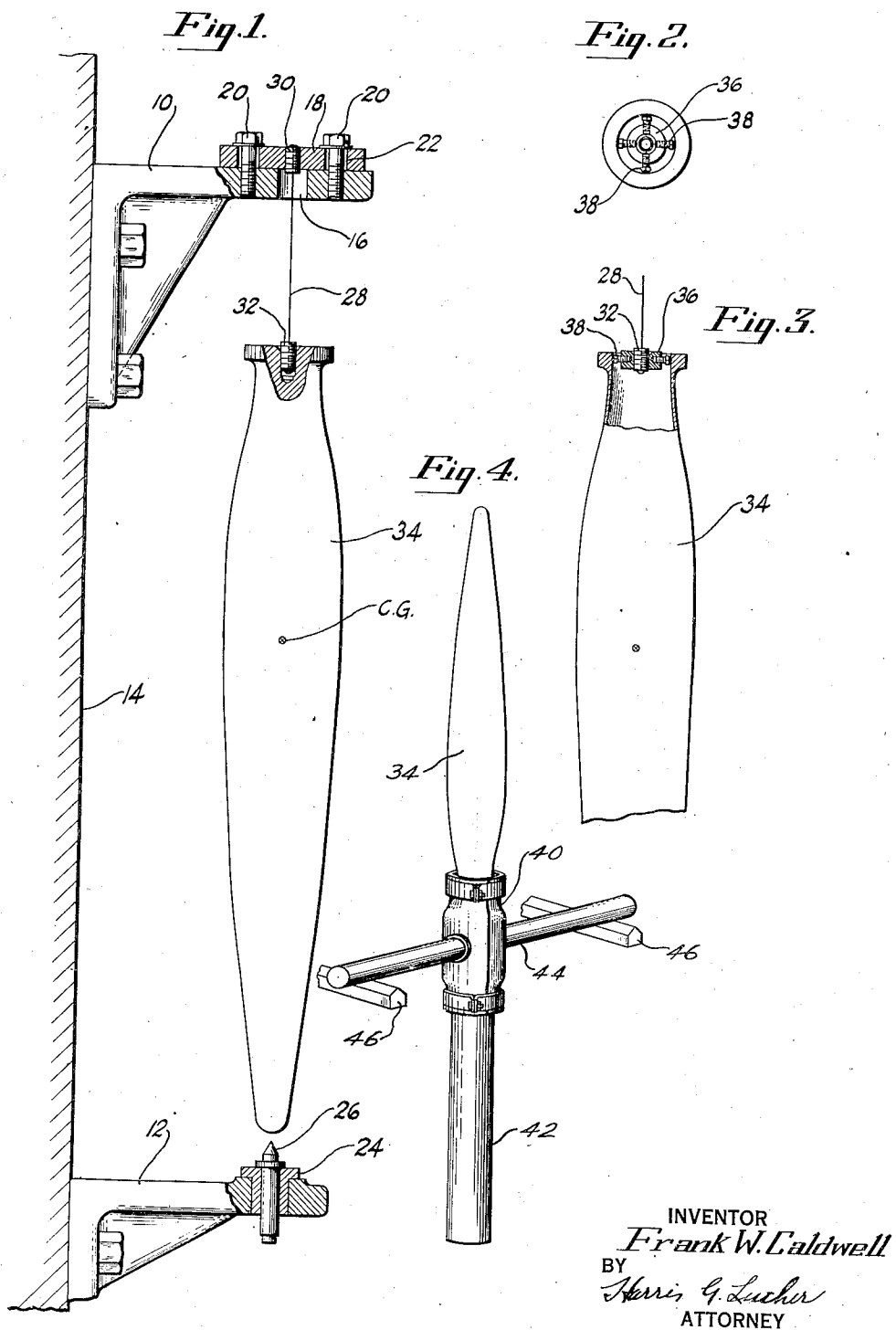


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F. W. CALDWELL
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PROPELLER MANUFACTURE

Frank W. Caldwell, West Hartford, Conn., assignor, by mesne assignments, to United Aircraft Corporation, a corporation of Delaware

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17 Claims. (Cl. 29—156.8)

This invention relates to improvements in propeller manufacture.

An object of this invention is to produce a propeller in which the center line of the blade end passes through the center of gravity of the blade.

Another object consists in provision of a means and a process for reducing the labor required, and otherwise facilitating the production of propeller blades which shall be in dynamic and static balance in various pitch settings.

Further and other objects and advantages will be apparent from the specification and claims and from the accompanying drawing which illustrates what is now considered the preferred embodiment.

Fig. 1 is an elevation, showing the means and method of locating a line through the center of gravity of a propeller blade.

Figs. 2 and 3 show means for suspending a blade of another type.

Fig. 4 is a perspective view of balancing and checking means.

This invention is particularly applicable to propellers of the detachable blade type, such as those shown in Patents Nos. 1,608,755; 1,769,775 and 1,836,700. In this type of propeller, the blades are detachably secured in a hub and are adapted to be adjusted in the hub to give various pitch settings. The portion of the blade which is secured in the hub is of circular transverse cross-section and is called the blade-end and in turning the blade in the hub to secure a pitch adjustment, the entire blade is turned about the longitudinal center line of the blade-end.

By shaping the blade-end so that its longitudinal center line passes through the center of gravity of the blade, the dynamic forces of the blade will always pass through the same point of the blade hub so that pitch adjustment will not vary the dynamic balance of the blade.

Furthermore, a set of blades in which the longitudinal center line of the blade-ends passes through the center of gravity of the respective blades, when secured and statically balanced in a properly machined hub, will be found to be in dynamic balance and will remain in dynamic balance for various pitch settings. This is necessarily so because if the propeller is statically balanced, the dynamic forces are necessarily equal, and if the center of gravity of each blade lies on the longitudinal center line of the blade end, the equal dynamic forces all act in a single plane normal to the axis of the shaft in which the hub is mounted and there are, there-

fore, no unbalanced forces to give dynamic unbalance.

In the drawing, a pair of brackets 10 and 12 are secured in vertically spaced relation upon any suitable means such as a wall or post 14. The bracket 10 is provided with an aperture 16 which is covered by a plate 18, which plate is held in adjusted position by means of screws 20. The plate 18 is provided with enlarged holes 22 to permit adjustment.

The bracket 12 is provided with a bushing 24 in which a prick punch 26 is slidably retained.

One end of a wire 28 passes through the center of an externally threaded plug 30, and is secured thereto as by brazing and an externally threaded plug 32 is similarly attached to the other end of the wire. These plugs are adapted to be threaded into plate 18 and propeller blade 34 respectively so that the propeller blade may be suspended by the wire 28 from the plate 18.

In case the propeller blade end is hollow, as shown in Figs. 2 and 3, a circular plate 36, having screws 38 extending radially therefrom, is adapted to be secured in the opening in the blade-end by backing the screws 38 out until they firmly engage the blade-end. The plate 36 has a threaded hole in the center thereof which is adapted to receive the plug 32 and is also countersunk to receive a lathe center.

In order to locate the center of gravity of a propeller blade upon the center line of the blade end, a propeller blade is shaped to substantially the contour desired in the finished article with the blade end, however, left slightly oversize. The propeller blade is then supported in a lathe or other suitable machine, and in the type of propeller shown in Fig. 1, a hole is threaded and tapped at the center of the blade-end. This may be conveniently done by clamping a block to the blade-tip to receive the head center of the lathe and supporting the blade-end in a steady rest.

In the type of propeller shown in Figs. 2 and 3, the blade may be supported between centers in the lathe, the hole in the center of plate 36 serving to support the propeller on one of the lathe centers. The plate 36 is then adjusted by means of the screws 38 until the outside of the blade-end runs true.

Plug 32 is then screwed into the accurately centered tapped hole in the blade-end, and plug 30 is screwed into the tapped hole in plate 18. This tapped hole in plate 18 has previously been accurately centered directly above the center of the prick punch 26, by suspending a plumb bob

from the center of the hole in plate 18 and adjusting the plate until the plumb bob and the prick punch register.

The propeller is allowed to hang freely from the wire 28 which passes through the center of the blade-end. The center of gravity of the blade, indicated by the letters C. G. on the drawing, will be directly under the point of suspension and as the prick punch 26 is located directly under the point of suspension, the prick punch point, the center of gravity of the blade and the center of the blade-end, from which the blade is suspended, will all fall in the same straight line. The prick punch may now be hit with a hammer to locate the point on the blade tip where this imaginary line emerges.

If this point should be outside of the blade tip, a suitable block may be fastened to the propeller tip to receive the prick punch mark. If it becomes necessary to add this block, care should be taken to make sure that the propeller blade is in the same lateral position at the time the mark is made, that it was, when it was hanging free without the addition of the block. This may be accomplished either by clamping the blade in its freely suspended position and then adding the block, and prick punching it or adjusting weights on the block so that the propeller assumes the same position after the addition of the block that it had before the addition of the block.

After the center has been located and marked at the propeller blade tip, the blade is hung between centers in a lathe or other suitable machine on the line connecting the center of the blade-end and the center marked at the blade tip and passing through the center of gravity. The blade-end may now be machined around this line to fit its supporting hub with the assurance that the center of gravity will lie on the longitudinal center line of the blade-end. As this is substantially the last operation to be performed upon the blade as far as any operations that would affect the center of gravity are concerned, as the blade has previously been brought to the correct size and shape, the center of gravity of the finished blade will still be on the longitudinal center line of the blade-end of the finished blade. Any finishing operations, such as buffing and polishing that may be later performed, will have either no or only a negligible effect upon the location of the center of gravity.

The above described process is of particular advantage in producing a propeller such as that described and claimed in my Patent No. 1,769,767, July 1, 1930. After a blade of the desired contour has been produced so that the centers of gravity of all the sections lie on a straight line as called for by that patent, the use of the above described process will enable the machining of the blade end with the assurance that the center line of the blade end will pass through the center of gravity of the blade. For all practical purposes, in a properly designed blade, this center line will then pass through the center of gravity of all the blade sections.

The position of the center of gravity in the finished blade may be checked in the following manner; the blade 34 is mounted in one socket of a holder which is preferably a two way hub 40 and an accurately sized cylinder 42 is mounted in the other socket. The hub with the blades therein is then mounted on a shaft 44 which in turn is placed on balancing knife edges 46. The blade 34 is so mounted that it may be turned in the hub socket and about its longitudinal axis

through 360°. The cylinder is chosen of such a size that its statical moment about the hub support is the same as the statical moment of the blade. The center of gravity of the cylinder will fall on the center line of the cylinder and hence serves as an accurate and simple means of checking the position of the center of gravity of the blade. The cylinder 42 is commonly referred to as the master cylinder, or if an accurately sized and finished blade is used instead of the cylinder for determining the balance of the newly finished blades, this accurately sized and finished blade is known as the master blade and indeed both the master cylinder and the master blade are often referred to simply as master.

The blade is balanced in various positions including horizontal and vertical positions. In the vertical position the blade is turned by steps or intervals through 360° in the hub socket. It is, of course, theoretically possible to determine the balance of the blade by moving it by steps through 180° providing the master is perfect. Movement through 360° will also, however, indicate any inaccuracy of the master or the hub. If the center of gravity of the blade is on the center line of the blade end, the blade will be in balance with the cylinder in all the various positions of the blade in the hub socket.

If, however, the center of gravity is off of this center line and the blade is turned in the socket to a position such that a plane containing this center and the center line of the blade end is at an angle to the plane containing the center line of the blade end and cylinder and the center line of the shaft 44, a condition of unbalance is created. Any variation of the center of gravity from the center line of the blade end can thus be readily checked and corrected.

It is to be understood that the invention is not limited to the specific embodiment or steps herein illustrated and described, but may be used in other ways, and the steps performed in a different sequence without departure from its spirit as defined by the following claims.

What I claim is:

1. In the manufacture of a propeller blade the steps of shaping the blade to substantially the shape and size desired in the finished blade, locating a point at substantially the center of the blade-end, freely suspending the blade from that point so that the center of gravity of the blade will be directly under the point of suspension, marking a point at the blade tip of the suspended blade substantially on the continuation of the straight line passing through the point of suspension and the center of gravity of the blade, supporting the blade upon the line between the said points at the blade-end and at the blade tip, and machining the blade-end while so supported so that the longitudinal axis of the blade-end will coincide with said line.

2. The method of forming a propeller blade which includes shaping the blade to substantially the shape and size desired in the finished blade, marking a point at the blade tip substantially on the continuation of the line connecting a point in the center of the blade-end and the center of gravity of the blade, supporting the blade at the center of the blade-end and at the point marked at the blade tip, and forming the blade-end so that its longitudinal axis coincides with said line.

3. In producing a propeller blade the steps of shaping the blade portion to substantially finished size and shape, supporting the blade on a line pass-

ing through the center of the blade-end and the center of gravity of the blade, and shaping the blade-end while so supported so that the longitudinal axis of the blade-end will coincide with the line of support.

4. The method of forming a propeller blade which includes shaping the blade to substantially finished shape and size and then shaping the blade-end to substantially circular transverse cross-section about a center line passing through the center of gravity of the blade.

5. The method of manufacturing propeller blades which includes shaping the blade portion to substantially finished size and shape, supporting the blade from a point at substantially the center of the blade-end, marking a point at the blade tip on the line connecting the center of gravity with the point of support, and forming the blade-end about said line as a center line.

6. The method of forming propeller blades which includes locating a point at substantially the center of the blade-end freely suspending the blade from that point marking a point at the blade tip substantially directly under the point of suspension of the blade, supporting the blade upon the line between the said points and forming the blade-end with that line as a center line.

7. In the manufacture of a propeller blade the steps of locating a center at the blade-end marking a point at the blade tip on the continuation of a line connecting the center of gravity of the blade with the center at the blade-end and machining the blade-end to substantially circular transverse cross-section with said line as the center line of said section.

8. The method of making propeller blades having blade ends of circular transverse cross-section adapted to be adjusted and held in a hub which comprises shaping the blade-end to circular transverse cross-section about a center line passing through the center of gravity of the blade.

9. The method of making a propeller blade which comprises suspending a propeller blade from approximately the center of the blade-end, marking a point at the blade tip substantially directly under the point of suspension and forming the blade-end so that its center line coincides with a line connecting said point and said center.

10. In manufacturing propeller blades the step of shaping the blade-end of a substantially finished propeller blade about a center line passing through the center of gravity of the substantially finished blade.

11. In the manufacture of a propeller blade the steps of shaping the blade to substantially finished shape and size except at the blade end, suspending the blade from substantially the center of the blade-end, and marking a point at the

other end of the propeller blade on the continuation of the line connecting the center of the blade-end and the center of gravity of the blade.

12. Means for locating a line through the center of a propeller blade-end and the center of gravity of the propeller blade comprising means from which a blade may be suspended, a flexible connection between said means and the center of the blade end, a prick punch directly under the point of suspension of the flexible connection and adapted to mark a point at the blade tip which will lie on said line.

13. Means for locating a line passing through the center of a propeller blade-end and the center of gravity of the propeller blade comprising, means on which a propeller blade may be supported from a point, a marking device located in spaced relation with respect to said means, said means adapted to be adjusted so that the point of support and the marking device are in vertical alignment, and means for supporting a propeller blade on said point of support with the center of gravity of the blade substantially on the line between the point of support and the marking device.

14. Means for locating a line passing through the center of a propeller blade-end and the center of gravity of the propeller blade comprising means from which a propeller blade may be suspended from a point, a marking device located in spaced relation with respect to said means, and adapted to mark a point in vertical alignment with said point of suspension, means for locating the center of the propeller blade-end and means for suspending the propeller blade from said point of suspension and on said center of the propeller blade end with the center of gravity of the blade substantially on the line connecting the center of the blade-end and the marking device point.

15. In the manufacture of a propeller blade, the step which comprises balancing the blade through 360 degrees about a vertical axis extending longitudinally of the blade.

16. In the manufacture of a propeller blade, the step comprising balancing the blade against a master which step comprises balancing the blade through 360 degrees about a vertical axis.

17. A method of making a propeller blade which comprises arranging a holder, supporting a blade and a master, in a balancing device, balancing the blade against the master in a horizontal position, placing the blade in vertical alignment with the master, rotating the blade by steps through at least 180° about a vertical axis and adding material to or removing material from the blade until it is in balance with the master in all vertical positions and the horizontal position.

FRANK W. CALDWELL.