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SOME THOUGHTS ON INDOOR MODEL AIRPLANE PROPELLERS

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This article is written in response to a request which apparently assumes that my experience with full scale propeller blade design fifty plus years ago qualifies me as a model airplane propeller expert. The fundamental geometry and function are the same, but differences in scale effect and construction methods are apparent. Even longer ago I was fortunate to have learned about model propellers of all types from such modelers as John Tyskewicz, Herb Greenberg, Pete Andrews, and others. The request for this article also specified that it include "no math," so with that limitation let us begin.

First, a foreword is in order. I would emphasize that the propeller is the most important part of the model. A model may be accurately built, finished and rigged but if it has. a poorly made, inefficient propeller, the flight results will be quite disappointing. .Conversely, a good prop can haul an unbelievably ugly crate through the air.

Pay attention to accuracy and suitability when making the propeller.

A propeller blade is a rotating airfoil which transforms horse power, through torque and revolutions rate into thrust, which propels the aircraft, just as a wing is an airfoil which provides lift to support the aircraft. They differ in that the wing moves on a flat plane through the air, whereas a propeller blade moves-along a helical path, and is itself a helical surface modified by thickness in the form of airfoil sections and bulk in the hub region. This intriguing shape, the helix, is a surface which is generated by a radius rotating about and translating along an axis at uniform rates of motion, Let us consider the elements of blade geometry: pitch, blade planform or shape, and airfoil section.

PITCH: The pitch of a propeller is the distance it moves forward in one revolution. It determines the pitch angle progression of the blade airfoil sections from hub to tip. These angles are measured with respect to the plane of rotation which is perpendicular to the thrust line. The progression of these airfoil pitch angles is called "basic pitch angle distribution." For some full scale aircraft, custom designed propeller blades will have slight variations from the basic distribution to accommodate changes in air flow caused by the shape of the forward nacelle or fuselage. However, for model airplanes, basic pitch angles without modification in the form Of "wash in" or "wash out" is probably the best choice, Although there is a slight relative increase in inflow velocity where the airstream passes through the tip area of the propeller disc, it may be advantageous not to "wash in" the tip to compensate, but rather to take advantage of the induced "wash out" which this slight inflow velocity increase causes, just as we "wash out" wing tips to minimize vortex drag and to delay stalling. The pitch angle in the shank or inboard area near the hub is also best left unchanged since this part of the blade provides very little thrust. For carved propellers it should be streamlined as best as possible.

The propeller block shape which will provide perfect helical pitch is shown in figures 1-A, 1-B, and I-C. A geometric shape such as this may be used either to carve a wooden propeller or as a form on which to construct built up propellers. A jig mounted on a flat board may be constructed having this form, composed of bulkheads located at specific blade radius percentages, each having the proper pitch angle. Next, all of the bulkheads are surfaced with planking.

The pitch we have been discussing is geometric or theoretical pitch. The actual pitch is less because, like any lifting airfoil the blade assumes an angle of attack to create its thrust. This angle will vary from as high as 6-8 degrees in a power climb to as little as 1 degree during the cruise regime. For a graphic idea of the two pitches see figure 2.

BLADE PLAN FORM: Depending upon limiting factors, such a diameter and function, blade shape may vary form a graceful willow-leaf pattern to a rather unattractive, but quite utilitarian rectangular paddle. The built up blades used on ultra-light models have no restrictions against diameter, pitch, or blade width, and may be shaped for high efficiency. For some other models, such as "Limited Penny Plane" or "Bostonian" the diameter is limited and yet these propellers must absorb the power of much heavier motors. The only answer is the use of wide paddle blades and higher pitch ratios (the ratio of the pitch to the diameter). Blade area distribution fore and aft of the spar may be varied to create blades of differing flaring capability. Several blade plan form shapes are shown in figures 3-A, 3-B, and 3-C.

AIRFOIL SECTIONS: The section shape currently in use for ultra-lights, AMA Stick, F 1D, ROG, etc. is a truncated ellipse with a camber height which may vary from 3-6 percent. Propellers whose blades are formed from sheet wood have a simple are for an airfoil shape. Carved propellers for flying scale, etc. have airfoil sections similar to the "Clark Y."

I hope that this article will provide some help to young modelers of all ages!

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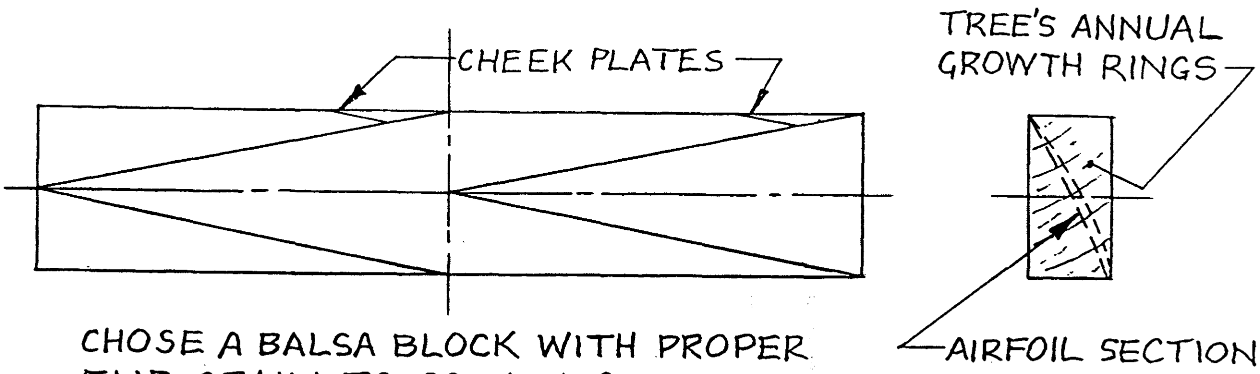
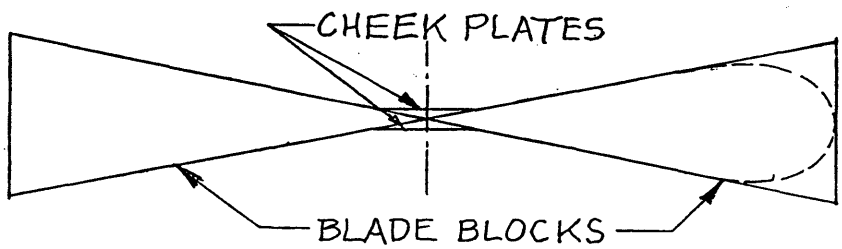


CHOSE A BALSA BLOCK WITH PROPER END GRAIN TO OBTAIN QUARTER GRAIN BLADE TIPS AND DIVIDE AS SHOWN.

FIG. 1A



ASSEMBLE WITH WHITE GLUE AND LIGHT CLAMPING PRESSURE

FIG. 1B

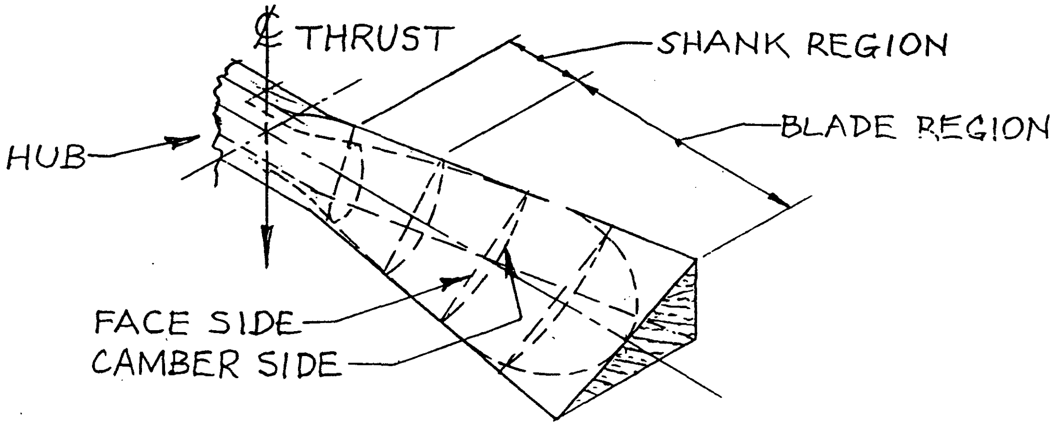


FIG. 1C.

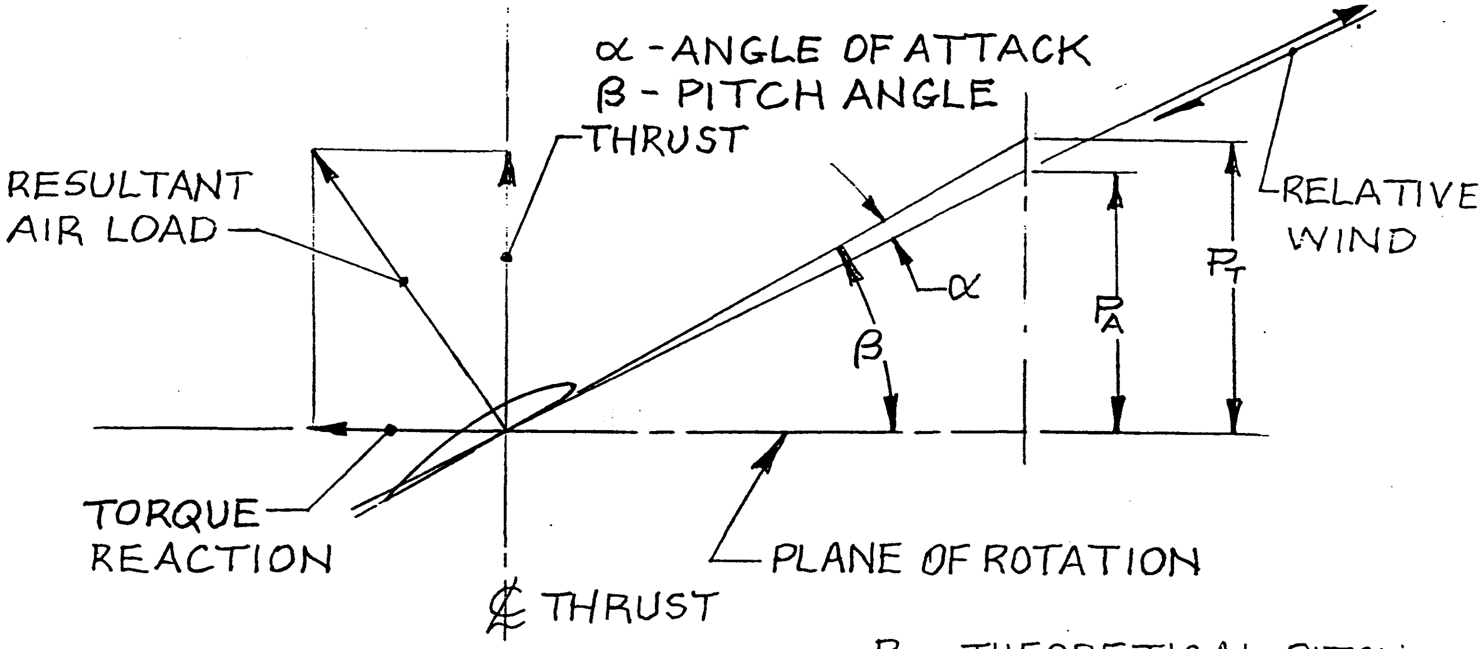

α - ANGLE OF ATTACK
β - PITCH ANGLE
THRUST
RESULTANT AIR LOAD
RELATIVE WIND
P_T
P_A
α
β
TORQUE REACTION
PLANE OF ROTATION
℄ THRUST
P_T - THEORETICAL PITCH
P_A - ACTUAL PITCH

FIG. 2

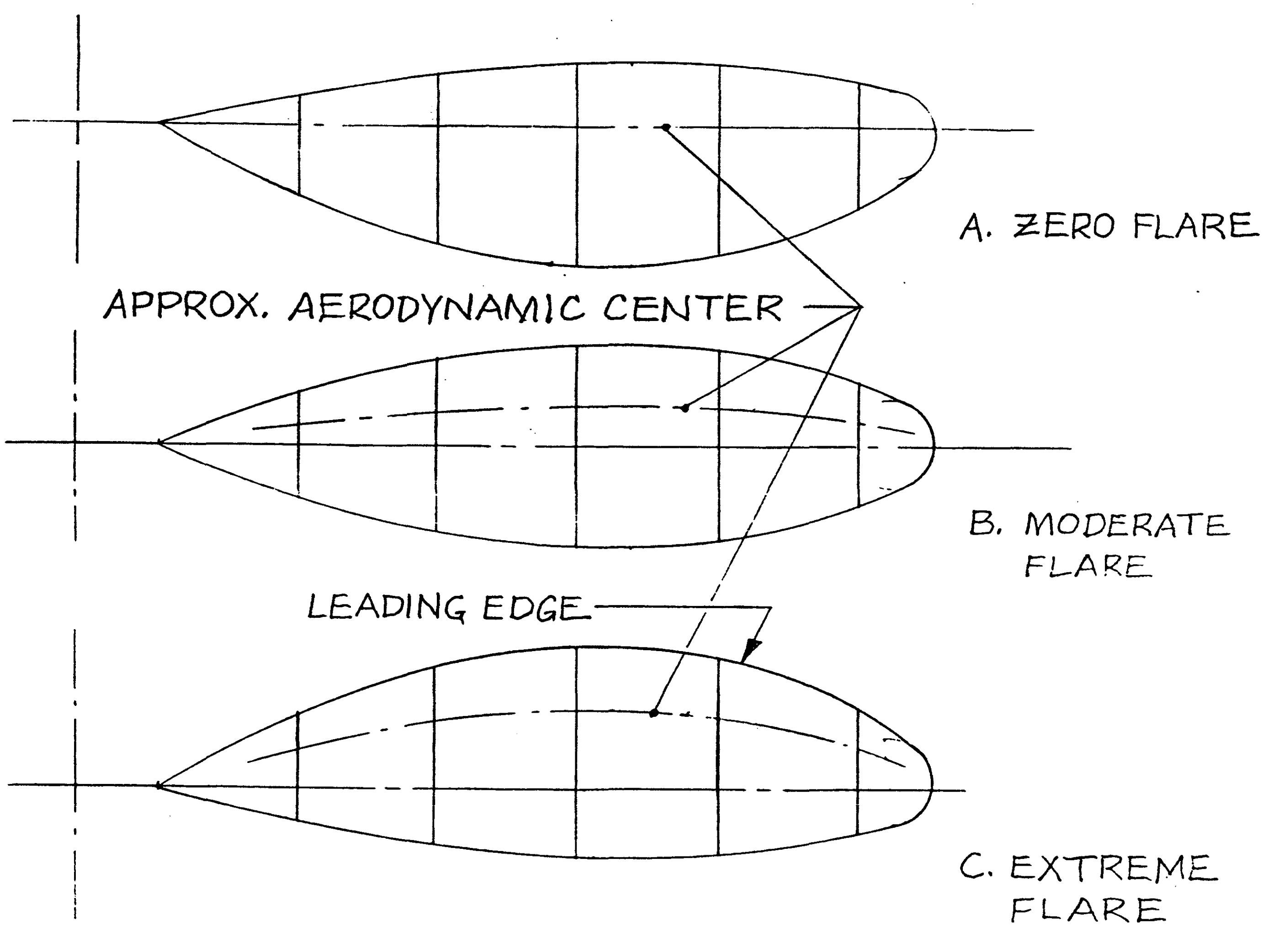

A. ZERO FLARE
APPROX. AERODYNAMIC CENTER
B. MODERATE FLARE
LEADING EDGE
C. EXTREME FLARE

FIG. 3