Beginners' Propeller Design

By Don Ross An August 19S3 article published in Flying Models *The author has devised an easy to use chart for selecting and fabricating the proper F/F prop.*

A famous designer is supposed to have said; "God is in the details." I'm sure He is, but in free flight modeling, "Performance is in the propeller". Once we beginners learn to build a fairly square frame, cover it smoothly, balance it correctly and even adjust for stable flight, we begin to think about getting it up there for some decent duration.

As a first season flyer both outdoor and indoors, I noticed that the experienced builders all used carved props and got some wonderful flights. I started asking questions about diameter, pitch, blade size, etc. and was either bombarded with highly technical details or told that the "T.L.A.R." (That Looks About Right) method was best. Everyone sincerely wanted to help but, it seems, everyone had his own method for prop design.

I found out why when I started a file on props. With articles from Jim Jones, Bob Hatcheck, Bill McCombs, Frank Zaic and others, I soon had an encyclopedia of prop info. Formulas, dimensions, proportions - most were similar but different enough to confuse a novice. Finally I decided to digest everything into the "Ross Simplifier". This is a portable device that reads loads of data, arranges it all in tabular order then asks, "what do I do if I want reasonable improvement without becoming an expert?"

Let's start with definitions and please stay with me because it gets very simple very fast.

I've divided rubber free flight into five general types: Indoor Scale, Outdoor Scale, Indoor Endurance (Easy-B, etc.) Outdoor Endurance (Coupe, Mulvihill, etc.) and Outdoor Sport. Outdoor Sport is somewhere between Scale and Endurance like Guillow's Arrow, Comet's Sparky or Jetco's Lark. Table I shows the three basics needed to design your prop.

Table 1 Basic Propeller Design Factors

	Indoor Scale	Endurance Indoor	Scale Outdoor	Outdoor Endurance	Sport
Prop Dia.	.8√W.A.	1.4-1.6 √W.A.	.8 √W.A.	1/4-√W.A.	1.1 √W.A.
Max Cord	16%	10%	15%	9%	12%
P/D	1.6*	1.6-1.8*	1.4	1.2	1.3

Note that the above factors are conservative and intended for the beginner to produce a model with good stability and improved performance over plastic props.
Larger diameters, higher PID ratios and wider chords may be better performing but would be harder to adjust for the first try. 'The general range of P/D for indoor scale would be from 1.4 *to* 1.8 *while indoor endurance would range from* 1.4 *to* 2. *These will vary depending on ceiling height with the higher P/D ratios used for lower ceilings.*

I will not define pitch and then derive a bunch of formulas that will give you the blade angle at different stations along the blade. I will start with diameter as the length of the prop from tip to tip and will show you how to choose diameter based on wing area. Blade maximum chord is the widest part of the blade and it occurs at 60% of the distance from the center of the hub to the tip (shown in Fig. A as .3L). Now we can almost ignore the whole complicated problem of pitch and work with Pitch-Diameter Ratio instead. The proper Pitch-Diameter ratio (P/D) from Table I will automatically factor in the proper pitch angles for the type of prop you want. Then Table 2 will give you the factors for the actual block dimensions which result in a prop with almost perfect helical pitch. Wasn't that easy? Now how about an example? Your model is an outdoor sport design with a span of 24 inches and a rectangular wing three inches wide. Basic formulas for area of a tapered wing are available but a close estimate by counting squares on graph paper will do just as well. Your area is 72 square inches so √w.A. (square root of wing area) is 8.48. Now let's go to Table I and we see that diameter for this type should be 1.1 X √W.A. Therefore, 1.1 X 8.48 is 9.32. Let's round that off at 9 inches. The same table shows that Maximum Chord is 12% Diameter which gives us 1.08 (use one inch). Last we look for P/D for this type and choose 1.3. Now we have all the numbers we need to design a prop block.

Table 2 shows the multiplying factors needed to get actual block dimensions. Follow your P/D line across, pick out the width, depth and tip height factors and multiply them by the Maximum Chord width. To follow our example, width will be I X .89 = .89 (WB). Depth will be I X .62 = .62 (HB). Tip height will be I X .33 = .33 (HT). Figure A will show you exactly how to mark your block for carving and you're ready to start. The rest of the process is straightforward. As shown in the note in Fig. A, carve the rear face first, then cut to the desired blade shape, then carve the front face.

Just a few notes to explain Figure A and you'll be ready to start. Hw should be 2% of L or I/8 minimum. HL. is 3/4 WB or wide enough to permit a proper fold if you are carving a folder. Check your fuselage width and add about two times HT.

Your blade should be I/8 - 3/32 thick near the hub, tapering to 1/16 - 1/32 at the tips. A thin airfoil with a flat rear side and a sharp leading edge will give you very good performance for your first try. Undercambered props are a little harder to carve and will do best on the smaller scale ships with the wider blades. Keep the leading edge "sharp" (a very small radius) for best efficiency.

Laminating sheet stock to get the right thickness is fine and will give you a very strong prop with little added weight. Be careful to match the sheets for hardness. Now drag out that kit with the plastic prop, carve a new one and surprise yourself with the performance. After a short while you'll have a library of different diameters and P/D's that will be a great help in setting up new projects for best performance and will erase those prop designing fears forever.

Table 2 Prop Block Dimensions at Selected P/D Ratios

Selected P/D	Block Width Factor (For W_B)	Block Depth Factor (For H_B)	Block Depth Factor At Tip (For H_T)
.3	1.00	.16	.09
.4	.99	.21	.11
.5	.98	.26	.14
.6	.98	.31	.17
.7	.97	.36	.19
.8	.96	.41	.22
.9	.95	.45	.24
1.0	.94	.50	.27
1.1	.92	.54	.29
1.2	.91	.58	.31
1.3	.89	.62	.33
1.4	.88	.65	.35
1.5	.86	.68	.37
1.6	.85	.72	.39
1.7	.83	.75	.40
1.8	.82	.78	.42
1.9	.80	.81	.44
2.0	.79	.84	.45
2.1	.77	.86	.46
2.2	.76	.89	.48
2.3	.75	.92	.49
2.4	.73	.93	.50

Note:
Table 2 is taken in entirety, with permission from "Making Scale Model Airplanes Fly" By William F. McCombs. Published by Aircraft Data, Box 32021, Dallas, Texas 75224

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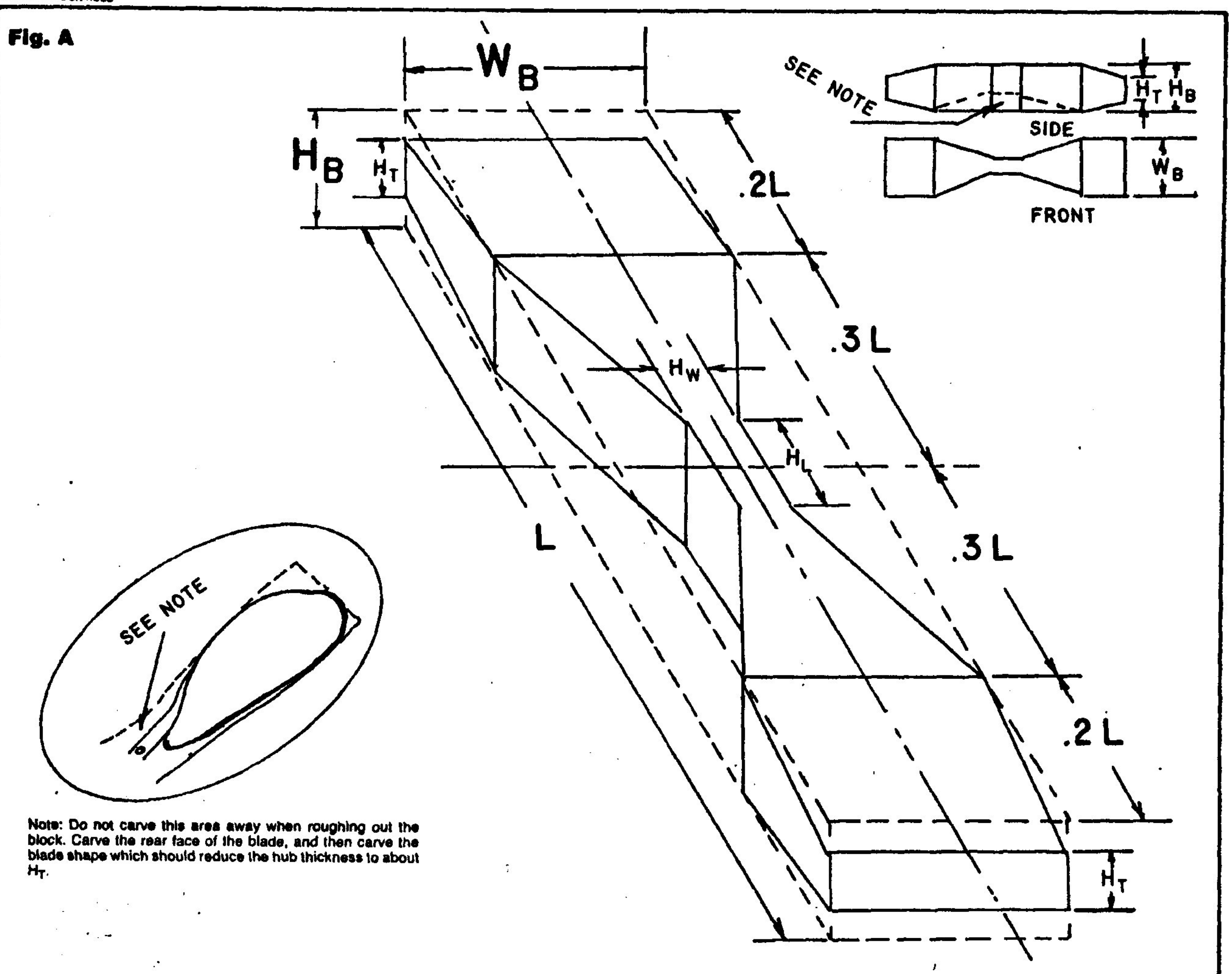
Fig. A



Note: Do not carve this area away when roughing out the block. Carve the rear face of the blade, and then carve the blade shape which should reduce the hub thickness to about H_T.