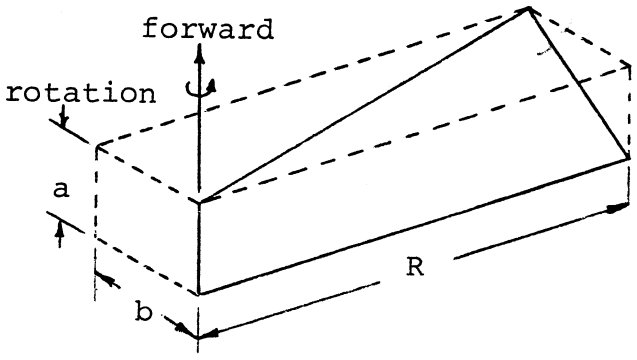
BUILDING WOOD INDOOR PROPELLORS

The biggest bottleneck for a novice indoor builder is constructing a good propellor. This paper is written to illustrate some of the techniques and to emphasize the critical factors in making an efficient propellor.

Theory

Most propellors are intended to have "true pitch"; that is, excluding any slippage, all blade stations would travel the same distance forward in one turn so that no portions of the blade fight one another. The geometry of such a blade is very simple. The blade lies on the twisted surface shown below



A form on which to build the propellor can be made from a rectangular block of length R, width b and height a. The formula for the pitch is

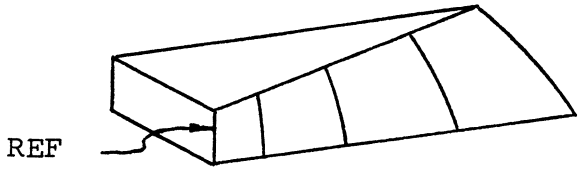
$$P = \frac{2\pi Ra}{b}$$

As an example of using this formula, we can find the ratio b/a for a given pitch to diameter (P/2R) ratio. For a P/D of 2, b/a=1.57. Indoor propellors usually have P/D ranging between 1.5 and 2.0. If made too large, the model is easily upset by disturbances in the air.

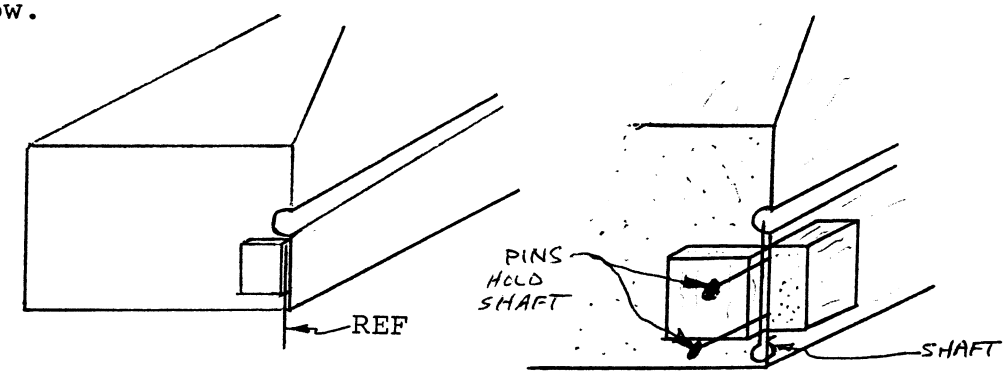
Block

Choosing a or b is simply a matter of making it large enough so that the blade fits within the surface shown above. A simple rule of thumb is to make b at least $4\sqrt{c_m}/3$, where c_m is the maximum blade width. Then a can be computed from the formula given above.

The block should be carved with a little camber in the twisted surface. Five or six percent of the chord is plenty. Keep the percentage constant over the whole blade. The block should be shaped as shown below.



The line marked REF above is the basic reference line for the propellor. The shaft must be exactly parallel to it in order to build the intended pitch in each blade. Because the spar is thickest at the hub and may not be tapered perfectly straight, it is necessary to cut a groove in the block in which to set the spar, and perhaps even to glue a small balsa plate on the end of the block to support the shaft when assembling the propellor. Cut the groove deep enough to completely submerge the spar. The groove and plate would appear as shown below.



Remember, the block is fixed in pitch, but any size propellor, within the limit of the block, can be built on it.

Blades

The blade thickness depends upon the size and weight of the model. As examples, for EZB's, they can be about .015" thick; for Pennyplanes, about .025" is more appropriate. Cut them from fully quarter grained stock of about 5 lb/cuft density.

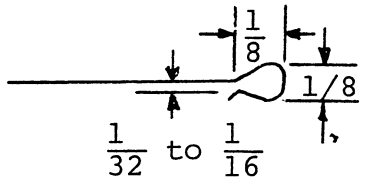
The shape depends upon the ceiling height. For low ceilings, some flare is desirable and the leading edge can be well ahead of the spar. For high ceilings the spar should be near the mid-chord. The blades should be widest at about 2/3 of R. Appropriate values for this width are 1" for EZB and 1 1/2" for Pennyplane. There should be very little area near the hub and the blades should terminate at least 1/2 inch from the hub.

Soak the blades in hot water for about 10 minutes, place together so they match, and place in the proper position on the form, with the tips at the full radius. Wrap firmly with a 1" to 2" width strip of bedsheet and bake in a 250° oven for about 15 minuts. Let it cool, remove the strip and carefully pry the blades from the block and apart from each other with a knife. They will maintain their shape for years.

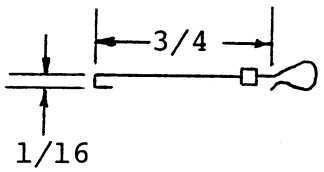
Spar

The spar carries the full load on the propellor and must be strong yet light. It should be out from 6 to 7 lb/cuft density stock and tapered from the hub. For EZB the size should be about .06" square tapered to .03" square; for Pennyplane .08" square tapered to .03" square should work. The spar need not extend the full propellor diameter; however it should be at least 2/3 of the diameter. When tapering, cut the spar oversize in length, as the end always sands away faster than the rest of the wood. Carefully sand straight tapers with 320 grit paper, finishing with 400. Both halves should have equal flexure under load.

The shaft should be bent from .014 to .016 music wire. The hook should appear as shown below.



Sharpen the other end of the shaft and push it through the center ofthe spar. Pull it through up to the hook and bend it 90 degrees 3/4 inch from the hook and in the plane of the hook. Then bend it again 1/16 inch from the last bend so it appears as below. Cut off all but about 1/32 of the turned-



back end, apply glue to this square "U" and slide the spar into it. Don't let the end of the "U" pierce the spar, but rather, twist the hook clockwise lightly (as the wound motor would try to do) until the free leg of the "U" rests against the spar. Add a little more glue over the wire and just a bit where the shaft exits the spar . Make sure the shaft is perpendicular to the spar and let it dry thoroughly.

Assembly

Lay the spar in the groove on the block and hold the shaft against the reference line with pins or tape. Spread a thin line of glue along the spar where the blade is to be joined and place the blade in position, making sure it rests firmly on the block. When dry, remove the propellor, rotate it, and repeat the steps to complete the assembly. For indoor models, weight balance is not nearly so important as matching the pitch of the two blades.