

# The Bearcat

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STUNT design is in a rut. The proven moments and areas to which we have all been slavishly adhering only represent what has already been tried and found to work. These self-imposed limits have virtually stopped the development of stunt ships since the Nobler. Yes, I know that it takes a whole winter to build next year's hope for glory, but when I have something hanging on the wall that flies, I tend to get awfully reckless with my spare time and have been known to follow some pretty weird tangents in an effort to improve the looks and performance of stunt ships. With my Mustang and Bearcat, I feel that I've begun to hit pay dirt. The indications are that as long as simple rules of aerodynamics are followed and competition construction techniques are used (build it straight and light), nearly anything can be made to fly competitively. What better way is there to prove a point than to build a successful but unlikely airplane.

The opportunity to build that different airplane came about a month after the 1967 FAI team selection. Dick Mathis dropped over for the evening to show his movies of the '67 Nats stunt event and the FAI ships at St. Louis where he judged. Afterward, we talked long into the night about stunt ship design and his research paper "The Psychology of Stunt Judging." After interviewing the '67 Nats stunt judges and tabulating the scores, Dick concluded that the appearance of the airplane strongly affects the judges scoring. Dick felt the optimum design for best scores should be either sleek and sensual like a Detroit automobile stylist might build or a semi-scale type, preferably Navy. As a matter of fact, Dick thought the Bearcat would be hard to beat if it could be made to fly.

Dick's words were prophetic. At the '69

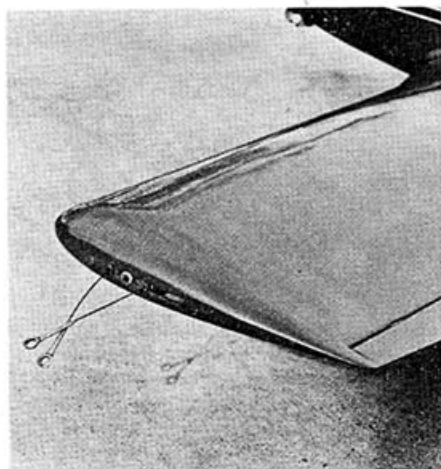
Nats, the Bearcat placed an undeserved second. There was no doubt that the judges loved the Bearcat as my scores were considerably higher than my flying deserved. In this, my second year of competition, the pressure was getting to me and I was a nervous wreck. Because of my poor showing, some of the big names in stunt thought the Bearcat only an average airplane at the Nats competition level. Tain't so. She's a grand machine and I'm proud of her. In spite of possessing a new Mustang which flies somewhat better, I still prefer to fly the Bearcat. She is a happy design and competitive on any level with a competent pilot.

I am frequently asked how any airplane as fat as the Bearcat could possibly stunt competitively. The answer, "the drag in-

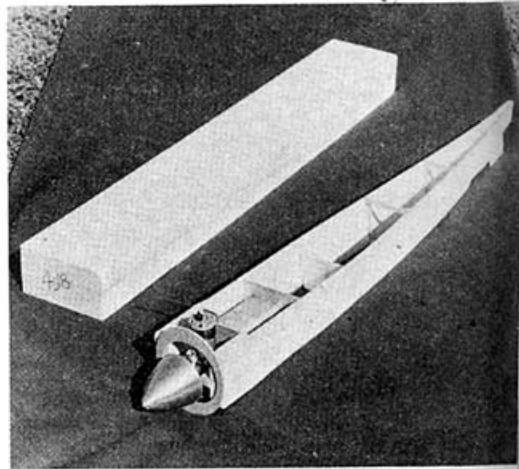
crease is slight," is difficult to swallow unless a person has some understanding of the nature of drag. Some explanation of drag is worthwhile as it should encourage the development of radically different, better looking, possibly better flying stunt ships.

Aerodynamic drag has two major components. The first component of drag is induced drag or that drag which is created when you make lift. This induced drag is low at low angles of attack and very high at high angles of attack as in a corner. The other major component of drag is parasitic drag which opposes the movement of any body through the air. Parasitic drag also has two components, skin friction and profile drag or drag due to shape or form.

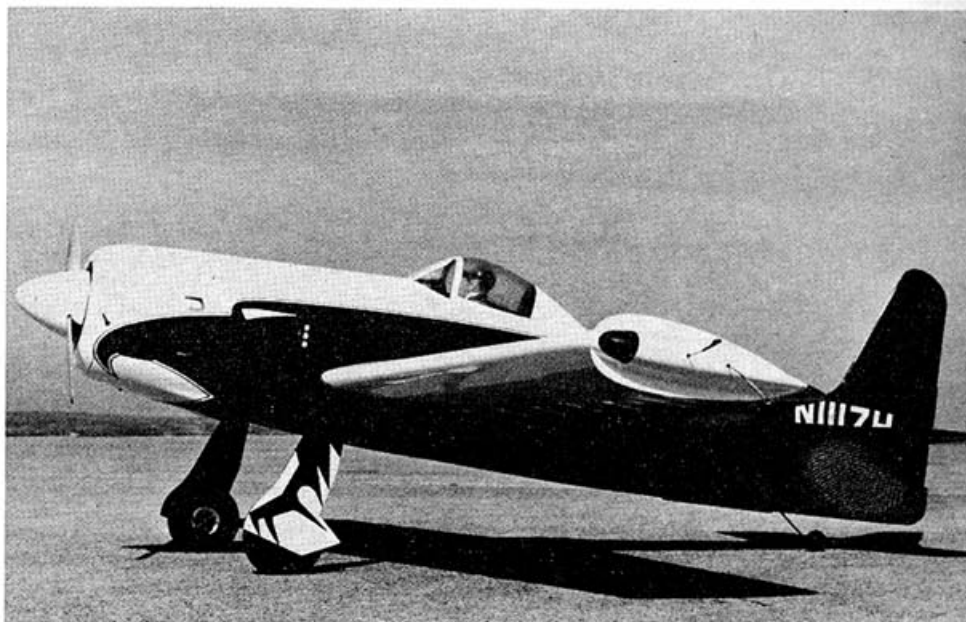
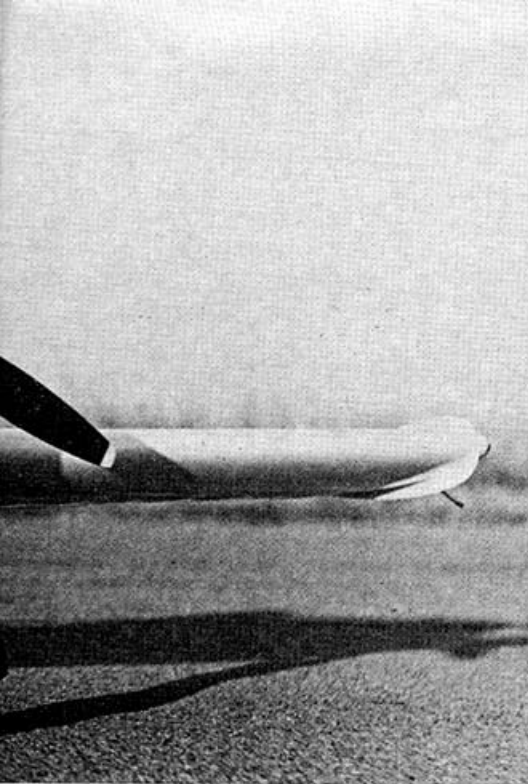
To understand some of the elements of



Leadouts on new Bearcats have up-line in front and are adjustable to get proper line tension under different conditions.



The rounded egg-shaped fuselage can be molded from sheet balsa, planked, or carved from lightest-weight contest-grade blocks.



Grumman's powerful Bearcat could do Immelmann takeoffs, beat a jet to 10,000 ft. One holds world's piston-engined speed record. Al's model proved a "fat" fuselage no handicap to a stunter. Has many special features, nearly scale appearance.

One of the most talked about ships at the NAT's, this C/L stunter is a great competitor.

induced and parasitic drag and how they affect stunt ship design let's compare the Bearcat's drag to a Nobler's drag. No accurate data is possible without wind tunnel or flight test, but some useful approximations can be made.

Induced drag is a by-product of lift. Since most of us use about the same airfoils and fly at about the same speed, induced drag is quite similar for each of our airplanes. The exception to this is the heavier airplane which requires more lift to fly. When a stunter corners, the induced drag probably triples at least, and the extra lift requirements of the heavy airplane are magnified to the point that it will noticeably lose more speed than a light airplane. Induced drag varies from being approximately equal to

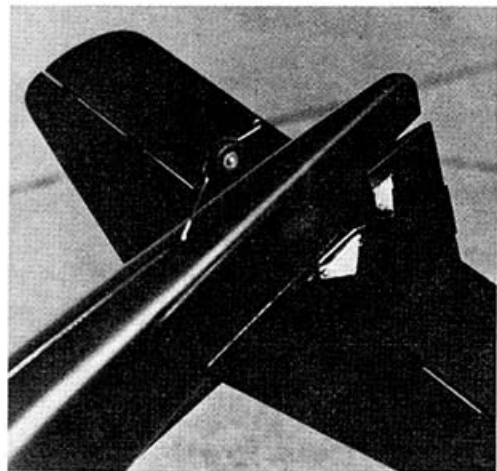
parasitic drag in level flight to approximately three times greater than parasitic drag at high angles of attack.

Parasitic drag is somewhat more complicated. At the cockpit, the Bearcat is 8½" high and 4½" wide compared to the Nobler's 5½" and 1½". The fuselage frontal area of the Bearcat is 25 sq. in. compared to the Nobler's 10 sq. in. In aerodynamic terms, the fact that the Bearcat has 2½ times more fuselage frontal area isn't significant. The same data is used, however, to compute total surface area which is the skin friction element of parasitic drag. With a few quick calculations, we find the Bearcat has 65% more fuselage surface area (wetted area) than the Nobler fuselage but remember, we are looking for total wetted area. When we

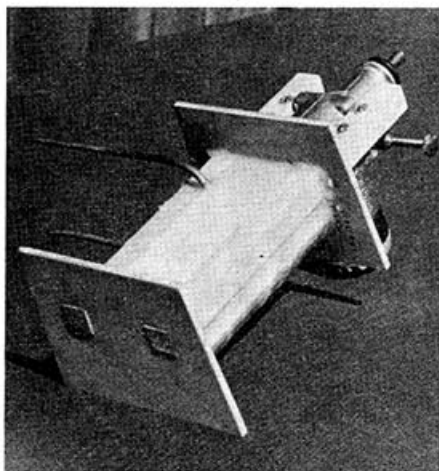
also include the wing, tail, landing gear, etc., in our computations, we find that the Bearcat has only 18% more wetted area than a Nobler. Half of this 18% is due to the larger wing. If the Bearcat were built to Nobler size, it would have less than 10% more wetted area.

Profile drag is harder to pin down as some shapes, regardless of wetted area, drag more than others. For example, the exposed wheels of a stunt ship probably have as much parasitic drag as the entire fuselage and more parasitic drag than the wing. Poor fillets, protuberances and inefficient cowlings can increase profile drag by an additional 50%.

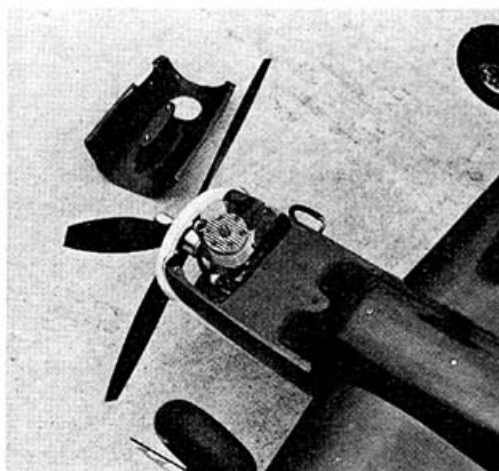
According to Hoerner, rectangular fuse-  
*Continued on page 69*



Rudder is linked with elevator to control propeller gyroscopic precession and prevent bobbling in tight corners. Use R/C horns.



Engine mounts, tank, and forward bulkheads are fibreglassed unit which resists vibration and fuel soaking. McCoy engine on this one.



Engine is completely accessible with belly cowl removed. Note rounded center support in cowl and exhaust extension piece.

# Bearcat

*Continued from page 27*

lages should be avoided because at high angles of attack the rectangular fuselage will have several times greater profile drag than a circular fuselage. The optimum low-speed fuselage shape is much like a jet fighter tip tank and should have a length to width ratio of 6 to 1. While not optimum in shape, the Bearcat's fuselage is rounded and does have a fineness ratio of 6 to 1. In a corner, this improved shape should compensate for the increased induced drag due to the Bearcat's extra weight, enabling it to match the performance of its slimmer, lighter competition.

In summary, first, remembering that parasitic drag is only approximately half the total drag and, taking no credit for any reduction in profile drag from a possibly better shape, the Bearcat should have only about 5% more total drag in level flight than a comparable size stunt ship. Second, the Bearcat should be no worse in drag than a

comparable size stunt ship at high angles of attack. Third, drag, in any form, only retards the speed of the aircraft. Drag has practically no effect on line tension or maneuverability and can always be compensated for by an increase in power. At the flying circle, the only noticeable characteristic of the Bearcat's particular combination of frontal area and low-pitch prop is the tendency of the Bearcat to resist speed build-up in consecutive down-wind maneuvers.

The cowling size of 5 x 6" dictates the use of a large diameter propeller to achieve efficiency. To turn this large prop and overcome drag, I need a large engine. The Bearcat uses an Aldrich customized Supertigre 46 and a Rev-Up 12-5 prop. I like big engines anyway and have yet to overpower a stunt ship. It seems that large quantities of torque improve line tension. Therefore, I select a big engine noted for power and

steady four-cycle operation, run it slow, control aircraft speed with prop pitch, and cram on all of the prop diameter the engine will stand. This method of improving line tension really hangs them up there on the reverse wingover but will cause problems with prop precession if you fail to use an operating rudder. The increased weight of the propeller and its larger diameter both increase the yaw from gyroscopic precession of the propeller, causing the airplane to fishtail excessively in corners and lose line tension on outside maneuvers. (For a more complete explanation of gyroscopic precession see American Modeler June, 1969, Mustang.)

When I designed the Bearcat, I was fairly certain the short nose wouldn't affect longitudinal stability (groove), but I was curious about its effect on handling qualities. I discovered, after building and flying the Bearcat, there is a considerable difference be-

tween "grooving" and having a "groovy" feel. The first, grooving, is simply longitudinal stability, easily obtained by a large tail-volume coefficient. This means a large stabilizer and elevator on a long moment arm. The Bearcat has a large tail-volume coefficient and therefore grooves fine. The groovy feel, however, is something else again, involving the psychology of the flyer and handling characteristics. Groovy feel is usually obtained by using a long nose to somewhat deaden the turn by placing the mass and inertia of the engine farther from the CG. In this case though, the turn is also harder to stop. The Bearcat, with its short nose, doesn't feel particularly groovy but it does lay in there, turns easily, and will stop turning quickly without overshoot or bobble. I'm not implying the Bearcat's handling qualities are unpleasant or inferior. After I became used to the Bearcat's feel, the square maneuvers seemed easier and more precise than with other airplanes I've flown.

Like my Mustang, I've also used dihedral on the Bearcat, partly to improve its scale appearance, but more important, to compensate for its low-wing configuration. Due to "dihedral effect," some effective dihedral is lost because of the deep nose. This, in effect, removes the slight ( $\frac{3}{4}$ " per panel) dihedral used so that the airplane is, aerodynamically speaking, equivalent to a straight mid-wing. Dihedral also gets the leadouts up nearer the vertical location of the CG. Without dihedral the wing tip will line up with the CG, causing the airplane to fly banked out when upright and banked in while inverted. The sorriest flying stunt ship that I ever built was a semi-scale Spitfire with a low flat wing. I fought that airplane for almost a year but no amount of trimming would make it fly or turn the same upright and inverted.

The landing gear on a full size Bearcat is extremely long and located fairly close to

the fuselage. The length was necessary for the Bearcat swings a prop which has a diameter equal to  $\frac{1}{3}$  of the wing span. The narrow tread (width) was for structural considerations and necessitates folding each gear leg double as it retracts to prevent the wheels from overlapping. This narrow, stiltly appearance has been duplicated on my stunter without degrading the takeoff or landing performance. The explanation is mostly for all of those kind folks who have pointed out that my gear struts are too close together.

The Bearcat has the unusual characteristic of flying equally well from grass or hard surface. This is achieved through proper gear location with respect to the CG and the use of 3"-diameter wheels. The large nose-high sitting attitude caused some takeoff problems at first. The airplane would lurch up on the gear with a bit of nose-swing first

out of the circle, then inward. This was trimmed out by realigning both main gear axles so that both wheels now point slightly inboard. This allows the Bearcat to roll smoothly around the circle with the nose pointed slightly outward. Now she sets up slow and smooth all by herself with neutral elevator and tight lines. Once up, you have 3" of prop clearance on a 12" prop, so roll as long as you like. I usually use a quarter to a half lap to get airborne.

Landing characteristics are best described as "fun." With this gear location the airplane behaves much like a real one. With some skill and practice the landings can be breathtakingly smooth. If you goof it will really bounce. As an average, I'd say that you can grease on about eight out of ten landings. Landing consistency has been good enough that I feel the airplane has a competitive landing; that is, the extra points for those beauties will about balance the points lost for bounces over a season. The big bonus is that grin which is so difficult to suppress when the bystanders burst into spontaneous applause for the beautiful realistic landing that the Bearcat does best.

I've also found the uncertainty of a challenging landing helps to maintain interest throughout the hundreds of practice flights required to develop a competition pattern.

Just as the Mustang was published as an improved Mk II version which did, in fact, fly better than the original, these plans show the Bearcat in a Mk II version incorporating improvements indicated by recent experience. The changes to the original Bearcat should erase any competitive advantage the Mustang II might presently have. Except for wing sweep, landing gear and flap, the Bearcat's wing is now the same as the highly satisfactory Mustang II wing and employs the same progressive airfoil and construction alignment procedures. This change is the result of the demonstrated

ability of the wing of the Mustang II to fly 56 oz. through a competition pattern better than the Bearcat's modified Nobler wing of the same area carrying 5 ozs. less weight.

The adjustable leadouts satisfy a need for a simpler and lighter mechanism which can be quickly adjusted in the field. This adjustment was tacked on to my last airplane almost as an afterthought but proved so valuable in trimming the airplane that I'll not be caught without a similar device again. Working both with leadouts and adjustable rudder offset you should be able to obtain better line tension than you have ever experienced before.

While the adjustable leadout is self-explanatory, the bellcrank orientation is not. It is not upside down. I put it in the Mustang II that way to make the front leadout the up line. As the airplane turns it is supported largely by one leadout or the other which tends to yaw the airplane slightly as the loaded leadout lines up with the CG. A conventional rear up line tends to aggravate gyroscopic yaw and the forward up line dampens it. This noticeably reduces or eliminates wobble from a hard corner. Don't worry about the strength of the backward bellcrank. I've pulled 50 lbs. with this arrangement.

Now for the discouraging word. The Bearcat takes approximately twice as long to build as a scratch Nobler. It is not difficult to build but it is time consuming and requires a fairly high level of craftsmanship and skill. Part of the fun of this game for me is my appreciation of the sight of a realistic Bearcat or Mustang hanging out there on the end of the lines, regardless of the effort required to achieve it. If you feel as I do, I doubt that the Bearcat would disappoint you. If you should build a Bearcat, send along a photo of the model in advanced construction, say on its gear. I will help the first 20 of these modelers by giving

them a custom-molded Bearcat canopy.

**Construction:** The biggest problem in building the Bearcat is finding sufficiently light blocks. I wouldn't have attempted to build a contest stunter this big without a source of light wood. This is such a massive airplane even using all contest balsa and 36 oz. Nobler techniques that it came out at 50.3 ozs. Without contest blocks you have only two choices. You can plank it or you can mold the top and bottom from contest 1/8" sheet as described in the June '69 issue of American Aircraft Modeler. Personally, I would lean toward the molding method. Although molding shells would be more work, they also would be lighter and, in a project like this, simplicity of construction must always be forfeit to weight considerations. For the same reason you should use a fiberglass arrow shaft pushrod and build up the tail surfaces instead of using 3/8" sheet. You can save 3/4 oz. here and you must. If you cut corners in construction, the weight will soar above 55 ozs. and you will have a great Sunday afternoon sport flyer instead of a competition winner.

**Fuselage:** To build the fuselage, first cut the 1/8" contest balsa sides and the 1/4" balsa external doublers and laminate them with aliphatic resin glue. While this is drying, build the engine-tank assembly consisting of a 1/8" ply firewall, 1/8" ply rear tank bulkhead, 1/2" - sq. motor mounts and a modified T-21E tank. Modify the Veco tank by removing the end and splicing on 1/4" section of another T-21 tank to increase the tank capacity to 5.25 oz. Replace the tank brass vents with annealed copper and bind the tank to the engine bearers with strips of fiberglass cloth and epoxy glue. This step is unnecessary as the Bearcat's tank isn't wedged in like most stunt ships and needs this support to dampen vibration and prevent fuel foaming.

The extra tank volume is required if you

o level laps per maneuver with a . Epoxy the fuselage sides to the ank assembly and add the ply nose d bulkhead "D" and the cross fusers of  $\frac{1}{8}$  x  $\frac{1}{4}$ " balsa. Tack glue the bottom blocks in place. Perma-lue the  $\frac{1}{2}$ " balsa nose ring in place e the entire fuselage. After shaping ks, remove them and hollow. Keep g until as much light shines your blocks as through a piece on est sheet when held up to a light. e  $\frac{1}{16}$ " wire tailwheel strut to the mount with soft wire and glue it in m block. Cut the root- and tip-rib templates 2 aluminum. Sandwich 13 pieces of ttest quarter-grain balsa between plates, and carve and sand one set o shape. Now duplicate this process 1 another set of ribs for the other

wing. Don't sand the bevel off the edges of the ribs as it will ruin their shape.

Make a jig alignment template from .020 celluloid by tracing from the plans with a sharp instrument to scratch the plastic. Punch the  $\frac{3}{8}$ " holes with a sharpened piece of  $\frac{3}{8}$ " tubing and a hammer.

To use the jig alignment template, align rib No. 1 on the bottom horizontal line of the template, with the horizontal line running through the center of the leading-edge cut-out and the center of the trailing edge. The trailing edge should be aligned with the diagonal line on the right end of line No. 1. Now use that sharpened  $\frac{3}{8}$ " brass tube to twist through the holes of the plastic template to cut holes in the balsa rib.

Rib No. 2 uses the second horizontal line from the bottom and the same diagonal line at the end of line No. 2, etc. When these ribs are spaced on the 6' x  $\frac{3}{8}$ " jig tubes you will

between outboard rib No. 1 and inboard rib No. 2. This addition will better distribute the bellcrank stresses to the top and bottom wing skins. Sheet the wing leading edge using plenty of pins and aliphatic resin glue. Now finish sheeting the rest of the wing using  $\frac{1}{16}$ " sheet. When you remove the center jig supports to sheet the bottom of the wing, support the wing at the leading and trailing edges and insure jig tube alignment by bore sighting them.

**Tail assembly:** The vertical and horizontal stabilizers are both built utilizing a main spar, several ribs and contest A-grain  $\frac{1}{16}$ " sheet balsa folded double to form the leading edges and top and bottom skins. Dampen the wood on the outside only. If you still have trouble folding it without splitting at the tip, sand a small spanwise groove on the inside of the sheet to reduce the thickness where you are going to fold it. The rudder and elevator skins are simply glued to the top and bottom of the spars. Building the stabilizer and elevator assembly this way will save about  $\frac{1}{4}$  oz. compared to using contest  $\frac{3}{8}$ " sheet.

**Assembly:** Fit the basic fuselage to the wing and epoxy in place using strips of fiberglass cloth and epoxy. This should be done with the wing in the jig because the jugged wing will be exactly level. You will be able then to use the jig base and the building board to precisely align the fuselage and tail surfaces. Make the elevator pushrod from two short lengths of  $\frac{3}{32}$ " wire and a 13" length of arrowshaft. The assembled pushrod will weigh less than a  $\frac{3}{32}$ " pushrod and will be much stiffer in compression, requiring no fairlead support.

Install the pushrod and glue the stab-elevator assembly to the fuselage. Now, add the vertical fin-rudder assembly and hook up the rudder pushrod. At this point all of the controls should be operating smoothly. If the complete control system is satisfactory, close the fuselage by adding the top and bottom blocks. The assembled airplane can now be removed from the jig. Build and install the dorsal fin, fiberglass the nose

and add a double layer of fiberglass and epoxy to the area around the trailing edge of the wing and the leading edge of the stab. Carve and epoxy the cowling and attach the canopy with strips of Celastic.

**Finishing:** Give the entire airplane two coats of clear nitrate (commercial) dope, sand lightly and cover with Jap tissue. Add two more coats of clear, two coats of nitrate-talc sanding sealer and sand with 320 wet paper. Now give it one more coat of nitrate-talc and sand with dry 320. Now apply the finish of your choice. I used Hobbyoxy and did not rub it out. The nitrate is cheap, has low shrinkage, is high in solids and both Hobbyoxy and butyrate dope stick to it well.

Good luck with your Bearcat.