

By William Steiniger and Jack Smith

IF you're a skin diver of any experience you know that an electric-powered sport submarine is great for underwater exploration. Seated in such a vehicle, you can cover more bottom simply because you do not expend your energy in swimming and your precious air can be made to last much longer. Also, Frances Gaar, the underwater swimming star who posed for our cover, will attest to the fact that it's great fun to operate.

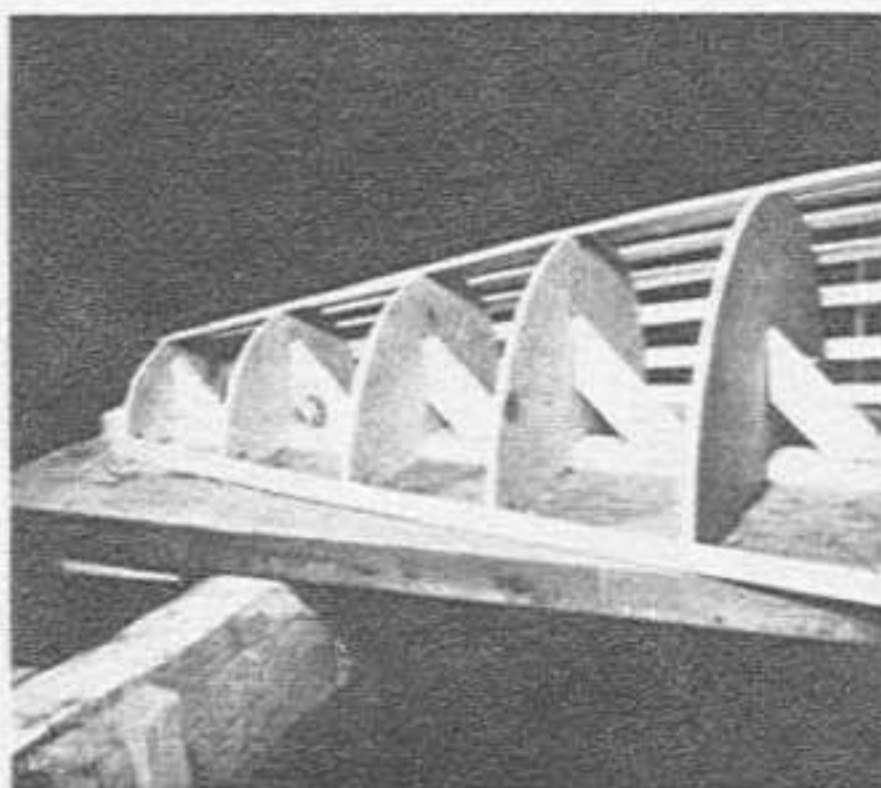
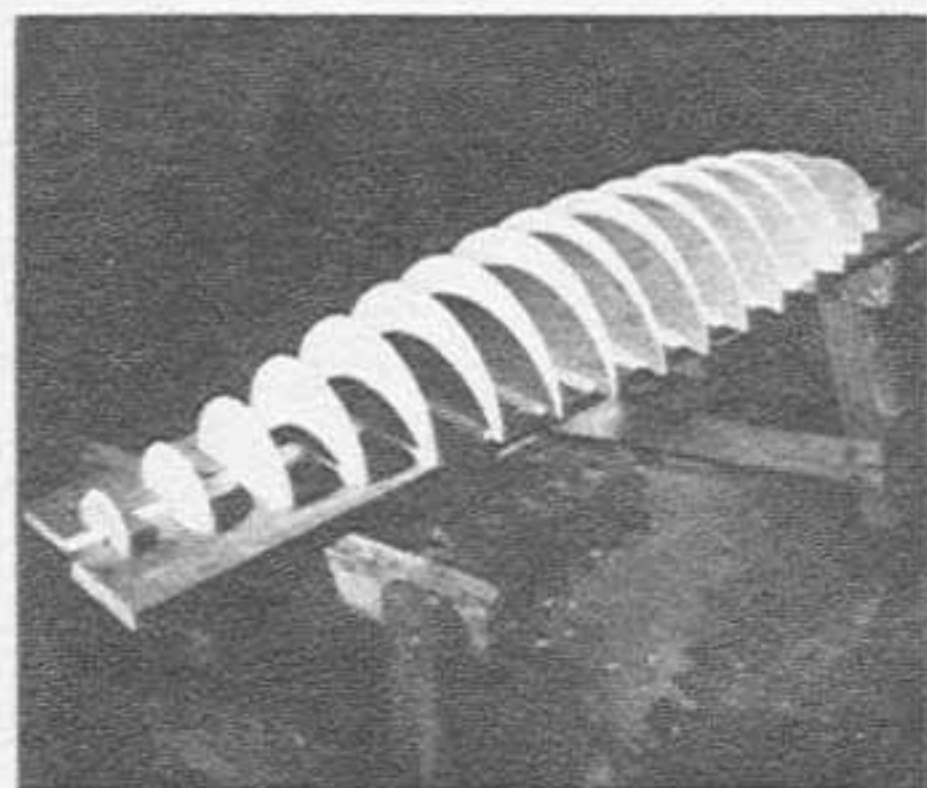
In building the sub, our original intention was to make it of fiberglass with a Plyfoam core. A wet sub (one that fills with water and is used with an aqualung) requires a certain amount of flotation and we felt the Plyfoam would be ideal. Sold by Plyfoam, Inc., E. Bethpage Rd., Plainview, L.I., N.Y., it is unique in that it is thermoplastic; that is, when heated to about 180°F, it can be shaped to any mold. Then when it cools it retains the form of the mold and its strength as well. With a layer of fiberglass bonded to each side, it becomes strong indeed.

We planned a wooden mold on which we would lay up a quarter-in. shell of Plyfoam. Then we would cover the Plyfoam with fiberglass, remove it from the mold and apply another layer of fiberglass on the inside. Doing it twice would give us the two halves of our hull.

We still think the foam core construction would be ideal. The only hitch was that we missed getting the technical bulletin normally supplied with every Plyfoam order. Instead, we had the partial information that polyester resin could be used on Plyfoam. The technical bulletin would have told us that it had to be a special formulation of polyester—one with little of the so-called styrene monomer in it. The styrene monomer in our run-of-the-mill polyester made sponge of our first Plyfoam shell.

Yet we figured we had paid for some learning (46 cents per sq. ft. for 24 sq. ft. of Plyfoam plus the cost of one coat of polyester). We agreed that we would get more Plyfoam and use epoxy, the resin that has no effect on the foam.

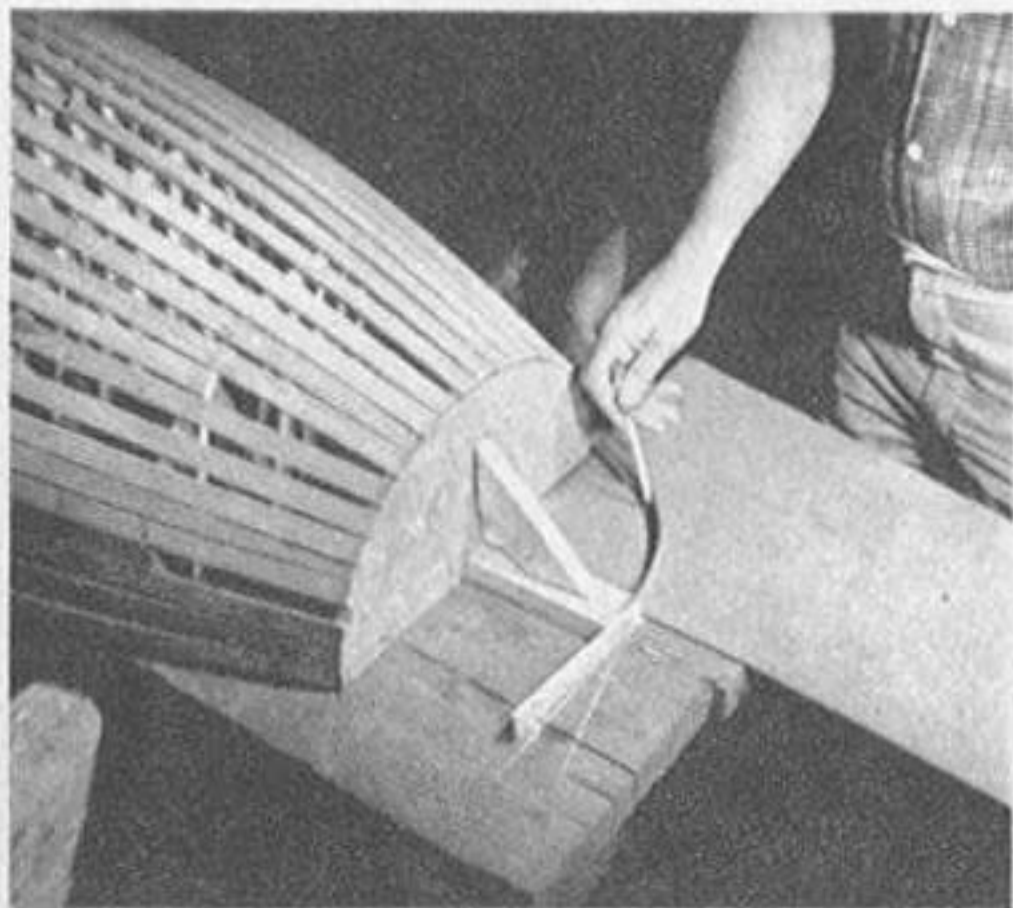
FRAMES (left) are erected at right angles to backbone nailed to building platform. Ribbands (right) are nailed longitudinally, giving hull its form.



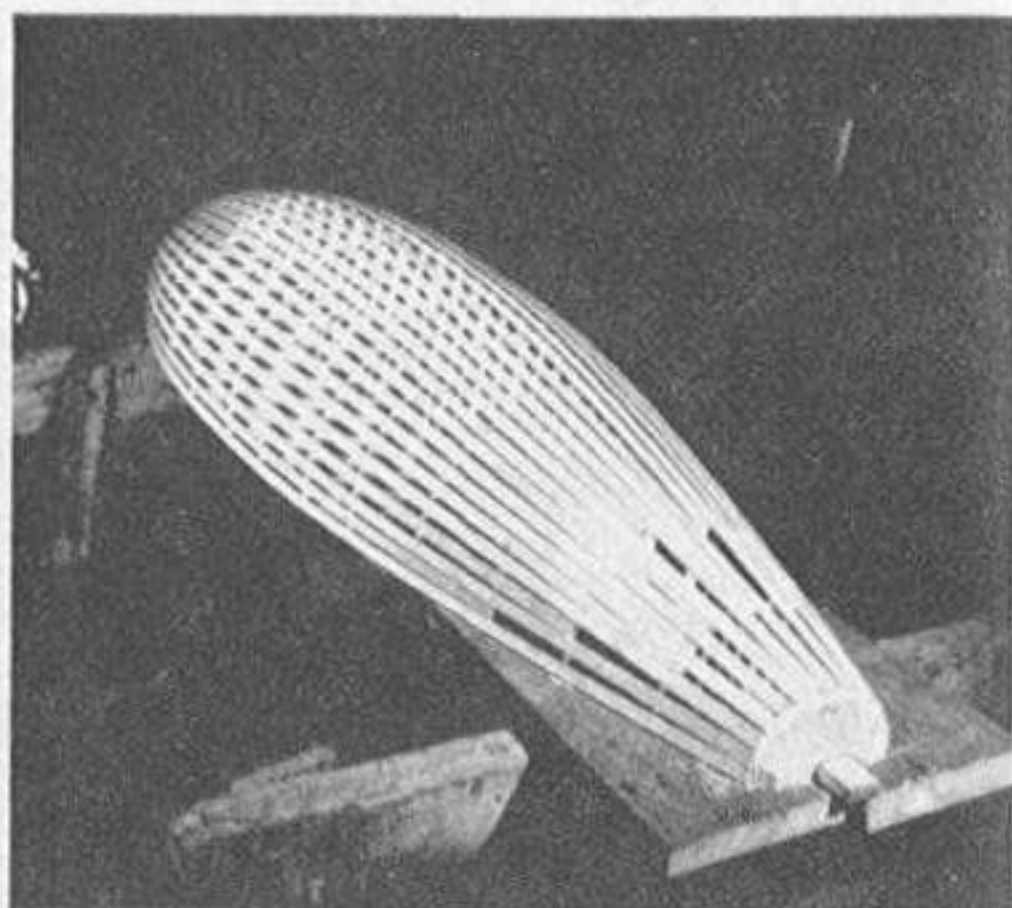
BUILD YOUR OWN



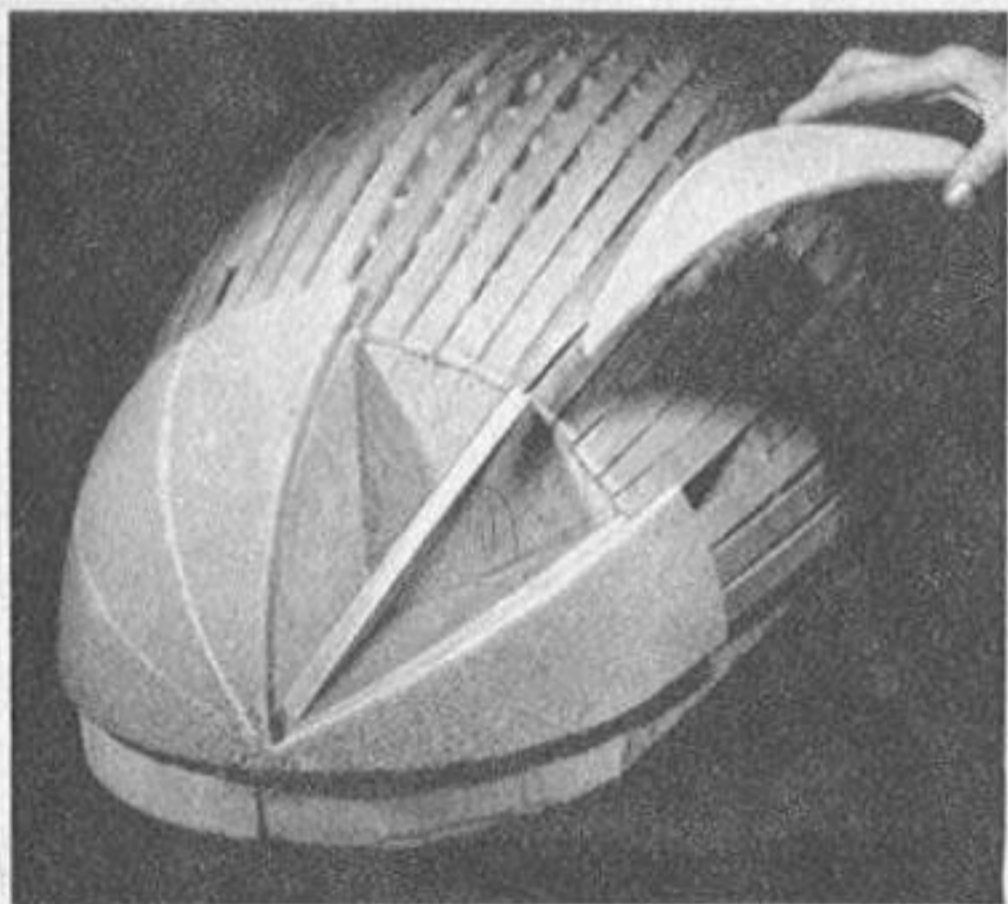
SPORT SUBMARINE



BATTEN is bent in smooth curve to make a template for $\frac{3}{4}$ -in. pine bow sections.



RIBBANDS complete basic mold, could be closed up, plastered, then sanded smooth.



BOW of mold is built up with individual Plyfoam sections heat-shaped on the form.

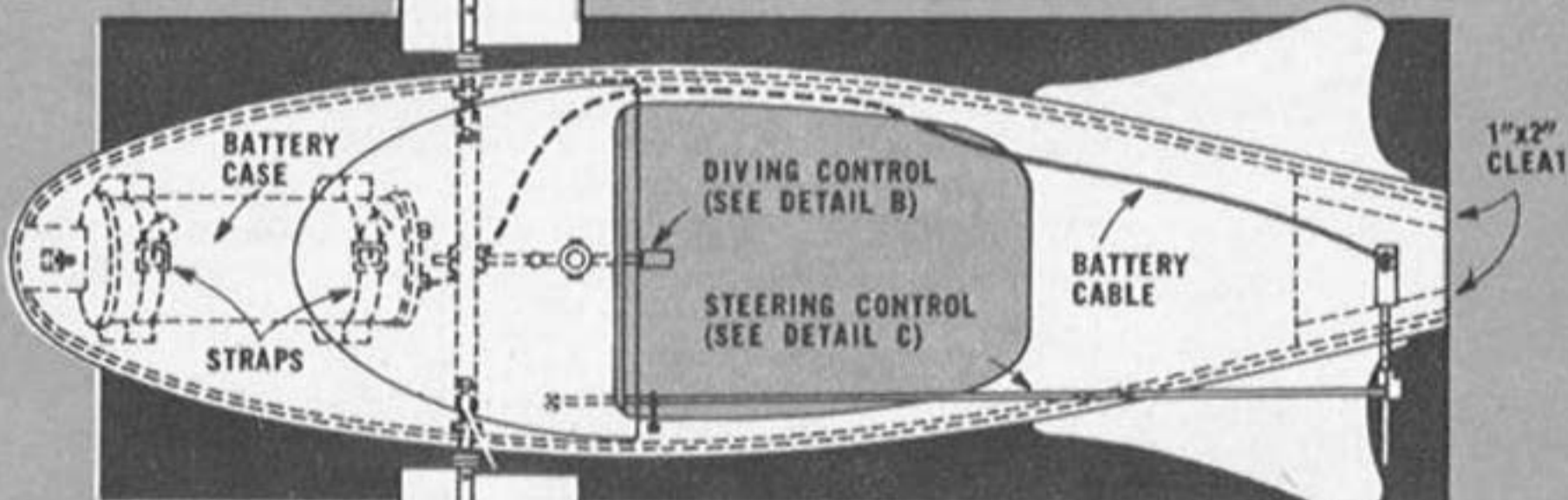
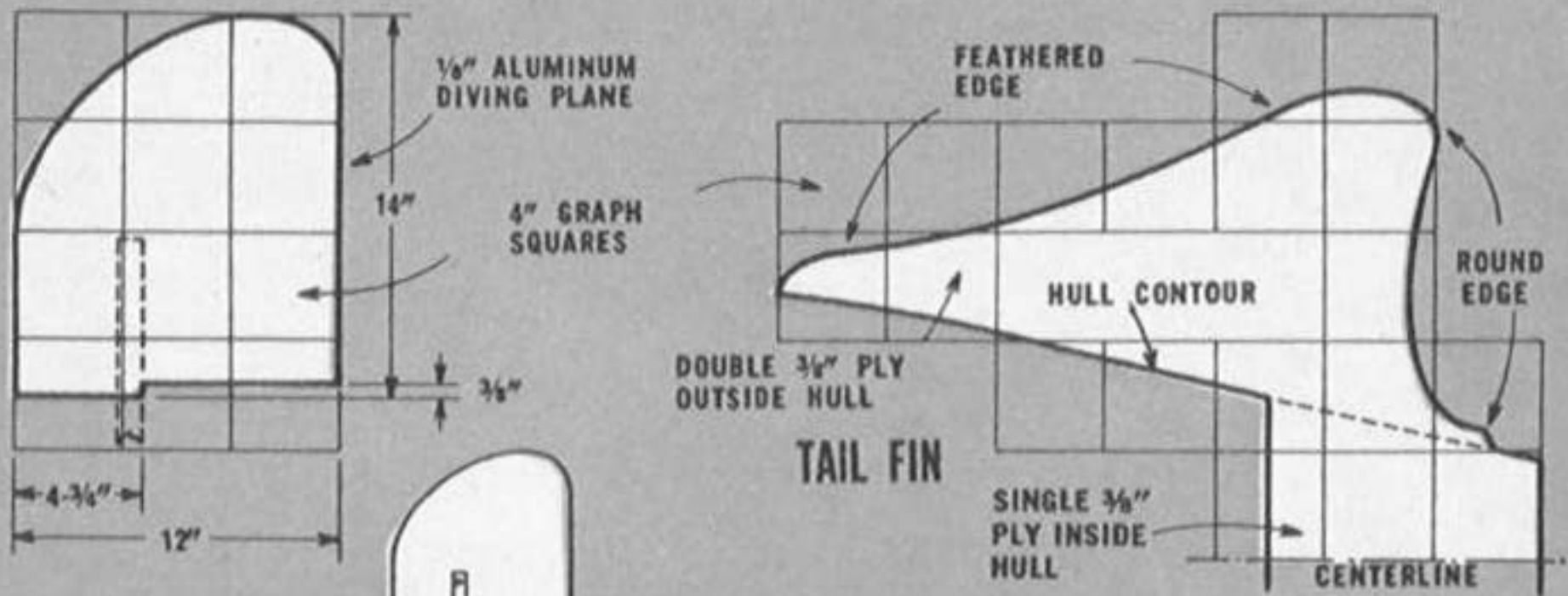


HEATER softens sheet Plyfoam for bending over the ribbands on the basic mold.

It was when we priced epoxy resin (\$86 for five gallons) that we changed our construction plans. We decided to use our remaining Plyfoam to make a smooth mold. Then we would cover it with thin sheet polyethylene plastic to protect it from polyester resin (\$5.50 a gallon) and lay up a straight fiberglass hull without the foam core. If money is no object, you can build the hull with Plyfoam and epoxy resin. Otherwise, follow our lead.

LARGE-SCALE PLANS

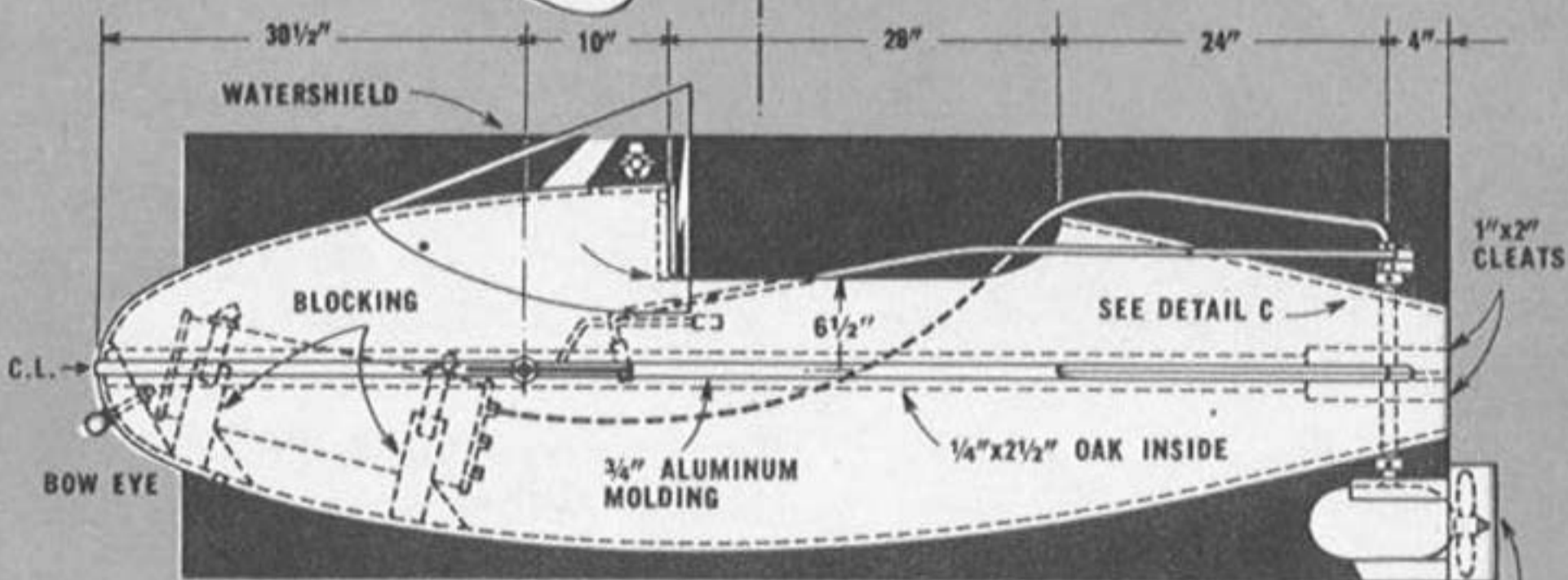
are available, complete with text and photographs. To purchase a copy, send \$5 to Mechanix Illustrated Plans Service, Fawcett Building, Greenwich, Conn. 06830. Specify Sport Sub, Plan No. SS-4-66.



TOP VIEW

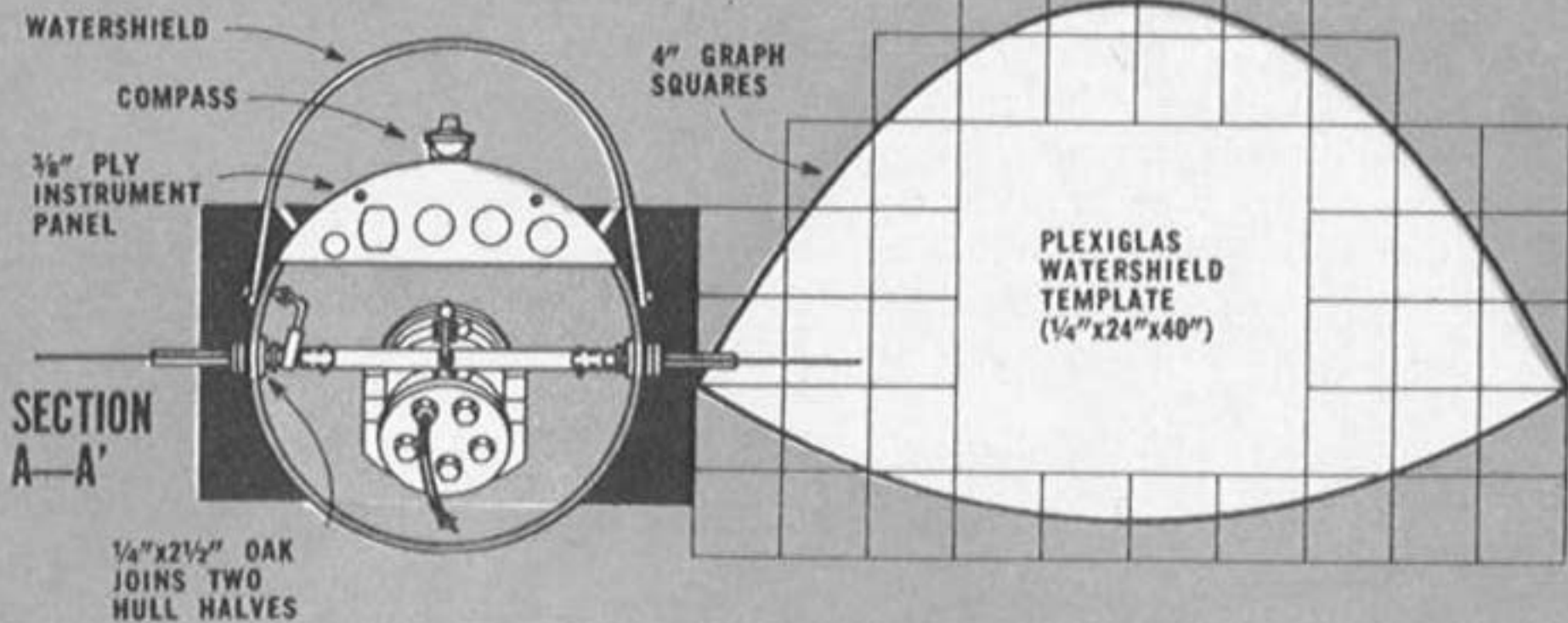
DIVING PLANE (2)

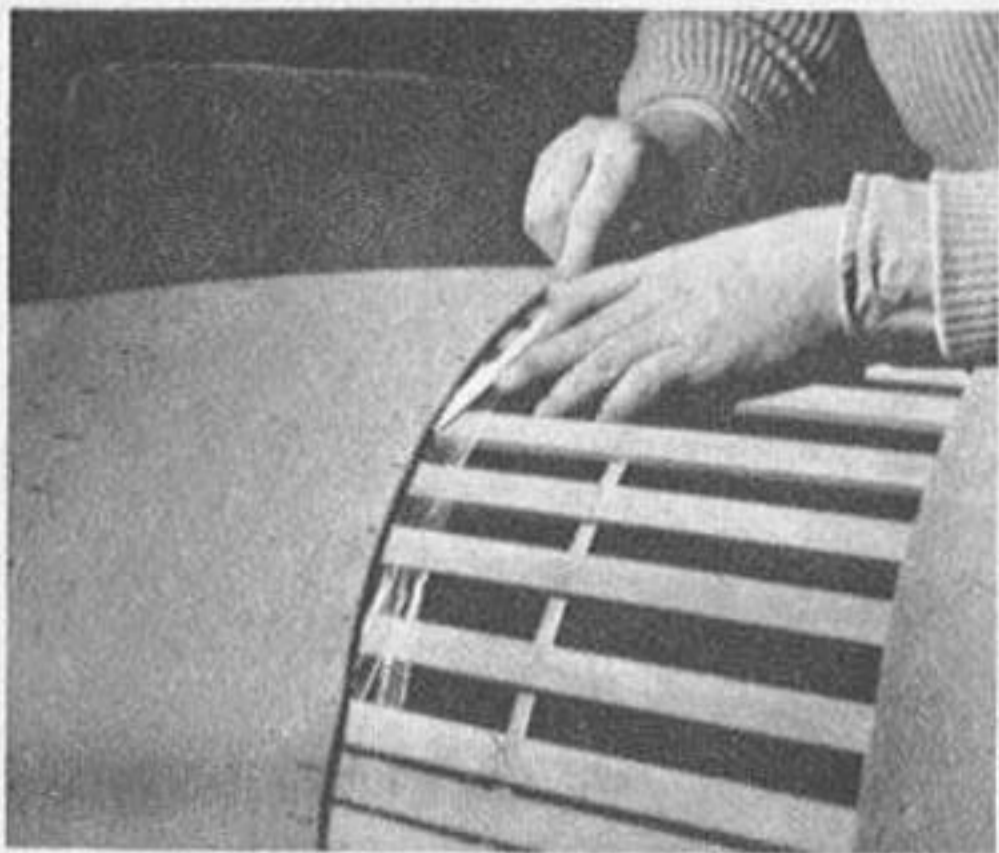
28"x3 1/4" TAIL FIN



SIDE ELEVATION

A'

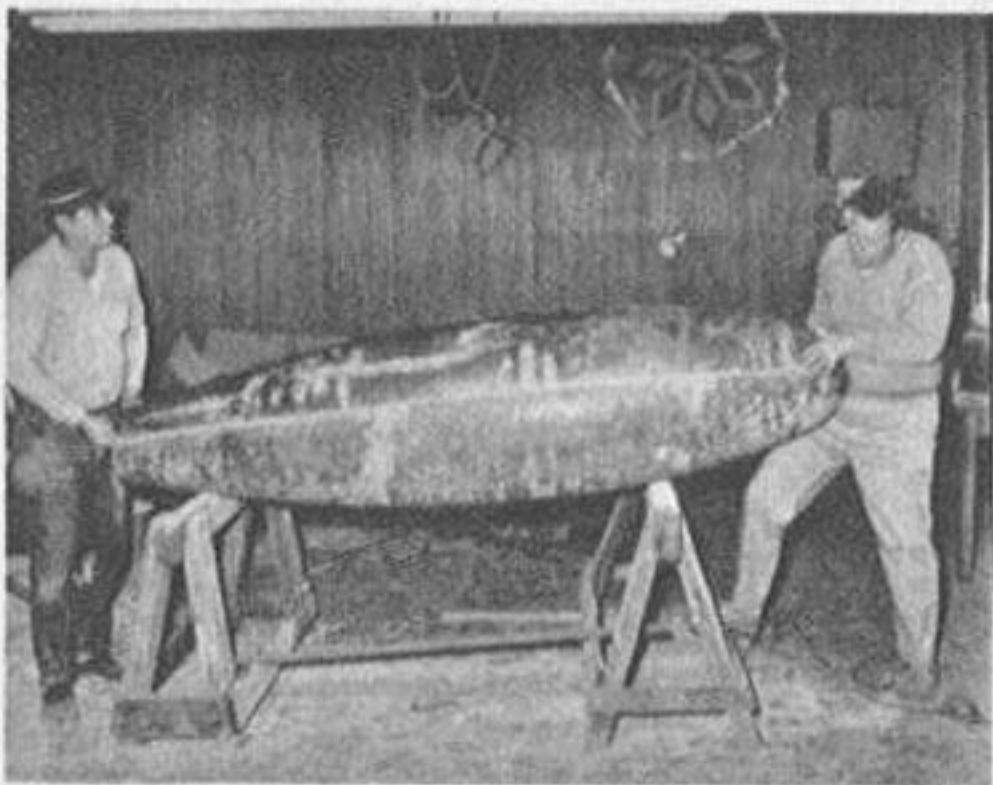




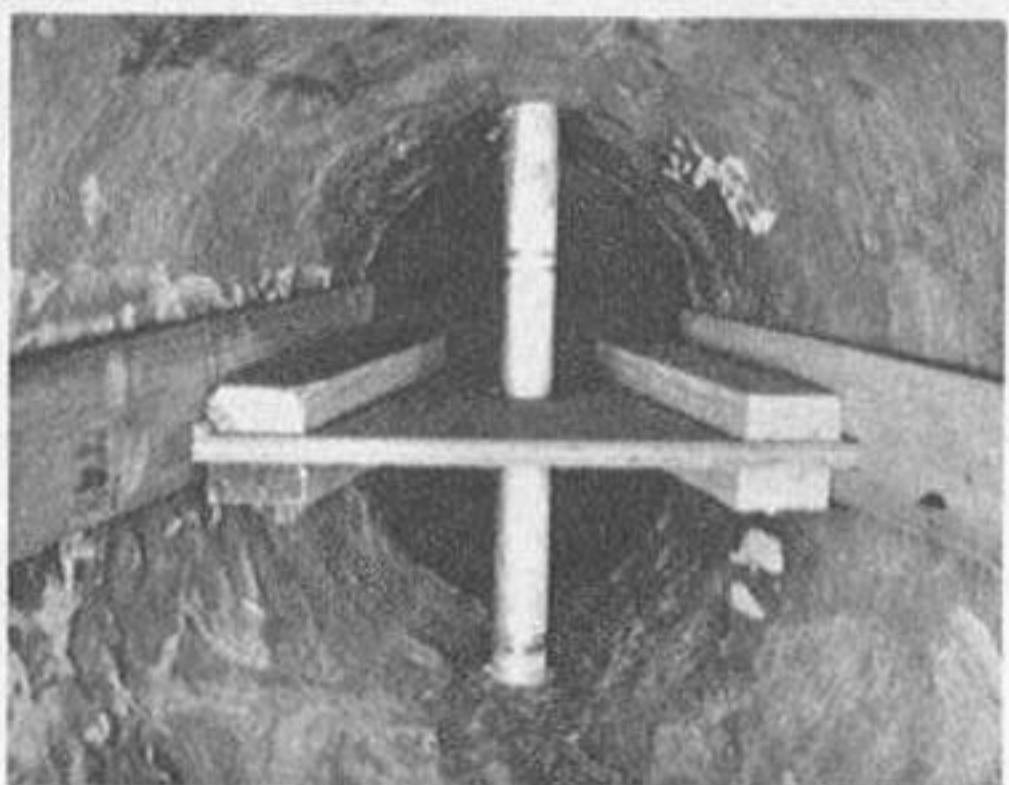
STRIPS of plastic under Plyfoam joints prevent epoxy resin from bonding to wood.



PLYFOAM makes smooth mold, is covered with thin sheet plastic for fiberglass lay-up.



TOP half of hull slips over projecting $\frac{1}{4} \times 2\frac{1}{2}$ -in. oak screwed to inside of bottom.



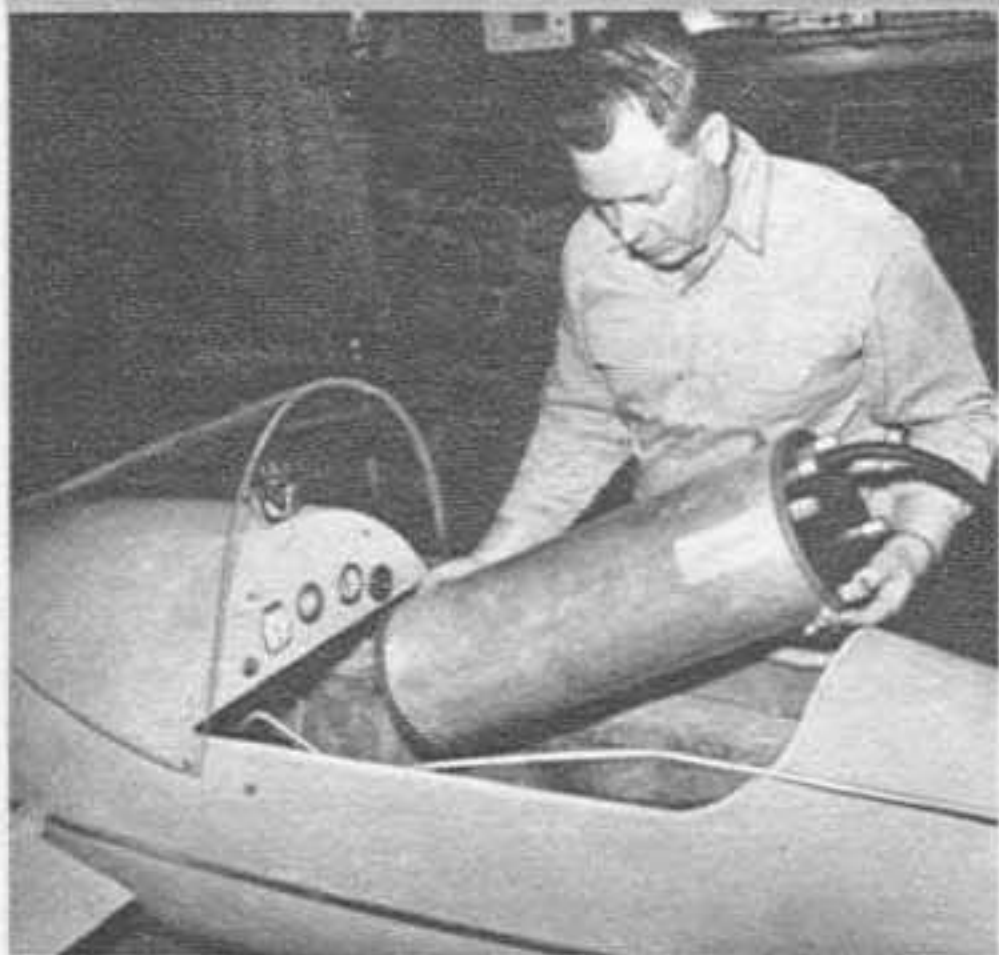
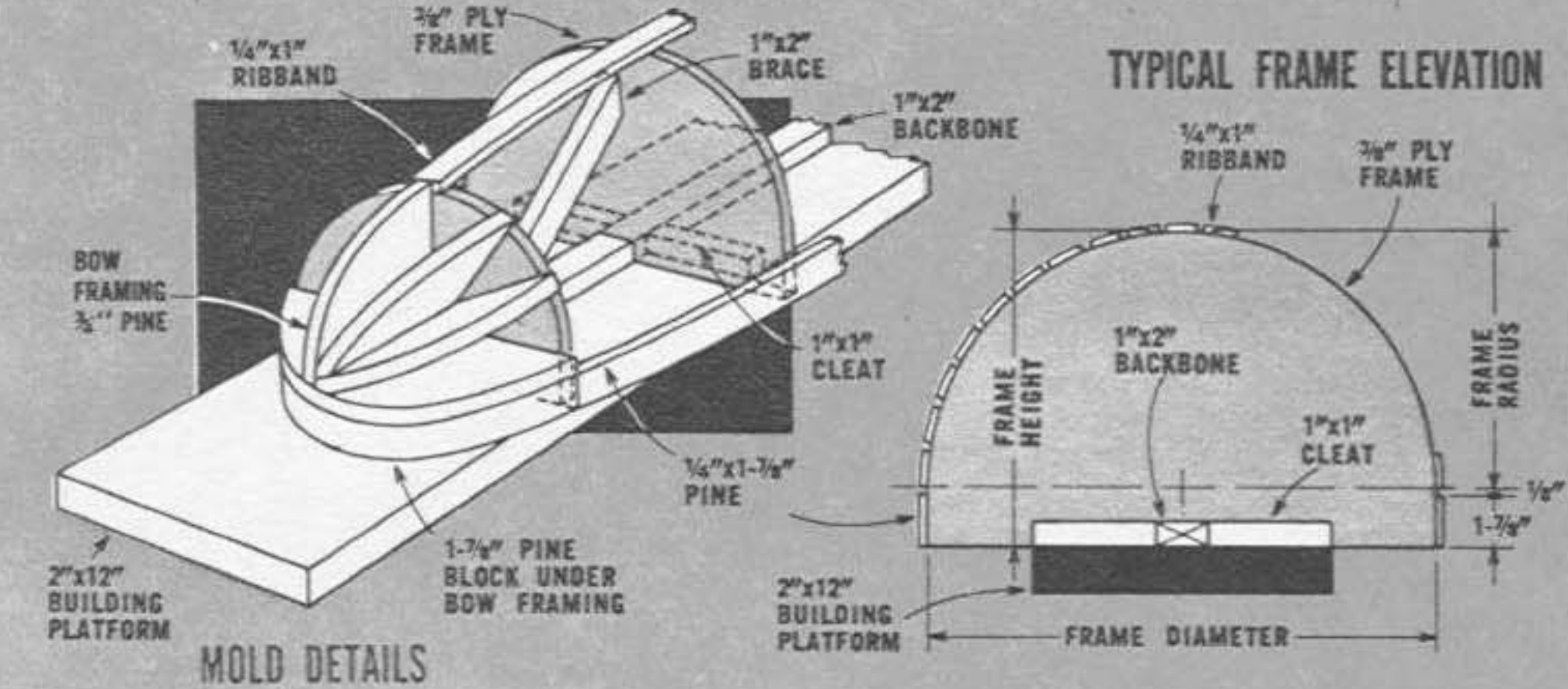
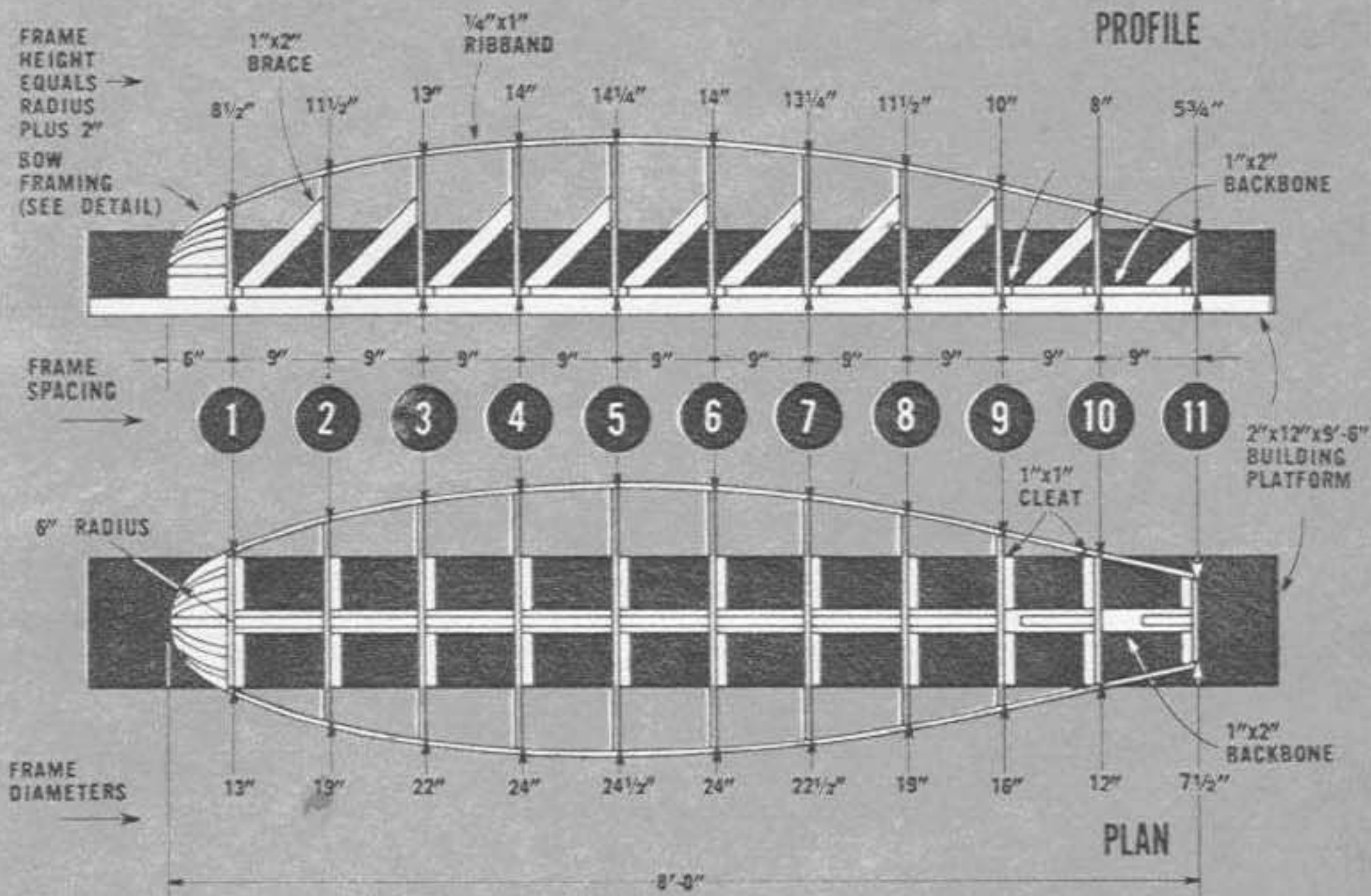
TAIL FIN passes through hull. This inside view shows cleats and motor shaft.

The drawings show the simplicity of the mold. Each frame is a half-circle—with an extra two inches at the bottom. As is the case with any original project, you often think of a better way to do something after you've done it. That extra two inches is the better way we didn't use in our construction. Thus the photos differ slightly from the drawings that should be followed.

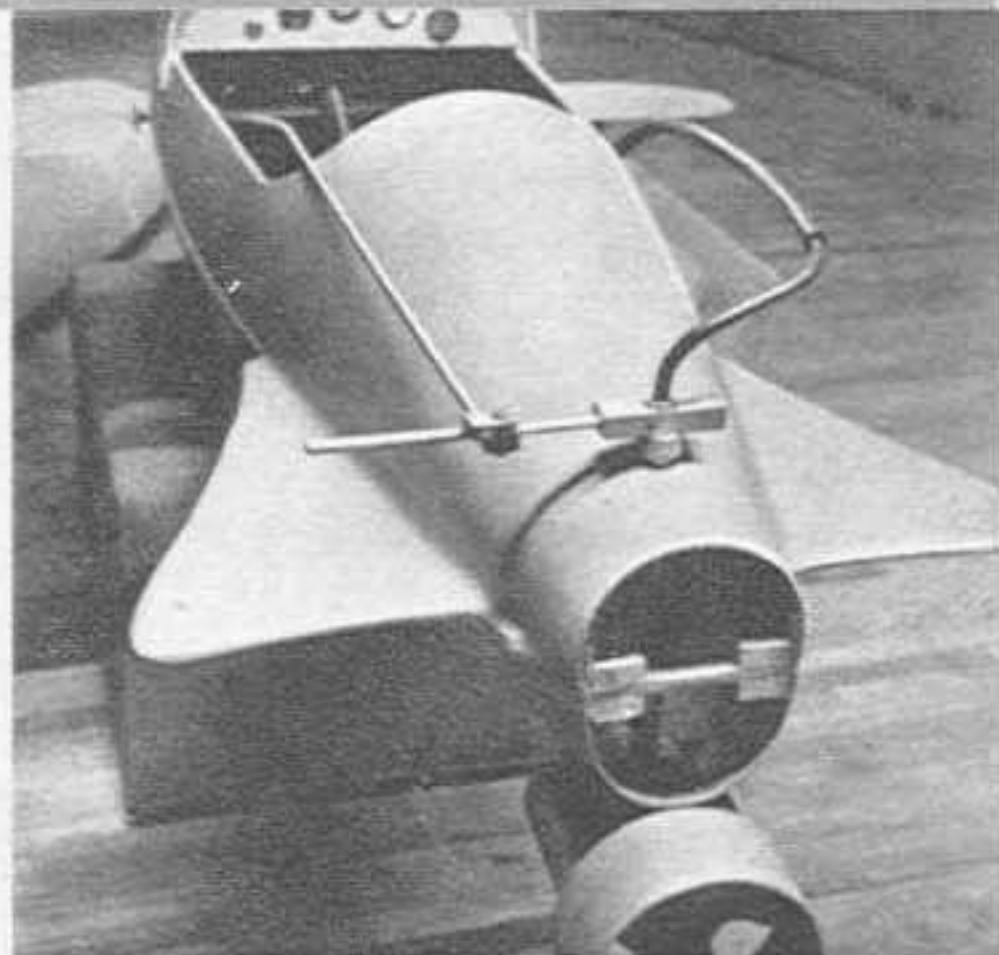
After going through the process of tacking the foam and the fiberglass on the underside of our mold, we decided it would have been better to have a straight band around the bottom to

which they could have been tacked. Furthermore, if a narrow, $\frac{1}{8}$ -in. slit were left at the top of the band, a sharp knife could be inserted and each fiberglass shell could be cut from the mold with uniform ease. That's why the drawings show a $1\frac{7}{8}$ -in. pine tacking strip around the bottom of the mold. There's a solid block under the nose.

The way the mold frames are erected and braced at right angles on the backbone and the building platform is well illustrated. It's also clear how the $\frac{1}{4} \times 1$ -in. ribbands are applied with half-in. brads. The nose is the only thing that

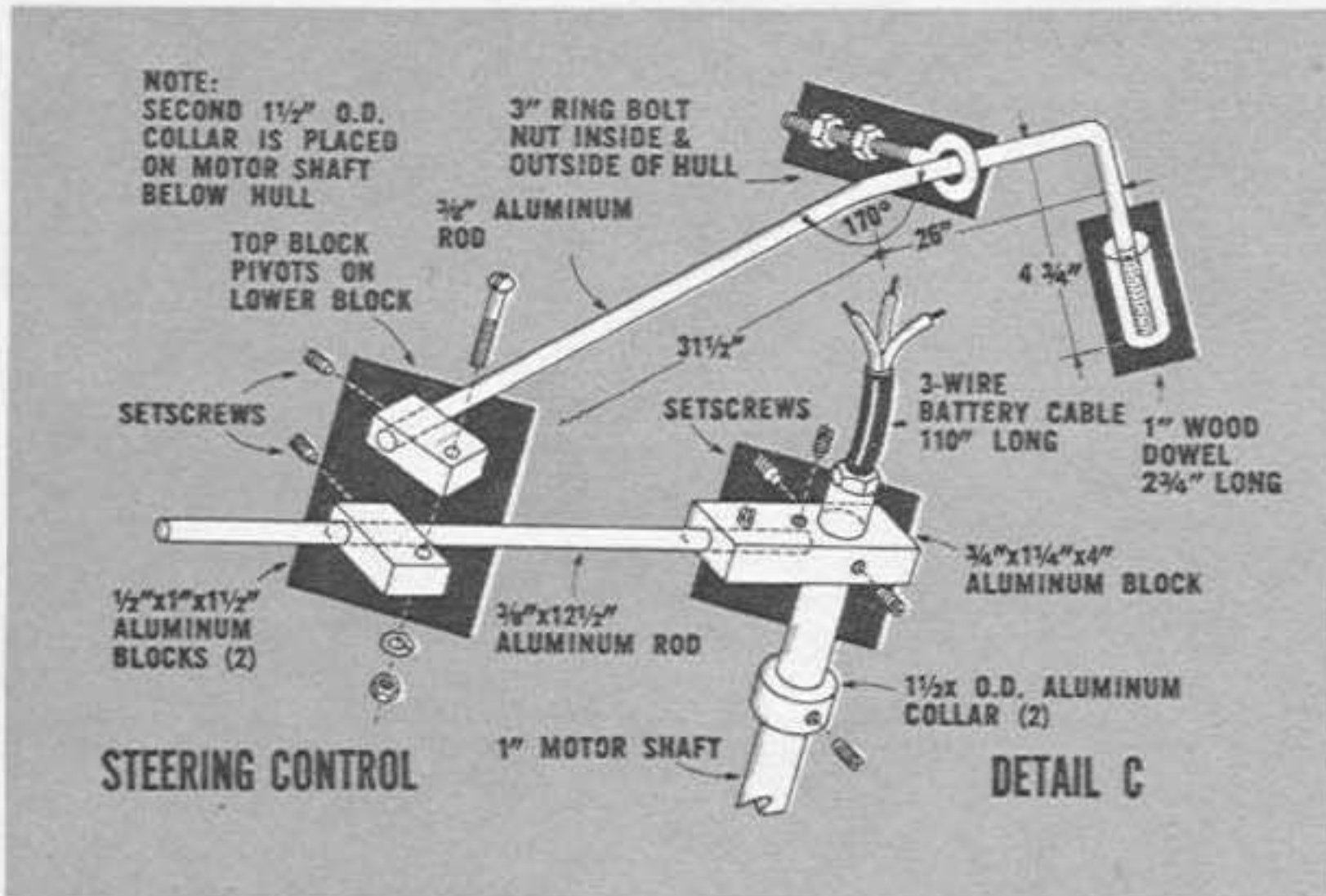
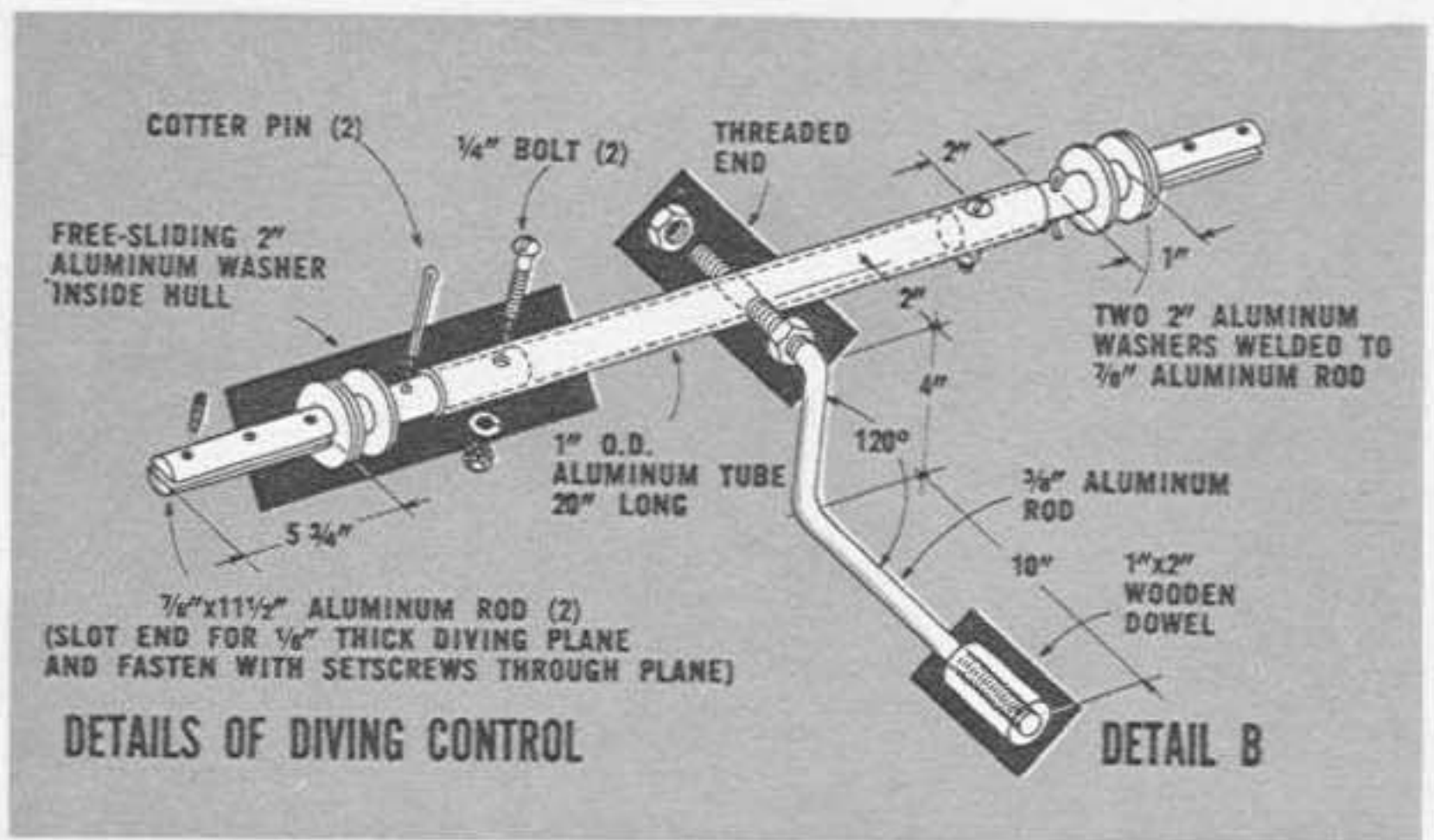


BATTERY CASE will hold two six-volt batteries. It is strapped in forward chocks.



STEERING is worked by means of pivoting-arm control attached to motor shaft.

SPORT SUBMARINE



requires extra care. As shown in a photo, take a thin, flexible batten and bend it from the side around to the center point of the nose on the backbone, establishing a smooth curve by eye. Then tack the batten in place and slip a piece of cardboard under it to make a template.

The template can be used to make up the 3/4-in. pine sections that form the bow. Naturally, the bottom edges of all but the center one will have to be cut and beveled to fit them in flush with the line of the hull.

At this point you could complete the mold entirely of wood, filling in all the open spaces and closing up small cracks with plaster or patching compound.

You then could sand the entire form smooth, coat it with a wax releasing agent and lay up your fiberglass. We proceeded in a different way, using our Plyfoam to make the smooth mold.

The Plyfoam was easily shaped over the mold with the aid of an electric heater. We just held the heater close and formed the foam with our hands when it got hot. Where it tended to buckle (we used sheets almost half the length of the hull), we cut narrow triangular darts from the bottom up and pulled the edges together smoothly. All edges of the Plyfoam were bonded together with epoxy resin after pushing strips of polyethylene plastic under the joints to keep [Continued on page 124]

Build Your Submarine

[Continued from page 92]

the resin from bonding to the wood.

The edges of the Plyfoam required some care. When two sheets were heat-formed around a curve and butted the edges tended to curl up. When the sheets were formed our first cuts were rough. Then, to get the edges to butt perfectly, we made a simple gadget. It consisted of two parallel razor blades clamped to a $\frac{3}{4}$ -in.-wide piece of wood. By drawing them along on either side of our rough cut, we got clean, parallel cuts—and also eliminated the slight curl at the edges. Epoxy resin and some staples into the wooden ribbands secured the sheets firmly.

On the nose, we formed and cut individual pie-shape sections of Plyfoam, then edge-glued them together along the centerline of each $\frac{3}{4}$ -in. pine section. A few brads driven in flush kept the foam in place until the resin hardened.

The fiberglass was laid up after we had covered the mold with thin sheet plastic. The first layer was heavy woven roving. After it was sanded smooth, a layer of 10-oz. glass cloth was applied. When this had cured, a complete sanding followed, with close attention to every imperfection. Where any bad spot was sanded out polyester patching compound was used to fill it in smooth.

With the $\frac{1}{8}$ -in. slit around the bottom, cutting each fiberglass shell from the mold should be easier than it was for us. But the hull sections at this point are still not stiff enough. A layer of 1 $\frac{1}{2}$ -oz. mat on the inside completes the job.

To get the two halves of the hull to mate perfectly we devised a scheme. A $\frac{1}{4}$ x2 $\frac{1}{2}$ -in. oak strip was screw-fastened to the inside top of the bottom half of the sub, half its width projecting above the edge. The ends of the screws, incidentally, were ground off flush on the inside. At the bow, a piece of 4x8-in. fir was shaped and fitted inside to take a bow ring later. Then the top half of the sub was fitted on and screw-fastened into the oak along the edge. On the outside, a three-in. width of glass tape was bonded over the joint with polyester and sanded smooth after curing.

Cutting out the cockpit opening was

[Continued on page 126]

next. On each side, 6½ in. above the centerline, we cut straight lines, curving them up by eye into the back of the cockpit. The cut across the front is a straight one from side to side. A curved 1½-in.-wide cleat was glued and screwed across the forward end of the cockpit on the inside to provide for fastening of the dash and ¾-in.-sq. cleats were glued to the undersides around the other edges. Then all cleats were covered with fiberglass tape which was later sanded smooth.

Rather than fasten a weak tail fin on each side, we made a one-piece tail to pass right through the hull. To accommodate it, a ¾x10-in. slot was cut in the lower half of the sub from the centerline down on each side. The part of the tail which passes through the hull extends 10 in. forward of the stern and provides great rigidity where it's needed. As illustrated, cleats brace the tail inside and the thickness is doubled with another layer of ¾-in. plywood on the outside. It's all faired off nicely, sealed at the joints with fiberglass tape and painted. It is not necessary to fiberglass the wood.

The watershield is necessary to keep your face mask from being torn off because the sub can move up to 4 mph under power. Cut the quarter-in. Plexiglas to the shape shown. Then hold the sheet in front of an open oven with the heat turned up high, bending it gradually to the hull form. The work can be simplified by making a mold from a sheet aluminum template which is bent to shape on the hull. Then the Plexiglas can be formed over the mold or you can send the mold to a plastics house to have the job done.

Our dash, a quarter-in. plywood panel, is fitted with a decompression gauge and four instruments: thermometer, depth gauge, timer and pressure gauge to keep a check on the air tanks. A compass, which aids in keeping the sub level, is mounted on top behind the watershield.

Little could be said about the steering control and the diving planes that isn't detailed in our drawings. Use an exterior-type construction-grade aluminum and paint the planes with epoxy after priming. Chocks for the battery case can be secured to the inside of the hull with epoxy resin.

The power in our sub is a pressure-

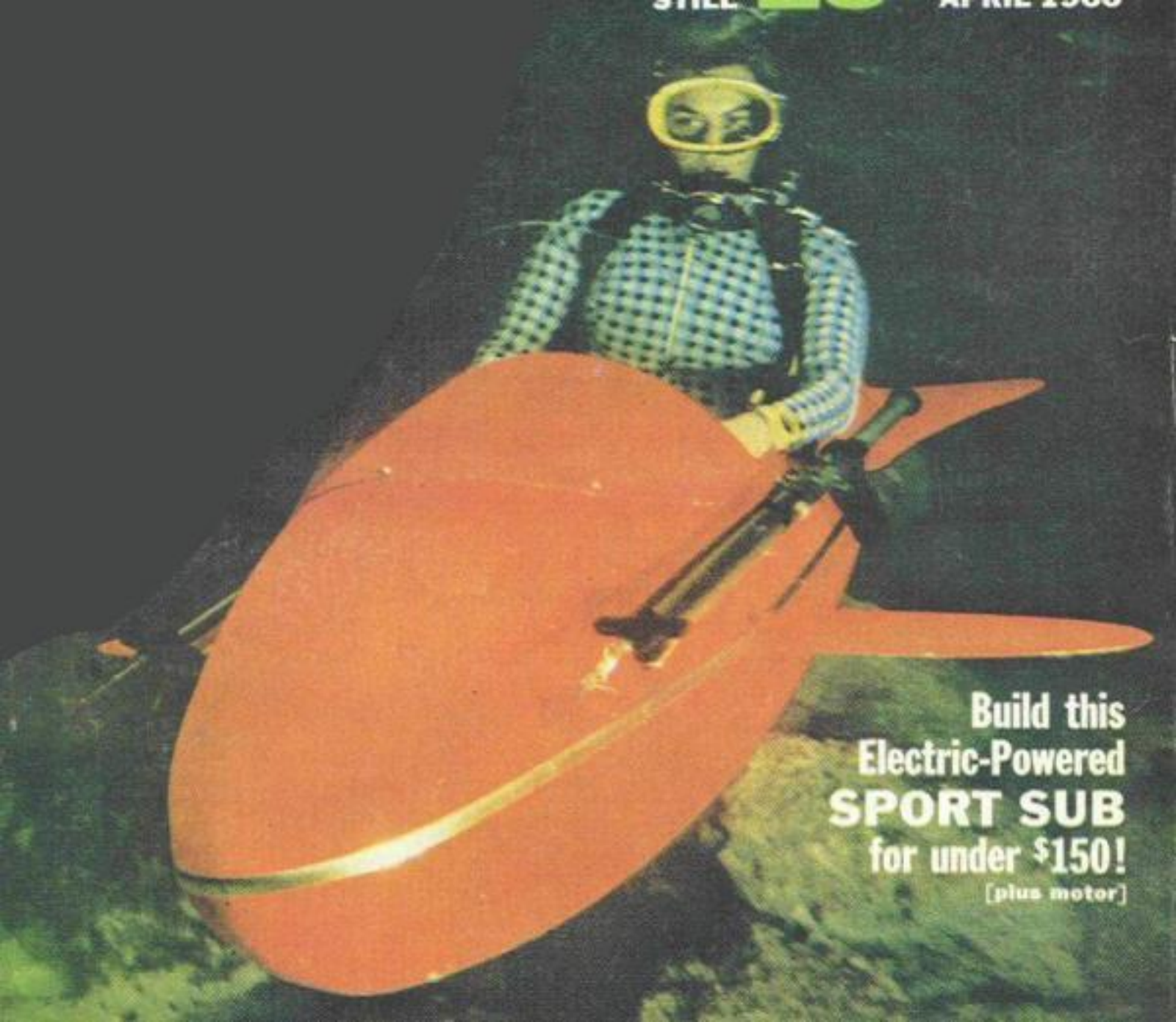
sealed ¼-hp, 12-volt motor developed by the Davee Co. of New York City and sold through Richard's Aqua Lung Center, 233 W. 42nd St., New York, N. Y. 10036. The motor and battery case have been tested to a depth of 100 ft. and this is the recommended safe limit for our sub.

With wiring harness and a safety shroud over the propeller, the motor sells for \$112. The battery case, complete with wiring, switch and O-ring seals, costs \$101. The case will hold two AC-78, 12-volt, aircraft-type, Exide batteries. They list at \$48.35 each. One battery may be used for slow speed; two batteries hooked in series to put 24 volts on the motor will give speeds up to 4 mph.

The sub must be buoyed in the same manner as a diver. This is accomplished by trial and error, using Styrofoam flotation and weights as necessary. Put the flotation in the top half of the sub fore and aft and secure it firmly when you have it right. Any weight should be in the bottom to keep the sub upright. Be sure it trims level fore and aft. Just the slightest amount of positive buoyancy so the sub floats with the top just awash at the surface is desirable.

In handling the sub the tendency of beginners is to over-control, depressing or elevating the diving planes too much and turning the motor too far. Only slight movement is required and it even would be advisable to put limit stops on the controls. Rolls should be avoided. The batteries won't spill in a quick roll but they will if kept upside down too long. One caution: the sub is not for novice divers. Become proficient as a free diver before you attempt to handle an underwater vehicle.

There you have it. In construction of the mold and the basic hull we used seven gallons of polyester resin (\$38.50); six yards of 10-oz. glass cloth (\$7.92); six yards of woven roving (\$8.40); six yards of 1½-oz. mat (\$6.60); two 4x8-ft. sheets of ¾-in. plywood (\$14); 224 ft. of ¼x1-in. pine strips (\$11.20); 16 ft. of ¼x1-in. oak (\$1.12); and the Plyfoam (\$16.50)—a total of \$107. Hardware and Plexiglas brought our full cost to near \$150. Complete, the sub can be put in the water for about \$476, which is less than half what a commercial equivalent was selling for when we set that mold up. •



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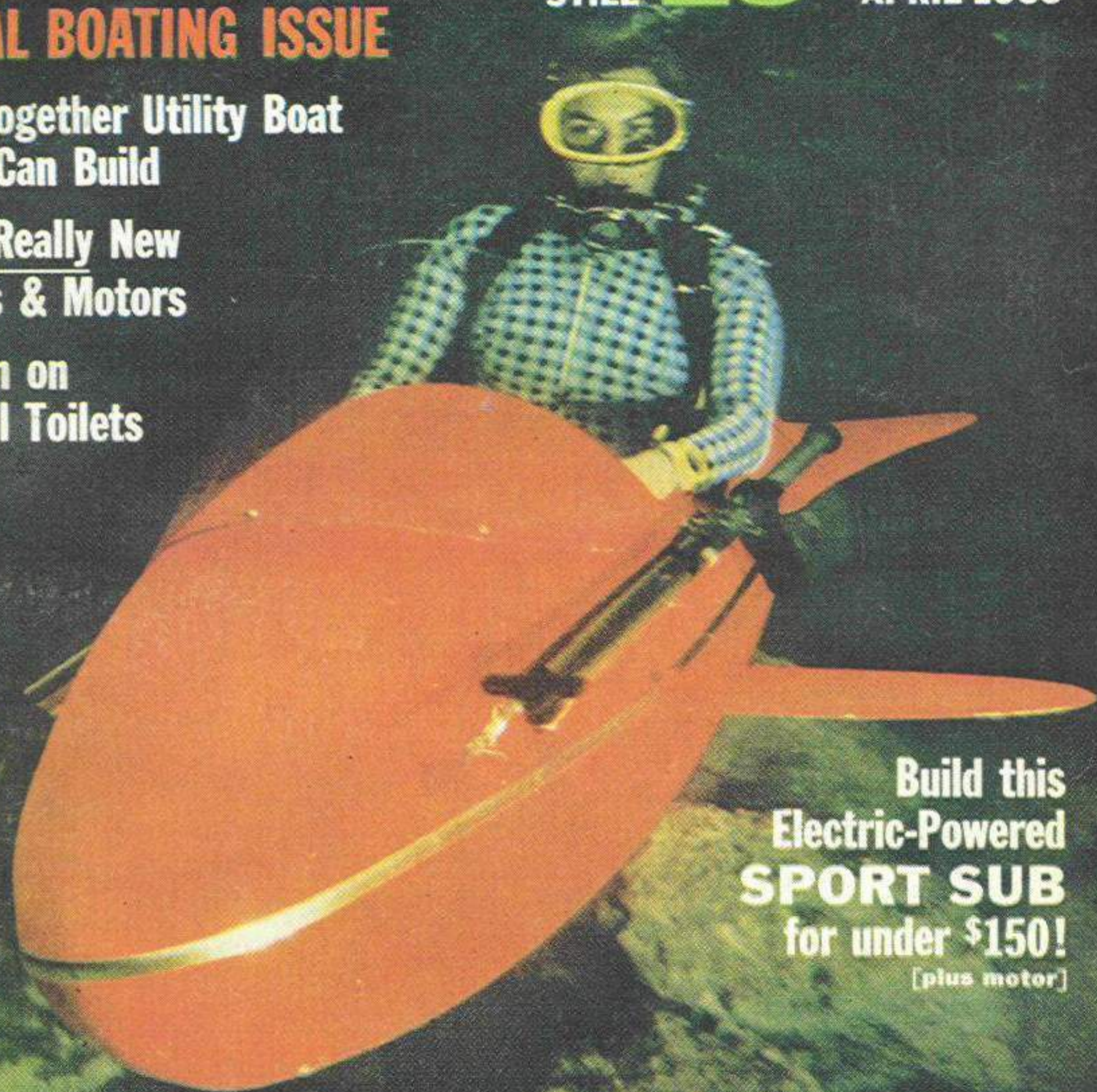
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