More Speed—More Stability with this HYDROFOIL BOAT

Want a faster boat? Or greater stability on rough water? If so, this willing mermaid is for you

By WILLIAM D. JACKSON

Craft Print Project No. 304

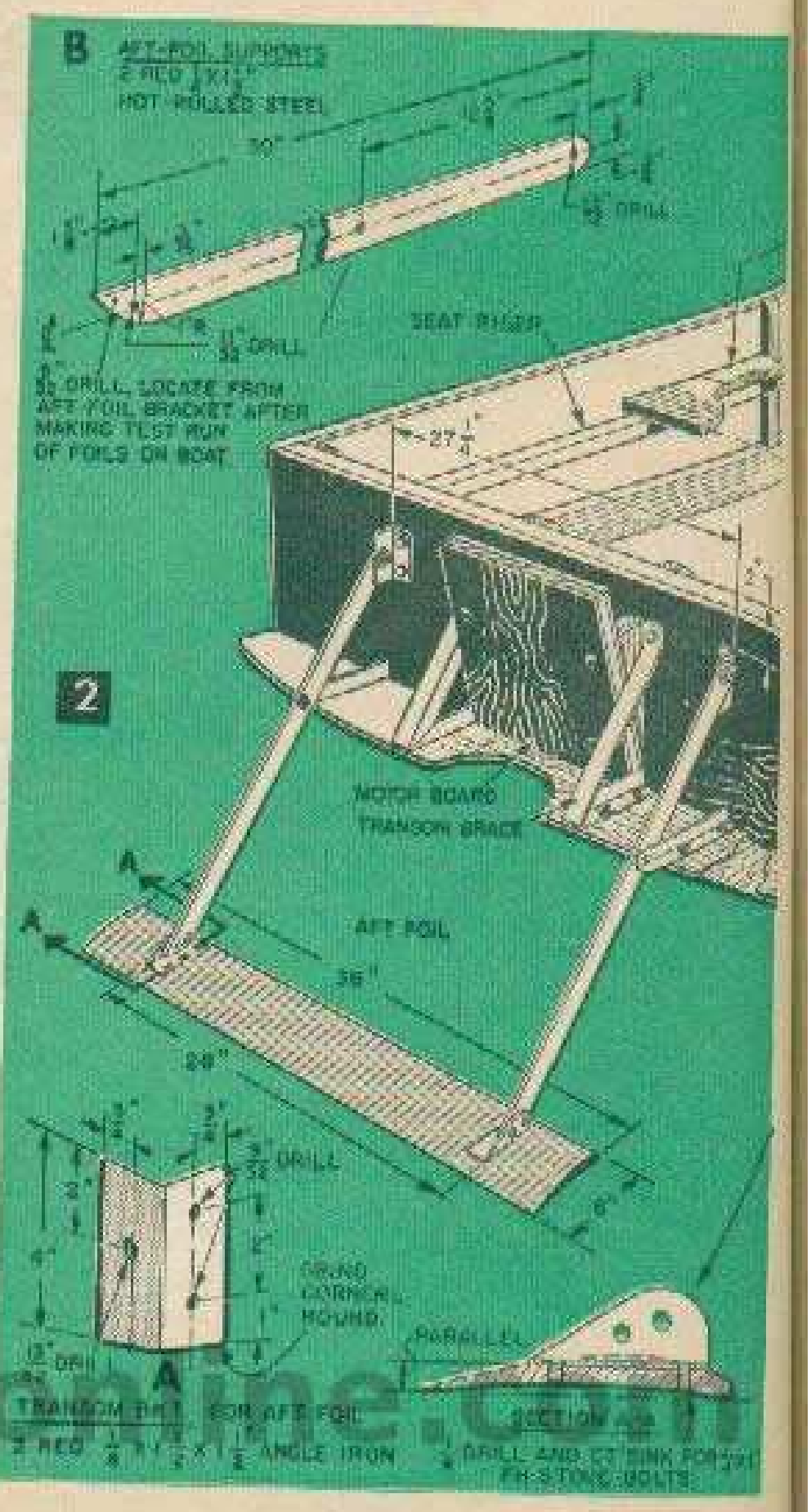
BECAUSE hydrofoils lift the entire boat hull above the surface of the water, they will usually increase the speed of a boat-and-motor combination by 25%.

Rough waves that will rock a conventional hull do not affect hydrofoils, which ride below the surface. Thus you have greater stability and a smoother ride with hydrofoils. And maneuverability at high speeds is good, because the foils don't skid on the water.

The building plans for the hydrofoils shown in this article are the result of designing and testing many different types, sizes and shapes of hydrofoils over a period of several years. Detailed plans for building the specific boat with which we tested these hydrofoils are given, but you can also use these hydrofoils on most any boat up to 16 ft. in length. Some experimentation as to placement of the two forward hydrofoils on any other boat will, of course, have to be worked out by a series of test runs for best performance. But more about that later. Right now, let's get started with the construction of the hydrofoils.

Making a Set of Hydrofoils. The set consists of three separate hydrofoils: two of them mounted on opposite sides of the boat hull up forward as in Fig. 2 and one foil fastened to the transom. All foils may be swung up clear of water so that boat can be beached as in Fig. 5.

Starting with the transom or aft foil make the metal parts detailed in Figs. 2A, B, C and D. If these hydrofoils are to be used on a boat other than the one shown here, you may have to alter the design of the aft-foil support bracket (Fig. 2C), by putting a 90° bend on it for fastening directly to the transom instead of to the projecting ends of the bottom planking as on our boat. The other parts should work well on any boat. Where



STATEMENT OF USES

USES: Experimental outboard powered boat and hydrofoils for testing speed increase, load carrying capacity and maneuverability of hydrofoil equipped boat. Boat may also be used without foils for sport and fishing use.

BOAT: Flat bottom, scow-type hull with battened air traps on bottom to aid foils in quickly lifting boat from surface of water.

HYDROFOILS: Steel framework with fiber glass, air-foil shaped lift surfaces. Foils are retractable.

POWER: 10 to 40 hp long-shaft outboard motors. 10 hp Evinrude '59 long-shaft motor used in making test described.

BOAT LENGTH: 10 ft. BOAT BEAM: 4 ft.

BOAT WEIGHT: 200 lbs. with foils and all equipment.

BOAT CAPACITY: 3 with foils. 4 without foils.

BOAT CONSTRUCTION: Wooden framework covered with sheet plywood.

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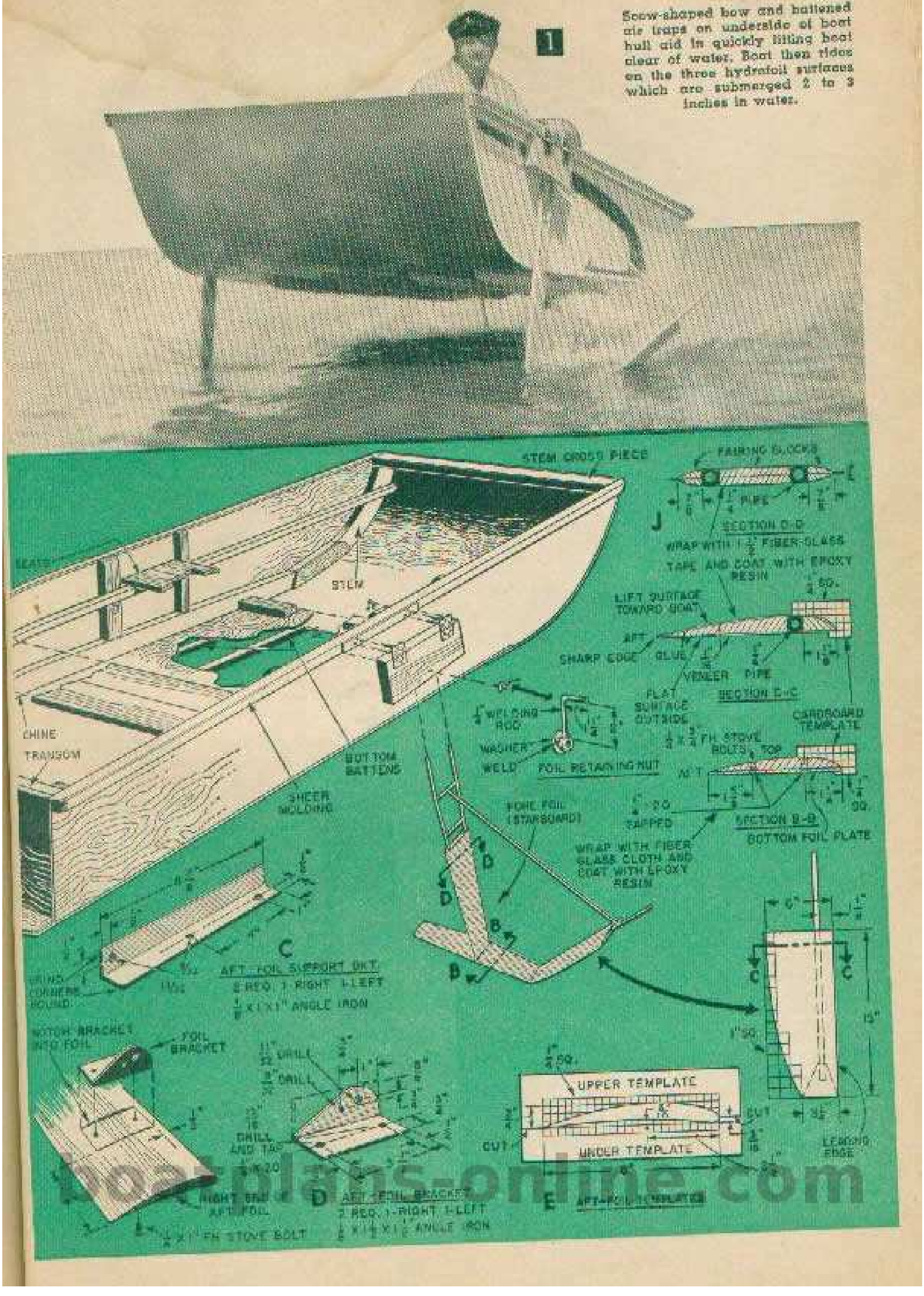
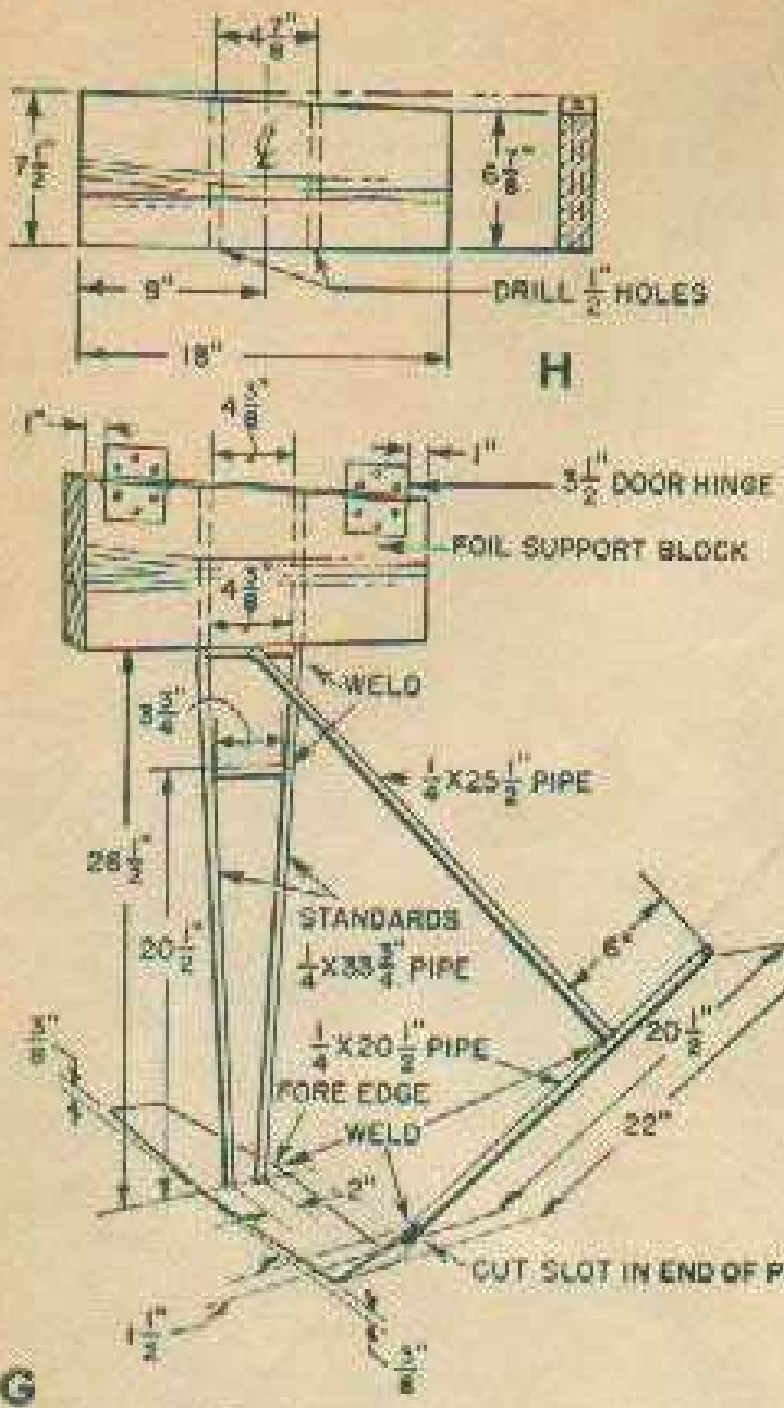
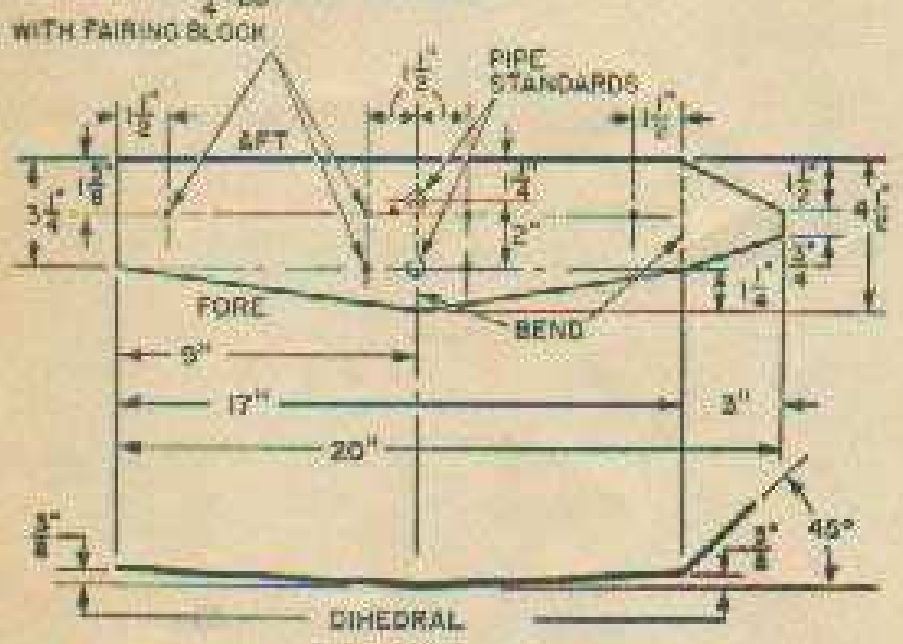
Scow-shaped bow and battened air traps on underside of boat hull aid in quickly lifting boat clear of water. Boat then rides on the three hydrofoil surfaces which are submerged 2 to 3 inches in water.



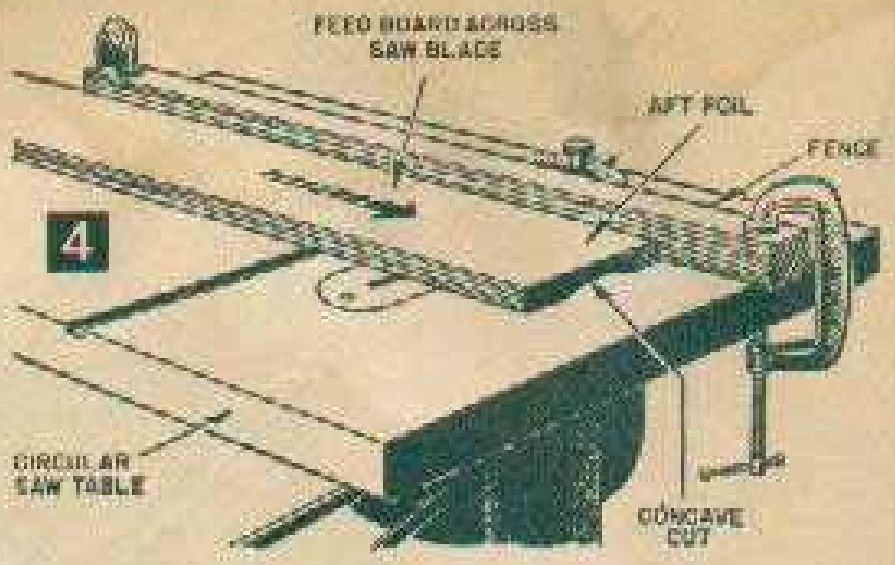




3 F FORE BOTTOM FOIL PLATE, 2 REQ
1/8" STEEL PLATE, 1-RIGHT, 1-LEFT

there is a rounded corner indicated on the metal parts, saw off the corner diagonally with a hacksaw and grind to shape.

Make the wooden aft foil from a ¾ x 6 x 36-in. piece of clear, straight grained fir. Since the performance of a hydrofoil in water is similar to an airplane wing in the air, its cross sectional shape must be similar. To shape the aft foil, first make a full-size drawing of the foil section on a 3x7-in. piece of cardboard as in Fig. 2E. Then cut the cardboard, making a template for both



upper and under foil sections.

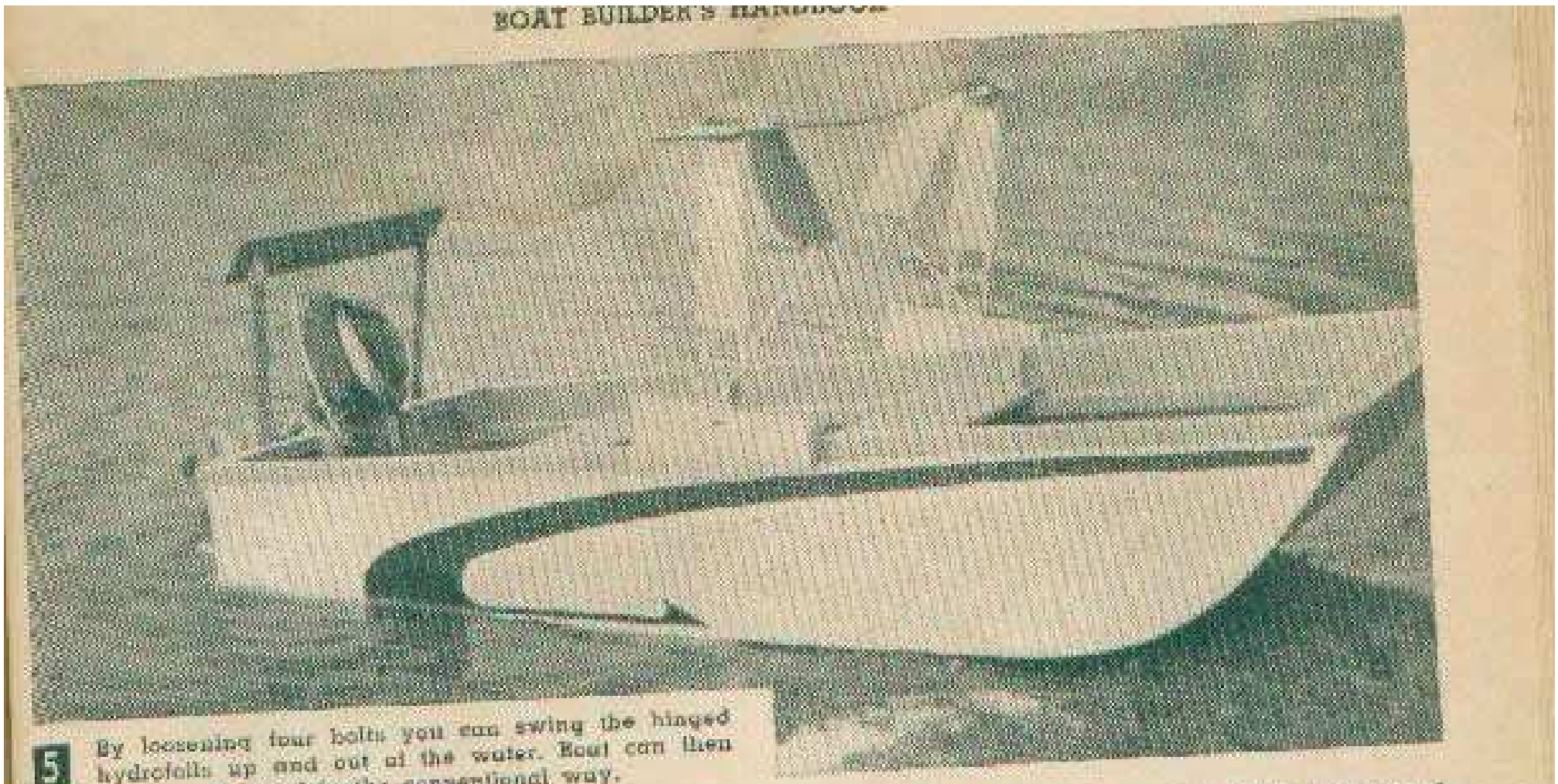
Shape the underside of the foil first by running the piece of fir stock across your 8 or 10-in. circular saw at right angles to the blade as in Fig. 4. Make the 3/16-in. deep concave cutout in three passes across the saw blade, raising the blade 1/16 in. for each pass. Then rough out the rest of the underside with a block plane and finish to the contour of the template with coarse sandpaper. Plane the upper side of the foil to shape with a jack plane and finish to the contour of the upper template with coarse sandpaper.

Now, cut two 1½-in. wide notches in the upper surface of the foil 28-in. apart, as in Fig 2D. This provides a flat surface on which to mount the two aft-foil brackets. Fasten the brackets to the foil with ¼-in. fh bolts as in Sec. A-A Fig. 2. Then bolt the other aft-foil supports and brackets together as in Fig. 2 and set the assembly aside for mounting on the transom of your boat later.

Two forward foils, for mounting on each side of the boat, are required. These are identical in size and shape but must be made in pairs—left hand for port side and right hand as detailed in Figs. 2 and 3 for fastening to the starboard side

MATERIALS LIST—HYDROFOILS

No. Req.	Size and Description	Use
	FORWARD FOILS	
2	1/8 x 4½ x 20" hot rolled steel plate	bottom foil plate
22 ft	¼" black-iron pipe	standards
1	¾ x 5⅝" x 12" ponderosa pine	fairing blocks
8	¼ x ¾" fh stove bolts	fore foils
4	3/16" door hinges	fore foils
1	1⅝ x 7/8 x 36" fir	support blocks
2	⅜ x 6" carriage bolts	support blocks
12	#7 x 1½" fh wood screw	hinges
12	10-32 x 2" fh machine screw	hinges
4	#7 x 1½" fh wood screws	support blocks
1	1/16 x 6 x 60" veneer	foil-covering
	AFT FOIL	
1	¾ x 7⅛ x 36" clear fir lumber	aft foil
2 ft	⅛ x 1½ x 3½" angle iron	brackets
5 ft	¼ x 1½" steel bar stock	supports
2 ft	⅛ x 1 x 1" angle iron	support bracket
8	⅛ x 1" fh stove bolts	aft foil
2	5/16 x 1" hex. head cap screws	transom bracket
4	5/16 x 1" hex head cap screws	foil bracket
4	¼ x ¾" hex. head cap screws	support bracket
8	⅛ x 1" fh stove bolts	foil brackets
4	¼ x 1¼" hex. head cap screws	transom bracket
	FIBER GLASS	
30 yds	1½"wide fiber glass tape	fore foils
1 yd	38" wide fiber glass cloth	foils
1 qt.	epoxy resin for above glass cloth	



5 By loosening four bolts you can swing the hinged hydrofoils up and out of the water. Boat can then be used in the conventional way.

of your boat.

First make the fore bottom foil plates (Fig. 3F), from ⅛-in. thick steel. Although you can saw this material with a hacksaw, it would be worthwhile to have it cut to shape on a metal shear or with a torch at your local weld shop. When bending these pieces, be sure to make one right hand and the other left hand.

Make the foil standard from ¼-in. black-iron pipe cut to lengths given in Fig. 3G. Saw 1½-in. long slots in the ends of the 20½ in. long pipes so they can be slid on the bent-up ends of the bottom foil plates and welded. All other pipe joints are simply butted together and welded.

Now make two foil support blocks as in Fig. 3H. Before drilling the ½ in. holes in the blocks, bend the top ends of the forward foil standards slightly so they will be parallel. Then measure the distance between the bent pipes and space the ½ in. holes so the ends of the pipes can be driven in them. Since ¼-in. pipe has an O.D. slightly over ½ in., the pipe standards will have to be driven into the holes in the blocks with a hammer. Drill two 9/32 in. holes through the short length of pipe between the standards under the block and drive two #7 x 1½ rh screws into the block.

Portions of the forward foils will have to be faired as in Fig. 2J to give the parts that remain in the water the shape of an airfoil section. Starting with the bottom foil plate, cut two ½-in. thick pine blocks to the shape of the plate, joining them at the center of the plate where the standards are welded. Plane and sand the top surface of these blocks to the contour shown in Sec. B-B, Fig. 2J. A cardboard template the shape of the fore or leading edge of the fairing block will help when planing the block to a uniform shape. Drill and tap holes in each side of the bottom foil plates as in Fig. 2F and fasten the fairing blocks with ¼ x 1 in. fh bolts.

Cut off the protruding ends of the bolts and file them flush with the surface of the steel foil plates. When the foils are covered with fiber glass and resin, there will be no danger of the bolts loosening and falling out.

Fair the 20½ in. long pipe that is welded to the bent up end of the bottom foil plate with two fairing blocks shaped as in Sec. C-C, Fig. 2J. When fastening these blocks to the pipe, be sure to have the flat surface on the outside and the curved surface facing towards the boat. Cover both surfaces with 1/16-in. thick veneer, glued and bradded in place to keep both fairing blocks on the pipe. Then wrap it spirally with 1½-in. wide fiberglass tape and apply several coats of epoxy resin.

Although the two vertical pipe standards extending from the bottom foil plate to the support block do not provide any lift, they must be faired to reduce water resistance. Use three pine fairing blocks shaped as in Sec. D-D, Fig. 2J extending from the bottom plate to the lower cross pipe between the two standards. Wrap these fairing blocks with fiber glass tape and coat with epoxy resin. Also cover the bottom foil with fiberglass cloth and resin. Use strips of fiberglass cloth to build up a streamlined fillet where the standards join the bottom foil plate. Give the fore and aft hydrofoils two coats of marine enamel to complete them.

Building the Boat. We selected a hull design having a scow-shaped bow with battened air traps on the underside because these high-lift characteristics aid the foils in lifting the hull clear of the water more readily than a conventionally shaped boat.

Start by laying out the two hull side pieces on a 10-ft. long panel of ¼-in. plywood to the dimensions given in Fig. 6. Note that the sides taper from 18 in. at the bow to 14 in. at the stern. The additional ½ in. shown at the top of the hull side

represents the sheer rail (Sec. D-D in Fig. 8) to be attached later. Be sure to lay out and cut the ⅜-in. notch on the bottom edges of the sides. Do not, however, cut notches in the hull sides for the 2 x 4-in. stock used to back up the seam in the bottom planking.

With the sides cut to shape, use them as patterns to mark the curves and notches for cutting the chines from 2 x 4-in. stock. Cut the 1⅝ x 3⅝-in. notches in the fore ends of the chines before fastening them to the hull sides. Rip saw the sheer moldings from 2 x 4-in. stock and cut a ¼ x 1⅛-in. rabbet along one side of each molding for the hull sides as in Sec. D-D in Fig. 8. Again using the curved bow of the hull sides as a pattern, lay out and cut a stem and filler block piece for each hull side. Also cut the two ¼-in. plywood gussets at this time.

Now, assemble chines, sheer moldings and stern pieces to the hull sides with waterproof glue and #8 x 1¼-in. *fh* screws spaced 4 in. apart. Use a double row of screws along the chines. When assembling the sides, be sure to make them up as a pair, one right and one left hand. Cut the aft side frames (Fig. 8E), foil retaining-bolt braces and upright (Fig. 8) and fasten to the hull sides. Rip the seat risers (Sec. A-A, Fig. 8) from a 2 x 4 and fasten to each hull side member with #12 x 2½-in. *fh* screws.

You are now ready to assemble the two sides to make up the hull. Since the bottom is covered with stock size plywood which is 4 ft. wide, cut the seat boards, stem cross piece, butt block and transom exactly 47½ in. long. First locate and fasten the seat boards to the seat risers with #8 x 1½-in. *fh* screws as in the top view Fig. 8. Then assemble the ¾-in. plywood transom to the aft side frame members with Kuhls or Stay Tite neoprene sealer instead of glue, and fasten with #8 x 1½-in. *fh* screws spaced 2 in. apart. Fasten the stem cross piece to the stems with two #12 x 2½-in. *fh* screws at each joint. The other transom frame members shown in Fig. 7 can now be cut to size and fastened to the plywood transom with glue and #8 x 1½-in. *fh* screws.

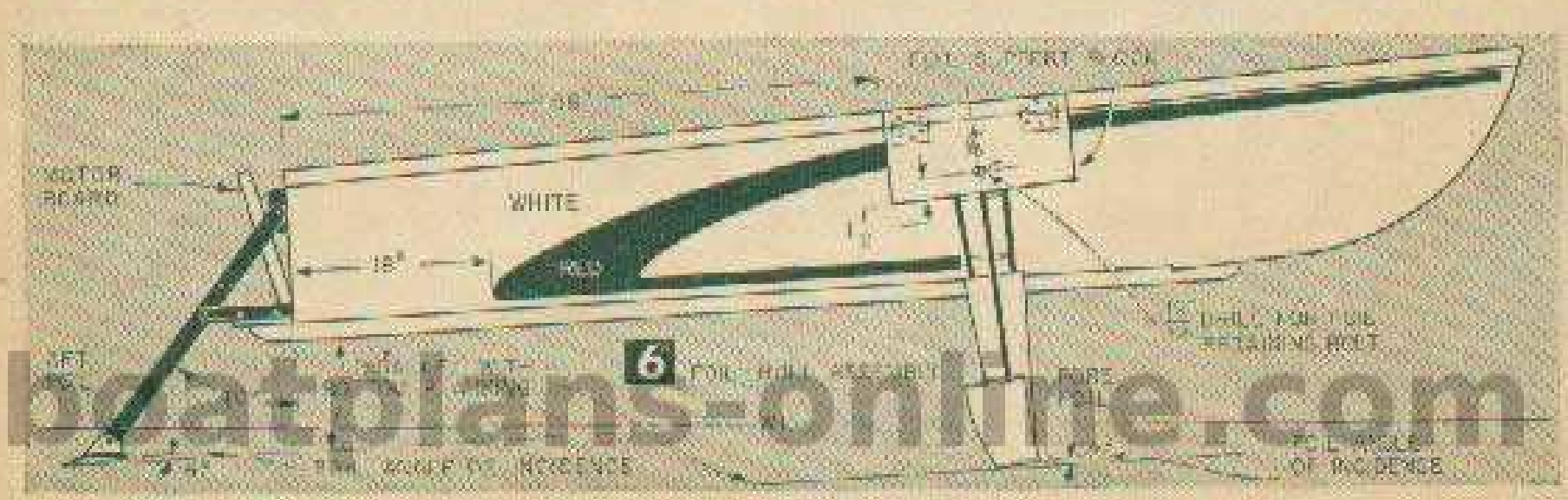
Next, turn the hull framework upside down and block it up off the floor on a couple of 2 x 4's. Check the chines with a level lengthwise and across them with a straightedge and level to make certain the hull framework is not twisted. Use a wedge or small block to raise a low side or corner if need be. Then place the 2 x 4-in. bottom-planking butt block in the notches cut in the chines and fasten with two #12 x 2½-in. *fh* screws.

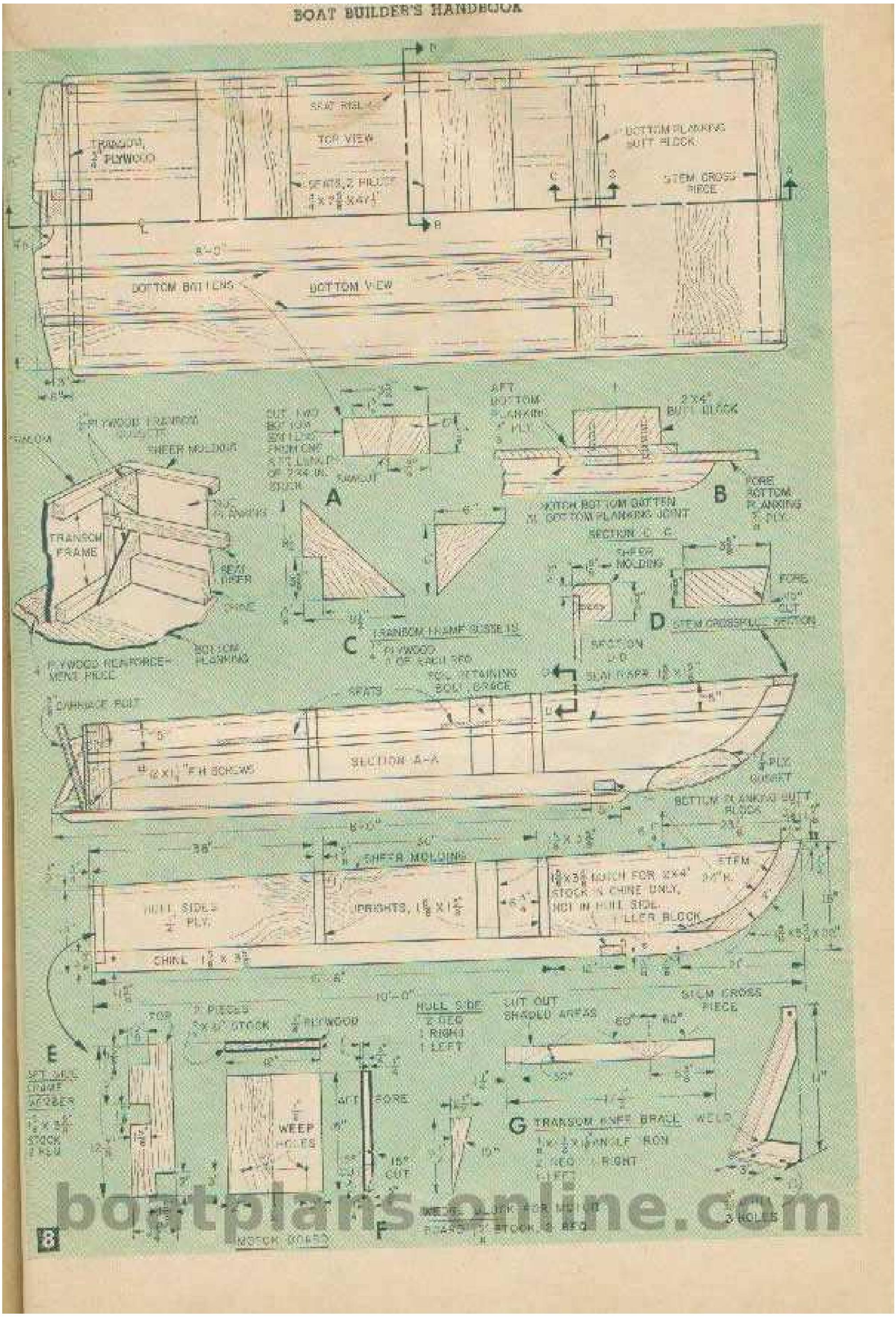
Before installing the bottom planking, fair the edges of the chines, butt block, transom and stems particularly where these members join one another so that the plywood planking will make good contact with them. Coat these contacting surfaces with neoprene sealer and place the 4 x 8-ft. panel of ⅜ in. plywood on the hull framework with the fore edge against the ⅜-in. notches cut in the chines and hull sides. The aft end of the plywood should project 6 in. beyond the transom. Fasten the plywood to the chines and transom frame with #8 x 1¼-in. *fh* screws spaced 2 in. apart. Space the screws about 6 in. apart when fastening the plywood to the butt block.

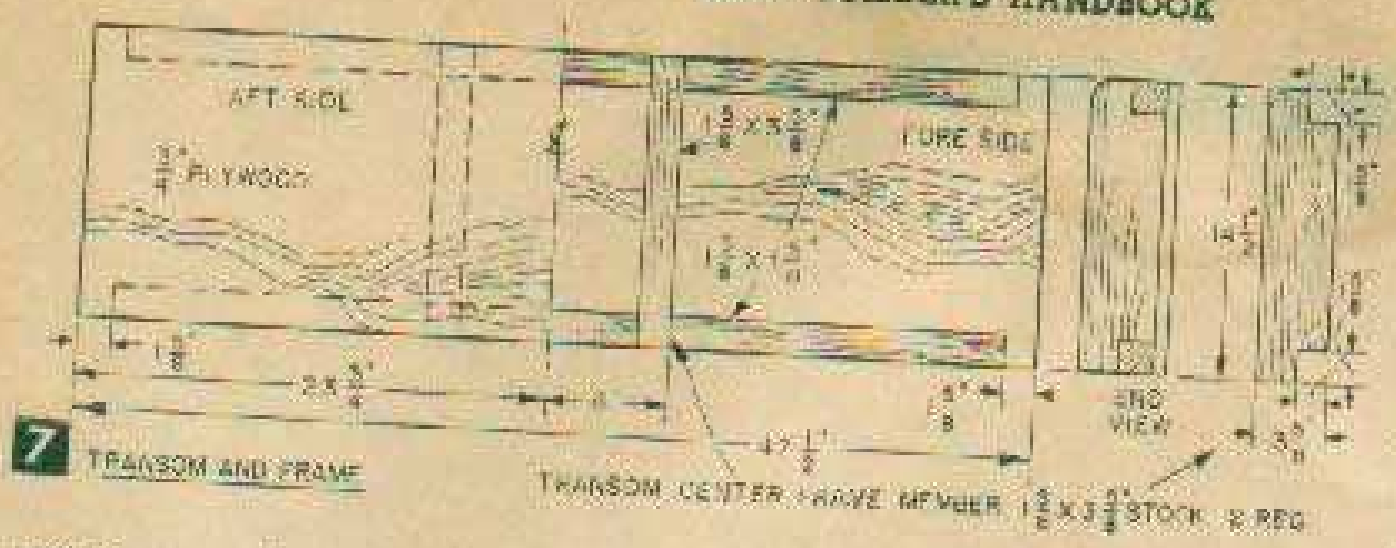
For the bow planking, use ⅜ in. plywood and install it with the grain running athwartship so it can be bent around the stems. Coat contacting surfaces with neoprene sealer and place the forepiece of plywood so that it overlaps the aft planking 5 in. Fasten fore plywood with #8 x 1½-in. *fh* screws driven into the butt block and spaced 4 in. apart. Then bend the plywood down and around the stems and clamp to the stem cross piece with C-clamps. Starting at the lapped joint and working toward the cross piece, fasten the plywood to the chines and stems with #8 x 1½-in. *fh* screws spaced 2 in. apart. Finally fasten the plywood to the cross piece.

Going to the aft or transom end of the bottom planking that extends beyond the transom (Fig. 8), lay out the curved aft end by bending and clamping a ⅜ x ⅜-in. batten to the plywood. Use a compass to mark the 4-in. radius cutout for the outboard-motor shaft. Then cut to shape with a coping saw.

Cut a ¼-in. plywood reinforcement piece for the aft planking extension (Fig. 8) and fasten to the top side of the planking with







7 TRANSOM AND FRAME

neoprene sealer and 1-in. wire nails clinched on the top side.

With your circular saw set for a 15° bevel cut, rip the four bottom battens as in Fig. 8A. Round off the ends and place them on the bottom planking 1½ in. from the aft end and mark the battens for notching at the lapped joint of the bottom planking. To locate the batten position on the bottom, draw four lines on the bottom 8 and 16 in. from the chines on each side as in Fig. 9. Then drill a series of 5/32-in. screw pilot holes, spacing them 6 in. apart along the four lines.

When installing the battens, coat contacting surfaces with neoprene sealer and center them on the lines of drilled holes. First fasten each batten fore and aft with #12 x 2½-in. *fh* screws driven into the butt block and transom frame. Then, before the neoprene sealer has a chance to set, turn the hull over and continue to fasten the battens with #8 x 1¼-in. *rh* screws and washers driven into the battens through the pilot holes drilled through the bottom planking as in Fig. 9.

Since a long-shaft outboard motor must be used with this hydrofoil craft, make the motor board 15 in. high as in Fig. 8F. Build up the board to a thickness of 1¼ in. by laminating ¾-in. solid lumber between two pieces of ¼-in. plywood. Fasten with glue and clamp until dry. Finish by sawing two 15° bevels along the bottom edge as in Fig. 8F. Drill the two ½-in. holes in the board to drain water splashed up behind the board. Make two wedge blocks as in Fig. 8F, and bolt the motor board to the transom with two ⅜ x 8-in. carriage bolts and two #12 x 2¼-in. *fh* screws.

Instead of using wood for the transom knees and locating them on the inside of the hull, we made them of angle iron and placed them on the outside as in Fig. 8. Make the two transom braces as in Fig. 8G so that you will have one right and one left hand brace. Bolt them to the transom at each side of the motor board as shown in Fig. 2, with ¼ x 1½-in. machine bolts and to the bottom planking extension with ¼ x 1½-in. carriage bolts.

For a finish, give the inside and outside of the hull one coat of white Firzite followed by one coat of enamel primer and one coat of marine enamel. Allow each coat to dry thoroughly and sand lightly before applying the next coat of paint. We used buff on the inside, white on the outside and red on the streamlined design on the side as in Fig. 6.

Mounting Hydrofoils on Boat. First assemble the aft foil complete with all brackets and fasten it to the center of the transom and aft planking extension as in Fig. 2 with C-clamps. Have the boat up on saw horses at this time so that you can clamp your long-shaft outboard motor to the motor board. We used an Evinrude 18 hp., '59, long-shaft model in the #2 tilt pin setting and the aft foil just cleared the underwater exhaust on the motor. If the foil does not clear the exhaust of your outboard, re-clamp the foil brackets and drill new 9/32-in. holes for the ¼-in. bolts fastening the foil supports to the support brackets.

MATERIALS LIST—HYDROFOIL BOAT

No. Req.	Size and Description	Use
9	1⅝ x 3½" x 10' fir or spruce	framing, battens, molding
1	1⅝ x 5½ x 48" fir or spruce	stems
1	¾ x 5½ x 60" fir or spruce	motor board
2	⅜ x 7½" x 8' fir or spruce	skegs
1	¼" x 4 x 10' AB exterior fir plywood	sides, brackets
1	⅜" x 4 x 8' AA exterior fir plywood	aft bottom
1	¾" x 4 x 4' AA exterior fir plywood	fore bottom
1	¾ x 15 x 48" AC exterior fir plywood	transom
1	⅛ x 1½ x 1½ x 30" angle iron	transom bracket
½ lb	1" wire nails	
4½ gross	#8 x 1¼" fh screws	
4 doz	#8 x 1½" fh screws	
4 doz	⅛" washers for above	
7 doz	#8 x 1½" fh screws	
2 doz	#12 x 2¼" fh screws	
2 doz	#12 x 2½" fh screws	
4	¼ x 1¼" carriage bolts	
2	¼ x 1½" machine bolts	
2	⅜ x 8" carriage bolts	
1 qt	Kuhls or Stay Tite Neoprene Sealer	
1 tube	Weldwood glue	

Use a protractor head with level to set the aft foil at the 4° angle of incidence with the hull bottom as in Fig. 9. Tighten the 5/16-in. bolt on the foil bracket to hold the foil at the 4° angle. Since it may be necessary to change the angle of incidence slightly, do not drill the 9/32-in. holes in the aft-foil supports to line up with the 9/32-in. hole in the aft-foil bracket until you have test run the boat.

Bolt the fore foils to the sheer moldings 58 in. forward of the transom as in Fig. 6, using a ¼ x 1⅝ x 18-in. wooden filler strip between the hinges and the sheer molding. Then drill a ⅜-in. hole at the center of the fore foil support block, 1½ in. from the bottom edge of the block as in Fig. 6, for the foil retaining

bolt. Drill this hole through to the inside of the hull and insert the retaining bolt from the inside as in Fig. 9. A ¼-in. welding rod welded to the foil retaining nut as shown in Fig. 2, will eliminate the need for having a wrench on hand each time the fore foils are raised and lowered.

Foil Adjustment. Since hydrofoils are still in the experimental stage, the only way you can achieve top performance from these hydrofoils is by trial and error methods during actual test runs. With a small boat such as this one the weight and location of the driver in the boat, or even the gas tank, can change the center of gravity enough to affect the angle of incidence of the foils. You may find that you will have to shift your setting position forward or backward slightly to trim the boat once it is up and riding on the foils.

The tilt-pin setting of the outboard motor is also an important factor in achieving top performance. With the 15° motor board on this boat we found the #2 tilt-pin setting on the 18 *hp.*, long-shaft Evinrude we used, worked out best. If you use another make or model outboard motor you may have to change the tilt-pin settings. Do not attempt to use an outboard motor having a regular or stock length shaft.

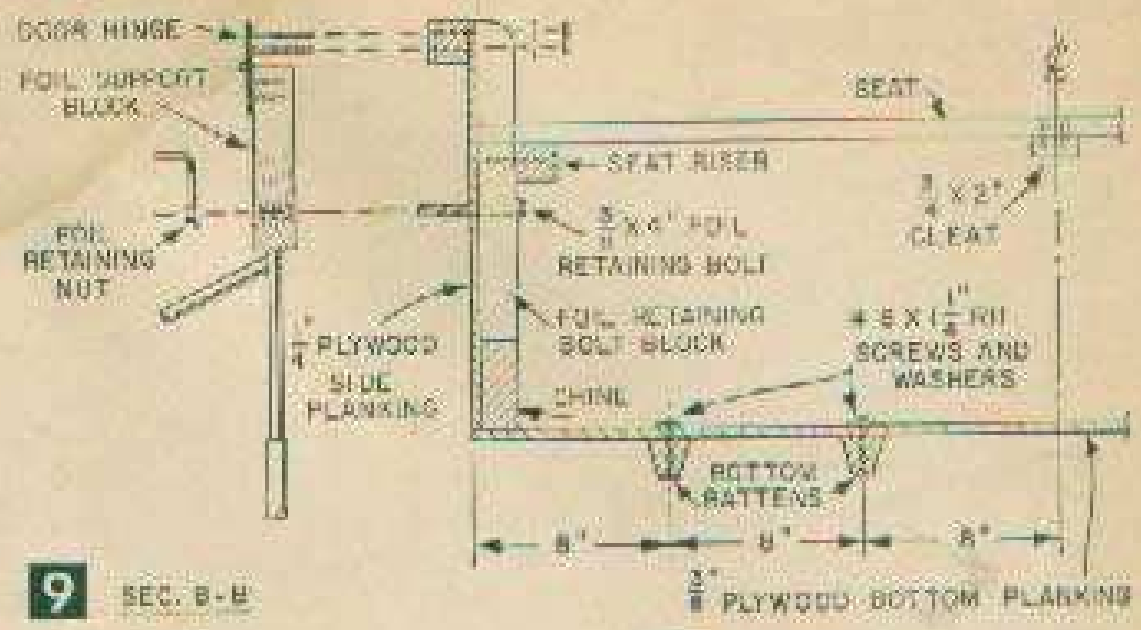
If the aft foil will not lift the stern of the boat during a test run, increase the angle of incidence to about 4½°. If that does not help, vary the angle of the motor.

Lift-and-fall action of the aft foil indicates too great an angle of incidence. Reduce it, even if you must make it less than 4°.

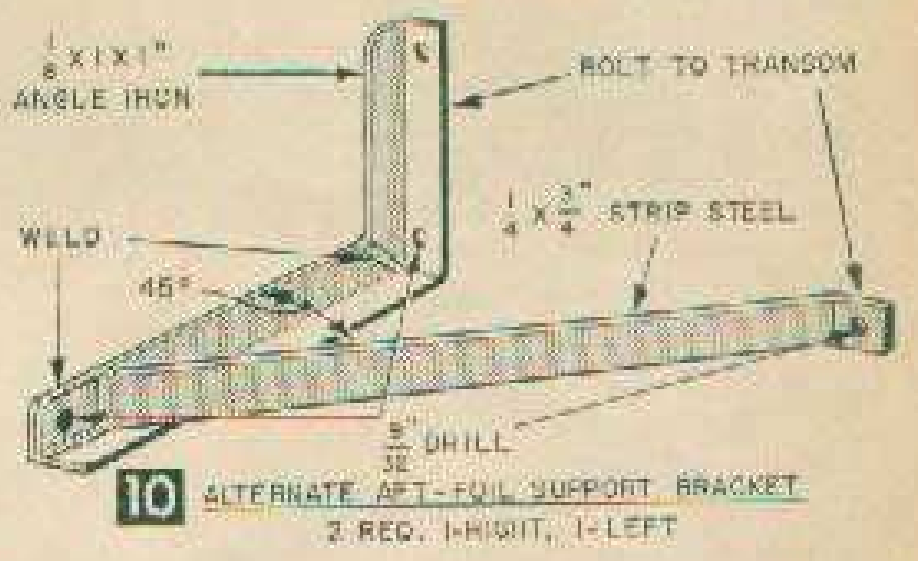
The angle of incidence of the fore foils is not adjustable as is the aft foil. If the fore foils will not lift, the angle of incidence is not enough as compared to the aft foil. You can remedy this to a certain extent by setting back further toward the stern and thus shifting the center of gravity to allow the bow end of the boat to lift higher. With the foils adjusted properly, your boat should start raising off the water after a run of about 30 ft.

Installing Hydrofoils on Other Boats. Probably the only change you will have to make in adapting the aft foil to any other boat is to make a set of alternate aft-foil support brackets as in Fig. 10. Follow the same procedure used to mount the aft foil on the transom of our test craft.

A good rule-of-thumb to follow when mounting the fore foils is to locate the aft edge of the fore-foil support block at about the middle of the lengthwise dimension of the hull. Use three heavy C-clamps with suitable reinforcement blocks to protect the hull sides to temporarily fasten the foils to the hull. Then make a test run and use the trial and error method to find the best exact location at which to permanently fasten the fore foils.



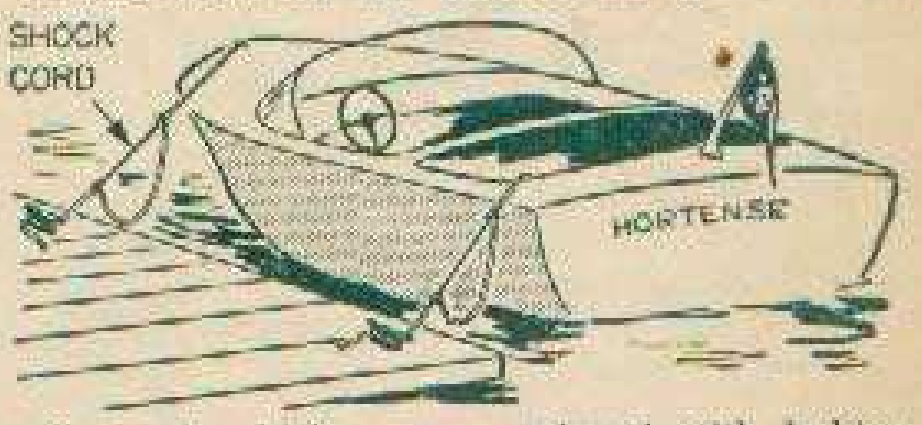
9 SEC. B-B



10 ALTERNATE AFT-FOIL SUPPORT BRACKET
2 REQ. 1-RIGHT, 1-LEFT

Shock Absorber for Anchor Lines

• An unusually resilient snubber for your boat can be provided by means of a shock cord (about 50¢ at auto supply stores) such as is used for lashing down car-top carriers and loads. When



the cord, which comes equipped with lashing eyes, is introduced into anchor or mooring lines of small boats, wave surges will have little effect upon the lines. For larger boats, two shock cords used side by side furnish effective snubbing.—Wm. D. Jackson.