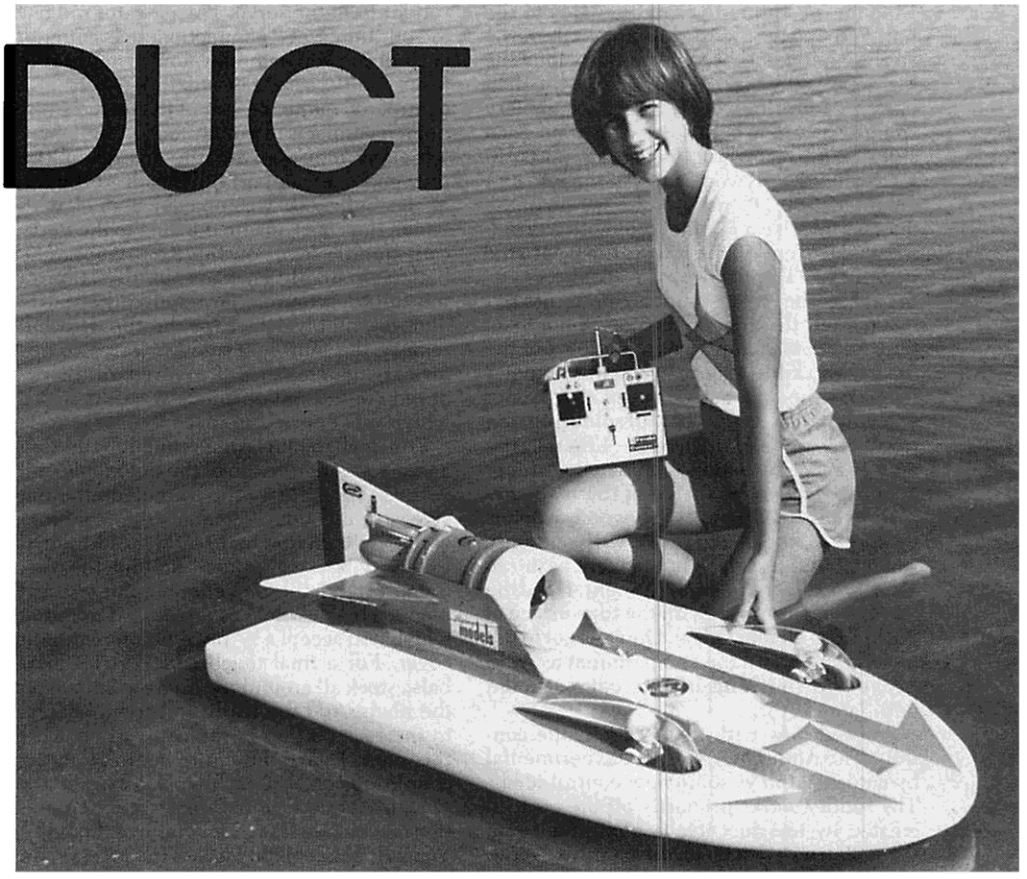
AQUI-DUCT 40

A new way to run an air-boat with a K&B 6.5 driving the Midwest RK-40 Ducted Fan. Here's a test bed design to get the experimental juices flowing/**Bob Aberle**

PHOTOGRAPHY: BOB ABERLE



Patti Aberle with Aqui-Duct 40, her Dad's new Futaba Contest-7 transmitter, with dual rate controls.

Propeller driven air boats are certainly not new to our hobby. Many R/C airboat designs have been published and to this day several very fine kits are offered on the hobby market. In just about all cases the airboat has been relegated to the R/C sport boating enthusiast as the serious competition minded "boater" is into more involved marine propulsion systems and does not usually consider this type of powerplant.

In the January, 1978 FLYING MODELS I had the opportunity of reviewing the then new Midwest RK-40 Axi-Flo Ducted Fan unit. Although originally intended for model airplane power there is no reason why ducted fan power couldn't easily be adapted to both model boats and car use. Along these lines the concept for the Aqui-Duct 40 evolved. The idea was to utilize the RK-40 Axi-Flo in an experimental boat that required an absolute minimum amount of construction time and material. Although many modelers avoid "scratch" building from plans, this boat is so simple you could hardly have any problems. In case you were wondering, yes, that is an elevator you see besides the normal rudder. More on this later.

The full size plans are a must in this case. From them you can use tracing paper to make all the necessary templates. The starting point is the foam hull itself. I originally tried to obtain a standard pool type foam paddle board. One of these boards had been used successfully in an R/C Modeler magazine article last year, employing a K&B outboard engine. Unfortunately I never did find an appropriate size board to handle the potential power of the RK-40 (which in my case is fitted with a K&B 6.5cc front rotor engine). Generally the ready made paddle boards were both too narrow and too thin. I needed a little extra thickness to house the R/C equipment. My friend Nick Ziroli came to my rescue with a 3" thick piece of expanded foam measuring 48" long x 24" wide. Nick band sawed the circular bow shape and I was on my way. Since then I have located a great alternate source for the foam. My local lumber yard (and presumably others around the country) offer 1" thick expanded foam insulation board, coincidentally measuring 48" x 24". They sell this material in my area for approximately $1.50 per sheet. You could easily cement three of these sheets together to get the necessary 3" thickness, at a cost of under $5.00.

Shaping the foam was easy. I bought a small (hand grip type) Stanley "Surform" sanding tool. It resembles a coarse file or rasp. Within 45 minutes I had the entire hull shaped (in some fashion). I did not calculate a thing in this design, it was all a great big guess on my part (I believe in being honest). I simply rounded the top edges of the hull with approximately a 1" radius. The bottom edge was rounded a little more (like 1½" radius). The bottom of the hull tapers upward somewhat as you approach the bow. After rough shaping I sanded the foam smooth with #80, 150 and 220 garnet paper. I did not round the edges at the stern. In fact I simply cut out a transom from ⅛" plywood and epoxied it in position. This provides a brace across the entire width of the hull (at the rear).

A few manufacturers shared my enthusiasm for this experimental project and were good enough to supply me with most of the necessary material. Not to sound commercial but I will mention items throughout this text as a courtesy to these people. To start, Midwest Products (Mr. Ed Rogala and Jim Newman) supplied all the necessary plywood for the boat. Just for information, I used two 48" x 24" sheets of ⅛" ply and a single, 48" x 24" sheet of 3/16" ply. That, plus a little ply, balsa and spruce scraps is the extent of the wood material. All the cementing of the plywood parts to the foam hull was done with the new Hobbypoxy Formula-3 (thixotropic) glue. This glue is very slow

drying, but stays in place and most important, doesn't attack the foam in any way.

Next item required in the assembly sequence is the duct support bulkheads. Two identical supports must be cut out of ⅛" plywood (use the side view outline for a template). As you can see both supports actually penetrate approximately ¾" into the top of the hull. Two slots were cut in the foam to this depth to accept these supports. Line up the supports at right angles to the hull and epoxy in position. Remember, to the spacing between the two supports must be the same as the outside diameter of the duct barrel. Mounting the RK-40 is then very simple. Just four 4-40 screws (two on each side) go through the plywood supports directly into the plywood rings of the RK-40. I mounted 4-40 "T" nuts on the inside of the duct barrel. Use a Dremel tool with a grinding wheel to cut-off the screws flush with the end of the "T" nuts.

Tackle the radio compartment next. I marked out the area on the top of the foam hull. You could simply cut or hollow out the foam with a knife to form the compartment. I found it easier to wrap a piece of #14 copper wire around my Ungar 47 watt soldering iron tip. Using a steel straight edge I then easily melted away the foam to achieve the proper opening. The entire inside of the R/C compartment is lined with ⅛" plywood which is epoxied to the foam. This will not only smooth out the surface but make it easier to waterproof the radio compartment. Have the ⅛" ply come up flush with the top surface of the hull (on all four sides). Don't forget to put the ⅛" ply floor in the compartment as well. Leave the finishing of this compartment until later.

Proceed now with the aerodynamic controls. The Aqui-Duct 40 being experimental by nature employs some new control ideas. The rudder works primarily off the air load created by the duct itself. Along the same theme I decided to try an elevator, like on an airplane, to control the pitch attitude. Patterns for both of these control surfaces can be taken easily off the full size plans. More will be said later about these controls. Use medium to hard ¼" balsa for the stab and elevator and follow the grain pattern shown. Because of the RK-40 fuel tank I was forced to separate the elevator into two sections which requires an extra control horn and rod. Epoxy the stab to the plywood support bulkheads. I also added some Sig Epoxolite fillets for additional strength.

The vertical fin construction is a little more complicated. For additional strength I employed some scrap pieces of ¼" ply and a ¼" x ½" spruce spar which actually projects all the way down to the bottom of the hull. It would be a good idea at this point to mount the muffler on the engine to check the necessary clearance. Since I used the K&B 6.5cc engine the natural choice was a MAC's extractor muffler and a tunable exhaust extractor (two separate items). These components were supplied to me by Wally McAllister of MAC's Mufflers, 8020 18th Ave., Sacremento, California 95826. This muffler set is attached to the K&B 6.5cc using K&B's #9024 adaptor exhaust extension and #9023 "O" ring. I did find it necessary to remove the rear cylinder head fairing which is normally attached to the inner pod of the RK-40, to clear the muffler. This causes a little loss in duct efficiency, but is within acceptable limits. With the muffler in place you can then fit the vertical fin around it and the RK-40 integral fuel tank. The rudder is cut from ¼" medium balsa. Use the heavy duty Du Bro or Klett hinges for all of these surfaces. Do not glue the hinges at this time.

Now we get to the actual control hook up. As you can see in the photos I cut recesses or channels in the top of the foam hull to accept the various Sullivan Gold'N Rod control tubes. One rod leads directly back to the rudder from the servo. The elevator rod has to split into a "Y" connection, one going to each of the separate elevators. The throttle takes a little care, but is still easy. I ran a control rod out to the rear of the duct. At this point it connects to a modified ½A bellcrank which is mounted on the inside of the plywood duct support bulkhead. At the top of the bellcrank I connected a steel wire which runs back inside the duct to the Perry carb throttle lever on the K&B 6.5cc. The bellcrank simply changes the direction of the throttle control. To remove the entire duct you simply detach the throttle wire and remove the four 4-40 screws. Out it comes for easy maintenance. I covered all the exposed control rod channels with 1/16" balsa which was epoxied in place.

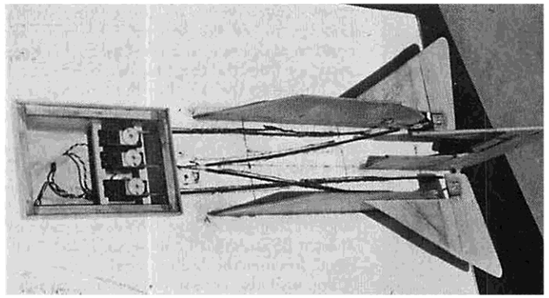
Finish off the R/C compartment by adding a frame around the top of the opening using ¼" x ½" spruce. Lay this spruce on the flat side and use epoxy cement (the 5 minute variety will do fine here). Add an additional frame of ⅛" x ½" spruce around the first frame. Stand these pieces in the vertical plane. This now leaves a recessed opening which will accept a ⅛" ply R/C compartment cover. For a final touch add ½" triangular balsa stock all around the frame as shown on the plans. Add the hardwood servo bearers to the rear portion of the compartment. At this point I gave the entire compartment a couple of coats of Hobbypoxy Formula 2 glue to act as a sealer against water penetration (especially from the bottom of the hull). You will notice that I located the R/C system switch in the front corner of the compartment along with the charging jack. Directly above the switch I mounted the top portion of a Hobbypoxy thinner can to the plywood R/C compartment cover. This is the portion of the can with the threads that accepts the cap. The cap itself then seals the opening. To turn the radio on or off you simply unscrew the cap and reach in with your finger. The same goes for access to the charging jack. It's simple and costs nothing. For the radio antenna I epoxied a piece of outer Gold 'N Rod into the R/C compartment cover. Pass the radio antenna up through this tube and then out to the front edge of the stabilizer. This gets a good portion of the antenna outside the R/C compartment.

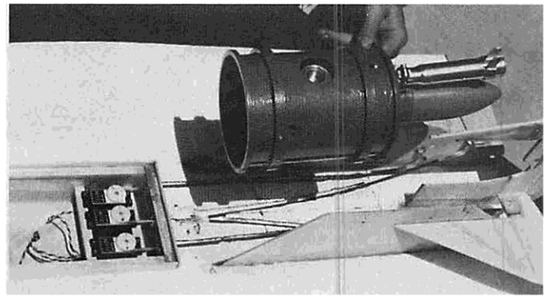
One last piece of structure must be added, the keel. Cut it out of 3/16" plywood and insert it in a slot cut along the bottom of the hull on the centerline. The soldering iron with a piece of copper wire attached can melt away this slot easily. Cement the keel in place with Hobbypoxy Formula 3 so that the glue doesn't run all over the place.

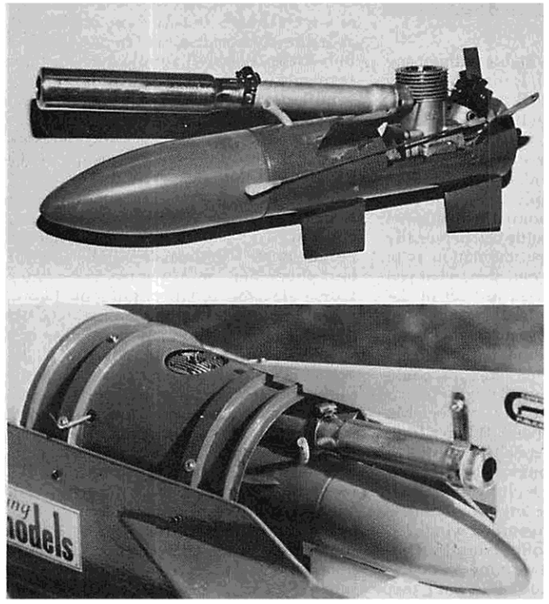
Now for the finishing. I tried to keep it as simple as possible because of the large area involved. The new Midwest Styromate did the real trick, but take heed of one caution. It does not stick to epoxy cement at all. To do the job right you have to coat all the exposed epoxy surfaces with Elmer's Carpenters Glue (the waterproof type when it dries) which sets up a barrier. I thinned the Elmer's glue about 25% with water and simply brushed it on over the epoxy areas. After this it was easy to brush on the Styromate. Before I forget, I did install the two pilots heads (Williams Bros. Military scale 2" #172) and the Sig 14" bubble canopies at this point (just before applying the Styromate). The canopies are epoxied to the foam hull. When dry I added a Sig Epoxolite fillet around the entire base of both canopies. It would be a good idea to cover both canopies at this time with masking tape to protect them during the finishing operation. Since the Epoxolite is an epoxy base, you better coat it also with the white glue mixture first.

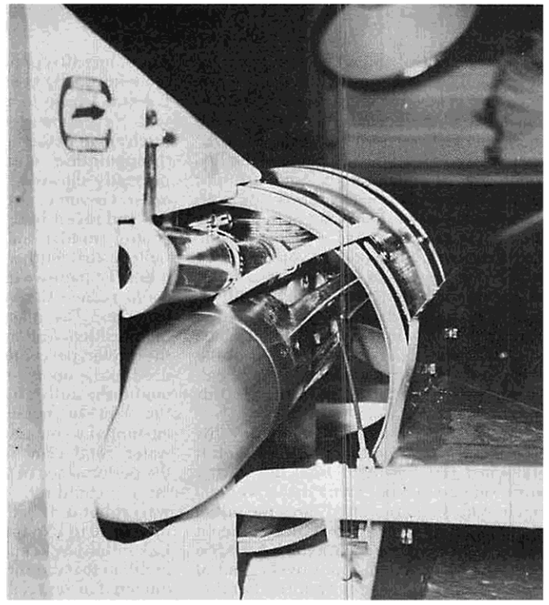
Because of the large size I found it easy to drill a hole in each end of the hull, on the centerline. In each hole I inserted a piece of 5/16" diameter dowel (with some epoxy glue). Let about 6" of dowel stick out on each end. You can then support the entire hull by these two dowels. A bench or stool on each end works fine. The entire hull then operates like a rotisserie on a Bar-B-Que. This speeds up the painting process and lets you still work by yourself. I brushed on two thick coats of Styromate over the entire hull. It took approximately 1 ½ jars (16 ounces per jar) to do the job. My foam was an open bead type so it couldn't be completely sealed. If I didn't care about weight I could have first brushed on a filler coat of thinned Dap spackle, before applying the Styromate. I sanded both coats of Styromate with #150 and then #220 paper. After this I applied three coats of Hobbypoxy white. The first two coats were brushed and the final coat was sprayed (thinned about 30%). This gives an acceptable finish. Stripes were masked off and hand painted with Hobbypoxy orange. Since the paint runs easily under the tape I was forced to use ⅛" wide D.J. (blue) Multi-Stripe all around the orange paint trim (which looks quite attractive).

The final step is to install the Axi-Flo, all the control surfaces and, of course, the radio equipment. For this application I chose my Futaba Contest-7 radio which was previously reviewed in detail in the August 1978 FLYING MODELS. The high output servos, with the ball bearing supported shaft make them ideal for model boat use. Best of all is the dual rate features. With it I can selectively reduce the amount of rudder and elevator control throw. The high rate



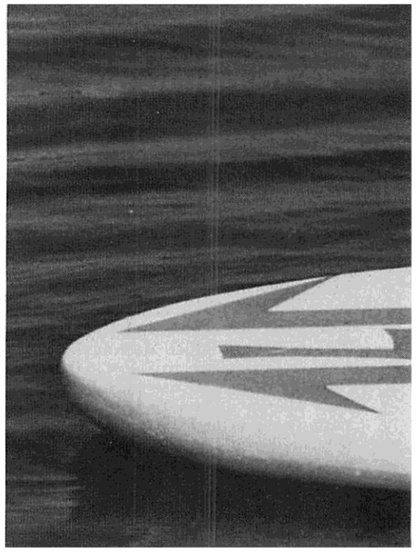


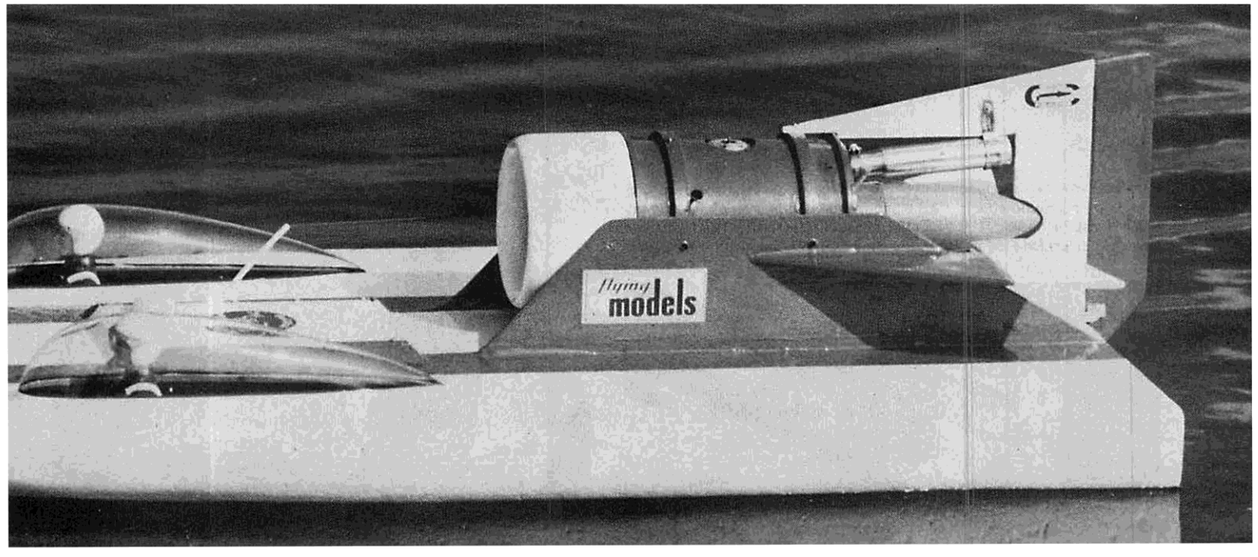


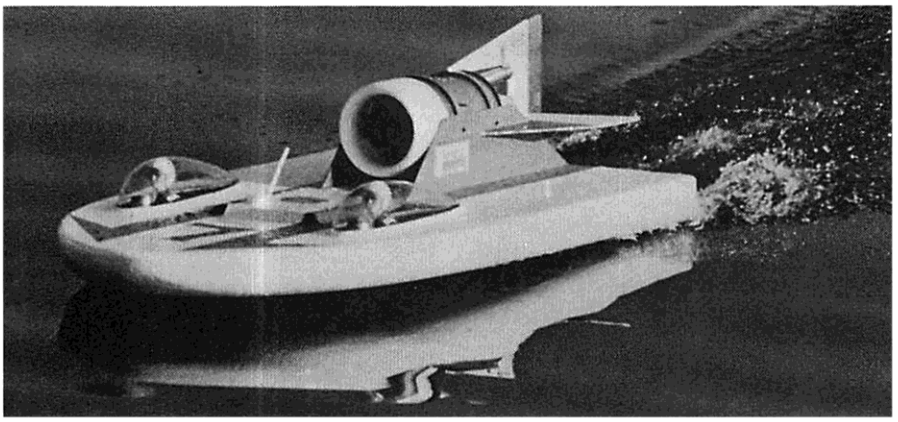


Top to bottom: Slots sliced in the foam hull for passage of the Gold 'N Rod control tubes. The elevator must be split into two controls (two elevators). **Center shot:** MAC muffler and extractor shown connected to K&B 6.5cc front rotor engine. Muffler/pipe can be tuned by sliding rear tube over front one. **Lowest photo:** The RK-40 with MAC muffler attached. Fuel tank is integral part of the duct. Bob uses 25% nitro Aldrich Magnum fuel on K&B 6.5cc mill.

Top shot: Axi-Flo RK-40 power unit being lowered into position to check on fit of vertical tail around fuel tank and muffler. Futaba servos positioned. **Center:** Looking from rear up inside duct, showing the throttle hook-up to the Perry carb on K&B 6.5cc engine. **Photo beneath:** A side view, just floating at ease. The model balances by the letter "D" in the FM logo decal. It runs quite flat, about as you see it in water. A good training boat to start on.





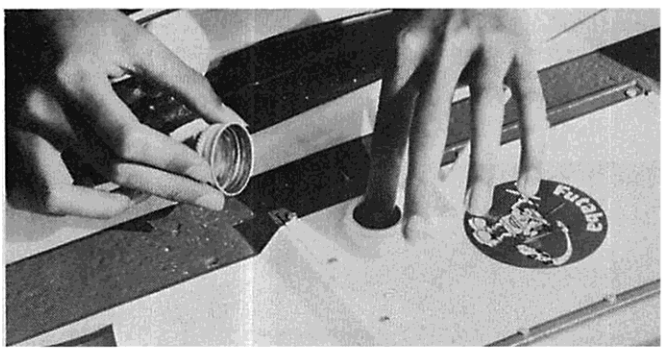


(maximum control throw) can be used for slow speed maneuvering, while the low rate comes in handy for high speed operation (much like a vernier control). After the radio is all checked out I added some ⅛" x ⅜" seating tape around the top frame of the R/C compartment. The ⅛" ply compartment cover is held in place with a series of ½" x #6 sheet metal screws. Don't forget to pass the antenna out through the tube before closing the hatch cover. From now on you only have to unscrew the cap to turn on the radio or charge the batteries. Final weight with all equipment installed was 9¾ pounds. A little heavier than I would have liked. Balance point was just about at the position of the duct rotor. I did not add any additional ballast since it really isn't that critical in this type of design.

Now for the big moment! How did this experiment work in actual practice? Well it performed just fine right from the start. I won't kid you into believing that it went 90 m.p.h. With all that "wetted" area the initial speed wasn't expected to be fast. But then it wasn't that slow either. With the K&B 6.5cc in the duct the sound is positively "out of sight". If you want to attract public attention at a lake or beach this is the way to go. The Aqui-Duct 40 is perfectly stable without any tendency to dig in or roll. It runs absolutely flat out. I have to admit that the elevator, with it's present area, had little affect on the pitch angle of the hull. This I found a little disappointing. A larger elevator (than is presently shown on the plans) would be in order. Or you could simply delete the control and revert back to normal two channel control (rudder and throttle). I personally believe that further experimentation is in order. To increase the speed somewhat you could reduce the hull area just aft of the canopies. The plans show this suggested modification. You might want to stick with the prototype configuration until you get used to the operation, then later you could modify the hull design. Surprisingly enough the duct did not ingest any appreciable amount of water at full speed. When a little water "hit the fan" so to speak it did little to the performance of the engine. I'm not saying you could run it through two foot high waves, but it didn't pose any problem running in 10 to 15 m.p.h. prevailing winds (on Lake Ronkonkoma, Long Island). One problem that did surface with my particular ducted fan was vibration. It wasn't that much, but enough to loosen almost all the screws (even some on the engine itself). Locktite on all the screws is essential for continued operation. A positive fuel cut-off, separate from the throttle, is a good idea. I couldn't stop the 6.5 after the first run. You can't throw a rag into the RK-40 to stop it. The rudder control proved somewhat inadequate at slow speeds. As such the plans now show a small water rudder extension (to the basic rudder). If you plan on using the Aqui-Duct on the ice in the winter I would suggest that you enlarge the rudder area by at least 25%. And, of course, add side "runners" to clear the bottom keel.

You will also note in the photographs that a special inlet duct was added to the front end of the Axi-Flo RK-40. This ring is made of a special high density foam and is available directly from the Axi-Flo designer, Mr. Bob Kress. Bob will supply a set of three segments (which make a full ring when assembled) for $5.00 (address is Kress Technology Inc., 27 Mill Pond Road, Lloyd Harbor, New York 11743). This inlet is essential to the proper performance of the RK-40, be it in the water or air.

The Aqui-Duct 40 is only a starting point. Remember, I only wanted to prove a basic concept. The rest is now up to you experimenters. Using smaller hull sizes the next generation "jet" boat has to be faster. Larger elevators should afford some form of meaningful pitch control. The new RK-049 (½A ducted fan) offers the possibility of a smaller Aqui-Duct using a commercially available foam paddle board. Another possibility is a catamaran type hull configuration employing two large foam floats connected with aluminum straps or supports. The duct could be installed between and above the two floats. That would greatly reduce the "wetted" area and increase speeds. If you have any additional ideas we would like to hear about them at FLYING MODELS. I'd personally like to see some R/C manufacturer promote this concept by sponsoring some sort of "jet boat" competition. Until then, good sailing!



Patti unscrews cap and reaches in to flick on the radio system. Waterproof!
Top: Sorry no sound effects, K&B 6.5cc with MAC's muffler/pipe is unreal.
Right: Kress Technology 4" foam outlet is essential for top duct performance.
Below: Midwest Axi-Flo RK-40, mounted in position. Use Locktite on screws.