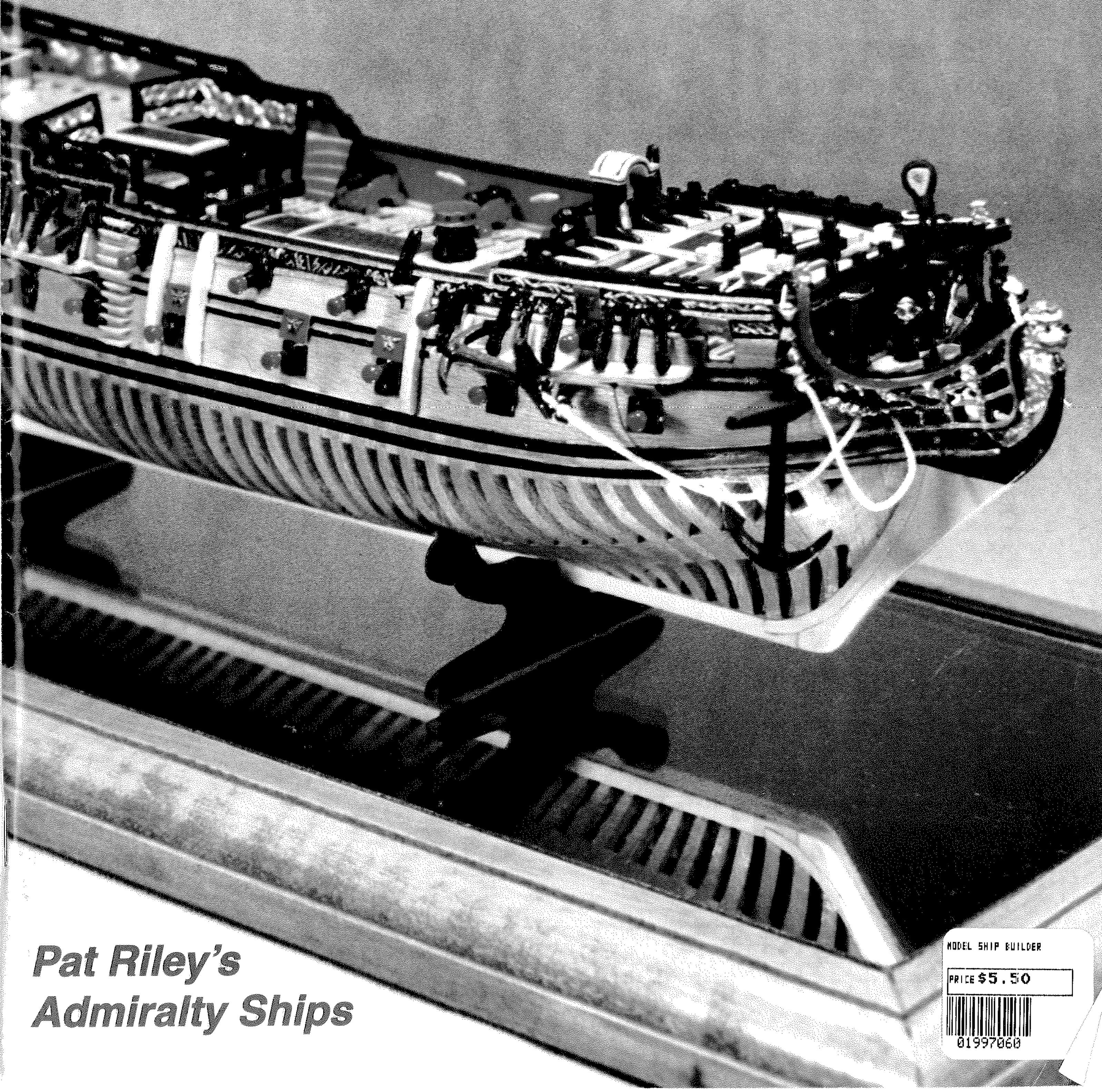
MODEL SHIP BUILDER

WORLD'S LARGEST MODEL SHIPS & BOATS MAGAZINE

No. 118 • March/April 1999 • $5.50
Canada $6.50



Pat Riley's Admiralty Ships

MODEL SHIP BUILDER

WORLD'S LARGEST MODEL SHIPS & BOATS MAGAZINE

No. 118 March/April 1999 Volume XX P.O. Box 128, Cedarburg, WI 53012 Phone/Fax: 414-377-7888

Publisher *Carol E. Borgwardt* *Editor* Jeffrey A. Phillips e-mail: msb@modelshipbuilder.net

Web page: www.modelshipbuilder.net

FEATURES

DEPARTMENTS

COVER

British Fourth Rates were used as escorts and couriers. Pat Riley made these models of no specific fourth rates, only typical ships of the period. The plans used were from a reconstruction of the lines taken for HMS FALKLAND, a 44-gun ship built at New Castle, New Hampshire, in 1690.

MODEL SHIP BUILDER: (ISSN 0199-7060) is published bi-monthly by Phoenix Publications, Inc., at P.O. Box 128, W63 N631 Washington Avenue, Cedarburg, Wisconsin 53012, U.S.A. Periodicals postage paid at Cedarburg, Wisconsin and additional mailing offices. **POSTMASTER:** Send address changes to *MODEL SHIP BUILDER*, P.O. Box 128, Cedarburg, WI 53012.

ADVERTISING: All advertising inquiries should be directed to *MODEL SHIP BUILDER*, P.O. Box 128, Cedarburg, WI 53012. Rate card available upon request. Deadline is two months preceding issue date.

ADVERTISERS INDEMNIFICATION: All advertising is subject to approval before acceptance. The publisher reserves the right to refuse any ad. All advertisers in *Model Ship Builder* for fair and valuable consideration, including but not limited to the printing of each advertiser's ad, the receipt of which is hereby acknowledged, hereby agree and hold harmless *Model Ship Builder* with respect to any claim made by a third party against *Model Ship Builder* as a result of publishing said advertisement in said periodical. Said indemnity includes, but is not limited to any claims by any party claiming that the publication of the ad violates any trademark, design or that it violates any fair business practice act and includes indemnification of *Model Ship Builder* for any and all expenses it incurs in defending said claim, including attorney's fees and court costs whether said claim is successful or not successful, plus any judgment that might be entered into.

FREE LANCE MATERIAL: *Model Ship Builder* welcomes manuscripts, photographs and plans, however, accepts no responsibility for such material while in its hands. It is assumed that such material as letters, club news, new product information, modeler's showcase, etc., is contributed gratis. Feature articles, photos, and plans are paid for on the 15th of the month following publication date. A writer's guideline is available free upon request from the editor. Unsolicited material, if not accepted will be returned **only if accompanied by a stamped, self-addressed envelope.**

SUBSCRIPTIONS: Single copies by mail at $6.75 each ($7.75 out of the U.S.A.). One year subscription - $26.95, two years - $49.45. Canada/Mexico subscription: one year - $34.00, two years - $62.00. All other countries: one year - $43.00, two years - $75.00. **U.S. FUNDS ON U.S. BANK ONLY!** Visa and Mastercard orders are accepted. Please allow six to eight weeks for delivery. Subscriptions start with next available issue and cannot be back dated.

CHANGE OF ADDRESS: Changes cannot be made without the old as well as the new address. Changes must be received 60 days before the date of publication. The Post Office will not forward copies unless you provide extra postage. Duplicate copies will not be sent. Notification of missed issues must be made within 60 days of cover date.

DISTRIBUTORS: Distributed to hobby and craft shops throughout the United States and Canada by Kalmbach Publishing Co., Waukesha, Wisconsin, U.S.A. (800-558-1544, ext. 413); in Germany by Christian Schmidt KG, Munich, Germany; in Austria by Buchhandlung Sallmayer, Vienna, Austria.

as the craft moved awkwardly away from the dock and forward speed increased so slowly as to put the issue in doubt. Finally the vessel began its painful climb from the surface. At some distance out, the HD-4 became fully extended on its main foils and at about 50 mph turned and began its clocked run on tip toe down the Bras D'or at 70.86 mph! I wish I had been there that day.

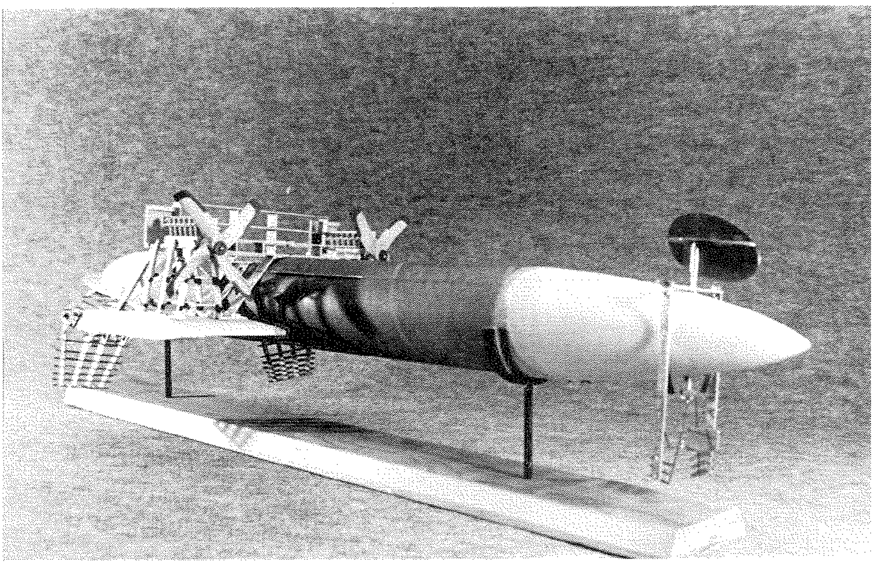
BACKGROUND

The HD-4 was an outgrowth of Alexander Graham Bell's early flight experiments with man-lifting tetrahedral kites. The kites had become larger and heavy enough to require towed water launches. Hydrofoils attached to the catamaran launching hulls provided about the only real successes in this dead-end search for heavier-than air flight. Subsequently, hydrofoil development later became a separate area of inquiry catalyzed when Bell met Forlanini, the hydrofoil pioneer, in Italy and rode in his ladder foil boat. The year was 1911.

Bell and Frederick W. (Casey) Baldwin's aircraft oriented approach was all but terminated with the outbreak of WWI in Europe in 1914.

Bell's laboratories and home at Beinn Breagh, near Baddeck, Nova Scotia, placed him in a delicate political situation. Being an American citizen in Canada, a combatant nation, he was reluctant to violate the spirit of neutrality that was the official U.S. position at that time, by developing a potential instrument of war. However, with the entry of America into the war in 1917 the picture changed when the Allied admiralties sought proposals for subchasers.

Bell and Baldwin tendered two designs for hydrofoil craft stressing the high speed potential and slight immersion which would immunize them from torpedo hazard and give the ability to operate over the top of anti-submarine nets. The capacity and lift of these boats was adequate for the carrying of torpedoes and depth charges. The first wartime proposal, the HD-4, designed by Baldwin, was pretty much what you see here a creature of the air as much as of the water.



This strange looking craft was an actual prototype vessel that skimmed along the water.

Building The Bell-Baldwin Hydrofoil HD-4

by Dave Acker

Back on September 19, 1919, cattle milled nervously in distant pastures as the two Liberty engines began blowing through twenty-four short exhaust stacks. The heart-stopping blast of noise and spray amplified as the craft moved awkwardly away from the dock and forward speed increased so slowly as to put the issue in doubt. Finally the vessel began its painful climb from the surface. At some distance out, the HD-4 became fully extended on its main foils and at about 50 mph turned and began its clocked run on tip toe down the Bras D'or at 70.86 mph! I wish I had been there that day.

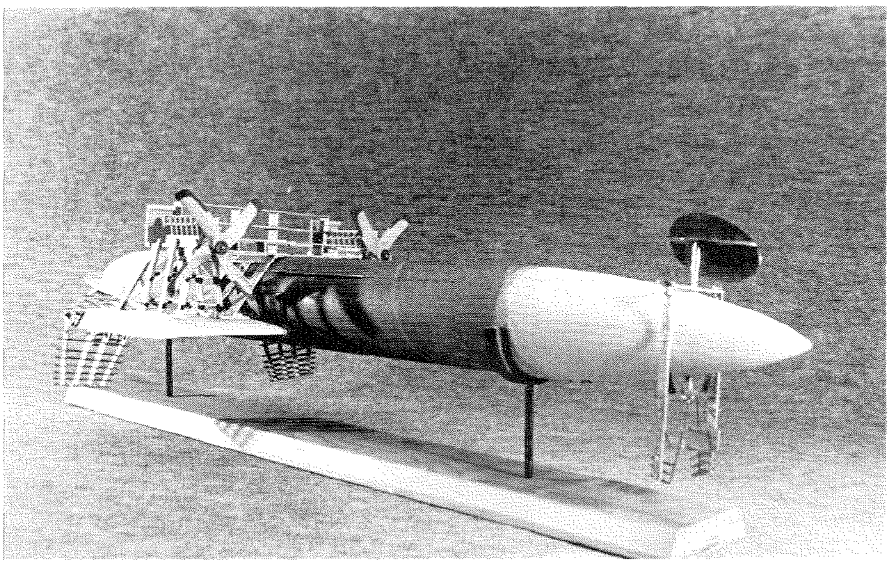
BACKGROUND

The HD-4 was an outgrowth of Alexander Graham Bell's early flight experiments with man-lifting tetrahedral kites. The kites had become larger and heavy enough to require towed water launches. Hydrofoils attached to the catamaran launching hulls provided about the only real successes in this dead-end search for heavier-than air flight. Subsequently, hydrofoil development later became a separate area of inquiry catalyzed when Bell met Forlanini, the hydrofoil pioneer, in Italy and rode in his ladder foil boat. The year was 1911.

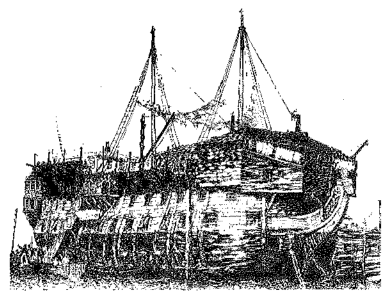
Bell and Frederick W. (Casey) Baldwin's first Hydrodromes (HD-1, -2, -3) were basically penguin (non-flying) biplanes whose major lift was stubby air foil wings. These proved unrewarding because of persistent structural weaknesses and the aircraft oriented approach was all but terminated with the outbreak of WWI in Europe in 1914.

Bell's laboratories and home at Beinn Breagh, near Baddeck, Nova Scotia, placed him in a delicate political situation. Being an American citizen in Canada, a combatant nation, he was reluctant to violate the spirit of neutrality that was the official U.S. position at that time, by developing a potential instrument of war. However, with the entry of America into the war in 1917 the picture changed when the Allied admiralties sought proposals for subchasers.

Bell and Baldwin tendered two designs for hydrofoil craft stressing the high speed potential and slight immersion which would immunize them from torpedo hazard and give the ability to operate over the top of anti-submarine nets. The capacity and lift of these boats was adequate for the carrying of torpedoes and depth charges. The first wartime proposal, the HD-4, designed by Baldwin, was pretty much what you see here, a creature of the air as much as of the water.



This strange looking craft was an actual prototype vessel that skimmed along the water.



A DESCRIPTION

As prelude it should be known that the hull/fuselage of the HD-4 was lightly built. She was much like an old-fashioned canoe which is to say it was made of formers or bulkheads connected by longitudinal stringers. This assembly was covered spirally with scarphed veneer stock and finally topped by a layer of 1/2" strip laid fore and aft. Embedded in the outer shell were steel wires for stiffness in the long axis. Spirally wound about the hull were eight pairs of cables for resistance in torsion. Final covering was marine glue, canvas and dark gray paint.

The hull was a 60', cigar-shaped cylinder with a maximum diameter of about 5.75'. This hull was the main structural member providing flotation at rest, crew accommodation, fuel, and proposed military load. The forward wing-like sponsons supported the power plants and their mountings and carried "Balancing Hulls" or pontoons of about 2' in length at their extremities.

The hydrofoil sets, of multiple-blades, were four in number. Each blade had an air foil cross-section:

The ladder-like bow preventer was essentially an anti-pitch device helping in initial rising and was clear of the water when the craft was fully extended.

The main sets, one on each sponson, were mounted on four braced struts and were adjustable for angle of attack as well as being set at a fixed dihedral.

The stern set pivoted on a braced post. The vertical members of this set acted as rudders and were supplemented by a small conventional water rudder and an air rudder fixed atop an extension of the post. Control was by a steering wheel in the cockpit via conventional cable and drum arrangement.

Large triangular spray shields were fitted from the bow to the leading edges of the sponsons. Later, another shield encircling the bow augmented these. These combined surfaces provided some paltry and inefficient lift, but did fulfill their function of protecting the propellers from spray.

The HD-4 was, from the outset, a test bed whose specifications changed frequently if not constantly. In fact, no two pictures seem to be the same in detail. The full-size replica at Baddeck captures its aspect on a given day and cannot show it as it was earlier or later. In fact, the drawing from which I worked did not match in every respect the replica which I viewed. This is not meant as criticism, but only as an observation of the ever-changing look of it. A few of several changes that occurred over a short time were:

a. Tendered drawings and patent applications show no air rudder.

b. The pontoons began as hull-shaped cylinders and were soon changed to shorter, flatter, rectangular cross-sections.

c. Early trials were with Renault V-12 engines of nominal 250 hp each.

d. Two-blade propellers were replaced by four-blade types.

e. De-tuned Liberty V-12 engines of 350 hp each replaced the Renaults.

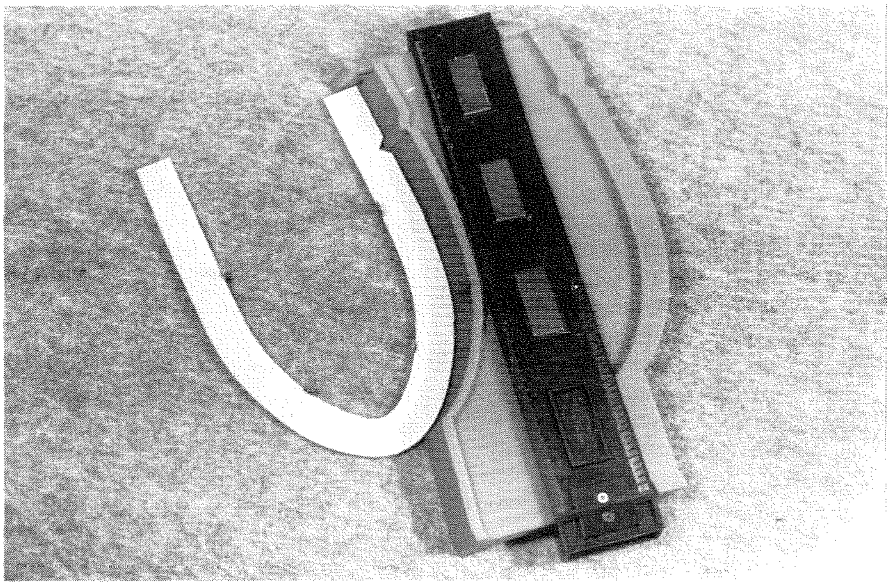
f. Motor supports were shortened.

g. The airfoil nest above the cockpit was lowered.

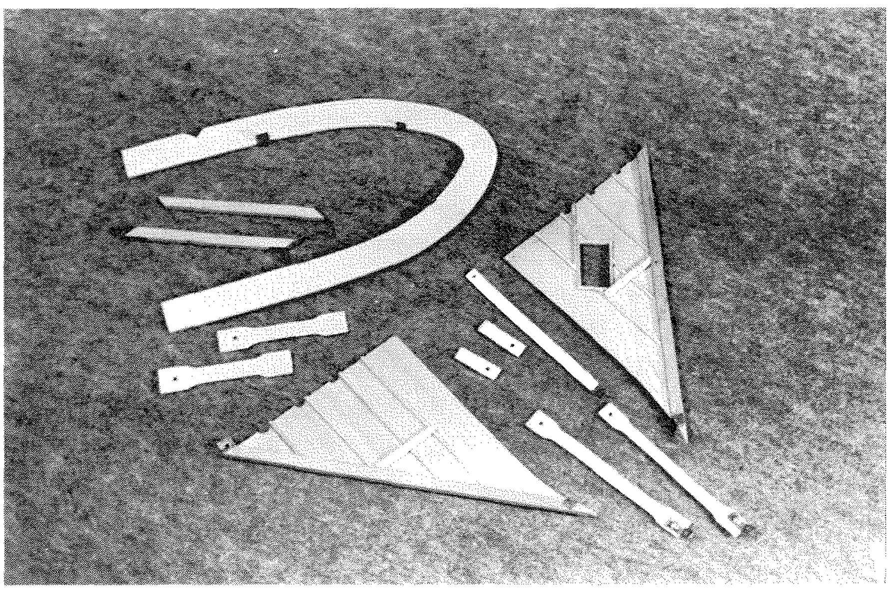
h. Spray shield applications and conformation varied.

i. A rectangular camera port was cut into the port side spray shield which may have required an additional strut on that side. The replica exhibits this asymmetry, the drawing does not.

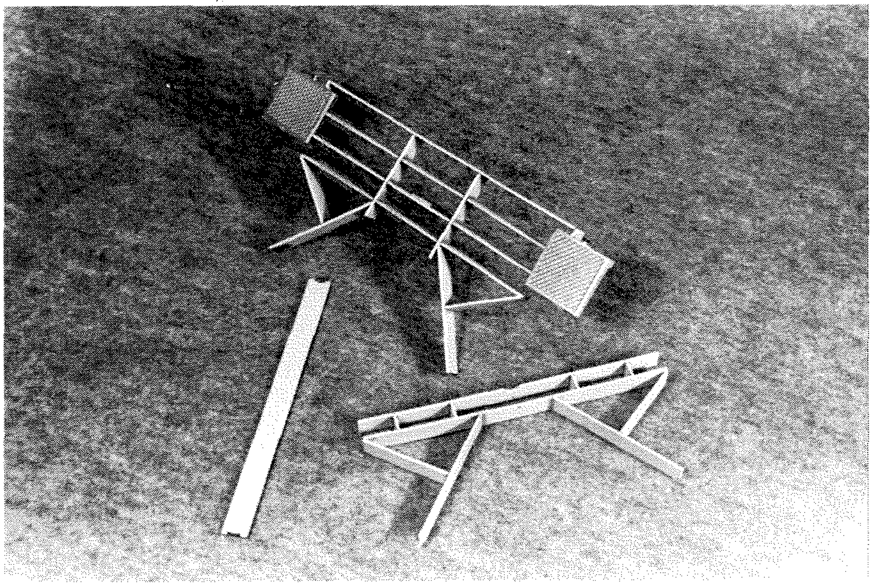
j. The hydrofoils themselves underwent constant re-design and refinement. In addition to adjustments of the angle of attack (the angle between the mean chord line of the foil set and the flow).



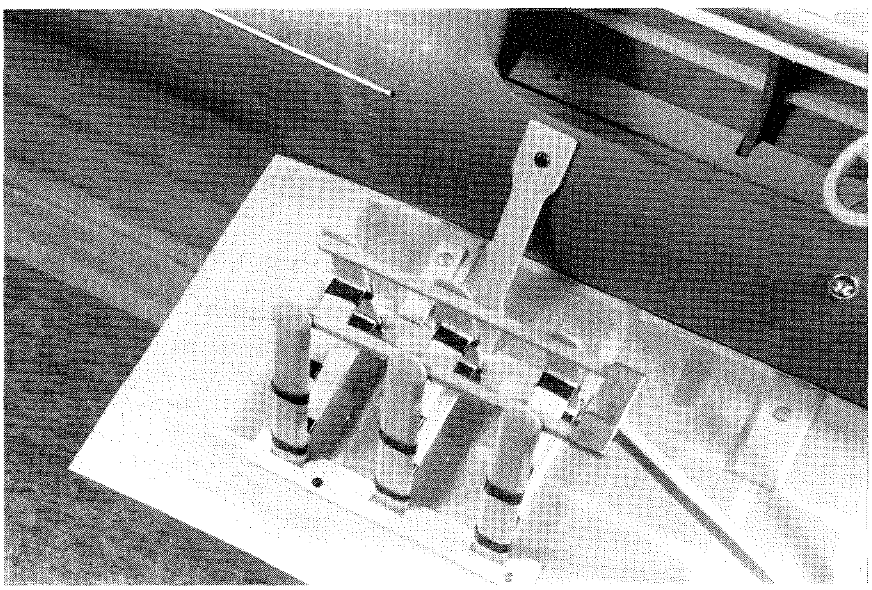
The odd profile gauge looks like a comb whose teeth are moveable. It takes on the form of any object against which it is pressed and makes the production of patterns easy.



These are the spray shield sub-assemblies.



I deviated from the original drawing of the airfoil to eliminate some of the weaker aspects of the structures and to enable them to be attached with screws.



The motor mount here shows the clamping dog at the rear inboard corner of the vessel.

k. Chronic under estimation of the needed material strength for struts and foils resulted in a harried search for ways to avoid the plague of parts failure in these components. Finally, the smallest foils – those at the bottom of the sets, were fabricated of saw blade steel and took nearly the full five tons of the craft's weight on their 6.37 square feet spared only the 500 or so pounds carried by the "dirty" lift of the spray shields and sponsons.

l. A large foil spanning the two main foil sets was swept away by misadventure on the day of the performance trial and was not replaced at the time or thereafter.

CONSTRUCTION

The project began in earnest when I saw a kit for a model of this vessel offered by a Canadian model airplane manufacturer, Easy Built Models™. Typically, their excellent offerings are of the traditional rubber band powered balsa wood and tissue paper type. Conceive of my astonishment at the prospect of a stick and tissue hydrofoil! I bought the kit at once in order to get the drawings, for I had never seen such a thing. If the original vessel was lightly built, then this kit was surely more fragile than a butterfly as it ironically duplicated the construction of the original more accurately than I subsequently did in the project at hand.

After examining the contents of the kit: good quality balsa sheet, print wood, sticks and silk span covering material, I felt that undertaking construction would surely tax even a master builder and result in a heart-breakingly fragile object.

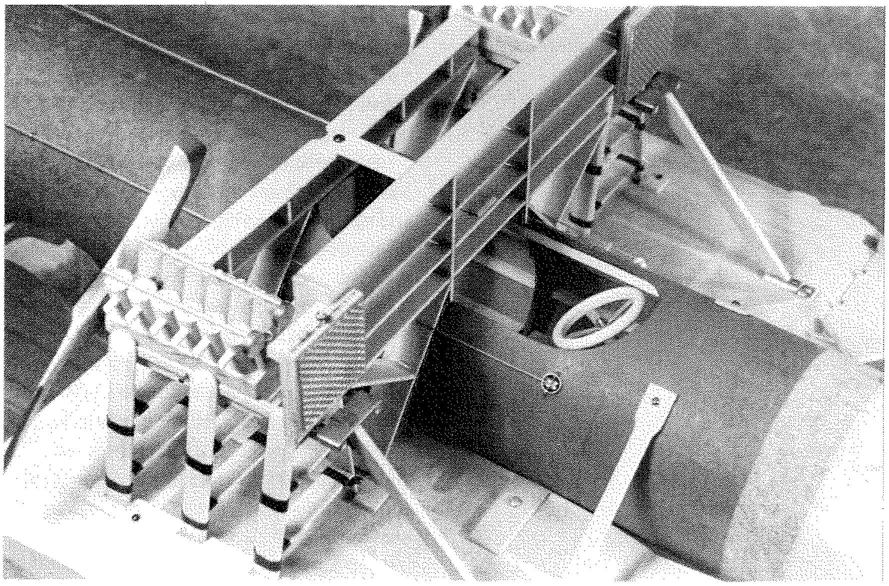
The working drawing was printed in parts on several sheets of small paper which I finally organized, glued-up into a 2' x 3' sheet, and began to study carefully. My first act was to consign all of the excellent balsa material and silk span to my stockpile of surplus and consider for some months just what it was I was going to do about it. Not building it was never a consideration.

One day, serendipitously, the UPS man delivered a stout mailing tube of 3' x 3 1/4" and having a wall thickness of 1/8". Here it was – strength, size, and shape: a perfect main structural member. The plan, however, called for a hull of 3" in diameter. A quick calculation told me that 3 1/4" was 1/12th larger than 3" and if I was going to proceed, I had better break out my long unused calculator and install fresh batteries.

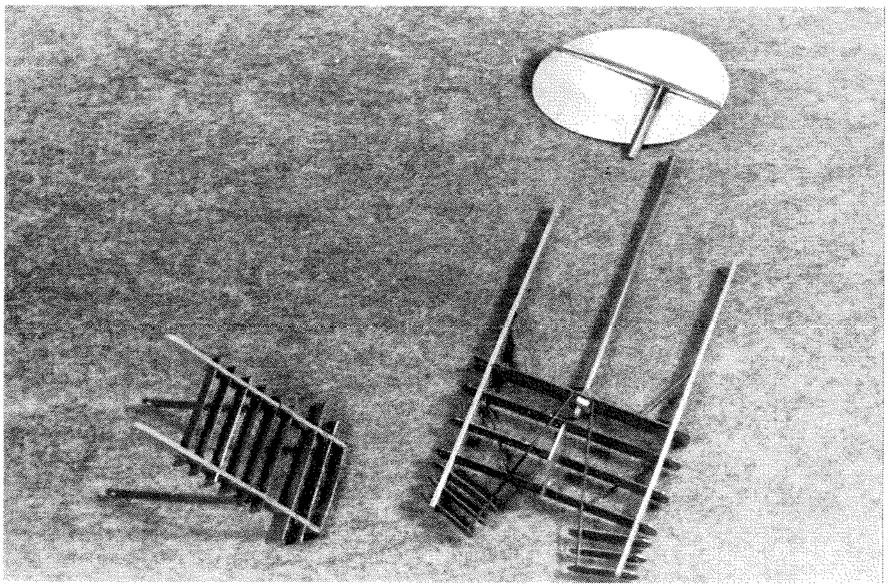
The plan also called for a total overall length of 30". Well, if the diameter is increased by 1/12th to 3 1/4", then the length must be increased by 1/12th to 32".

Suddenly I was leaving the realm of 1/24th scale size and entering 1/22.5 scale territory. My resolve was firm. I got a table of decimal to fraction equivalents and for the next three months, off and on, every dimension was increased by .083", or 8.3%, or 1/12th, or what have you. There was much rounding-off up and down, but things rarely got more than .030" - .060" (1/32" = 1/16") out of size. All this can be avoided, however, if you find a tube of just 3" in diameter then you can work right on the drawing and use the kit-provided material for patterns or application. I will speak no more of it.

The tube was carefully sawn to proper length and center lines penciled full-length top and bottom, 180° apart. Establish the location of the cockpit opening and lay it out on the top center line. A pencil compass and a long straight edge make it easy. Drill several 5/16" or 3/8" holes carefully well inside, 3/8" or more, and all around the cockpit lay out line. The cardboard tube drilled easily enough, but any cutting or drilling will leave ragged and weak-edged openings. Sawing or



With the airfoil nest in position you can see the interior stringers. The motor mount and Liberty engines are also in position.



The front preventers, or initial rising foils, are on the left. The uprights are made from 1/32" plywood and .015" iron blades. At the right is the rear foil set. The uprights are made from laminated aluminum. The iron blades are .015" in size except the top one which is .022" iron. The 1/8" brazing rod steering/rudder post is also attached. At the top of the photo is the air rudder made of .022" iron tube which was incorporated to fit the rudder post.

sanding the tube is the safest and most accurate way to alter it.

I connected the just drilled holes with a carefully cut or sawn line and removed the ugly result. What I did was fashion a V block of 6" or 7" in length on which to rest the fat, round tube. I established its true vertical orientation while in the V block. I mounted a 1" diameter sanding drum (the rubber expandable type that uses abrasive sleeves) in my drill press, lowered the quill until it was well-inside the ragged hole just formed in the tube now mounted on the V block and locked it in that down position. Turning the drill press on, it was the work of five minutes to feed the tube into the drum and make a clean, vertical sided cockpit opening precisely to the layout line. An electric hand drill using the same drum with careful employment could do almost as well. Even a high speed rotary hand tool could do it.

Next, to strengthen the tube, I coated it with epoxy resin. This may sound nasty, but it is not and I consider the step to be among the most important phases of the work. The only tools required were a cheap, stiff brush of about 1" in width and somebody's hair dryer. I have little hair, so I borrowed one for the job. Hobby shops and home supply stores have those metal handled, short bristle brushes that are specific for glues and epoxy application and are meant to be expendable.

I mixed a small batch - one ounce or so - of slow cure (two hour type) epoxy. You'll probably require more, but the one ounce will give you a feeling of how much is needed and how to work with it. There's plenty of time, so you can always mix more as you go, of course. I started by heating the tube with the dryer and began applying the resin generously to the heated area. I kept the dryer pointed at, and up close to the brush.

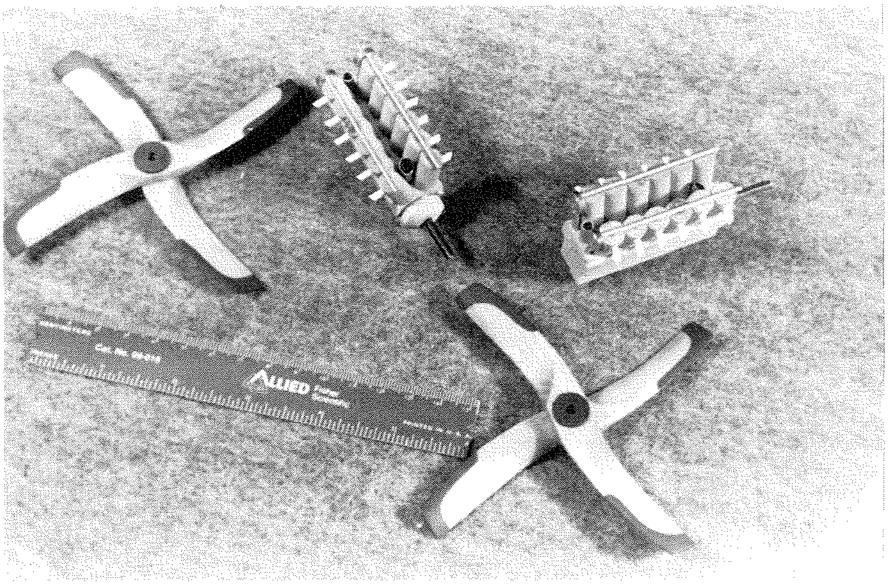
The resin immediately thins out from a heavy syrup to almost water consistency and penetrates spectacularly into the cardboard tube. You can gauge your progress as the tube becomes darkly soaked with the warm liquid. Work quickly since no delicacy is required. Fuzz, dust and other junk will begin to raise from the cardboard. Ignore it, mix more resin if needed and keep going. When the whole surface and all edges are thoroughly soaked, its over. The heat will speed up the cure considerably. If runs appear, brush them out. It will be tacky dry in a fairly short time, but I would suggest letting it go overnight or even an extra day. When the surface is rock-hard to the touch, it may be sanded.

Despite its formidable hardness, the material sands easily. Medium grit paper and a little time will yield a glass smooth surface on a cardboard tube that has become a plastic pipe!

At this stage I departed almost totally from the drawing. You may wish to work closely with it or follow me. Frankly, if you've come this far, you are surely qualified to make the choice.

My choice was that the model, or more precisely, my impression of the HD-4, should be robust and palpable and to that end it would be built as sub-assemblies fastened to the hull with small screws. The use of adhesives was kept to a minimum.

The nose and tail cones can be built with balsa wood and tissue per the plan and be quite attractive and appropriate in appearance. The downside is that they would be feloniously fragile and quite unsuitable as



The V-12 Liberty engines were made from wood. The propellers were constructed from yellow pine.

mounts for any but the most ephemeral of attachments. I chose to glue up into blocks some scraps of clear white pine left over from an earlier project and prepared to carve. They were a project that required a lathe, regrettably, which I don't have.

I went to see my friend, Rick the carpenter, with the intention of using his lathe and turning the cones between centers. He suggested turning them on a face plate. Lagging the block, nose-end first, to the face plate with sheet rock screw nails, he proceeded with the turning at the fat end and worked toward the point at the head stock, glancing at the drawing from time to time. In less than 10 minutes he smoothed it with sandpaper, turned off the machine and was done. My jaw was slack with amazement when he turned the lathe on again and proceeded to hollow it!

Now this is surely beyond what most modelers, including me, have to work with. I mention it because the unerring skill with which Rick worked is worth mentioning and is a shining example of the mastery of tools. Humbly, I finished off the point of the cone with a knife and sand paper after the block was dismounted from the plate. My estimate is that whittling both cones from blocks would cost between five and eight hours of work. Hollowing-out is not necessary.

When the cones are finished I would recommend they not be glued to the tube yet because:

a. Their added length makes handling the craft awkward.

b. There is work to be done on both cones in mounting foil sets.

c. Installing some kind of cockpit interior is easier if you are able to work from each end of the tube.

Installing the rudder post is probably best done with the real cone mounted on the tube. Drilling and bushing that hole I found to be among the most difficult jobs in the project because I didn't do it that way.

If you are not going to make the sponsons removable, the drawing can be followed fairly closely and the work is straightforward. However, if the structures are to be removable, some planning and advance work is in order.

I would suggest building the motor bearers at this time in order to determine just where on the sponsons their mounting spots will be so that hard points can be provided for the screws.

A local craft store offered large bags of what appeared to be popsicle sticks. Their size was correct for both uprights and cross members of the pedestals, and more to the point, they were of polished birch and extremely strong. Departing from the drawing slightly, I made all the uprights of the same length. Merely flattening slightly the upper surface profile of the sponsons allowed the motor bearers to be built incorporating a flat base which lent itself to a strong screwed-down fastening. A wooden gauge block assisted the construction greatly (Illustration Two).

The cross members are not glued to the uprights directly, but to sheet metal brackets which are in turn attached to the uprights. Epoxy is my choice of adhesive. Each end of the bracket is strain-relieved with a ring of shrink-tube. When all the joints are cured and the tubing shrunk, the structure becomes extremely rigid and able to take all reasonable stress put to it. Now the frames of the sponsons can be laid out with an eye to where the motor bearer was mounted.

The ribs of the sponsons I made of hard 1/8" thick balsa. The leading and trailing edges can be of pine, hard balsa or anything that comes to hand. I used hard balsa from my scrap box. My first choice would be yellow pine parting strip obtainable from any lumber yard. Illustration One shows the path I took.

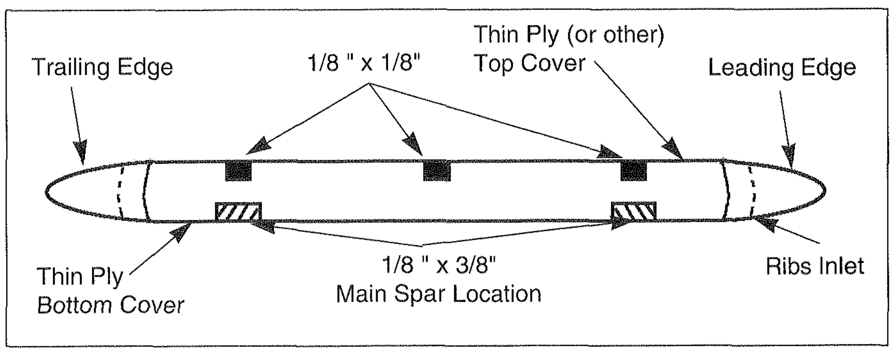


Illustration One. The following steps show the order in which I made the sponsons. I inlet the ribs into the leading and trailing edge stock. The deeper you go is better. You must avoid any butt joints. The three top spars were located so that the middle one was able to take a fastener from the front of the motor pedestal in its correct position. The two large bottom spars were located directly beneath the front and rear top spars. The main mounting fasteners utilize both these pairs. When building the sponson, I used dummy spars for the bottom pair. Do not glue them to the ribs or anything else. I shaped the leading and trailing edges. I constructed the pontoons from pine or hard balsa, attached them to the end of the sponson and matched them to the top sponson surface. I covered at least the bottom surfaces of the sponsons preferably with 1/64" plywood. (This illustration is not to scale.)

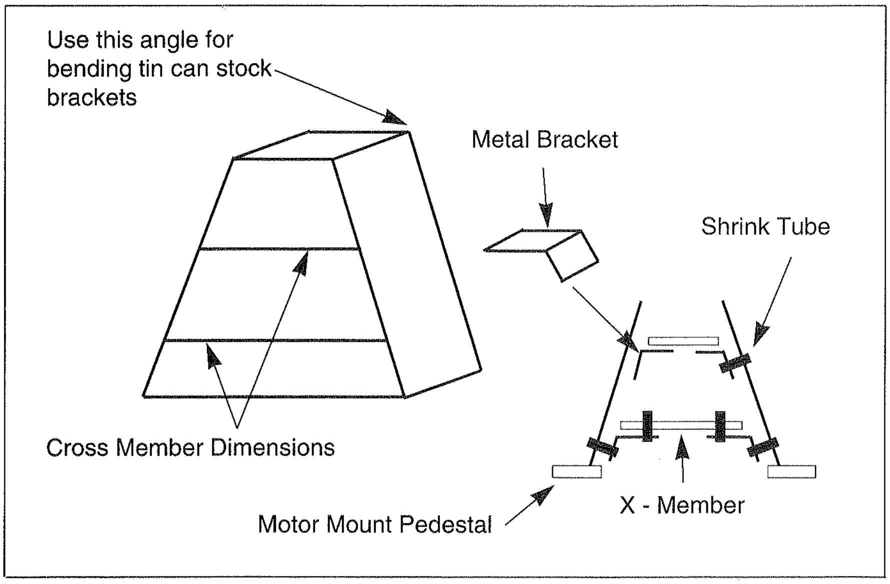


Illustration Two. The gauge block was formed from 3/4" wood to the inside shape of the pedestal structure.

If you're familiar with the polyester heat shrink materials, they could be used here in conjunction with the ply. In any case, when the bottom is ply covered, there will be created boxes to capture both bottom spars which will be built into the hull. The function of the dummy spars then, is to align the bottom spar notches while the sponson was being built.

The main spar installation in the hull began by precisely locating the sponson in its fore and aft alignment. Mark the leading and trailing edge positions on the hull with pencil marks or tape. I determined the precise height of the bottom surface to the sponson from the bottom centerline on the hull and marked it.

Using a straight edge and pencil I drew a line on the hull at the height parallel to the bottom center line. The bottom of the bottom spar then would lie on this line. I carefully applied the sponson structure to its fore and aft and bottom marks and marked the locations of the bottom spars on the just penciled height line using the empty space boxes as guides. I did both sides at the same time and verified that all marks were properly in register.

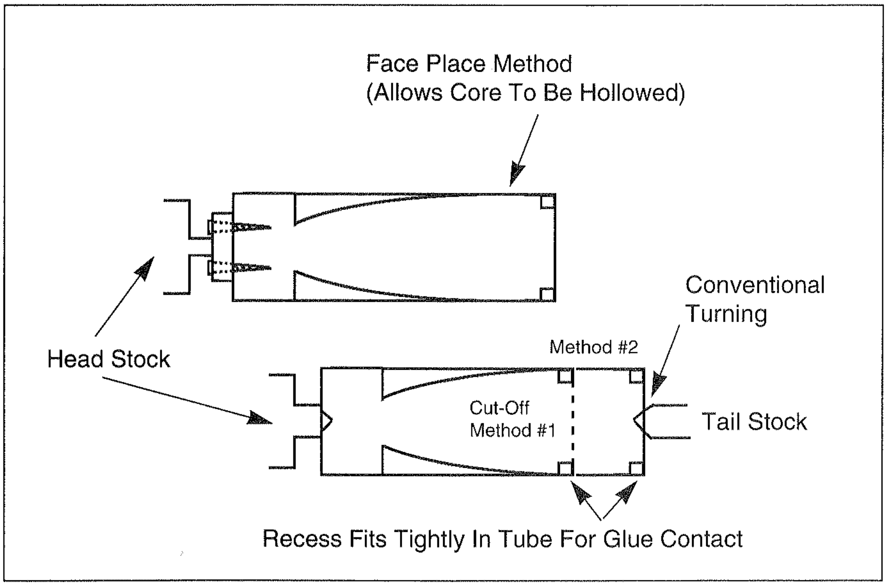


Illustration Three. The nose and tail cones were turned on a wood lathe.

I pierced the epoxy shell at the spar locations with a small drill or sharp, pointed blade and with a sanding stick or small file made four rectangular holes that would allow snug passage through the hull of the spar material. The holes do not extend below the height line.

Each spar should be of one piece and long enough to reach through the outermost rib notch and butt into the pontoon on the sponson's extremity. I made trial fits and trimmed until this condition was achieved. If all is done fairly, the spars will extend the proper length on each side, be perpendicular to the hull's vertical center line, and when viewed from front, rear, or measured, be of the same height, and be a snug fit in the sponson boxes. I fit every thing together snugly to the hull, verified alignments and applied the glue to the hull/spar union inside the cockpit and allowed it to cure.

It was now self-evident where the mounting screws go, which was as near as is practical to the hull, through the front and rear top spars and into the larger bottom spars. The motor bearer pedestals were aligned along the spars for mounting points. The pontoons or outer ribs were attached with two outer screws. The middle upper spar took the inboard front corner fastener, and the rear spar mounting screw was clamped to the rear inboard corner with a dog made of the birch popsicle stick material. (Or a piece of stiff metal if you prefer.)

The hydrofoils were built, in my case, in three different ways: The bow preventers were of 1/3" ply for the verticals and .015" sheet iron (tin can stock) for the blades, all cyanoacrylated (cyanoed) and epoxied together. The stern set had epoxy laminated aluminum strip verticals and .015" sheet iron blades except for the top blade which was a .022" (22 gauge) strain bearer--taking the rudder post, all cyanoed and epoxied together; the main foils were entirely of .022" sheet iron strips soldered.

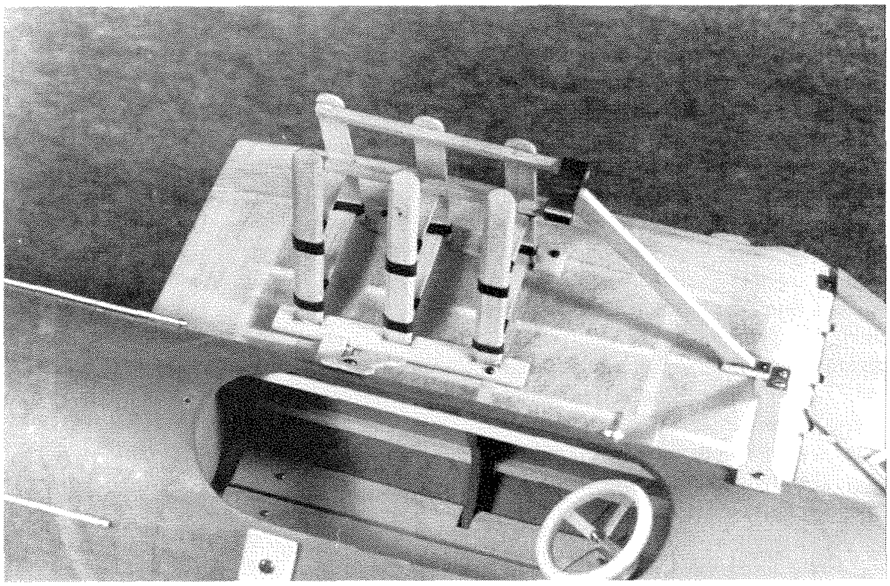
Early on, I considered all-wood construction and even had the front set of hydrofoils built of thin basswood strip. It looked good and built easily, but was extremely fragile and was totally unsuitable for anything except the original stick and tissue construction.

The composite wood and metal front set hydrofoils, strongly braced as it was, I would judge to be minimally adequate. The rear all-metal cyano/epoxy set is notably more rigid and more adequate for my purposes. The main sets of soldered iron strip were incredibly strong and their ultimate strain limit will not be met in any foreseeable situation. The choice of construction materials and adhesives then is for the builder to decide.

The construction method called for in the drawing was to build them like grating, that is to say that intersecting members locked in half-depth notches. The technique is sound and with care any reasonably competent worker could manage this. When working with metal though, the material offers greatly increased resistance to your efforts.

In all my days I had never used a high speed rotary hand tool and of course, did not own one. A good friend who does china repair and restoration loaned me one of his old second echelon tools for my first trial. What drew my attention was the stack of a little abrasive cut-off wheel. I was assured that they were, indeed, extremely effective cutters-off. More interestingly, the little wheels were a nominal .020" thick and would be perfect as notch makers in the tough 22 gauge iron–and everything else.

If I had possessed more experience with the rotary hand tool, the job would have gone more quickly with fewer false starts. As it was, with a jeweler's saw for the thin slots and the . 026" wheels for the thick ones, the job became, if not easy, at least do-able.

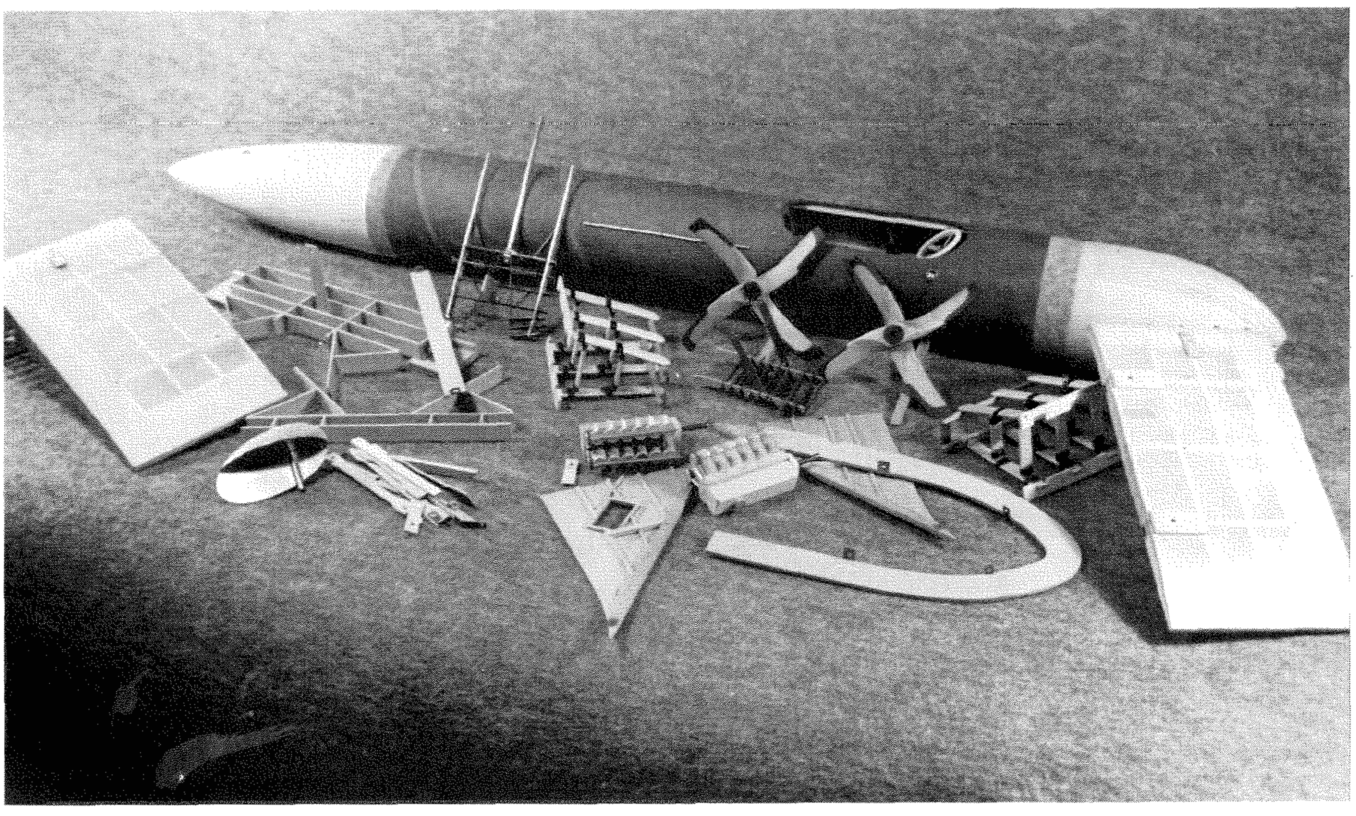


The functional front strut was attached to the hull, from the base of the front motor mount bracket strut. You can also see the interior of the cockpit from this view.

FREE ADVICE

1. Draw a pattern or make a jig on a piece of wood for construction of the foils, especially the main sets. There will be lots of handling before the job is done. It will also be possible to fasten the work down and it will be easier to check bends and angles as you go.

2. If there will be no great stress put on the parts, cyano and epoxy are adequate adhesives even for metal in conjunction with the grate type construction.



This is the model with all of the detachable sub-assembles taken off.

3. When grinding slots or sawing, use a steel straight edge as a guide, not marks. Alignment is critical. Misalignment wastes time, causes warps, and makes scrap.

4. When all slots are properly cut, the grate assembly should snap together dry and become quite strong. That is the time for glue, cyano, epoxy, solder, or what-have-you.

5. Metal strips, if used, are best made with a shear--they come out flat, smooth-edged, and free of distortion. If you use snips (I do), they come out sharp-edged, distorted, and curled and must be flattened and filed before use. A small bench vise is invaluable in swaging pieces flat.

6. Wear eye protection when grinding slots. The cut-off wheels are brittle and a shattered one could be a calamity on your face.

7. Make a stand for the boat as soon as the hull tube is prepared--work is eased considerably.

ASSEMBLY STRUCTURES

The rear set of foils indicated on the plan was shown as a ladder-like-structure similar to the front anti-dive set. The replica craft at Baddeck however, had a different form, which I used. The photos show the difference.

The air rudder can be made in a straight forward construction, per the kit if you choose. I made mine from 22 gauge iron for the sake of strength. A tube was included so it could be dismounted for removal of the rear foil assembly.

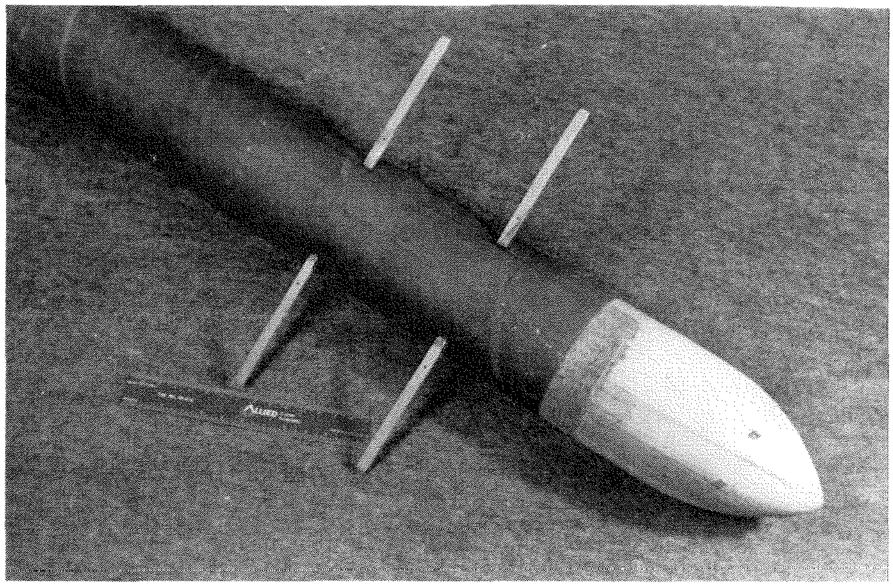
The spray shields can be built right on the hull/sponson assembly. Curiously, the drawing was mute as to what type of covering to use. At first I didn't know that they were spray shields. I thought they were bracing for the sponsons. A query to the kit manufacturer yielded a response that the structure was uncovered. This was the event that prompted a week-long sojourn to Nova Scotia. I had to see this for myself. I can report that the main shields (on the replica) are wood covered on the bottom surface only. In my version I epoxied small metal tabs to enable screw fastening it to the nose cone and sponson leading edge.

The bow shield shown on the plan was at variance with the replica at Baddeck. I went with the replica type. Useful in making this closely fitted piece is the odd profile gauge. A hardware store or building supply outlet should stock them. It looks like a comb whose teeth are moveable. It takes on the form of any object against which it is pressed and makes the production of patterns easy. The attachment of small metal tabs enabled a nice screw fastener fit to the nose cone.

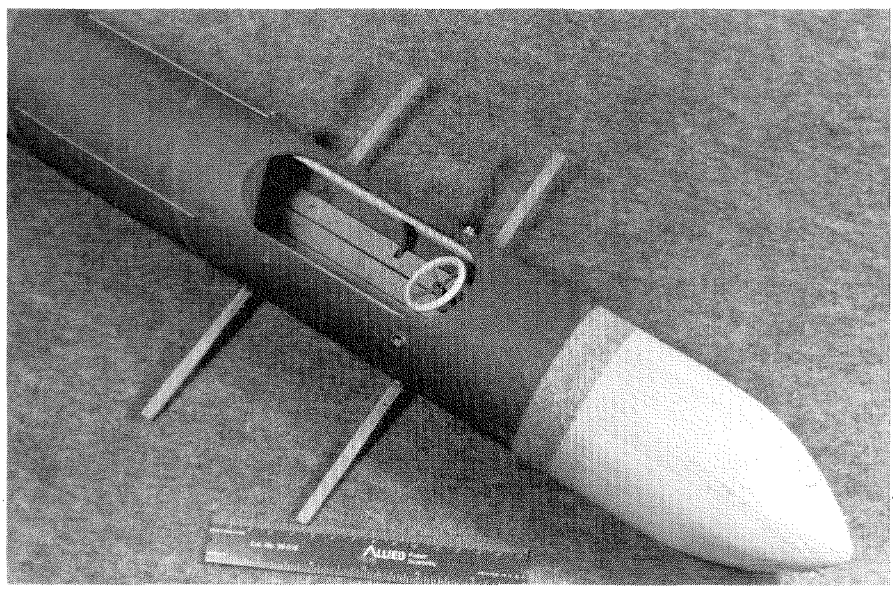
Sources indicated that the cockpit was fully instrumented, i.e. switches, tachometers, water temperature, oil pressure, oil temperatures, inclinometer, speed indicator, air tank pressure (the starter motors were air driven), ammeters, and probably a fuel level indicator of some sort. The drawing is again mute and the replica at Baddeck had a drop cloth over the cockpit at the time of my visit. I'm not sure that if it were uncovered, anything would have been visible.

For more information about the site of the reconstructed HD-4, contact: Parc Historique National Alexander Graham Bell, P.O. Box 159, Baddeck, Nova Scotia, Canada. A large archive is on the premises. The excellent museum with a helpful staff is dedicated to Bell and his works.

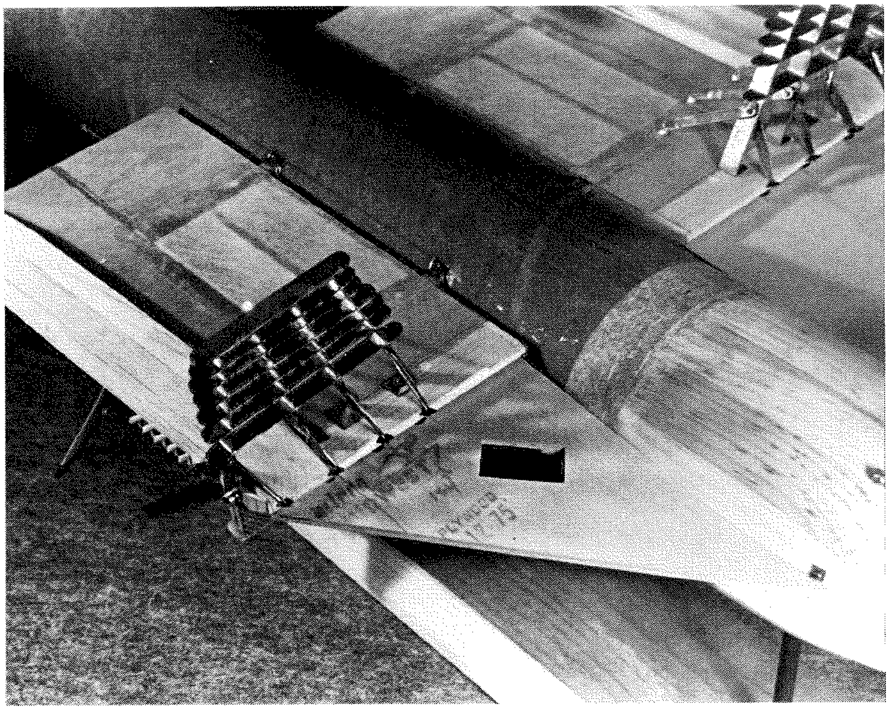
I had a badly obscured glimpse of the steering wheel and it appeared to be a disc of wood of about 2' or 2 1/2' in diameter! Once more the plan was no help. The wooden wheel I felt, was an execrable lapse in aesthetics and I could not bring myself to make it. Instead, a dashing item of flat



The sponson spars have been mounted on the bottom of the hull.



With the hull flipped right side up, you can see the sponson spars, floorboards, and steering wheel.

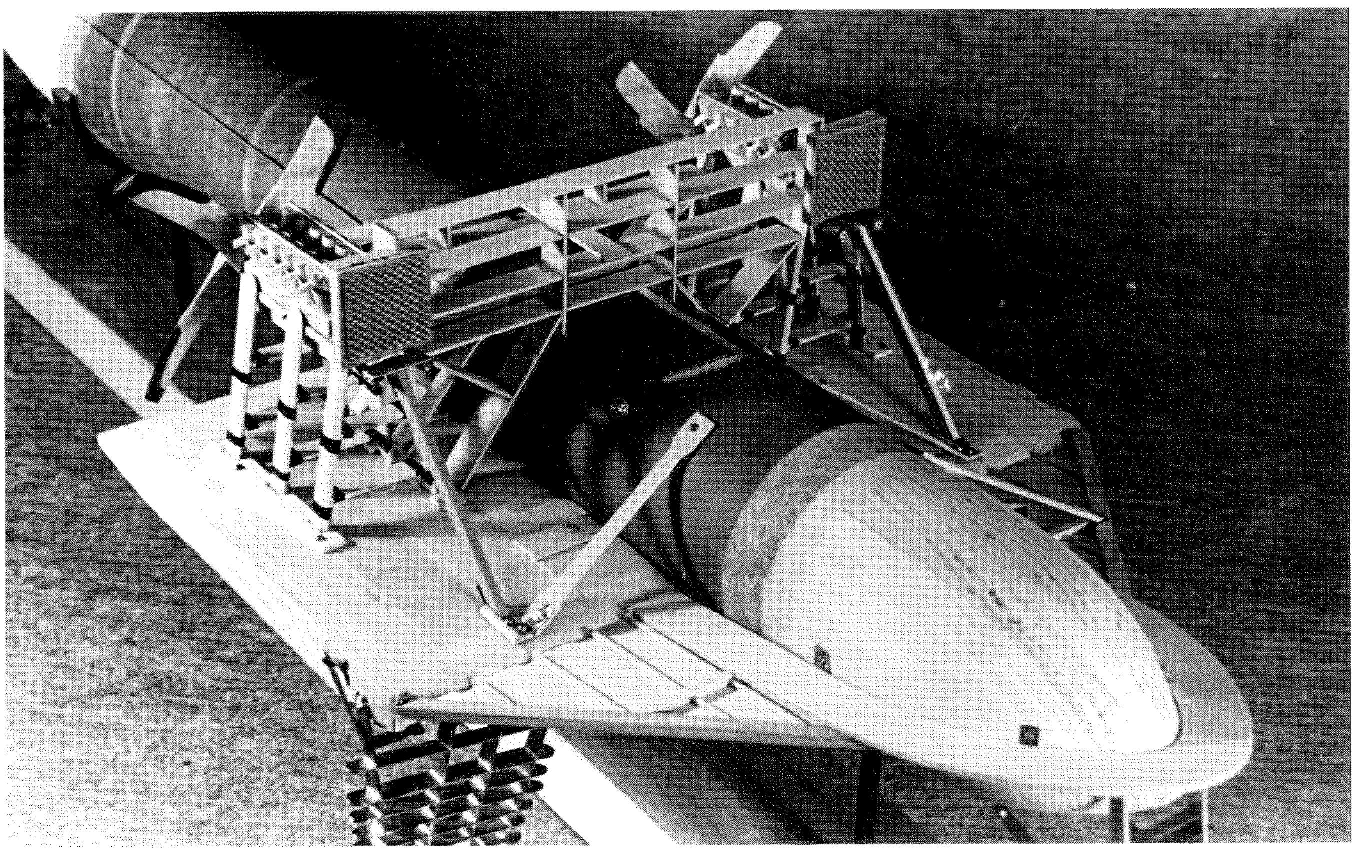


The bottom part of the sponson was made from .022" sheet iron foil strips and .015" braces. The rectangular hole is a camera port. The bottom of the sponson shows 1/64" plywood for the spar boxes.

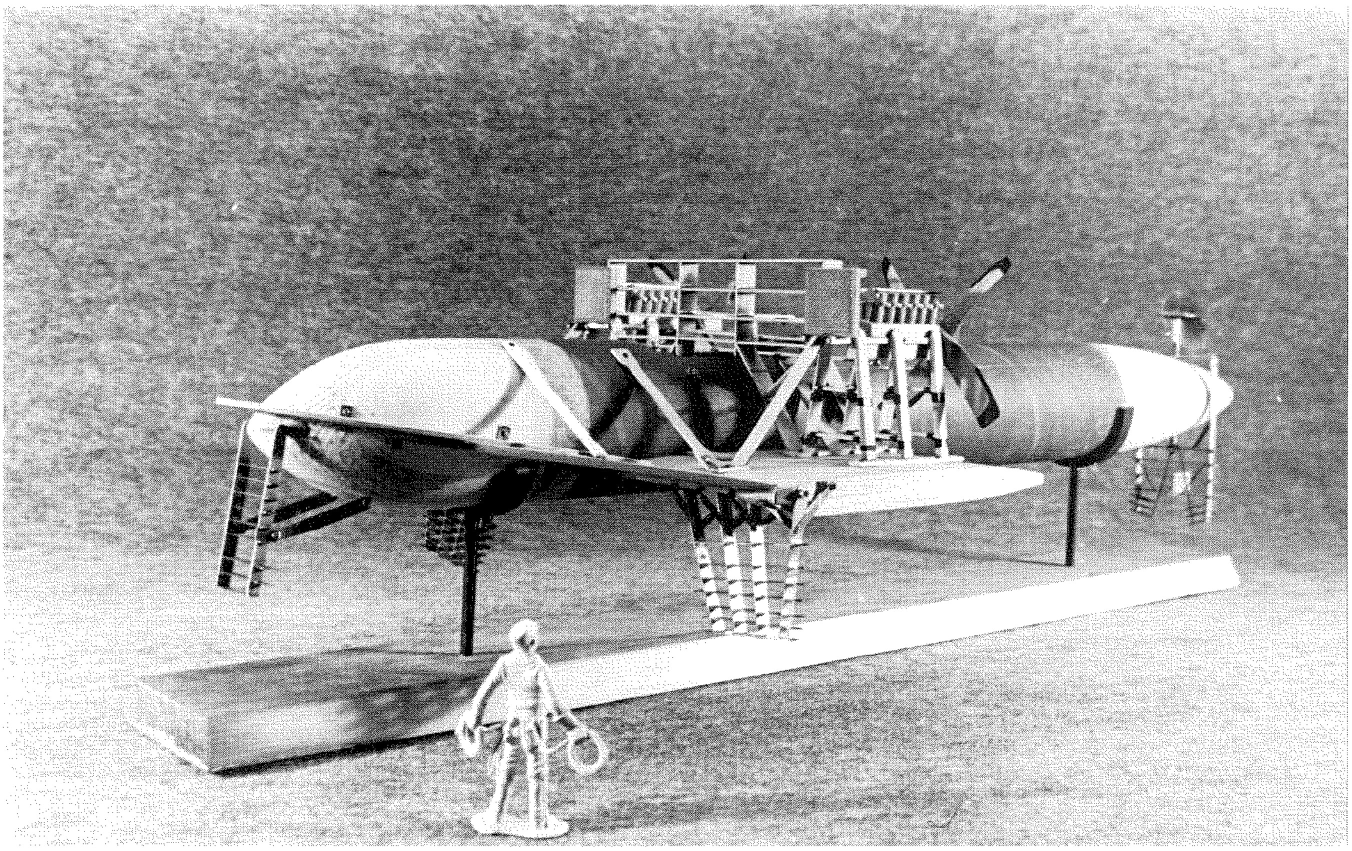
aluminum and a slice of plastic pipe was built for which no apology is offered.

Before the front and rear cones were affixed, I decided to place faux bulkheads and stringers in the cockpit. The circular cross section of the hull interior made the job easy. The assembly consisted of three identical balsa rings carefully notched on the same patterns, along with any number of 1/8" square spruce or balsa sticks. I used nine sticks. The cockpit interior was sprayed a dark gray before the installation and the bulkhead/formers and stringers were left unfinished. Unfinished floorboards were installed across the spars. No instrumentation was installed.

The drawings for the topside airfoil nest are good. It can be built right on the plan. I used 1/16" basswood strip and attempted no airfoil cross sections. I deviated from the drawing to eliminate some of the weaker aspects of the structures and to enable them to be attached with screws. The more elaborate front set was a tight fit in the cockpit opening and was wedged against the motor mount bases. It has a longitudinal member screwed to the rear set.



The front strut on the model is functional.



The telephone lineman (boarding party?) stands 3" tall or 5' 7.5" at scale height.

The middle airfoil was metal bracketed and screwed to the inside of the middle vertical member of each motor mount. The rear set is wedged against the motor mount base and was screwed to the top of the hull/fuselage. It also was screwed to the longitudinal member of the front set. The whole nest thereby, was wedged and screw-fastened firmly and became a rigidly fixed and strong assembly.

The Liberty engines were a separate modeling project in themselves. I gave them a slightly more elaborate treatment than the drawing and omitted all wiring, accessories, and plumbing from the radiators in the interest of easy assembly and dis-assembly. You of course, may take the construction as far as desired. My motors were through-pinned to the mounting rails of the motor pedestals. The propellers were made from yellow pine. They were easier to carve than it would appear. However, I claim some experience in this area. The plan offers adequate drawings as a guide. Yes, the four-blade propellers are each a pair of two-bladers on the same shaft, 1919 style.

The overall color of the replica at Baddeck is dark flat gray. The main hydrofoil blades and struts (excluding the braces) are a milky yellow -- about like a canary . The outer tips of the third, fourth and fifth blades from the bottom are marked I, II, III respectively for photographic observation.

The rear foil blades except for the top one are of the same yellow color, as were the struts. The verticals were yellow to a point even with the hull bottom.

On the front set only the three bottom blades were yellow. The verticals were yellow their full length. The braces were yellow for 6" or 8" back from their connection with the vertical struts.

EPILOGUE

By the time the HD-4 had reached its peak of development, the war in Europe had bled to a close and both the British and American admiralties, if they had ever been enthusiastic, were cooling rapidly. Committees listlessly evaluated and commissions dutifully tested.

However, the craft was not an efficient load carrier. It was fragile and easily disabled. Its abilities in rough water and open seas were suspect. Even worse, the naval treaties following the war restricted expansion so the funding of development was unlikely.

In the end, the hull was re-used as a target by the Canadian government in 1921. The clapped-out motors were junked, with one later rescued, and the remains were beached at Beinn Breagh and weathered outside until 1953.

Bell himself never rode in the HD-4 although his wife, Mabel, audaciously passengered over to Baddeck one day at 31.5 mph. Patents on the HD-4 and a proposed HD-5 shared with the Casey Baldwin and Sydney Breeze were the last to appear in Bell's name. He died in August, 1922. ■

REFERENCES

Alex Babbour, extract from *Draft Report EA-PC-82-15 "Reconstruction of the HD-4 Hydrofoil 1976-79"* Parks Canada, Atlantic Region, Nova Scotia, 19__.

A monograph, "Search for Yesterday", April 1981, Baddeck Public Library., Nova Scotia, 19__.

D.W. Fostle, *Speedboat*, Mystic Seaport Museum, Connecticut, 1988.

Roy McLeavy, *Hovercraft and Hydrofoils*, Arco Publishing Co., New York, 1977.