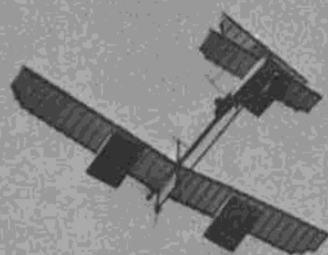
Henri Fabre's Magnificent 1910

HYDRAVION



By FRANCIS REYNOLDS . . . Build yourself this unusual standoff scale seaplane and you'll draw the curious from miles around. The *Hydravion* has enough wire rigging to put a *Taube* to shame!

• "And now for something completely different". This model is an 1/8-size, Standoff Scale model of a 1910, canard pusher, triple-float seaplane with wing-warping, lateral control actuated by "rudder" pedals, twin forward rudders controlled by the "stick," along with a steerable nose float. It has a monoplane wing but biplane canard surfaces. The upper forward plane is the elevator and the lower forward plane is the stabilizer. The pilot sits on top of the fuselage. Is that completely different enough? *(I'll say! wrf)*

The *Hydravion* (French for "hydro-aeroplane" or "seaplane") was designed, built, and flown by Henri Fabre in France a year before Glenn Curtiss got his first seaplane off the water at San Diego. Monsieur Fabre was an engineer and naval architect. He had never been up in an airplane, but had read the papers of Bleriot and other landplane pioneers. After completing the *Hydravion* he put it into Lake Meade near Marseille, climbed aboard, took off, and flew 1640 feet on March 28, 1910. The next day he flew it 3-3/4 miles!

The original *Hydravion* was on display at the Musee de l' Air at Chalais Meudon, 10 miles south of Paris. That museum was recently closed for reconstruction, and the *Hydravion* is now (Dec. '82) reported to be on display at the Airport in Marseille. Henri Fabre was still living, and he celebrated his 100th birthday anniversary in 1982.

Information on Fabre, the airplane, drawings and photos of the *Hydravion* were obtained from the Musee de l' Air (with translation by Mademoiselle Frederique Dupont of Paris and Pierre Mirande of Seattle). *The Encyclopedia of World Aircraft*, 1903-1914 by Kenneth Munson, *Remarkable Flying Machines*, by Henry Palmer, and *Who's Who in France*, 1981-82. A Polish article on the Hydravion from *Skrzydlata Polska* magazine was translated by Daniel Pietrzak of Seattle. An article from *Flying Models* magazine for September 1976 by William R. Stroman for a .02-powered free flight model of the *Hydravion* was also reviewed.

My RC *Hydravion* has some intentional deviations from scale, to make it a practical flying machine, so it is actually a sport scale or standoff scale model, but the overall scale effect is good. Fabre's *Hydravion* underwent a number of changes during 1910 to improve its performance. These changes have been

Author makes a few pond-side adjustments.

described in the literature and are evident as differences between three-view drawings of the plane from different sources. This RC model represents the October 1910 configuration. For the purist, the intentional deviations from scale include model floats 15% larger than scale and putting the wing and foreplane spars below the zero-thickness surfaces instead of on top of them.

Another necessary deviation from scale was to provide a place to mount the radio control equipment. On a strictly scale *Hydravion* there is no place to hide the RC gear (except inside the floats) as it has a stick fuselage and zero-thickness wing and other surfaces.

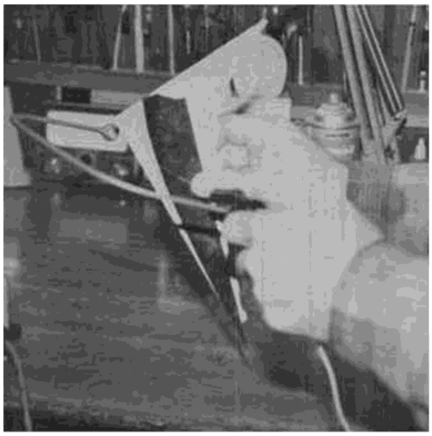
This is *not* a model for the beginner. In some respects it is very simple to build, but in other repects it is quite difficult and very different from customary model construction. Like all scale models, fidelity requires effort and innovation, and the extensive wire rigging takes much more time than one would estimate. Special fittings such as the unique motor mount, the wing warping bell crank, and the elevator pivot assembly were custom made by the author.

As an RC model it is unusual not only in appearance, but also in performance. Like the original airplane, the wing loading is very light (the weight of the model is also approximately to scale) giving it a very low flying speed.

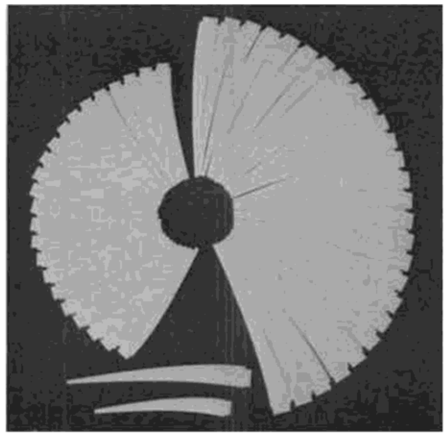
The fact that it is a canard makes it fly still slower. The angle of attack, and therefore the lift of a canard's wing, is increased for landing by increasing the lift of the stabilizer, while on a conventional airplane the angle of attack is increased by putting an aerodynamic down-load on the horizontal tail. In a canard, therefore, wing lift plus "tail" lift equals weight. In a conventional configuration wing lift *minus* tail down-load equals weight. The result is markedly lower stall speed for canards. You can practically jog along side this model while it is flying (if you can jog on water). Don't fly it in a wind or it will make negative headway ("tailway"?). Of course a canard (which flies backward) flying backward (therefore forward?), would look more normal anyway, so suit yourself. *(Somebody please stop me from laughing! wrf)*

On the subject of canards flying backward, Curtiss made an experimental canard, the XP-55 "*Ascender*" in WW-II. Guess what nick-name it acquired? Just change the "c" to another "s".

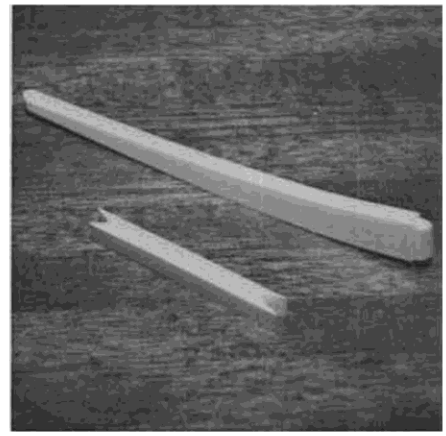
Canards are generally very stable



Aerolite ribs can be hot-wired from a single sheet using a curved template.



Canard ribs and wing ribs cut from a circle of 3/16 Aerolite. Hardly any waste.



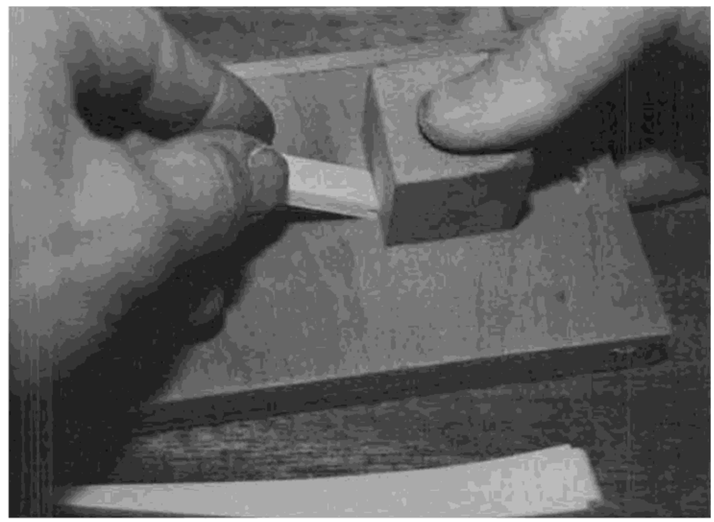
Aerolite ribs are pointed and sealed at both ends by notching and gluing.

airplanes, and this model is no exception. The huge aft fin overcomes the destabilizing effect of the small forward rudder, providing good directional stability Pitch stability is achieved by CG placement and by operating the forward lift surfaces at a higher angle of attack than the wing. Incidentally, no CG information was given in any of the historical data on the *Hydravion*, so I made a simple scale model glider and experimentally determined the CG requirements. Like conventional airplanes, the flight of canards gets squirrelly when the balance is too far aft. If you get the CG too far forward, you won't have enough lift from the foreplanes to stall the wing for landings, so balance your model as indicated on the plan, or within a half-inch either side of the point shown. The ample dihedral of the original is retained on the model, providing good roll stability.

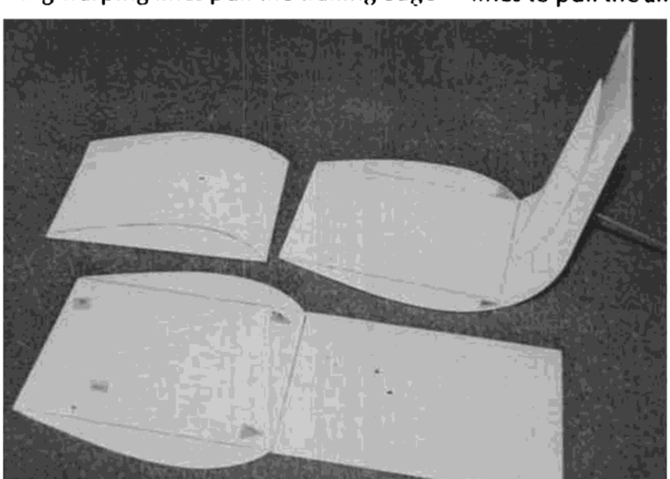
Wing warping for roll control is obsolete because modern airplane wings are much too stiff in torsion to permit its use. The structure and rigging of the *Hydravion* make wing warping easy on the RC model. Wing warping seems to scare off a lot of modelers. Don't let it frighten you. It is a wonderful attention-getting feature on models of these ancient birds.

You will note from the plan that the wing warping lines pull the trailing edge of the wing tips down (oppositely of course), but there are no lines to pull them back up. They are not needed, and were not provided on the full-scale *Hydravion*. The air load on the inner wing in a turn, and the slack wing-warping line on that side wash the inner wing out providing the equivalent of up aileron. Actually, some of the very early aileron-equipped planes were rigged the same way. I saw an early Bristol Boxkite biplane fly at Old Warden field north of London, which had horns and lines to pull the ailerons down, but none to pull them back up. In the air, the airloads provide up aileron, but on the ground both ailerons hang straight down, looking like over-lowered flaps.

To point and seal the ends of the ribs, put Zap or Hot Stuff in notch and close it by pushing end into a corner until the cyanoacrylate adhesive cures.

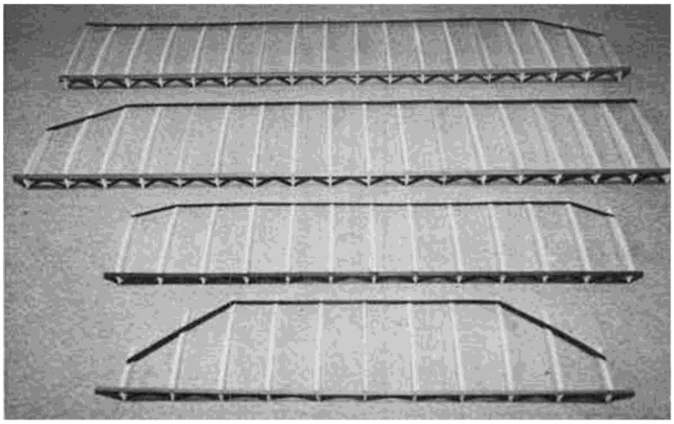


In addition to the unusual features already discussed, the *rigging* of this model always invites attention and comment. Most antique aeroplanes had some rigging, but the *Hydravion* may be the record holder for number of rigging lines. It is difficult to even get a count on the historical three-view drawings, but I counted 66 wires and lines on my RC model!

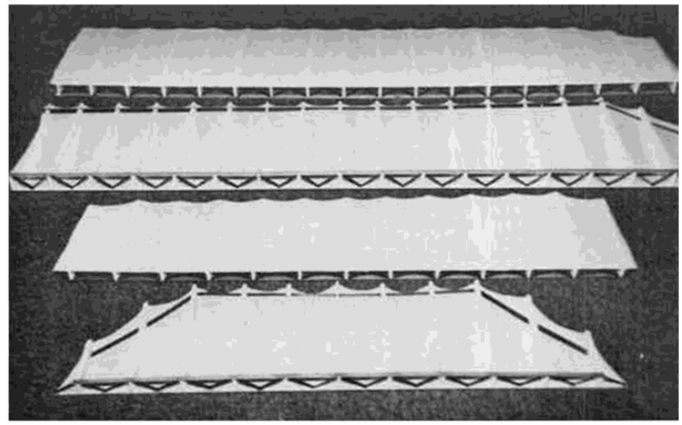


Here we see a finished float, a half-finished float, and a float pattern with the four tie points not yet installed.

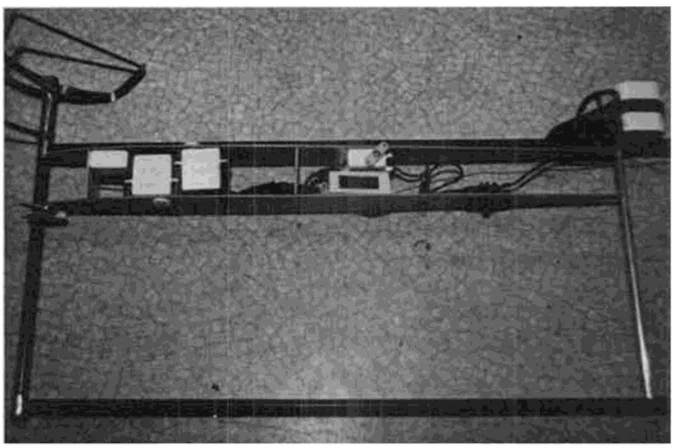
Aerolite (1/16) construction of float: score inside of bend, fold 90°, Zap inside of bend. Simple, quick, neat!



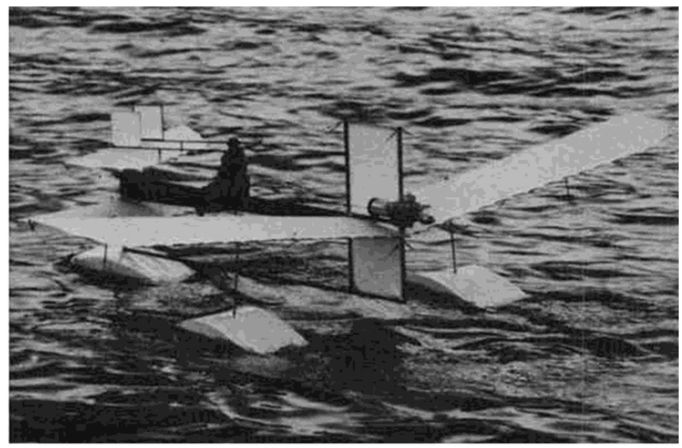
Canard, foreplane, and wing panels are framed and ready for covering. Author used carbon fiber TE, but 1/16 wire is recommended.



Panels in photo to the left are now covered. Note exposed trusswork spars. Coverite Micafilm (white) was used as covering.



Side view of fuselage framework. Radio compartment is open, battery is installed behind seat, and elevator yoke is in place.



Hydravion taxis by camera. Note that the nose float, forward rudders, and elevator/canard are all yawed for the left turn.

Builders of sport and aerobatic RC biplane models usually stress the wing structure to stay in one piece without rigging, and they may or may not put on a little rigging for show. That practice can't be used here. Because of the zero-thickness flight surfaces, the high aspect ratio wing, the stick fuselage, and the very light structure of this model, it would be as limp as a rag without rigging. Every wire and line on the model is necessay to keep it in shape and to provide strength enough for flight. A time or two I was tempted to leave some particular wire off the model to simplify it, but a little analysis or testing soon showed me why Fabre put it there in the first place. A study of the various tensions and compressions in this airplane is fascinating.

You cannot use nylon rigging lines on this model. Nylon is much too stretchy. I used 20 pound test, seven-strand stainless steel fishing leader and some Kevlar line that I happened to have. Although you will put out quite a few bucks for all the Proctor turn-buckles and Proctor swage fittings in the rigging, don't try to do without them. Because of the general floppiness of the unsupported structure and the interaction between the various wires, it is next to impossible to rig it without turnbuckles or to get it true and with the proper incidences and float angles. Even with turnbuckles, rigging takes nearly as much time as building the structure (which is basically very simple).

Stranded stainless fishing leader is usually nylon jacketed. If you can't find some without the jacket, beware that the nylon tends to cause the wire to slip out of the crimped swage under load. To avoid this trouble, you can strip the nylon off the wires at the ends (which is time consuming), or do as I did and put a drop of CA into the swage just before swaging it flat with a pair of pliers. I could never get a zapped one to slip.

Don't forget to secure both ends and the middle of each turnbuckle with fine soft wire as soon as you have it adjusted. Actually, the model won't let you forget it, because if you leave an adjusted turnbuckle without securing it and go on to the next one, the one you left will usually back itself off while you are not looking. The amount of tension to put into the various guys and lines varies and

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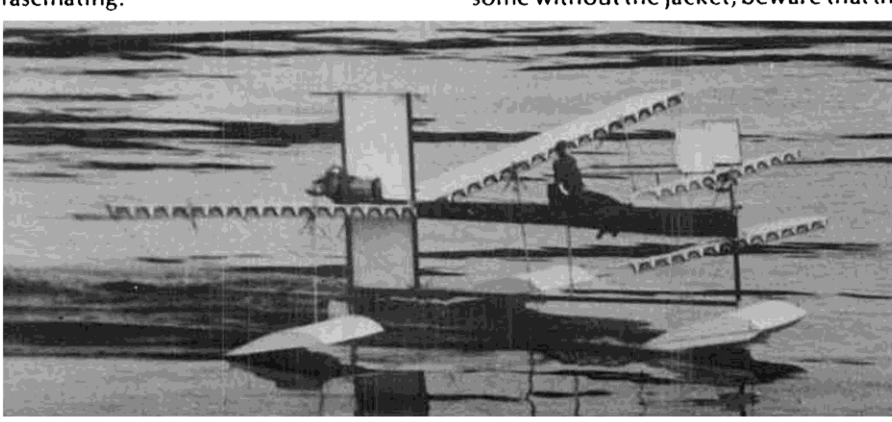

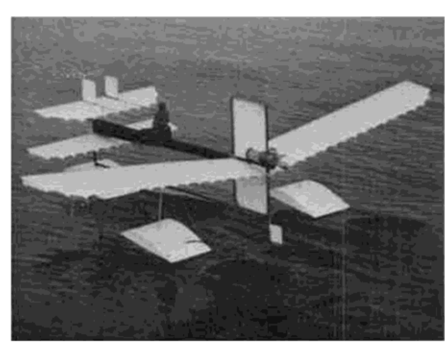

Sometimes the *Hydravion* skips across the water just before takeoff. Note "float prints" on water in above photo.

is a matter of common-sense judgement. You may find that you have all the lines taut with the model supported by the fuselage, but when you set it on its floats, some of the lines go slack. It is a flexible model. *(Sounds like an entertaining challenge. wrf)*

Supporting the assembled model for rigging and other work presents a problem. I clamped the fuselage lightly between two scraps of plywood in a bench vise. Grooves in the boards to match the upper and lower fuselage tubes hold the model securely and prevent flattening of the tubes. If your vise will rotate on its base, the model can be swung around to any convenient working angle.

As I live on a lake, I have little need to transport the plane and therefore built it in one piece. It did fit all assembled into our smallish Volvo station wagon when I took it to a model show, however. (My *Hydravion* placed first in the Seaplane Division of the 1983 Northwest Model Exposition at Puyallup, Washington last February.)

If your flying water is not within walking distance, and you don't have a station wagon, van, or truck, you can revise the design to make the wing demountable, but connecting all that rigging and aligning the model at the shore will be a sizable chore (a shore chore for sure). *(Boo-o-o.)*

One bit of the historical data on the *Hydravion* indicates that the airplane may have been steered on the water by turning the nose float. At any rate, I chose to do that on the model, and it steers very well at all taxi speeds (with the rear water fin, but not without it). Actually, this is the second airplane I've built with a steerable nose float. The first one was an aerobatic seaplane of my own design (like a tricycle-geared landplane), which also steered well on the water. The *Hydravion* model nose float steering is a cinch, as it is accomplished by a torque tube through the front vertical member of the fuselage. The rigging to the steerable nose float stays tight when the float turns, as the upper ends of these lines terminate essentially at the center of rotation.

The short, wide, flat-bottom floats are the same shape as the original ones. In spite of their unusual shape by modern standards, they are very efficient at producing lots of lift at low speeds. Their main disadvantage is rough riding on waves. They would impose serious rough-water stresses on an airplane planning at high velocity. As the floats are way forward and way aft, the *Hydravion* cannot "rotate" for takeoff. Fore and aft floats leave the water at the same time. Therefore, we must provide sufficient incidence in the wing and foreplanes to permit the airplane to fly level off the water. It takes off with a very short run with the .10 powerplant.

One thing you will notice in operating with these strange flat-bottomed floats is the lack of a distinct "hump" speed where they start to plane. Completely flat-bottom floats rise out gradually from 100% static buoyancy to full planing.

As this is not a construction article for the beginner, I won't explain how to glue stick A to stick B, but some construction and materials hints are in order where these are different from conventional model practice.

I chose to make the floats, the ribs, and the radio and servo compartment out of Aerolite, made by Aerolite Products Inc., 1325 Millersport Hwy., Buffalo, NY 14221. I highly recommend this material if you haven't used it yet. It is a very light, foam-core, plastic-faced sheet stock available in various thickness. The Aerolite is ideal for floats as it is completely waterproof, light, strong, and requires no finish.

You can use the optional laminated wood wing ribs shown on the plan instead of Aerolite ribs and be a little more true to scale, but they would take longer and be heavier. If you go the Aerolite ribs route, note that I designed them so they have the same arc top and bottom and can be cut from a circular sheet of Aerolite by the hot wire method with a single cut per rib (see photos). Aerolite sheet material requires different construction methods than balsa wood. It is similar to paper-faced foam board, but lighter. It is fuel and water proof, and doesn't need any finishing . . . if you are satisfied with the snow white color. Read and follow the instructions for use which you will get when you buy the material.

There are a few additional tricks in working with Aerolite, as illustrated in the photos. I use chiefly cyanoacrylate in building with Aerolite. Zap and Zap-A-Gap adhesives work very well with almost no dissolving of the foam core. The Zip Kicker instant setting spray saves a lot of time, but I still use baking soda sometimes. If you have a gap or a depression at a joint in Aerolite or balsa construction, fill it with *dry* baking soda, level it off and drop a drop of thin cyanoacrylate on the soda. It will penetrate to the bottom and set instantly, making a very hard, strong, adherent patch which can be sanded beautifully. In patching Aerolite with sodium bicarbonate and cyanoacrylate adhesive, there is the added advantage of the matching white color which needs no finishing. Don't use viscous type gap-filling cyanoacrylates with baking soda. They don't penetrate the dry powder.

I used a technique in building the Aerolite floats which doesn't show on the photo of the float construction, because both the skin and the foam core of the Aerolite are white. This technique, which is included in the plan, is to strip parallel strips of the inner skin off the Aerolite where it is to be curved. The literature from the Aerolite company recommends stripping the entire inner skin off in areas to be curved. This works, but the resulting structure is considerably weakened by the loss of the inner skin. If you carefully razor blade cut through just the inner skin in areas to be curved (not through the foam core) in strips parallel to the bend and about 3/16 wide, then peel every other strip off, the material will bend smoothly, yet it will retain better strength and stiffness.

Micafilm, by Coverite is an excellent covering material for the *Hydravion* model, as it is very light, yet very strong. It is easily applied, and requires no finishing. Use the white Micafilm and don't apply any finish to it.

I used a Cannon Super-Micro RC system, which is ideal because of its very small size and weight. (Less than four ounces total flight weight, including receiver, battery and four servos.) If you use larger RC gear, you will have to enlarge the RC compartment, and you may seriously increase the wing loading. At least use a small battery pack if you must use standard miniature servos.

The motor I used is an O.S. Max .10. It is plenty. Don't use a larger engine. Pusher props are a little hard to find, but they are available in this size range. If you can't find a suitable prop. carve your own. It is an interesting challenge. We old timers carved all our own "gas model" props back in the 1930s. Manufactured props were nonexistent. Actually, the prop on my *Hydravion* is a nylon pusher prop of the proper diameter which originally had too much pitch. I lowered the pitch by carefully heating each blade at the root and reducing the blade angle by hand while the nylon was soft. On a small engine, this is a good technique, but don't do it on large nylon props. It may weaken the blade roots.

The fuel tank is a Sullivan R-2 (two-ounce, round). I put a band of .001 thick brass shim stock around it for looks, and made two clamping rings to support the tank and mount it to the fuselage tube. If you lack thin brass, wrap aluminum foil around the tank, but leave the ends bare. Being able to see fuel level through the translucent plastic is a handy feature of an external tank. This tank location is non-scale. The 1910 *Hydravion* had the tank suspended by rigging above the fuselage halfway between the fin and the pilot. Model engines don't run well with the tank that far away, but the original, seven-cylinder, 50 hp Gnome Rotary didn't mind.

My motor mount was machined from nylon. If you lack power tools, start with a commercial radial mount to fit your engine and mount it to the fuselage tubes by binding, bracing, and gluing a plywood disk to the fuselage, then bolting the motor mount to this "firewall".

To join the fuselage tubes, I used silver solder to make up fittings of thin wall brass tubing as these could be polished to give a classy, antique look. Without silver soldering equipment, you can bend some landing gear spring wire into 90-degree angles and epoxy them inside the tube joints without external joint fittings. I used 5/16 fiberglass arrow shaft tubing for the fuselage. Aluminum tubing would do. I prefer the fiberglass tubing because it is non-conductive and won't interfere with the receiving antenna pattern. *(Heaven knows, you've already got enough steel wire rigging to worry about! wrf)* Arrow shaft tubing is available from archery shops and some model shops.

The scale control poles and the curved handle bar (the "stick") are attached to the elevator and rudders so they move in pitch and yaw like the original plane's controls. I also put on operating pedals connected to the RC wing-warping control system.

The pilot was built up from a commercial plastic model pilot bust with helmet and goggles, and an assortment of doll parts (lightened as much as possible) and doll clothes. He is bolted to the fuselage through his seat. My pilot looks realistic, but he is too stiff to be moved by the controls as though he was flying the airplane. His hands and feet are therefore moved off the stick and pedals for flight. By building a light profile pilot with loosely-hinged joints, you could let the controls move him, and also reduce weight and drag, but at the expense of appearance. To my eye, cartoon-type, two-dimensional pilot simulations spoil the appearance of an otherwise classic antique "aeroplane" model. Snoopy on his RC Sopwith dog house was an exception, as Snoopy *is* a cartoon character.

The gimbaled arrangement of the elevator (top foreplane) is unique. The whole surface rotates in pitch about a horizontal shaft and rotates in yaw about the vertical front tube of the fuselage by the elevator and rudder servos, respectively. The forward air rudders are attached to this movable elevator, as are the control poles and pilot's handlebar. To yaw left, the pilot pulls the handlebar to the right. To pitch up, he pulls the handlebar down.

Photos of the full-scale aircraft reveal that the *Hydravion* model taxied and flew well, I had to make four changes, all of which have been incorporated in the plans. One of the changes was to add a couple more rigging lines to keep the stabilizer from twisting in the air, others were a larger front float, and the central aft water rudder. A fourth change was a shift of the balance point.

Canards do fly differently, as do antique planes in general. The first real flight of the model was somewhat of a white knuckles affair, but not too bad. She took off and gained some altitude while I tried to learn to fly it. It required quite a bit of up elevator and tended to dive in the turns. No sign of stalling however. Turning it was an experience. The wing warping wasn't doing much. The rudder alone was (and is) much more effective in turning it than wing warping alone. A combination of wing warping and rudder flies it very well.

The tendency to dive more in a turn than an ordinary airplane, is, I suspect, due to the fact that the elevator yaws with the forward rudders, reducing the effective elevator span when a rudder command is given, thereby reducing the forward lift and letting the nose drop. That is the way Fabre built it originally, but there is some indication in the historical data that in a later revision he fixed the elevator in yaw and yawed only the rudders. If so, I expect he made the change to eliminate the tendency to dive in turns that I notice in my RC model.

HYDRAVION	1/8-Scale RC Model	1910 Original
DESIGNED BY	Francis D. Reynolds	Henri Fabre
TYPE AIRCRAFT	Sport Scale	First seaplane
WINGSPAN	69 inches	14 meters
WING CHORD	7.1 inches	1.25 meters
TOTAL WING AREA	483 square inches	17.25 square meters
WING LOCATION	Rear	Rear
AIRFOIL	Single-surface cambered	Same
WING PLANFORM	Rectangular	Same
DIHEDRAL, EACH TIP	5.0 inches	1.20 meters
O.A. FUSELAGE LENGTH	38.7 inches	7.73 meters
RADIO COMPARTMENT SIZE	14.7 x 1.4 x 1.4 inches (max)	Not applicable
STABILIZER SPAN	25 inches	5.1 meters
STABILIZER CHORD	5.35 inches	1.01 meters
STAB. PLUS ELEV. AREA	230 square inches	9.5 square meters
STAB. AIRFOIL SECTION	Single-surface cambered	Same
STABILIZER LOCATION	At front below Elev.	At front below elevator
VERTICAL FIN HEIGHT	14.8 inches	3.22 meters
VERTICAL FIN WIDTH	6.6 inches	1.2 meters
REC. ENGINE SIZE	.10 cubic inch	50-hp Gnome rotary
FUEL TANK SIZE	2 ounces	Unknown
LANDING GEAR	3 Flat-bottom Floats	3 Flat-bottom Floats
REC. NO. OF CHANNELS	Four	Not applicable
CONTROL FUNCTIONS	Rudder, elevator, wing-warping, throttle	Same
MATERIALS IN CONSTRUCTION	Aerolite, aluminum, fiber-glass tubing, spruce, Micafilm, Kevlar, plywood, balsa, stainless steel	Ash, mahogany, cotton canvas, iron, leather, bungee cord, wicker (seat)
WEIGHT READY TO FLY	40 oz. (plus 2 oz. fuel)	450 kilograms
WING LOADING	11.9 oz./sq. ft.	26 kg/sq. meter
TOTAL SURFACE LOADING	8.1 oz./sq. ft.	16.8 kg/sq. meter

Back to the first high test-flight of the model. (I had made some earlier test hops up to about six feet off the water.) After I found our how to steer it and to give it enough elevator control, it was fun to fly. After flying most of the tank out, making overhead passes for the benefit of the photographer (my son Greg), I brought her in for a beautiful three-point landing, taxied it back to the beach, and shut off the engine. A very successful test flight, but with enough challenge to prevent boredom.

The next day I removed the pilot to lighten the plane and reduce drag and also to move the CG back farther (an inch behind the position shown on the plan). I flew it again. This time the CG was too far aft for comfort, making it harder to control and less predictable. The nose didn't want to drop in a glide for one thing. On the first landing I carelessly mushed it in flat from about eight foot altitude at a fairly high sink rate. With no damage and the engine still running, I taxied it close to the dock where I was standing to visually check the fuel level in the translucent tank. I then taxied back out and took off again. After a few more minutes of flying, I brought it in for a good landing, taxied back to the beach, and shut off the engine.

Test program was complete, and the airplane was still in one piece. Conclusions: (1) Don't fly with the CG very far from the position on the plan. (2) The O.S. Max .10 is plenty of power for it. The plane climbs well and accelerates well. You won't need a very low idle rpm, however. The plane will land at 1/3 throttle. With all this rigging the drag is huge, and the glide ratio is only about four to one. (3) Shes flies slowly and realistically at about 25 mph. Assuming a maximum lift coefficient of 0.7 for this old, bird-type airfoil, my calculations show a stall speed for the airplane of about 15 mph. (4) The wing warping isn't very effective, probably for the same reason that the ailerons on some planes haven't worked well. The adverse drag and yaw caused by the down-warped wing combined with the righting effect of the dihedral results in little net roll and yaw from warping the wings. By flying with wing warping plus rudder to correct the adverse yaw, it works very well. (5) The airframe is light, but fairly strong and resilient. It stands up well under hard landings and handling abuse. I'm always snagging a rigging line or two when I'm trying to work with it, but have never damaged it. (6) It doesn't like wind or waves. To play safe, don't fly when there is over a two mph breeze or over one-inch-high ripples. (7) It isn't a high performance airplane, nor an aerobatic airplane. It is an antique flying machine.

I will close with a bit of philosophy. If you want high performance and effortless flying, neither this airplane nor any other early antique airplane scale model is what you want. The charm of these ancient flying machines is in their whimsical appearance, the challenges they offer in both building and flying, and the wonderful fact that they flew originally at all, and will fly as RC models. Have some challenging and educational fun. Get out of the rut and get your feet wet.