A tiny "Cannonball"

by Bob Aberle

Miniature radios like Cannon's Tiny Series open up new possibilities for R/C planes, like this twin-tailed .020 racer for pylon or sport.

The April 1976 FLYING MODELS carried my product review of the Cannon Electronics, "Tiny Series" R/C equipment. It was only natural at the conclusion of this review that my thoughts turned to the possibility of a new design, expressly intended for this extremely small radio unit. As I went back over approximately ten years of model publications covering *1/4A* (the usual terminology for the .020 displacement engine), I found that the majority of these designs were built around the simple pulse proportional type radios utilizing magnetic actuators to move the control surface. This type radio system is very light, but limited to single channel operation, for the most part. Some individuals did manage to rig up coupling schemes to include elevator control as a second function, but by in large these techniques left plenty to be desired. A good many of the designs had high aspect ratio wings which put the model in the category of a powered glider. Another item which caught my attention was the continual reference to the need for throttle restriction on the Cox TD .020, simply because the power output was too great for the radio control unit to handle. What a terrible waste of a good little engine, such as the TD .020.

After completing my "literature" search I settled upon a wing area of 125 sq. inches, a wing span of 22 inches and an average chord of 5¾ inches. The wing aspect ratio of 3.83 is a little higher than that presently used on the .049 size, ½A R/C pylon racers. Since most of my R/C flying time of late has centered around ½A pylon racing, the influence is obvious in this new design. Because of the fact that I had two digital proportional channels available I naturally selected a flat wing with aileron control. It is basically the aileron/elevator control which makes this design stand apart from its predessors. A wing *with* dihedral, using only rudder and elevator control, is simply a trainer, any way you look at it. The "Cannonball" is definitely not a trainer. It has full performance capabilities and should not be considered as a project for a "first" R/C model.

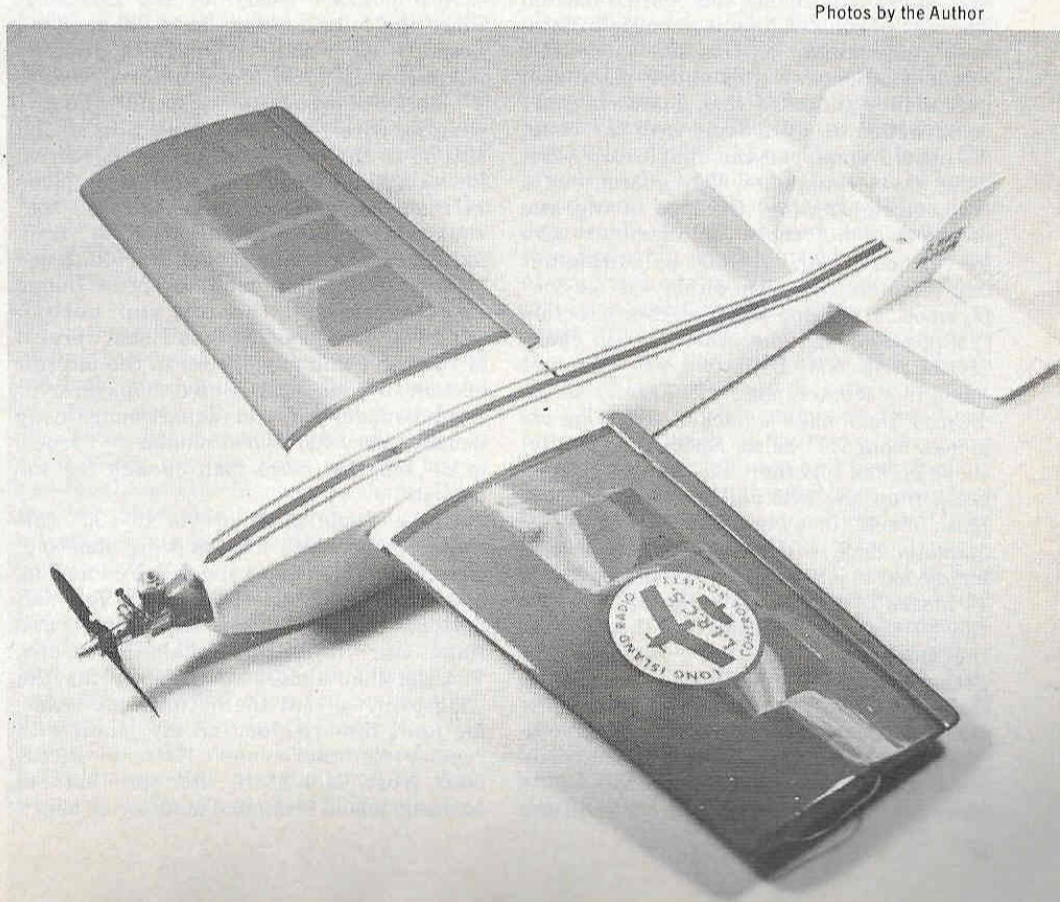
One of the big considerations in a design as small as this is the weight factor. I set up a design goal of 11 ounces total weight, less fuel. Surprisingly enough I almost hit this target weight, the end result being 11.8 ounces. The basic weight breakdown is as follows: bare model weight 4.8 ounces, Cannon two channel radio 5.3 ounces, Cox TD .020 engine and propeller 1.1 ounces and the last big surprise, 0.6 ounces for the foam rubber receiver and battery pack padding. As a matter of interest my bare structure weight, less paint and MonoKote came out to 3.5 ounces. At first glance this may seem extremely light by itself. After you study the plans for a while you will realize that nothing was comprised from a structural strength standpoint. This is a strong little bird. My favorite spruce spars were used in the wing as well as for bracing in the fuselage. The wing ended up almost completely sheeted. I was also able to use 1/16" balsa as the basic building material instead of the more common 1/32" balsa previously used on ¼A models. When you sand 1/32" balsa, a *little*, you have nothing left. As a result of achieving the 11.8 ounces total weight my wing loading worked out to a very respectable 13.5 oz./sq.ft.

The shoulder wing configuration was chosen mainly because it makes the plane easier for the average modeler to hand launch. A low wing design, in this respect, is difficult to grasp when hand launching, resulting in many mishaps. The high wing also gives a little margin of roll stability. It seems that these small designs can be very sensitive to aileron control.

Everyone will probably wonder about my choice of the F-14 "Tomcat" style, twin vertical fins, with the offset angles. Well, I must admit that as a Grumman engineer I was influenced to a degree. If you follow some of my designs regularly in FLYING MODELS, you must be aware by now that I always try to put a different type of tail on all my designs. I try to make each new design both different and distinctive, otherwise you reach a point where everything looks alike. This is what happened to our basic high performance pattern planes. They all resemble each other.

To complete the design discussion, I permanently mounted the wing to the fuselage, providing access to the radio equipment through a lower, removable hatch cover. This cover exposes the servo and receiver area completely. The small 225 mah battery pack is passed through the open former (F-2), into a front compartment. That completes the design rationale. Now for the building.

Photos by the Author



No, no, look at the airplane! Bob's wife Irene helps out here, to give you an idea of the small size of the aircraft. Both in matching colors, brilliant red and white. Get the crayons and begin.

Construction

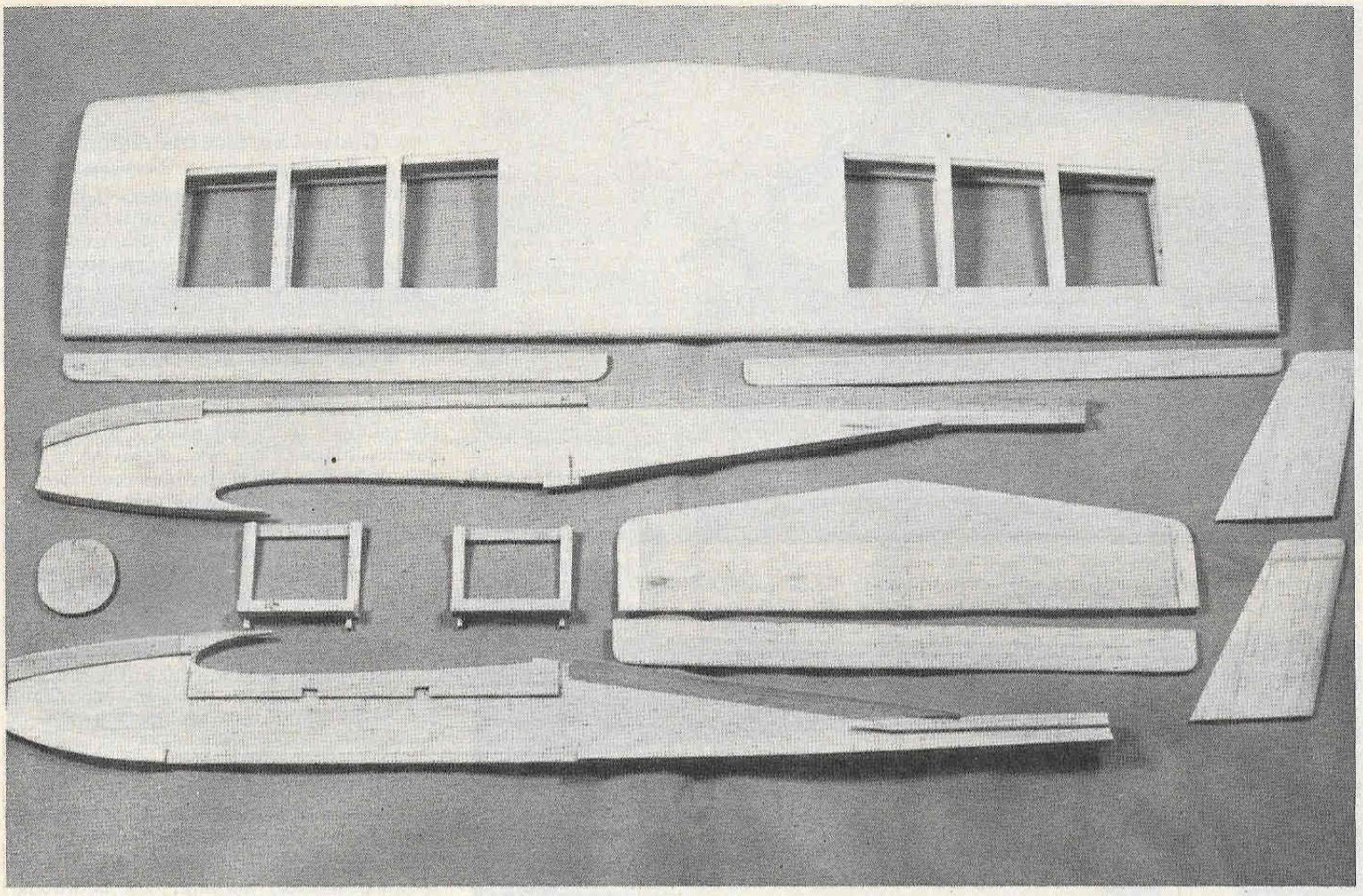
What a surprise you will get when you find out that two sheets of 1/16"x3"x36" balsa and one sheet of 3/32" balsa plus a few sticks will build this entire model. The cost of construction is peanuts! Another big advantage for this size model. Or put it another way, this entire plane cost less than a gallon of fuel. I always start construction of my models with the wing. As usual I employed the simple two wire, wing jig technique, which guarantees a true, straight, wing. Because of the size of the model, I chose 1/8" diameter wire for this particular jig. Start by cutting out two template ribs from either 1/32" or 1/16" plywood. Make one the root chord section (#1 position) and the other the tip chord section (rib #7). Drill two 1/8" diameter holes in each template rib exactly as indicated, then make a stack of five wing rib blanks from 1/16" balsa. Spot glue (lightly) these blanks together. Place the #1 template rib on one side and drill through the balsa stack (in two places) using a 1/8" diameter drill. A drill press comes in real handy for a job like this. Insert two 4-40 1" blocks of wood) to "suspend" the two the #7 template rib on the other side of the stack and clamp the "sandwich" together using 4-40 nuts. Now proceed to carve and sand the balsa down to the plywood templates. Mark for the spar locations and then separate this first sandwich. Repeat this process for a second set of ribs (the other wing half). As you will see on the plans there is no #1 rib as such. It is only used as a template to help create the other ribs. Make two tip ribs (#7) out of 3/32" balsa using the tip rib template.

Now you are ready for the assembly. Place the full size plans on a flat building board (I use a piece of 3/4" thick plywood measuring 24"x48"). Make up three spacers 1" blocks of wood) to "suspend" the two wing jig wires over the plans. Slip all the ribs on to the two 1/8" diameter jig wires. Position the ribs evenly over the plans in their correct locations. Add the 3/16" square leading edge and the 1/8"x1/4" trailing edge at this time to get started. I use "Hot Stuff" at this point to speed things up. Next install the top and bottom 3/32"x3/16" spruce spars. Yes I said *spruce*! If you can't find any spruce in the aircraft section of your local hobby shop, go over to the model railroad department. They usually carry hardwood similar to spruce, in 24" lengths (more than enough for our needs).

Use a single piece of 1/16"x3"x36" soft contest type balsa for the wing sheeting. Pre-cut this sheet into the required leading and trailing edge portions, both top and bottom. Install the top sheeting at this time. Use "Hot Stuff" again for speed. You can then almost immediately flip the wing over, so that the bottom side is facing up. I first re-glued all my joints with regular Ambroid cement. It's not that I don't trust "Hot Stuff", it's just that I'm basically an old fashioned modeler at heart. Add the two spruce (3/32"x3/16") wing-center-section braces at this time. These braces are cemented directly against the top and bottom spars, at the center-section. Use 5 minute epoxy on these two joints. Install the small scrap balsa insert blocks, as shown on the plans, to help anchor the aileron hinges. Sheet the bottom leading and trailing edge area. For this step I first spread the Ambroid cement over the structure and then pinned the sheeting in place. Finish the center-section and tip sheeting. Remember, the bottom center-section portion is left open. In this area the servos and receiver will actually protrude. This feature enables a low fuselage profile. Sand the entire structure with #150, 220 and finally 320 grit paper. At this point my wing weighed 1.4 ounces. Use this as a guide in your building.

Cut out the ailerons from 1/8"x1/2" trailing edge stock. Try to select a light weight piece of wood. Since this model is so small you will have to prepare your own aileron torque rod assemblies. There is no commercially made hardware available at this time (I hope that will change in the near future). I used 1/16" diameter wire and 1/16" I.D. brass tubing. Since the aileron servo is off center, please note that the two torque rods are of different length. The photographs should clarify this assembly. The attachment points for the Goldberg "Mini-Links", going to the aileron servo, were made from 1/8" brass tubing. Use two 1/2" lengths. Solder the tubing first to the wire, then squeeze the protruding ends flat in a vise. Drill a 1/16" diameter hole in the flat area to accept the "Mini-Link." I actually cemented both torque rod assemblies to the wing trailing edge at this time. Use 5 minute epoxy and wrap a small piece of fibreglass cloth around the tubing to strengthen the joint. Put the completed wing aside.

The second of the two pieces of 1/16"x3"x36" balsa is used for both fuselage sides, the top and the bottom rear. This sheet should be medium weight (not contest type). The leftover scraps (this was planned in advance) were actually used for the wing ribs. Cut out two sides per the in-board profile view. I usually spot glue two oversized pieces of balsa together, trace the outline to the wood and then cut both sides out at one time. When finished the two sides are separated. Doing it this way you will end up two nearly identical sides. Install the 1/4" triangular shaped balsa and the 3/32"x3/16" spruce longerons to the inner sides of the fuselage. Likewise, install the front, inside support pieces which are made from 3/16" balsa scraps (hopefully from your leftover wood storage box). Remember, as always, make one right and one left side. While this is drying cut out the firewall (F-1) from 1/8" plywood. Pre-mount the TD .020 engine using 2-56 X1/2" hardware and blind mounting nuts. Then remove the engine and get it away from all the sawdust. The remaining formers (F-2) and (F-3) are both actually built up from pieces of 3/32"x3/16" and 3/16"x1/4" *spruce*. These formers are quite strong and yet very light. The heavy bottom piece (3/16"x1/4") is also part of the lower hatch cover hold-down system. Begin the assembly by installing formers F-2 and F-3 between the two fuselage sides. Use 5 minute epoxy



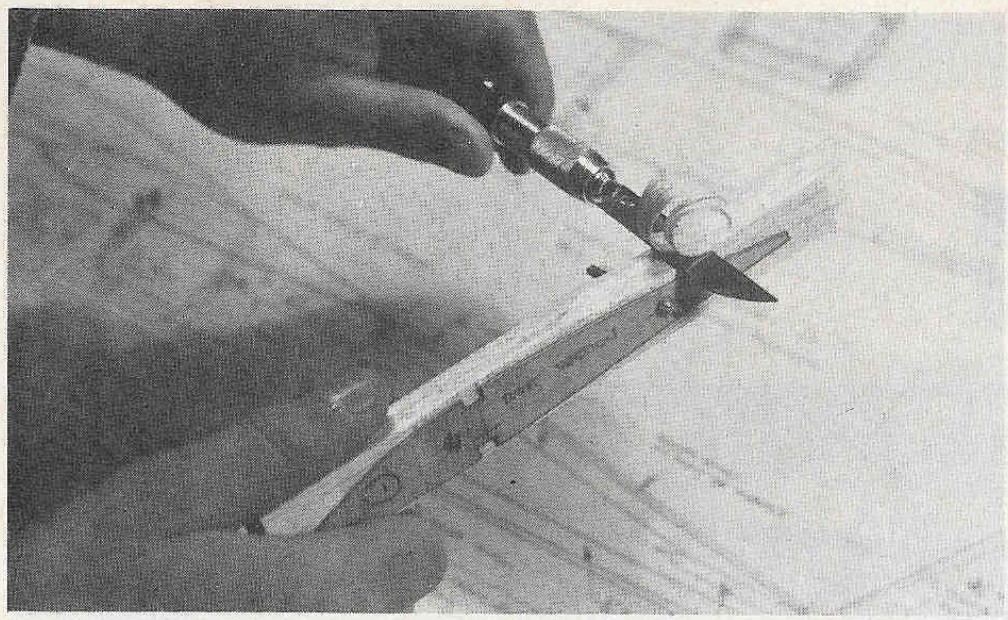
You might call this a complete kit of sub-assemblies to build your very own "Cannonball." About $4.00 buys the necessary wood. That's comparable to about five 11" props for a .60 powerplant. Anyway you figure it the smaller ships take less time, loot and space. Structure is simple and sensible.

cement for this. Draw the fuselage together around firewall F-1 using tape or rubber bands to hold the assembly together while the epoxy cement cures. Temporarily bring the sides together at the tail using a piece of scrap wood. Leave the sides approximately ½" apart in the rear as shown on the plans. By doing this the tail cone will remain open at the rear. The elevator control wire can then exit directly out the rear of the fuselage and attach to the control horn. Next cement the 1/16" balsa top in place (from the wing trailing edge to the stab leading edge).

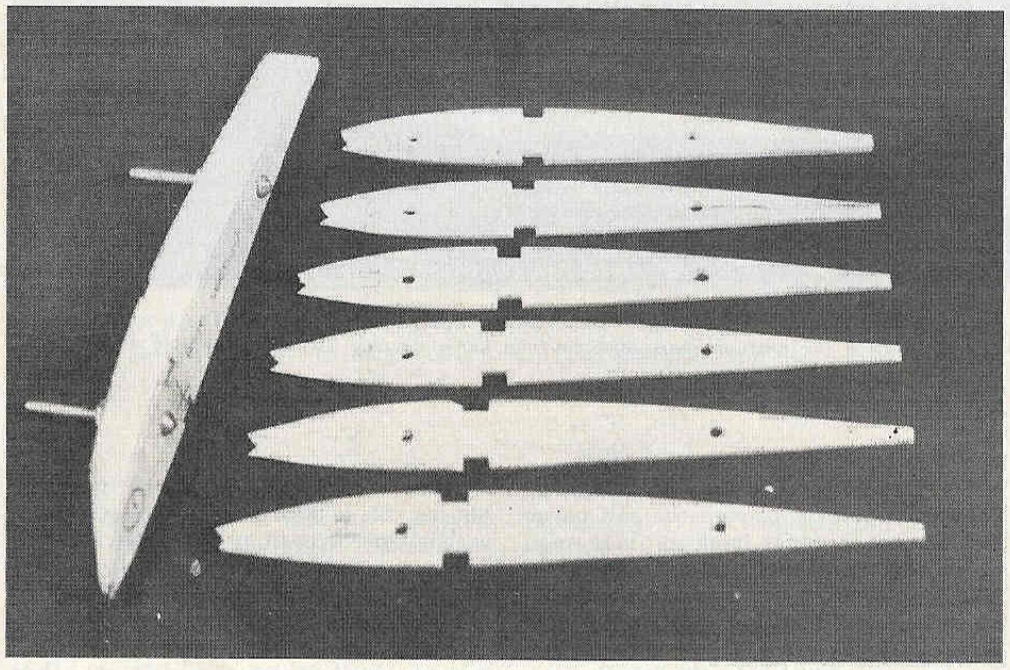
Before going any further you must construct the lower, removable hatch cover. Start by cutting the two side hatch rails (3/32"x3/16" spruce) to length. Place these two rails directly up against the exact same type of spruce strips, already attached to the fuselage sides. I hold these rails in place temporarily with several cloth pins. Add the spruce cross-pieces and then glue all the parts with 5 minute epoxy. Be careful not to let the removable rail assembly get stuck to the fuselage rails. When this dries cut out a piece of 3/32" balsa the exact length of the hatch cover and a little wider than the fuselage itself. Spot glue this piece to the removable rail assembly. Again be careful not to get glue on the fuselage rails. When dry remove the "rough" hatch cover and re-glue all the joints for additional strength. As you can see on the plans I added small 3/32" plywood inserts on each end of the hatch cover. These inserts prevent the hold down bolts from pulling through the soft balsa. Put the hatch cover back in place once again and mark the location of the two hold-down bolts. Drill through the hatch cover (ply inserts) and on through the 3/16"x1/4" spruce piece (lower part of each former). Use a #43 drill for this job. Remove the hatch cover. Tap the holes in both the 3/16"x1/4" spruce pieces using a 4-40 tap. Do it carefully since the spruce is actually quite soft. Enlarge the two hatch cover holes to clear a 4-40 thread. Attach the hatch cover to the fuselage at this time using Prather Products 4-40 nylon screws (1" length cut down to approximately 5/8").

Continue the fuselage construction by adding the lower rear 1/16" sheeting. Add the front fuselage sheeting, both top and bottom. I used 3/32" balsa, cross grained. The cross grain enables the sheeting to bend easier. At this point you can carve and rough sand the fuselage to shape. With the 1/4" triangular balsa you can achieve a reasonably neat, rounded shape on the corners, aft of the wing trailing edge. The hatch cover gets sanded "right into" the bottom sheeting. At the rear of the hatch you transition from 3/32" down to 1/16" balsa so do a little extra sanding in this area.

At this point the wing can be installed. Remove the lower hatch cover for this operation. Trim the fuselage sides carefully (if necessary) to get a good fit. That wing incidence angle shown on the plans *is correct*. It may look slightly negative but it's not, so please don't monkey around with it! Once in position glue the wing with 5 minute epoxy. While this is drying cut out the tail surfaces from 3/32" balsa. Use a soft piece of wood for this. Note that the stab and vertical fin tips have cross grained inserts. Don't forget these inserts, they prevent warps and generally strengthen the tail surfaces. Glue the two fins in position using guide blocks to achieve the proper angle. I cut two blocks out of hardwood using a radial arm saw. When this has dried, install the complete tail surface assembly to the fuselage. Use a lot of pins and eyeball the alignment. When you have it set in place apply some "Hot Stuff." This will hold everything in position until you mix up a batch of 5 minute epoxy. Your structure is now complete. Do all your finish sanding at this time. I applied a piece of 3/4 ounce fibreglass cloth to the firewall area and back approximately 1". I also extended this fibreglass cloth to cover the bottom, forward fuselage. This will impart some extra strength in the battery compartment area. It will also prevent the battery pack from being "ejected" out the bottom on a hard landing. The final item is to install the spruce skid along the bottom of the fuselage. This skid is actually two pieces. One part is attached to the lower, forward fuselage while the other is attached to the removable hatch cover. With the skid in place you won't have to countersink the two



Bob's son Tom here busy cutting a stack of ribs down to the template. A little carving and sanding. **Beneath:** A stack in the process, and a finished pile of ribs. Work neatly with sharp model knife.



nylon screw heads. Remember, at this point everything weighed 3.5 ounces, less covering, paint, hinges and control wires.

Finishing

There are probably many simple ways to finish a small plane such as this. The easiest way would be to cover the entire plane with either Solarfilm or Super MonoKote. Of course, covering the fuselage and tail surface of a model this small may prove a little tedious to say the least. Another consideration is that the high nitro fuel (above 30% nitro content) tends to eat under the plastic film coverings. In my case I employed my standard technique which consists of both Hobbypoxy products and Super MonoKote. The fuselage and tail surfaces received two coats of Hobbypoxy clear. After each coat this was sanded thoroughly with #220 sandpaper, two more coats of Hobbypoxy white followed. The white unfortunately isn't heavily pigmented, so my particular finish left plenty to be desired. A third coat would have produced a better finish. The four coats of Hobbypoxy (two clear and two white) added a total of 0.6 ounces to the model. I then applied Super MonoKote to the wing and ailerons. The joint between the paint and the MonoKote was covered with Bridi ¼" wide trim tape. The Super MonoKote and trim added another 0.3 ounces to the model. I might add that the final finish was reasonably neat and is certainly durable. I try to get two years life (minimum) out of all my models. Please remember to select very bright color schemes for your model. Visibility is definitely a problem with these small planes. The brighter the colors the better chance you will have to fly and enjoy your model.

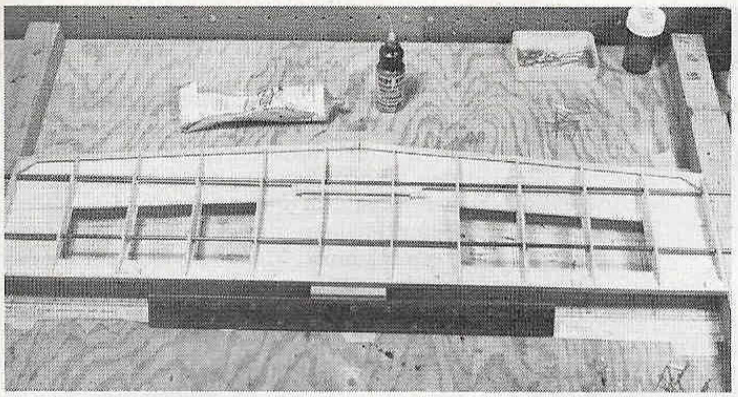
Before I forget, you will notice a canopy shown on the plans. This was originally planned for appearance sake to keep pace with the F-14 type vertical fins. I must admit I was in such a hurry to get this little plane in the air that I chose to omit the canopy. You could easily make a custom canopy of this style using the technique described by Gene Thomas in the April 1976 FLYING MODELS. I doubt if a small, vacuum formed canopy would add more than a ½ ounce to the overall weight. If you have the time try it!

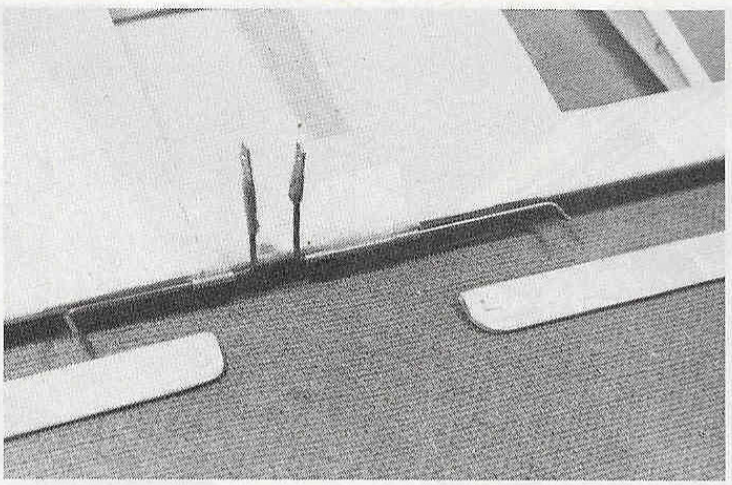
Control Surface Installation

Here again we have to be very careful because of the models small size. Regular Klett or Du Bro hinges are out of the question because of the thin balsa wood employed. MonoKote hinges are somewhat risky because of the high nitro content fuel used in these engines. My final choice for hinges came from an idea supplied by my flying partner and fellow Grumman engineer, Glenn Spacht. Glenn has successfully used 4 to 5 mil drafting type mylar (similar to "Chronaflex") for control surface hinges. The use of mylar is not new, however, the mylar idea really works great in conjunction with the new super type glues, such as "Hot Stuff." For my application I cut strips of mylar approximately ⅜" wide by ¾" long. The actual surfaces were marked and slots were cut using a #11 X-Acto knife blade. You then insert the hinge in one side and apply the "Hot Stuff." Let it set for a few minutes so it can soak into the wood and cure. Then insert the hinge into the mating side of the surface. Place the surfaces as close as you want, just so long as they don't actually touch each other. Apply the "Hot Stuff" once again and let it set. The resulting hinges are anchored solidly and are quite flexible. The big advantage is that they weigh practically nothing. One additional point, I couldn't find a small enough control horn for this application. However, I was able to use the tiny control horn supplied by Carl Goldberg along with a ½A U/C bellcrank kit. Try this little horn, it's just the correct size for this model. Possibly Carl might consider marketing this item separately. The actual connection from the servo to the elevator control horn was made with 1/16" diameter wire. The fuselage length is so short that it doesn't pay to rig up the usual nylon rod within a rod (such as the Gold N' Rod or Nyrod). Control surface movement for your initial flight testing should be +/− 5/32" for the elevator and approximately +/− ⅛" for the ailerons. You may want to cut this down somewhat after you get used to the flight characteristics.

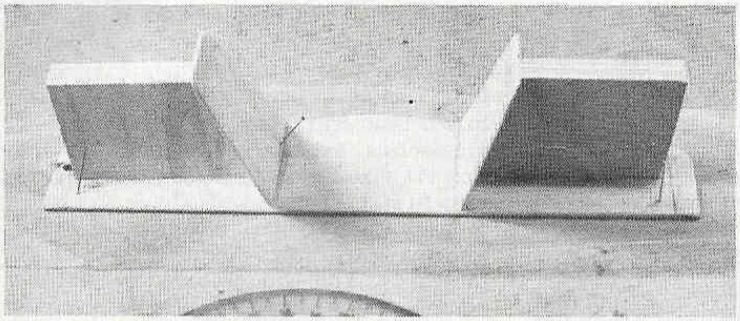
Radio Installation

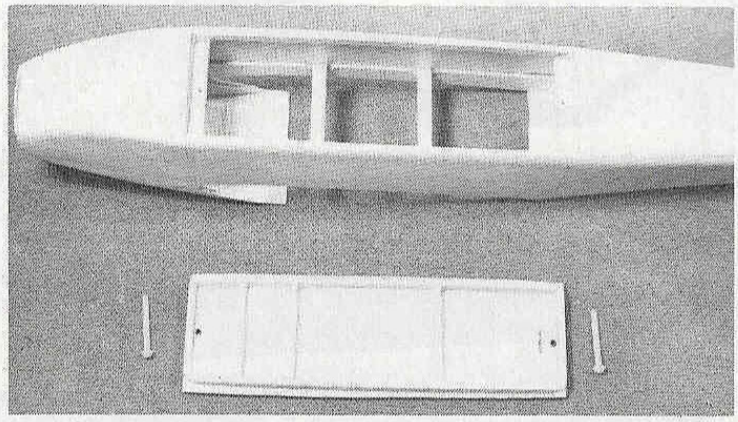
The Cannon radio system, as said before, was selected because of its small size. I doubt if any other manufactured R/C system would fit in this particular design. As stated in the beginning, this design was intentionally developed around the available radio system. Begin the radio installation by wrapping the 225 mah battery pack in *light weight* ¼" thick foam rubber. Insert this pack through the opening in former F-2 and push it forward until it is against the firewall. Next install the two Cannon CE-4 servos. The aileron servo is connected with two short lengths of Goldberg "Mini-Links" (1/16" dia. wire plus link connectors). Connect up the 1/16" dia. wire from the servo out to the elevator control horn. Install the small switch next. I didn't receive a metal switch plate with my set, but it proved easy enough to fabricate one out of 1/32" thick aluminum. Connect up all the cabling at this time.





Overall look at the wing in the jig. ¾" plywood building board, wires adequately supported. Note steel straight edge. **At right:** Bob made this aileron hardware, hopes manufacturers will produce for the little ships.





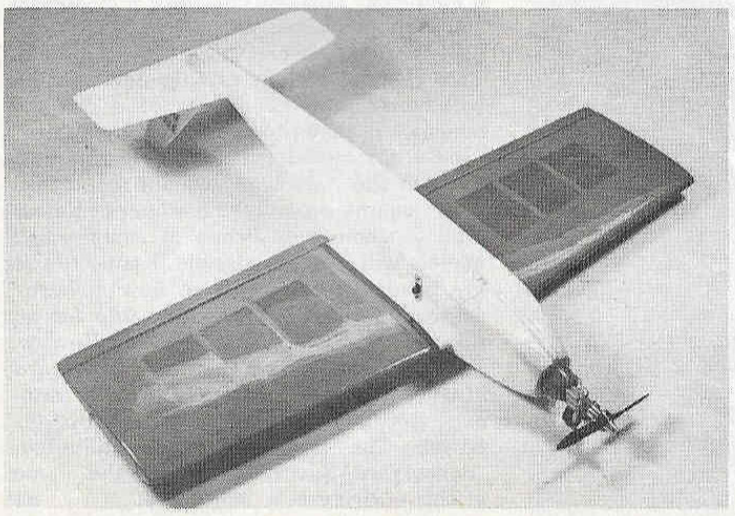
Two wooden anythings cut at 75 degree angle hold the fins in place while drying. Later on you hope the blocks come loose. **Right:** Fuselage under construction. Be careful not to accidentally cement the hatch in place.

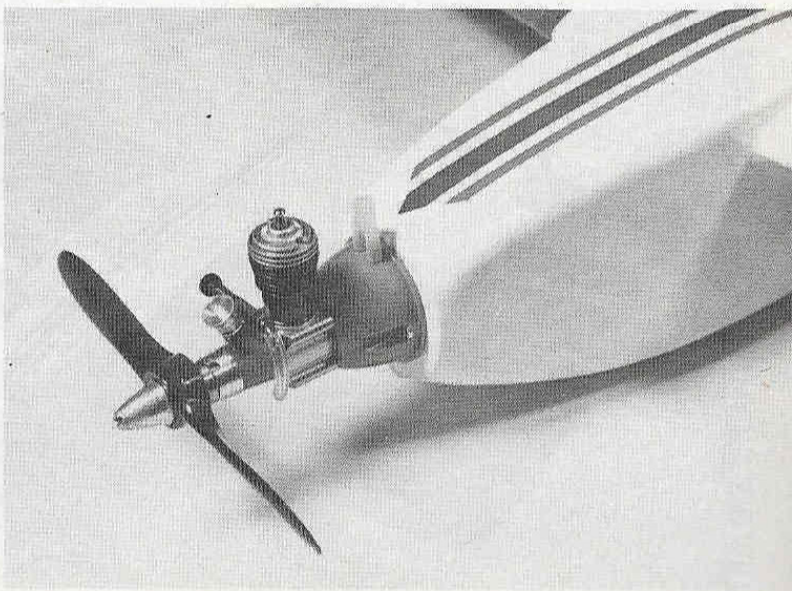
Turn on the transmitter and check that the control surfaces are moving in the proper directions. Now wrap the receiver in foam rubber and insert into position with the connectors as close to the servos as possible. The receiver antenna was fed out the front set of wing jig wire holes out through the tip rib. I used a piece of inner Gold N' Rod to assist in this job. The balance of the antenna was then run back through the rear jig wire holes towards the center of the fuselage. I decided on an internal antenna because the little plane looked ridiculous with such a long piece of wire trailing off the back end of the tail. Since these small models are almost out of visual range at 300 feet, radio range really isn't a problem. However, since this is contrary to good R/C practice I suggest you make a ground range check with your particular radio to verify its performance.

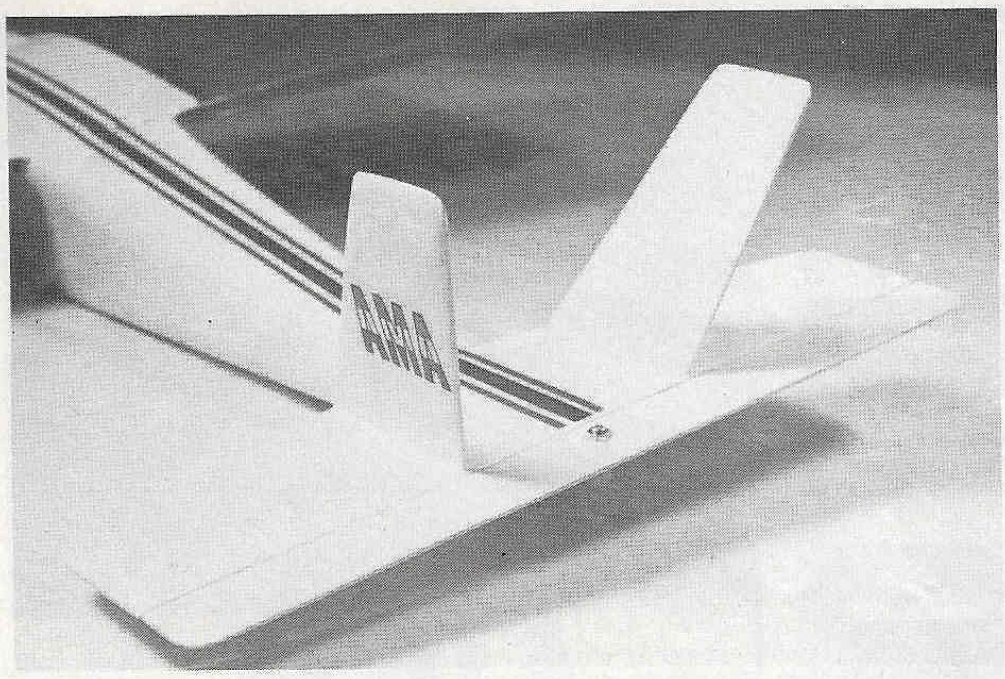
Flying

Check the C.G. before flying. The original balanced slightly nose heavy from the (25% of the MAC) position shown on the plans. If anything, have it a little nose heavy, *but never tail heavy*. Don't try to test glide this plane. It is not a Free-Flight. Remember, you just paid $200 for the R/C unit, use it! Test gliding won't tell you anything and could lead to needless damage. On your first flight have someone launch the model for you. Have him run the plane into motion with a minimum of actual throwing. A javelin type launch will sure as anything kill that little engine. As you get accustomed to the plane, adjust the control surface movement to minimize any over control tendency. Do this carefully since you will be making only "dead stick" landings (remember—no throttle!) which requires more control than during powered flight. If you want to stop the engine during flight for any reason you will have to roll the plane inverted and hold it until the fuel runs out of the line. If you don't know how to fly inverted, then this isn't the model for you to build at this time.

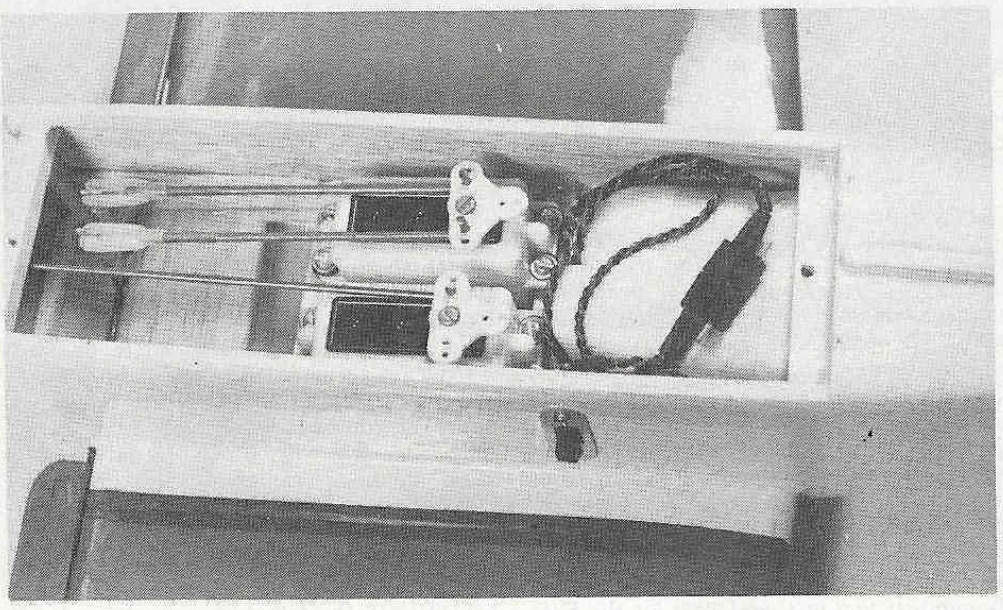
Right: Belly up. Hobbypoxy finish on fuselage resists high nitro fuels. **Below:** TD .020 and 4-2.5P Cox plastic prop. Note anti-syphon tubing.

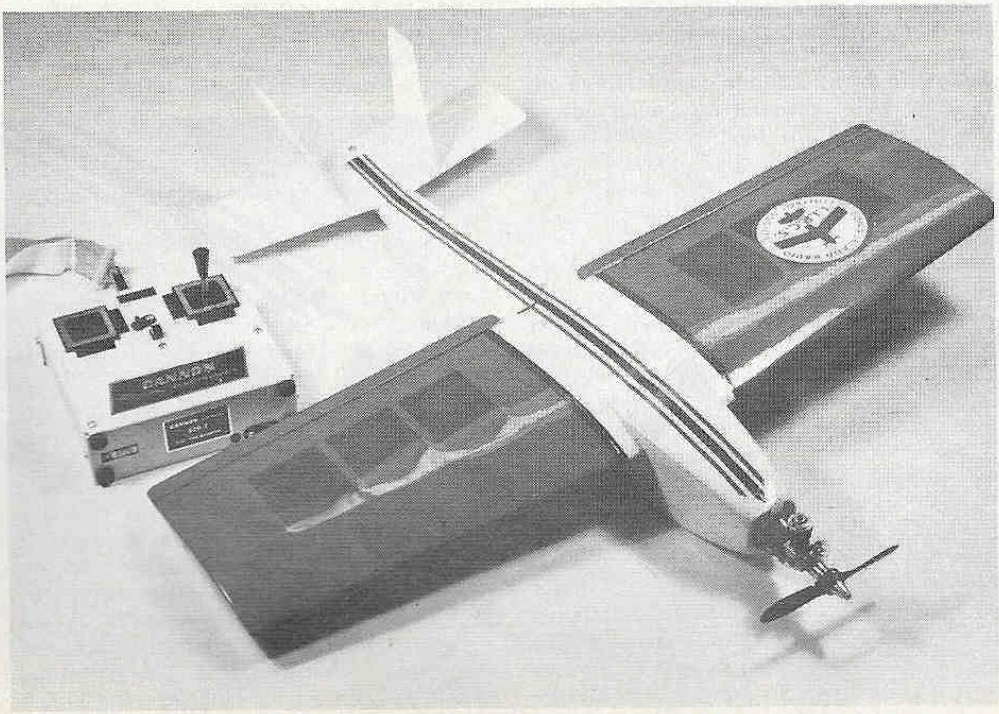






Twin fins for appearance sake. Trim it in bright colors with maximum visibility uppermost in mind. **Center:** Hatch cover removed. Aileron control uses Goldberg's Mini-Links. Charger cable coiled up. **Below:** At rest here with its transmitter. A match for each other. Bob flies in his lunch break.





About the Engine

The little Cox TD .020 will probably prove to be the weakest link in the whole aircraft system. The engine itself is a work of art. Unfortunately, because of its small size, it must be treated very carefully, otherwise you can expect a lot of "down time." As said so often, *keep the fuel clean.* A filter element directly inside the fuel can cap is a must. Clean this element often. Use-a syringe type fueler (such as the new Tatone two ounce job). Try to avoid the rubber fuel bulbs since the rubber tends to deteriorate with age. The built in fuel tank will only run for approximately 2½ to 3 minutes on 30% nitro Cox Racing fuel (at 50% nitro I blew a glow plug on every engine run). I could have put a larger external tank in the fuselage, but decided against it for simplicity. I do plan to try a Tatone small pen bladder tank to provide pressurization. The pressure should really help since these little engines have marginal suction to begin with. I'd really like to see Dale Kirn come up with some new accessories expressly designed for the Cox TD .020. Try a Cox black plastic 4/2.5P prop to start. You may also have luck with the Cox 4.5/2.5P black plastic prop. Avoid the Cox grey props because they break too easily. You will probably see in the photographs a small "U" shaped piece of fuel tubing across the two tank vents. This suggestion, of Glenn Spacht, prevents fuel from syphoning out of the tank while the engine is running. A problem of Free-Flighters years ago which was previously unsolved. Try it! You may also want to consider bring a *clean*, spare engine with you in your field kit. It only takes a minute to change engines. I like to fly on my lunch hour every day, if possible. A piece of dirt in the TD .020 could eliminate my usual four flight routine. With a spare engine I'm flying again in about three minutes. At $15.00 or less for an engine it's certainly worth it. By the way, always carry several extra glow plugs in your field kit. Their life span is quite unpredictable.

What's Next?

Well, if you attended our recent 1976 trade shows you must know by now that Bill Cannon has done it again. He has introduced a "Super-Mini" system which will have a full four channel weight of only *4.2 ounces* (believe it or not!). This new system has 12 MM servo motors which result in an individual servo weight of 0.7 ounces. The battery pack is a special 100 mah quick charge variety which can be charged between flights at the field. Two channel weight of this new system will be around 3.2 ounces or a full 2.0 ounces less than the present "Tiny Series" used in my model. Installation of this new radio in the airplane would result in a total weight on only 9.8 ounces. Better still, a whole new breed of super small models will now be possible. I hope to get my hands on one of these new airborne systems as soon as it is available for an upcoming FLYING MODELS Product Review. Following that, you just know I'll be hard at work at some new type of high performance R/C model using a Cox TD *.010* for power. The possibilities are unlimited. "Schoolyard Specials" will be the name of this entirely new ball game.