CARDBOARD P-51 MUSTANG

A control line article in an old model magazine aroused my interest in the low cost and utility of cardboard as a construction material for model aircraft. Since that time, I have built several airframes, ranging from boxy trainers to stand-off scale subjects, while learning the structural techniques, advantages, and limitations of this material.

Cardboard allows you to build a lightweight, solid-structured fuselage with few or no internal bulkheads. Its other attributes include vibration absorption, durability, and minimal cost.

A preference for scale models and a recent visit to my area by a Confederate Air Force P-51 Mustang inspired my choice of aircraft to model. The flat sides of this aircraft lend themselves to this construction material. A few minor changes from scale were made to the design to make it easier to fly. The tail was lengthened and the horizontal stabilizer enlarged to improve flying characteristics.

The most important change, however, was in the wing design. Most scale aircraft having heavily tapered wings have poor low-speed flying characteristics due to tip stalling. Usually, a constant chord wing is used to eliminate this problem, but this ruins the appearance of most warbirds. Cardboard has the ability to be formed into limited compound shapes and this capability is exploited to create a taper chord semi-symmetrical airfoil wing with tips which utilize a flat-bottomed airfoil. This totally eliminates the tendency to tip-stall on landing.

These features, together with the medium 25 ounce wing loading, make this an ideal first scale subject to transition from lightly loaded trainers to scale models which routinely go over a 30 ounce wing loading.

CARDBOARD P-51 MUSTANG

Designed by:
Stevan Baker

TYPE AIRCRAFT
Sport Scale

WINGSPAN
54 Inches

WING CHORD
11-3/4 Inches (Avg.)

TOTAL WING AREA
628 Sq. In.

WING LOCATION
Low Wing

AIRFOIL
Semi-Symmetrical

WING PLANFORM
Double Tapered

DIHEDRAL, EACH TIP
3/4 Inches

OVERALL FUSELAGE LENGTH
42 Inches

RADIO COMPARTMENT SIZE
(L) 14" (W) 3-1/2" (H) 2-3/4"

STABILIZER SPAN
21-1/2 Inches

STABILIZER CHORD (inc. elev.)
6-1/8 Inches (Avg.)

STABILIZER AREA
131-1/2 Sq. In.

STAB AIRFOIL SECTION
Flat

STABILIZER LOCATION
Top Of Fuselage

VERTICAL FIN HEIGHT
9-1/2 Inches

VERTICAL FIN WIDTH (inc. rud.)
7 Inches (Avg.)

REC. ENGINE SIZE
.45-.60, 2-Stroke

FUEL TANK SIZE
6 Oz.

LANDING GEAR
Conventional

REC. NO. OF CHANNELS
4

CONTROL FUNCTIONS
Rud., Elev., Throt., Ail.

C.G. (from L.E.)
4.0 to 4-3/4 Inches (At Fuselage)

ELEVATOR THROWS
3/8" Up — 3/8" Down

AILERON THROWS
3/16" Up — 3/16" Down

RUDDER THROWS
7/8" Left — 7/8" Right

SIDETHRUST
(As Required)

DOWNTHRUST/UPTHRUST
(As Required)

BASIC MATERIALS USED IN CONSTRUCTION

Fuselage	Cardboard, Balsa, Ply
Wing	Cardboard, Balsa, Spruce
Empennage	Balsa
Wt. Ready To Fly	108 to 112 Oz. (6 Lbs. 12 Oz. to 7 Lbs.)
Wing Loading	25-26 Oz./Sq. Ft.

CONSTRUCTION

I generally start every project by gathering all the materials and making a kit by cutting all the parts out. The first thing to do is to ensure that all the necessary supplies are available from the local hobby shop. If everything is not available, now is a good time to call in an order to suppliers, while you can make up a large enough order to meet minimum order requirements.

Significant savings can be made when

Dumpsters in light industrial areas are an excellent source of cardboard.

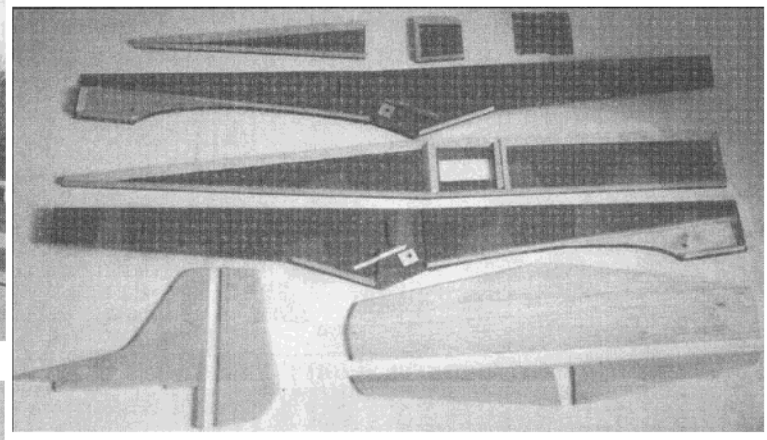
Some of the specialized materials and tools used in this project: paint thinner, aliph resin glue, polyurethane varnish, a long solid straightedge, a screen door rolling and a utility knife.

ordering from wood suppliers, particularly on plywood. I always order extra quantities to assure a good selection of weights and hardness, as well as to stockpile for future projects. Service response is usually excellent if you phone suppliers and use a credit card. Delivery is usually less than one w You can avoid back order problem having them check to ensure that everyt is in stock while you are on the phone.

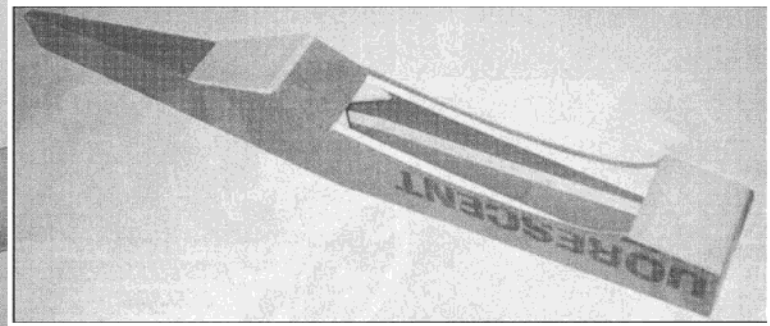
Cardboard can be obtained by chec dumpsters behind retail establishmen strip office centers. It can also be purchased wholesale from paper suppliers. You want 1/8" standard corrugated cardboard in 150 lb. or 200 lb. test strength. Select cardboard which has no blemishes and has not been wet. Do not use the yellowish-colored cardboard which comes from Asia since it is heavy and weak.

Purchase a quart of polyurethane varnish and a gallon of paint thinner. Mix three parts thinner and one part varnish and paint all of the cardboard with one coat on each side. Once it dries (overnight), you will find the cardboard is waterproof, crisp, and cuts easily. Use a utility knife with a fresh blade to cut the parts out. Do not try to use a hobby knife as it is too difficult to control.

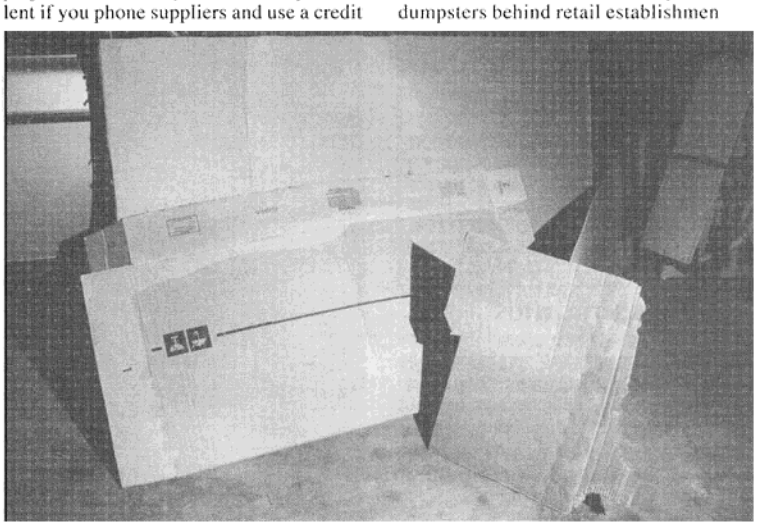
To mark the large pieces like the fuselage sides and wing skins, lay the plans on top of your cardboard and prick through with a pin. Make sure the grain of the cardboard is lined up with the arrows on the plan. Use one pin-



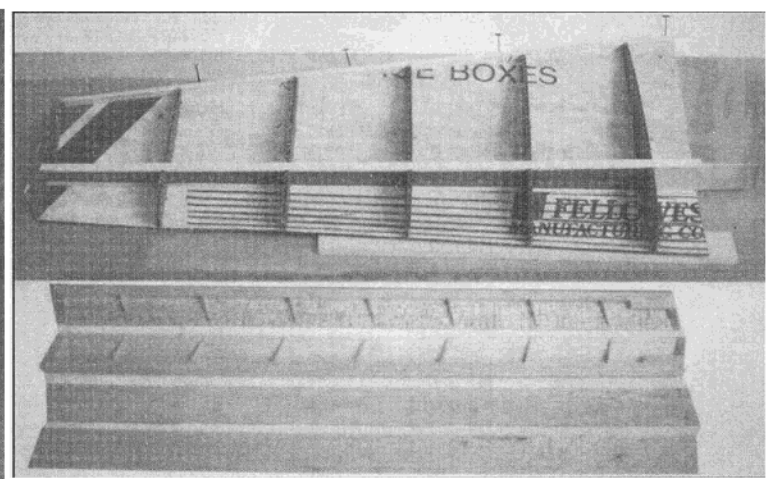
Note the locations of balsa, tri-stock, plywood, spruce, and cardboard doublers. Ensure that everything is pinned down flat to dry thoroughly before proceeding.



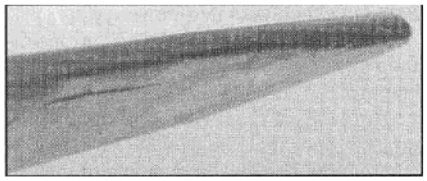
Basic fuselage structure with doublers, tri-stock, and balsa blocks in place.



Allow cardboard to dry overnight after painting on both sides with the varnish/thinner mix



The lower wing skin and ailerons under construction. Note that the crease lines on the lower wing skins do not extend all the way to the tips. This gives the change in airfoil, providing low speed stability to the model.



The leading edge of the wing, looking from the landing gear mount to the tip. Note the droop at the tip, indicating the change in airfoil.

fuselage sides and right and left upper and lower wing skins with the smooth side of the cardboard on the outside.

Once everything is creased, massage each crease so the skin holds its shape. Sometimes it helps to use a small, narrow board or a yardstick to help massage the creases. Be careful not to kink the cardboard and make sure the tips of the lower wing skins don't get bent. Glue tri-stock, doublers, triplers, and reinforcement points to fuselage sides. Then glue the spars, ribs, and trailing edge stock to the lower wing skins as shown in the photographs. It goes without saying that you need to use a flat board for this.

Be sure to fit the tri-stock joints carefully. I use an X-Acto Miter Box, razor saw, and a good sanding block. Tite Bond aliphatic resin glue is used for all joints involving cardboard. I also use it for all other joints since it works well, dries fast, and because, after many years of building models, I have developed a respiratory allergy to cyanoacrylate.

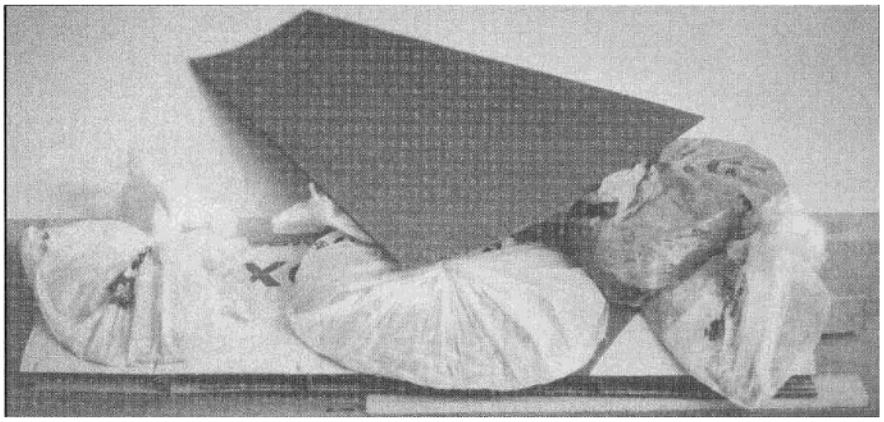
Make sure that the ribs are fully in contact with the lower skin by pinning them down and blocking up the leading edge. The airfoil behind the spar is flat, which makes it easy to pin the whole thing down to the flat board. I used some old trailing edge stock to block up the leading edge of the lower skin. Add the upper spar at this time. Some small boards and weights carefully placed across the ribs and on the top spar will hold everything down tight while the glue dries.

Once the glue is dry, add the shear webs in-between the spars, making sure the grain of the cardboard goes up and down. When dry, remove all pins.

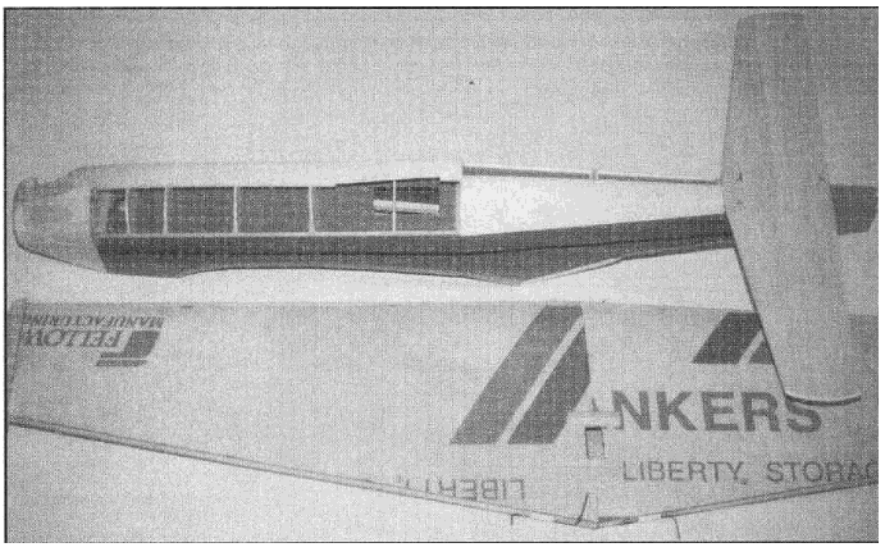
Carefully plane the top of the trailing edge spar down to match the angle of the ribs. Spread glue on the top of the main spar, trailing edge spar, and ribs. Do the ribs last because you don't want too much glue to run down into the corrugations. Refrigerating the glue helps to thicken it if this is a problem.

Quickly place the upper wing skin on, lining the trailing edge up to the trailing edge spar. Use weights to clamp the skin down (bags of sand work best). Let this dry for 24 hours.

Drill the dowel holes in the fuselage sides, then take the fuselage top and pin it to a flat board. With the front end at the edge of the building board, glue and pin the sides to it. Insert, but do not glue, the fire wall between the fuselage sides. The rounded top portion will hang off the end of the board. You can then add the five bottom pieces to the fuselage, gluing and pinning them as you go. Getting this square should be no problem because of the fire



Upper and lower wing skins joined and weighted. Allow this to dry overnight. Note the upper wing skin laying on top and the curve created by creasing and massaging the cardboard.



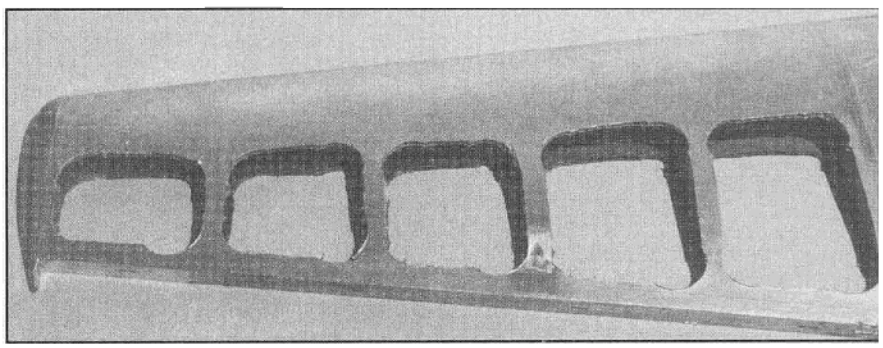
The fuselage is sheeted in four pieces. Use warm water to help the balsa form around the bulkheads. Note the servo rails glued directly to the wing skin.

prick at each end of straight lines and multiple pricks on curved areas.

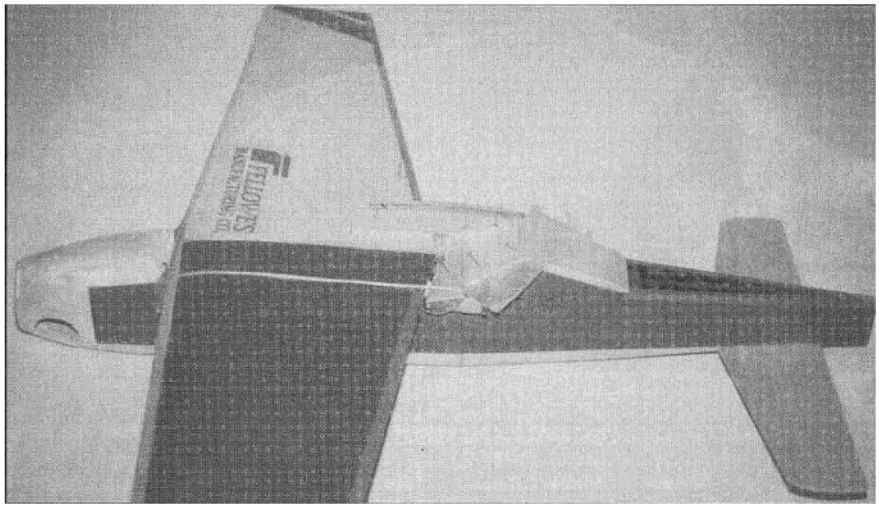
Using a long straightedge as a guide (I used a piece of angle iron), carefully cut out the cardboard scoring on the first pass, then bearing down harder to cut through on the second or third pass. Don't do this on linoleum. I used a large piece of old loose pile carpet as a cutting surface.

To cut the small pieces, photocopy them from the plans, then get some spray adhesive and coat the back of the copies. When the adhesive has dried for one minute, cut up the copies with scissors and place them on your balsa or cardboard material. You can now cut out the small parts. This is absolutely the best technique for cutting out parts accurately. It works especially well with balsa because the paper counteracts the wood-grain's tendency to make the blade drift. It also helps hold the balsa together when making cross-grain cuts. Once all parts are cut out, peel off the paper and discard it.

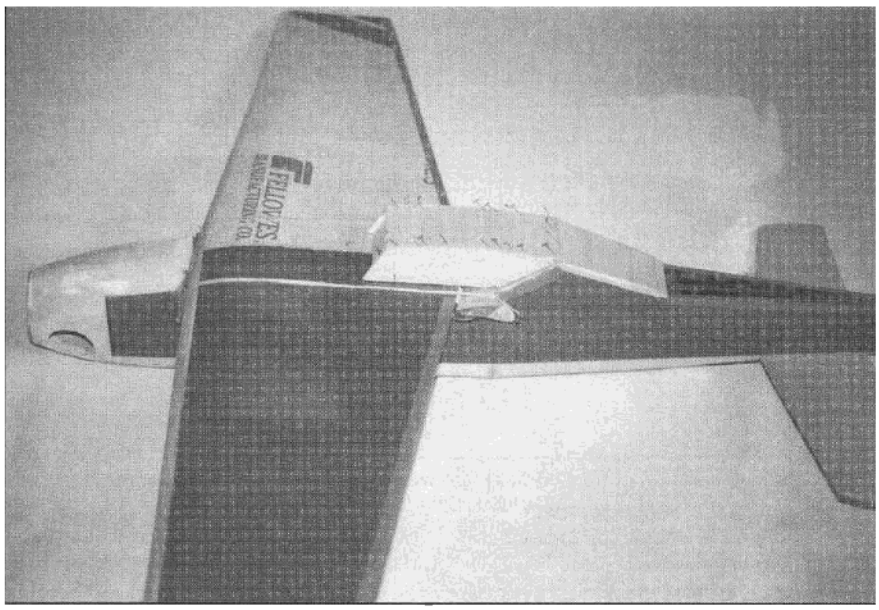
Note the crease lines shown on the wing skins and the one crease line on the fuselage side behind the wing saddle. Mark them in pencil on the inside of the parts. Using a straightedge and a screen door rolling tool, carefully crease the cardboard as indicated and make sure you have the right and left



The completed wing, with optional cutouts, ready for covering with plastic film. A 6-8 ounce weight savings can be achieved this way. Neither dope nor paint need be used if covering with film. The varnish treatment, however, is essential.



Temporarily install wing saddle padding before building the air scoop. Do not, however, install padding on the area behind the trailing edge of the wing.

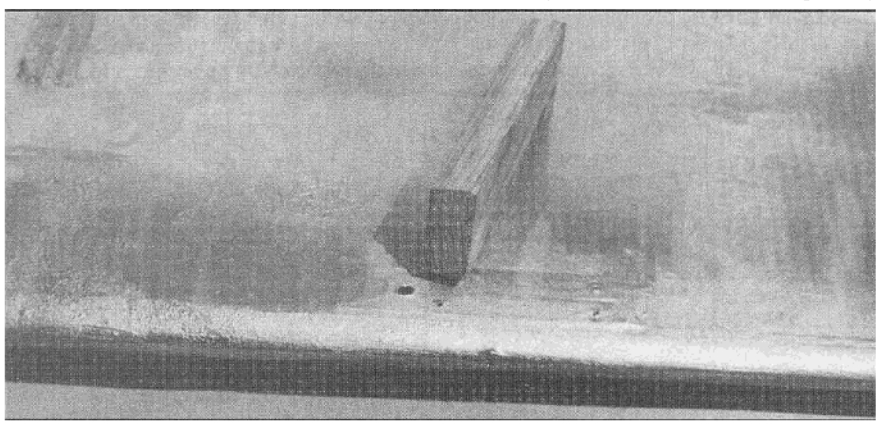


The fuselage/air scoop joint angle significantly increases the "hard landing" survivability for the airframe.

engine mounting because the cylinder does not detract from the lines of the aircraft silhouette on fly-bys. However, make sure your muffler clears the fuselage and doesn't dump oily exhaust out onto your wing.

Be sure and install one washer under the top bolt and one under the left-hand side bolt of the radial engine mount to ensure sufficient down thrust and right-hand thrust for easy take-offs. Install the throttle pushrod and drill fuel line holes at this time.

Use spray contact cement to temporarily



A new landing gear block, correctly planed to match the curvature of the upper wing skin. Note also the block mounted in the wing and the screw which pulls it into solid contact with the leading edge.

wall, but check with a square anyway.

While this is drying, make up the empennage out of medium to lightweight balsa. Round all edges and sand. You can now take the fuselage off the board, leaving the pins in place, since the glue may not be fully dry. Remove the fire wall and then add the top decking bulkheads and the 1/8" square edging strip. You will glue the top sheeting to this strip, so it must be placed 1/16" from the edge of the fuselage.

Reinstall the fire wall by adding tri-stock all the way around the inside of the nose and gluing the fire wall in place. Take extra care to join all the tri-stock carefully. You can use epoxy, but Tite Bond works fine. Install the center stringer on the bulkheads.

Once the wings are dry, remove them from the board. Trim off any excess cardboard. Using a long sanding block or a T-bar, with 100-grit paper glued to it, square up the front edge of the wing. If you sand lengthwise, taking care not to catch the ribs with the end of the block, you will find the sanding goes quite nicely.

Install the leading edge tri-stock and add some additional scrap at the tips so you can shape the leading edge droop. Add the soft balsa wingtips at this time.

Ailerons are made next from hard 1/16" sheet. Strip out the skins a little large and glue the 1/4" x 3/8" stock; then glue on the top skin. Make sure you pin this down to a flat board until it dries. You can also glue on the tri-stock leading edges to the ailerons at this time.

Cut out the landing gear blocks from whatever lumber is at hand. I have used yellow pine and mahogany. The blocks should be 3/4" thick by 1-1/2" wide. Carefully cut a hole in the lower wing skin, using the block as a guide. Plane the top of the block to match the curve of the underside of the upper wing skin.

Drill a hole for the landing gear torque rod extension. Coat the top and front of the block and the cardboard edges with Tite Bond and insert the block. Drill a hole through the leading edge of the wing into the middle of the block, and insert a 1" long countersunk sheet metal screw which will ensure a tight fit between the back of the leading edge and the landing gear block. Once this is dry, the exposed part of the block can now be planed down flush with the lower wing skin and you can shape the wing leading edge, trim the cardboard trailing edge, and shape the tips. Fit the two wings together with one wing flat and the other blocked up 1-1/2" at the tip. Trim and sand the joint, then install the joiner in one side using 5-minute epoxy. Also, glue some hard balsa joiners to the inside of the leading and trailing edges.

Once this is dry, join the wing. In addition to gluing the joiners, coat the ends of the wing skins with Tite Bond before joining. Next, install the engine and start building up the cowl.

I have designed this airplane for a 3" spinner, which is the lowest cost large spinner available. You can mount this engine any way you want, but I prefer a horizontal

Materials List

1 — packet blind nuts 6-40
1 — packet 6-40 cap screws
1 — Hayes 60 sized engine mount
1 — packet washers
4 — wire pushrod ends with clevises
1 — Du-Bro 60 sized tail wheel bracket assy.
17 — Klett Hinges
1 — 3" spinner (Du-Bro)
1 — set aileron torque rods
2 — control horns
1 — throttle flex cable
1 — utility knife
1 — screen door rolling tool
1 — bottle aliphatic resin (Tite Bond, etc.)
1 — epoxy glue
1 — packet 1/2" nylon wing-joining tape
several sheets cardboard
1 — Sig WWII 13" canopy
1 — pint polyurethane varnish
1 — gallon paint thinner
1 — 3/4" tail wheel
1 — packet 5/16" nylon landing gear straps
1 — pair Sullivan Skylite 3" wheels
1 — 5/32" x 36" music wire
1 — packet 5/32" wheel collars
1 — bottle R/C-56
1 — Sullivan 6 oz. slant fuel tank

Painted Covering Items

1 — quart clear dope
2 — sheets heavy silkspan
Black Baron spray paint
1 — roll electrical tape
1 — roll brown paper tape (packing tape)

Balsa

2 — 1/4" x 36" Tri-stock
1 — 1/2" x 36" Tri-stock
6 — 3/8" x 36" Tri-stock
2 — 1" x 36" Tri-stock
1 — 3/16" x 3" x 36" sheet
1 — 1/8" x 3" x 36" sheet
1 — 5/8" x 3" x 36" soft sheet
4 — 1/4" x 3" x 36" sheets
2 — 1/16" x 3" x 36" sheets
2 — 1" x 1" x 12" soft blocks
2 — 1/4" x 1/2" x 36" sticks
1 — 1/4" x 1/8" x 36" stick
2 — 1/4" x 3/8" x 36" sticks
2 — 1/4" x 1/4" x 36" sticks
2 — 1/8" x 1/8" x 36" sticks

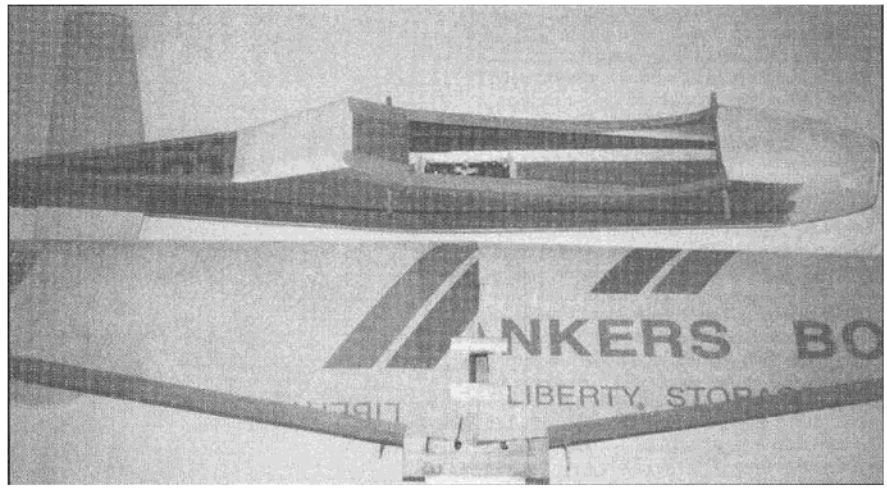
Hardwood/Plywood

1 — 1/4" x 36" dowel
1 — 3/4" x 1-1/2" x 12" pine
4 — 3/8" x 1/8" x 36" spruce or basswood
1 — 1/4" x 12" x 6" plywood
1 — 1/8" x 12" x 6" plywood
1 — 1/16" x 12" x 6" plywood

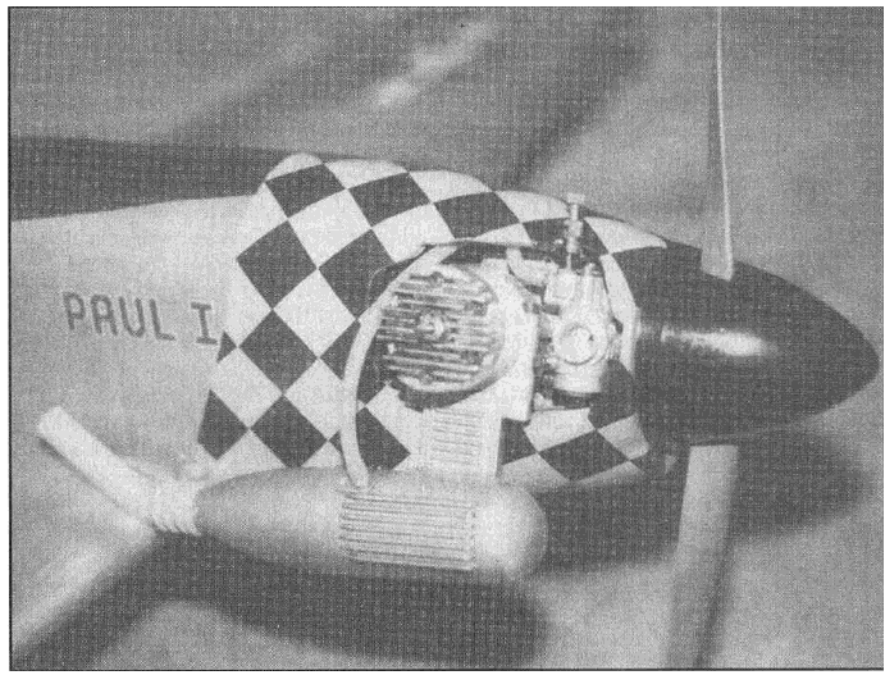
glue a 1/16" balsa ring and then the 1/8" ply spinner ring to the back of the spinner. Install the spinner and build up the cowl from soft balsa between the fire wall, the ply ring, and the lower fuselage extension. I do not like the inconvenience of a removable cowl, so once I have enough balsa to hold the spinner ring on, I remove the engine and fill in with balsa all the way around.

You should now put the 1/16" balsa skin on the top of the fuselage. Medium balsa is used, and the top is covered in four pieces. Use warm water to dampen the outside of the balsa so you can make it curve more easily, especially at the front where you have a compound curve.

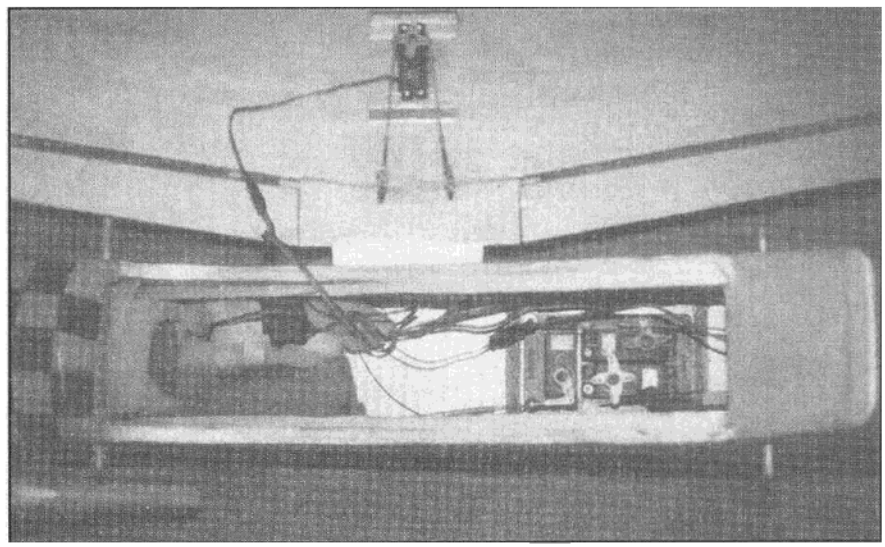
Once all fuselage sheeting has been installed and all glue has dried, carve the cowl to shape and sand everything smooth.



The completed airframe components ready for covering or painting. If you elect to cover with MonoKote, you can cut holes in the wing behind the spar, this will save 6-8 oz.



Carve a hole in the cowl just large enough to squeeze the engine in. The opening is surprisingly small and much simpler than a removable cowl.

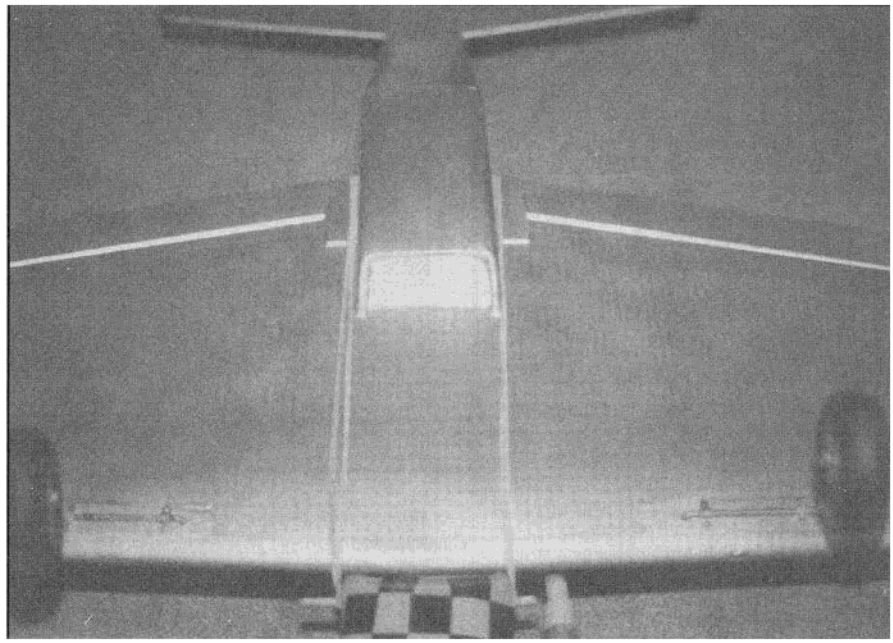


The lack of bulkheads allows for a simple and neat radio installation. The battery compartment, in the rear of the air scoop, ensures that the battery cannot move around during maneuvers.

ABOUT THE AUTHOR

Born in St. Albans, Hertfordshire, Great Britain, in 1958, Steve immigrated to the U.S. along with his parents in 1968, settling in Charlotte, NC. In the 1940's, Steve's father flew tow-line gliders, and introduced him to rubber-powered models when he was a child. Later, when he was a senior in high school, Steve purchased an M.E.N. Trainer, a Fox .25, and a 4-channel Futaba radio system.

Since no R/C flight instructors were available, Steve tried to teach himself to fly, with somewhat predictable results. The aircraft was then put on a shelf while he went to college, got married, and then started his business career (a total of eight years). After a few complaints from his lovely bride who objected to his large investment in R/C equipment just setting around and dripping oil, he decided to give it another try, and this time he was successful in teaching himself to fly. He has been flying ever since. Steve is now one of the volunteer instructors for his club, helping others learn to fly R/C.



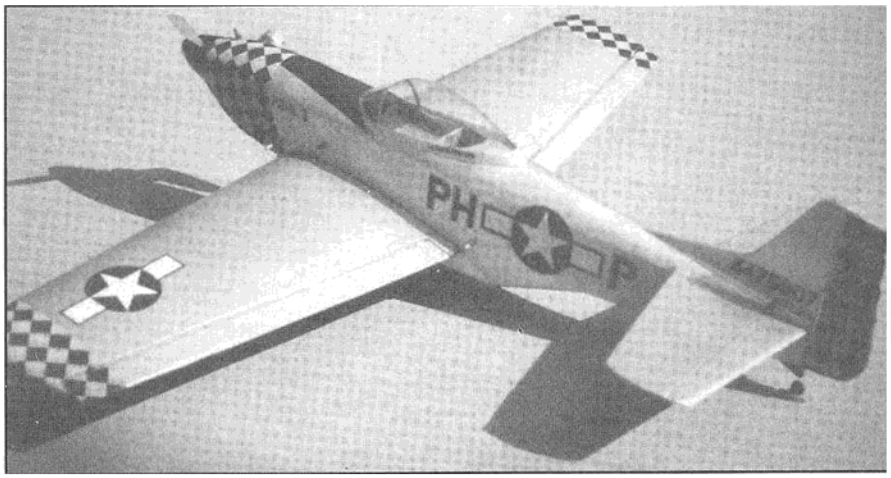
The finished air scoop and underside of the aircraft. Note the landing gear blocks which are very strong, being made from solid pine blocks.

Once the nose is shaped and sanded, carefully carve a hole just large enough to squeeze the engine in. The hole is relatively small and much less trouble than a removable cowl.

Install the wing dowels in the fuselage. Rubber band the wing in place and start building the air scoop as shown in the photographs. Be sure and install the aileron torque rods before you start and put wax paper between the wing and fuselage. While this is drying, glue on the vertical fin and horizontal stabilizer. Carve and install fillets out of light balsa.

Use brown packing tape, cut into 1" wide strips, to cover all areas where the end grain of the cardboard shows. Cut the opening for the cockpit. Dope the entire airframe with butyrate dope twice. Glue or dope 1/2" nylon cloth tape around the landing gear blocks. This will ensure that the skin stays glued to the blocks. Sand lightly and cover all balsa parts with heavyweight silkspan. Put two more coats of dope on the balsa parts. Install all control surfaces and a steerable tail wheel. I use pinned Carl Goldberg Klett hinges secured with Tite Bond.

Paint with Coverite's Black Baron spray paint. Be careful to let the paint dry thoroughly between coats, particularly where you have to mask off areas with tape. The checkerboard patterns on this aircraft were done by painting the affected areas yellow and then sticking black rifle target pasters on top. If you cannot get target pasters, self-adhesive sheets can be obtained from office supply stores; cut them with a paper cutter. Use a flexible ruler to line the squares up. Start the first line of squares on the far side of the cowl from the engine cut-out. Spray-paint over with a contrasting color paint and, when completely dry, carefully peel off the pasters. This method works well because you can trim the squares to go around compound curves. If any paint bleeds under the



Ready to fly; a very nice Sport Scale model with a minimum investment in time and money.

squares, you can take a clean wipe dipped in paint thinner and wipe it away from the affected area. Be careful not to smear by wiping only in one direction and by changing wipes frequently.

Trim the canopy to shape. Mask off the areas inside the canopy which need to be clear and spray-paint the cockpit framing. Since this framing is painted on the inside, it will never get scratched off.

Install the radio system, fuel tank, and landing gear. When gluing down spruce rails and tri-stock for the aileron servo, use R/C-56. I used a flex cable for the throttle and 1/4" square balsa for the rudder/elevator pushrods. Glue the canopy on with R/C-56. Be sure to cool the R/C-56 in the refrigerator before applying to the inside of the canopy right at the edge. However, if you allow it to freeze, the R/C-56 will be ruined.

Temporarily tape and rubber band the canopy in place and, as the glue warms, it will flow into place and make a nice invisible seal. If you are covering in plastic film, you can skip the dope, packing tape, silkspan, and paint. However, make sure you fuelproof the engine compartment. You can also cut lightening holes in the wing behind the main spar, which will save about six ounces. Make sure to leave 3/8" cardboard overhangs at the ribs, spar, and trailing edge when making the cutouts. You'll also want to give all the corners a 1" radius. Before covering, take a spoon or blunt knife and smooth all cardboard edges down so they don't create a ridge underneath your covering.

Program your radio or adjust your linkages to give the following control throws: rudder 7/8", elevator 3/8", ailerons 3/16". These figures represent the deflection in each direction. With these throws, you should not have too much difficulty on your first flight. You may increase them as you wish later.

You will find that on a good .60 size engine, this aircraft will climb out nicely. However, use your rudder on take-off and advance the throttle slowly. Get it good and high and trim it out immediately. The aircraft will perform very smartly and grooves well through all maneuvers. The airframe is aerodynamically clean but the thick airfoil stops excessive speed build-up. Practice a few landing approaches, from 50 feet "too high," to get a feel for the higher landing speeds. I find that a few clicks of up-trim on the transmitter will increase the angle of attack and slow things down significantly. When you have things set up right and land into a stiff breeze, the aircraft will come down like it's on an elevator. The tip airfoils will give you control all the way down. If you hit hard on landing, you will find that the resilience of the airframe and the rubber band wing hold-down system will take a lot of abuse. Have fun!

"Cardboard allows you to build a lightweight, solid-structured fuselage with few or no internal bulkheads. Its other attributes include vibration absorption, durability, and minimal cost."

From RCModeler Sep. 1996