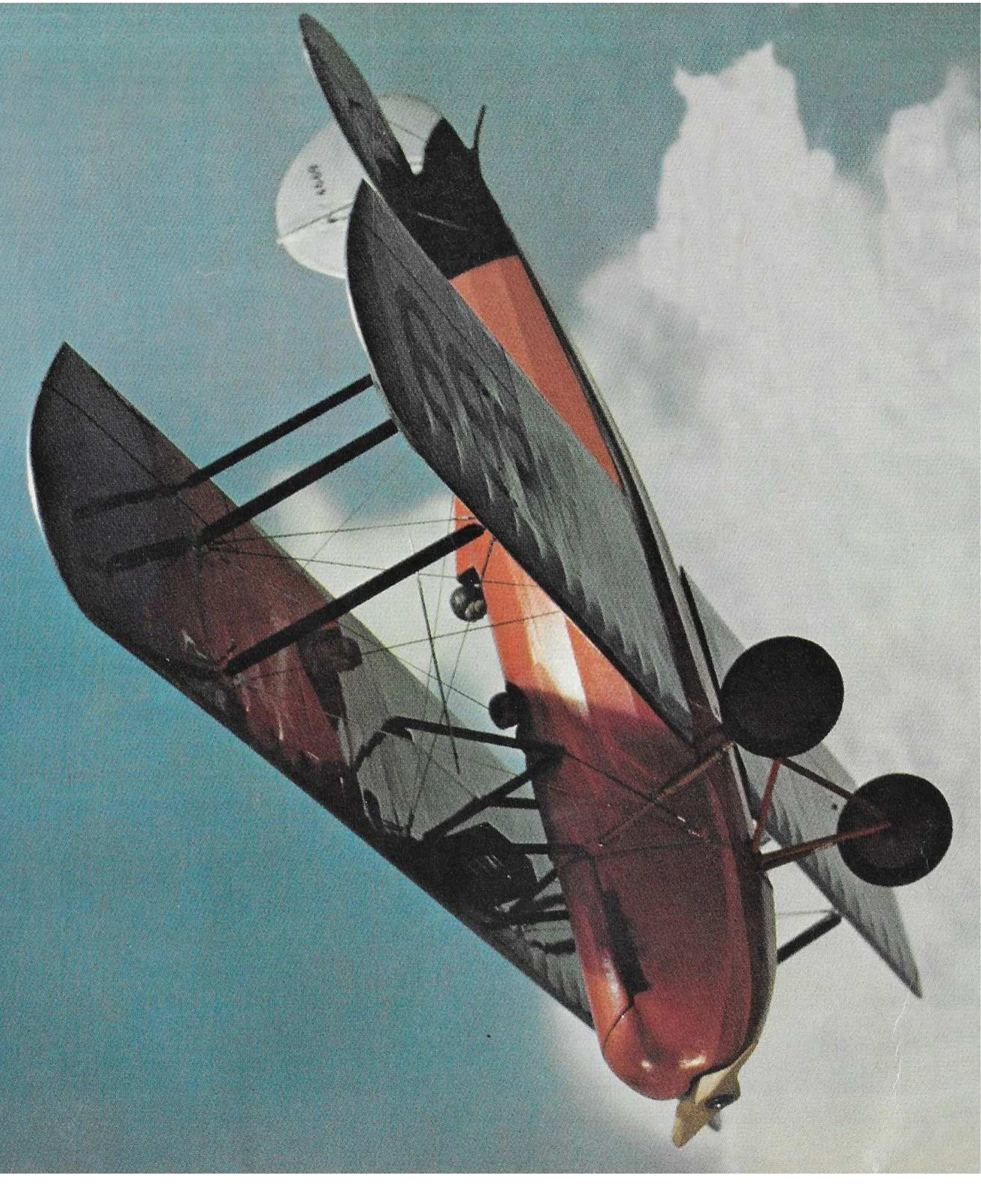
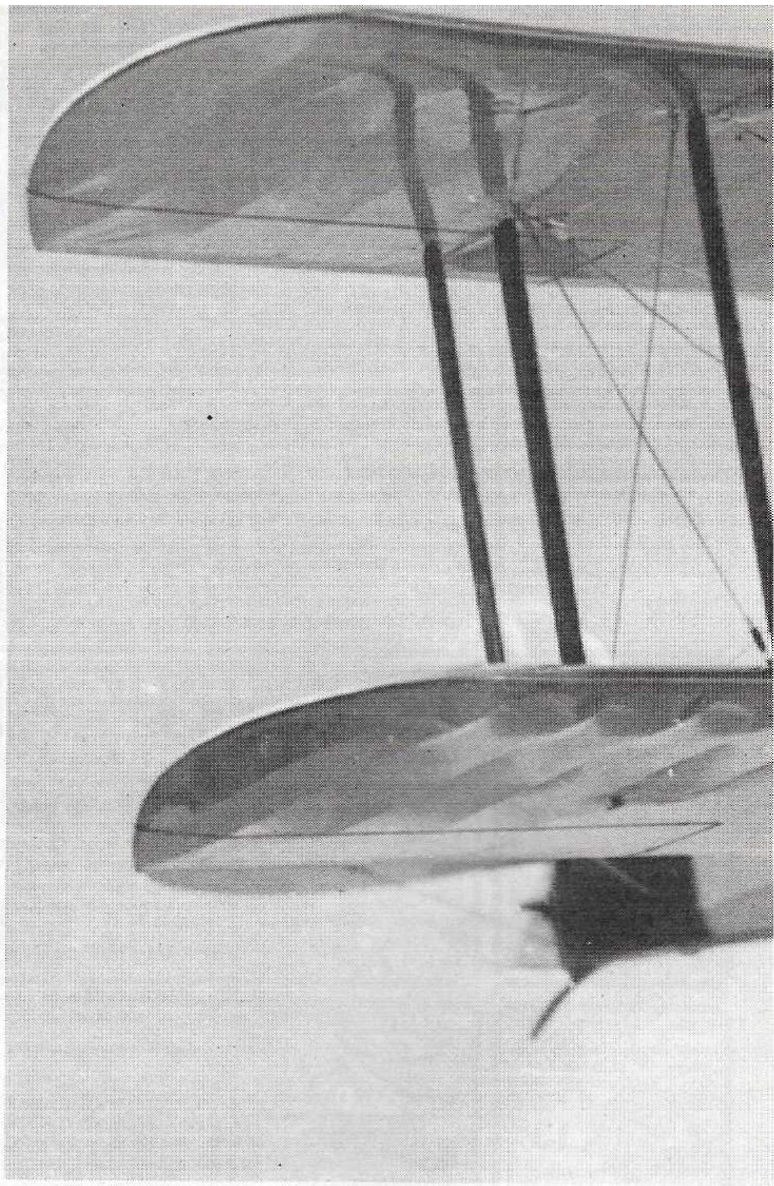


R/C Scale

Waco 10

This amazing example of the scale aircraft builders art in ½A is correct not only in looks but also in stringer placement and stress arrangement. It's not for the beginner but it's rewards are great/**Ned Kragness**



PHOTOGRAPHY: NED KRAGNESS

Barnstormers loved the Waco. In 1928 a price of about $2500 got you a new one with a good-as-new Curtiss OX-5 engine. Practically all of this class of airplanes carried three people—two passengers and a pilot. More payload would be asking too much of the OX-5 engine. Heavier payloads simply made performance marginal.

The OX 5 powered Ten got off the ground quickly, climbed well in ground effect at full gross weight and rather slowly thereafter. Controls were light and response was pleasant, rather better than the Cubs, Aeroncas, etc. which would soon appear. Today the Waco Ten would be called a STOL aircraft. However, by the standards of her day she was only a little better than average in small field operation. With higher power engines the airplane naturally climbed much better. With the 200HP Whirlwind the gross weight takeoff was immediate, well under 400 feet in still air and against a breeze as little as three or four airplane lengths. Climb was spectacular. The OX-5 airplanes did not have brakes and ground maneuvering required a nice hand on the throttle. A sharp turn on turf was made from a stop; full rudder, full stick forward and then an abrupt blast of power sufficient to raise the tailskid and let the rudder act but chopped off before any forward movement could develop. It was a great disgrace to get too far into a fence corner and be forced to climb out and carry the tail around until headed away from the fences.

During the short period from Lindbergh's trans-Atlantic flight to the market collapse of 1929 many manufacturers competed vigorously. Some of these other names were: Air King, K. R. Challenger, Commandaire, Swallow, Travel Air, Eaglerock, International, Thunderbird, Curtiss and American Eagle.

Waco Tens came initially with the OX-5 engine, and for the better heeled, with the Hispano Suiza, both engines being surplus from WWI and much cheaper than new engines. Soon newer and more costly engines such as the Wright J-5 Whirlwind and Siemens-Halske were available as the popularity of the Waco grew.

The ten-series had a tendency to be tail-heavy, particularly as fuel burned off and the OX-5 airplane could and did spin flat on occassion. There was no washout and stall-spin accidents were common.

The straight wing aircraft were built with two interchangeable kinds of center section struts. The later design produced a 2″ more rearward upper wing location.

The Waco Ten and Taper Wing series airplanes shared fuselages and tail surfaces with the same dimensions and structural geometry. Differences in tubing dimension and wall-thickness took care of stress problems.

The OX5 version of the Ten had a look-alike sister. The only visible differences were an air entry cutout in the nose above the propeller hub and the underwing radiator was not installed. This airplane used the Tank engine, made in Milwaukee, which was an aircooled V-8 intended to replace the OX-5. It employed a substantial number of OX-5 parts which were plentiful, cheap and which would otherwise be particularly expensive to make.

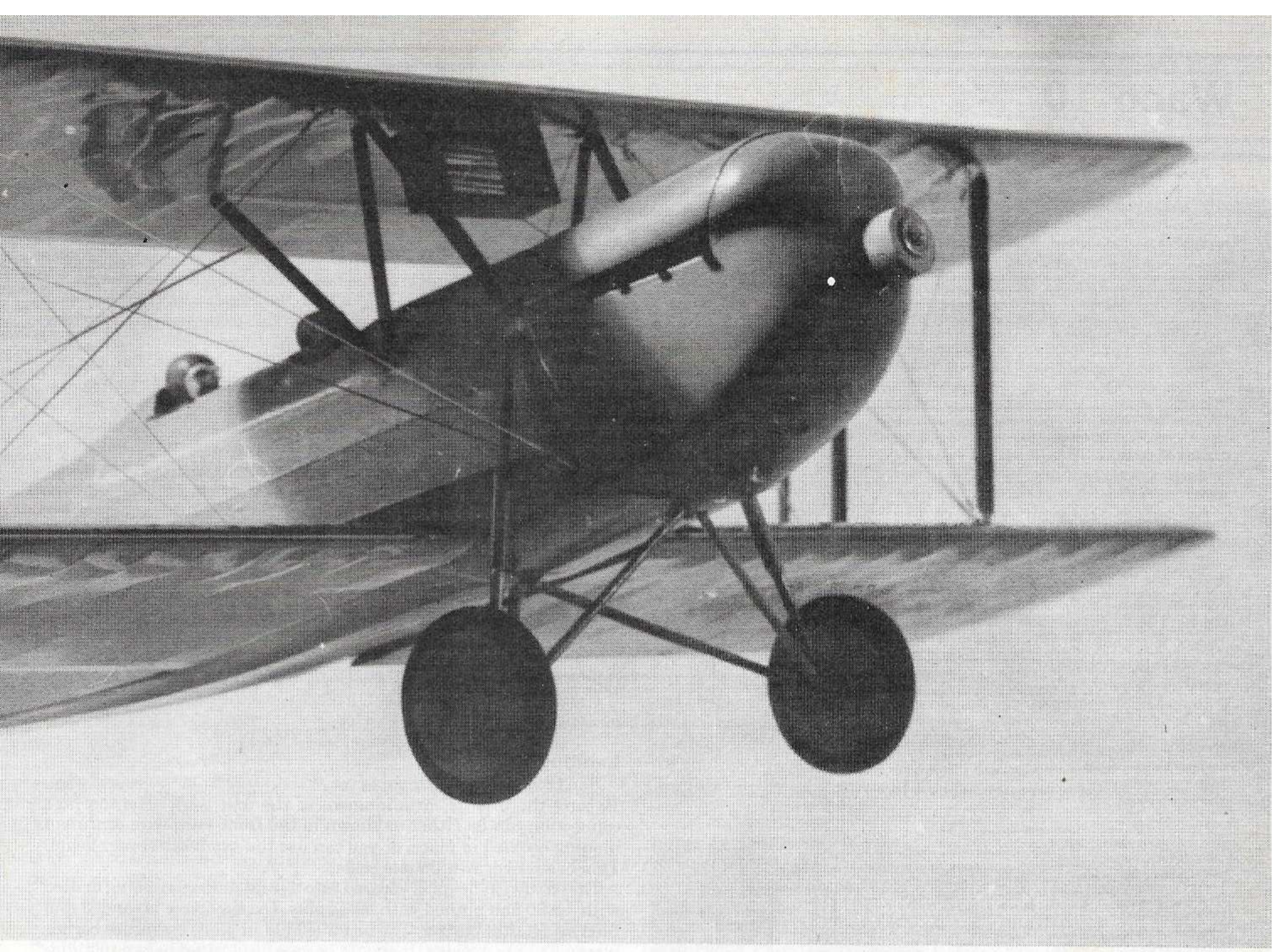
This engine almost succeeded in establishing a market, for a considerable number were sold before the 1929 depression struck the company down. You can duplicate a Tank Waco by opening the engine cowl front and omitting the radiator. This will allow cooling air to your engine and reduce drag. Incidentally, both OX-5 and Tank versions often flew without the upper cowl. This upper cowl was held in place by leather straps which in a short time chafed thru the paint of the cowl leaving bright aluminum showing through. The lower cowl was a single piece and required propeller removal to get it off. This lower cowl had a large open bottom triangular area ahead of the fire-wall which allowed air out, drainage and carburetor access.

This model is built to 1/12 scale (one inch equals one foot). There are two square feet of wing area.

Full scale dimensions are: Span; 30′ 7″ upper, 29′ 4″ lower; 23′ 6″ LOA; 9′ 0″ high (3 pt.).

The model as shown by drawings and photographs weighs 17½ ounces with a Cox 049 Golden Bee engine and Cannon 3 channel radio with 100 mah battery; resulting in a wing loading of 8¾ ounce/square foot.

Construction is straightforward but is unusual in the use of plywood gussets throughout the fuselage structure. Laminated wing



tip bows and tail surface outlines reduce weight and improve strength. Metal fittings are easy to make if Stay-Brite or TIX solder is used. All brass parts are 1/64" wall tubing and 1/64" sheet.

This model depends on its wire bracing for strength and is much lighter than would otherwise be possible. Where the full scale airplane used streamline wire with round threaded ends on this model I used 20 lb. test flat mono-filament obtained from the Cortland Line Company. The ends are formed into loops thru a ferrule of 1/16" OD aluminum tubing which is then pinched flat. These end loops attach to metal fittings or into epoxied hardwood since monofilament will cut through unprotected wood under stress.

This airplane had four ailerons. The lower ailerons were activated by push/pull tubes in the lower wings, and the upper ailerons were moved via a streamline interconnecting strut. A 1/12 scale model does not need ailerons in flight and benefits more from simplicity, ruggedness and weight reduction than from their presence.

By using a radio tray module which slides in through the firewall, only minimal access openings are needed. Push rod connections are exposed in the cockpit and allow easy disconnection and removal.

The nose cowl is made up of balsa blocks. This entire unit is removable for access to the radio installation which, as mentioned above, is a slide-in unit.

The nose block transfers all lateral loads into the firewall by dowels and is held against the firewall by flat tabs and screws. Locating the dowel hole centers is difficult unless a transfer template is used. Since the nose block has a 1/32" ply rear face, this piece can be used as a template to drill #60 holes in both the nose block and the firewall, thus assuring a perfect match. The entire cowl interior must be fuel-proof, using either fuel proofer or urethane varnish.

It is necessary to use an engine shaft extension if we are to keep the cylinder far enough back to be inside the cowl. This is a piece of 3/8" diameter aluminum rod drilled 1/8" through the center, cut 5/16" long with both ends faced square to the center hole. You can mount the engine further forward, without the extension but this will require a cowl cut out. An extension for the needle valve will also be required.

The radio battery is carried behind the engine and the switch is mounted directly above the battery.

The landing gear is built up in the same general way as the center section strut unit. The full scale airplane used round tube for the two vees. The model has round plastic cocktail straws over the wire. The shock struts are functional. They are made of K&S brass tubing with a ball point pen spring in the cylinder. Shock absorbers are not really necessary; however these are easy to build, nice looking and work well. Now that you know what to expect we can discuss how to go about building the model.

Fuselage

This fuselage uses plywood gussets placed to increase glued areas and to put these joints in shear. Structural members are located to duplicate the full-scale aircraft.

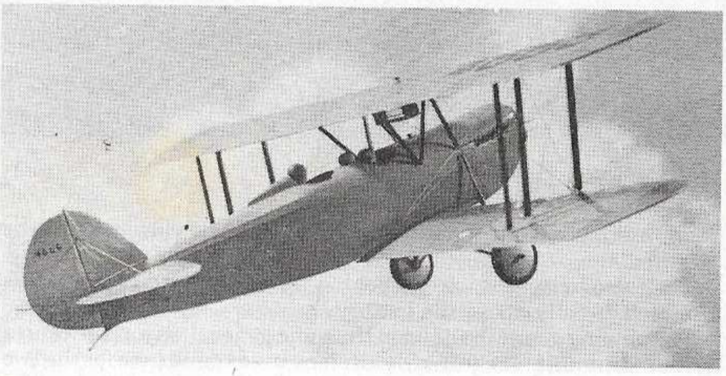
In order that later assemblies will fit; stay as close to dimensions as you can, and remember that square and parallel mean just that. It is important that you build accurately since the other items are attached to hard points which control the entire geometry.

The fuselage frame geometry is scale, but uses wood strip and ply to replace steel tubing. Since welded fuselages rarely have curved tubing, the lower longerons are made of three pieces of wood with long scarf splices to accomplish the more abrupt changes of direction.

Start by making the lower longerons which have two scarf splices each. These are best cut close to the correct angle and then rubbed on fine face-up sandpaper. These long bevels can be checked by pressing against another piece of stock and checking the angle against the drawing. Make sure the gluing face is flat and square to the four sides of the stock so that no twist is present on the finished longeron. If you start with excess length stock for each piece you can keep sanding until the angle is exactly right. These joints should be glued with Tite Bond under firm clamping. When dry, build up two fuselage sides to the side view layout and exact duplicates of each other. Use ambroid for these joints; you may want to use solvent to re-do or repair them. Add the side gussets, positioning each precisely, and remember, one right and one left side. Note that the lower longitudinal gussets are slotted to match the fuselage vertical members spaces and the ply butt wing ribs are slotted to match so that the lower wing incidence will be correct and equal for both wings. The fuselage is easily assembled because of the transverse gusset arrangement. Notice that the cutouts in these side gussets allow for the 1/32" ply lower longitudinal inner doubler which carries the wing tab slots, and at the top, an opening for space to pass the bindings for the center section wires. The firewall gussets similarly allow for center section wire bindings. The fuselage sides are best assembled to each other, front end first; the forward three bays being of equal width.

Cement the transverse gussets to the fuselage side members, being sure they are symmetrically located and are square with the side frame. Prepare six forward cross pieces, all a little overlength, and make up the vertical ply transverse web gussets. The fuselage top is a flat surface, so we will assemble it bottom-up on the building board. The crosspieces are now sanded to final lengths (to allow for gusset thickness differences) and cemented to the transverse gussets. While assembling the two sides, take special care that they are parallel to each other and perpendicular to the top deck of the framework. Use temporary diagonal braces whenever needed. The forward fuselage should be exactly 3" wide outside dimension at each crossmember. The sides should be square to the building board.

The lower fuselage crossmembers at the wing spar locations include 1/16" x ½" ply straps to which the ply wing tabs will be fastened.



(This fastening should be a 3/32" diameter pin made from a round toothpick cemented in place. Leave enough sticking up to be reached by needle nose pliers if replacement ever becomes necessary.)

Once the forward fuselage is assembled, mark a tiny center dot or pinprick at the center of each crosspiece, then install the cross members just forward of the rudder post. Proceed to place intermediate crosspieces, rotating them where necessary to allow gussets a flat cementing seat on both its cross member and side truss member. Now fit and install diagonals to align the dots exactly.

As you proceed, use temporary diagonals to bring the center line dots into perfect alignment, using a flexible straight edge of cardboard or thin metal. Join the upper and lower longerons with beveled faces, but do not install the tail post tube. Finally install the gussets which tie the diagonals in position as shown on the drawings. When dry remove the frame from the board and sand the top surface on face-up sandpaper.

The fuselage upper surface is used as the assembly jig for the cockpit cowling. Tack cement the four cowl bulkheads in place, add the cowl internal edge and center doubler strips and cement 1/16" sheet edges to the bulkheads and internal edge strips. It may be necessary to wet this 1/16" sheet to obtain the curvature. When dry, trim and sand lightly. Proceed to add the turtleback formers and stringers, taking care to make a good fit against the cockpit cowling. When all cement is dry, use thinner to free both parts from the fuselage. Set them aside for later reinstallation. The landing gear beam and its attachments comes next. Fabricate the beam as shown on the drawing, leaving 1/16" excess end stock for accurate fitting to the fuselage cross-members. This beam is 1/16" ply on each side of a 1/32" aluminum core sheet which carries the lugs for the landing gear wires. I used epoxy, cyanoacrylate, and common pins to make this sandwich solid. In the event you prefer to bind the landing gear wires to the cross members, this beam can be a piece of spruce of ⅛" ply, retained with corner blocks and ply gussets. Note in the side view that the fuselage floor vee bracing ties to the *lower* edge of the crossmember at the rear landing gear fitting.

My model uses a 5/32" OD aluminum rudder post tube to accept the fin spar dowel. Very careful use of a round needle file established a good fit and cyanoacrylate held it in place. Later thoughts caused me to also apply epoxy fillets just before covering it all up. You should do the same, being careful not to create interference with the elevator horn or tailskid mount. At this time the upper landing gear fittings should be made ready for installation. The upper gear fittings are 3/32" OD tubes ½" long inserted as shown in the drawings just beneath the longeron at the front center section strut. Again I used tube which was threaded 1-72 inside. The tube is finally made firm when the center section is bound and epoxied in place. I used a 4" piece of 1/16 music wire temporarily thru both tubes, across the fuselage to assure its alignment and location. Don't epoxy this wire in place!

The forward upper inner ply deck gusset provides a nose block retention tab and accomplishes load distribution into the fuselage. Cut and fit it but don't cement in place until the nose block retention is completely fitted.

Landing gear

Bend two landing gear wires very accurately from 1/16" music wire. Be sure there is no misalignment of the axle ends. The fuselage connection can be either as shown in the front view wire or thread binding epoxied in place, or you can use the sandwich center beam. This beam is drawn double scale.

The sandwich beam is epoxied into a solid unit after being drilled with a #60 and pinned with brass pins. Excess epoxy is sanded and filed away after curing. The beam is held in place by spruce corner blocks and ply gussets. It should be carefully fitted before installation.

The gear wires are tied together at the axle stubs by 5/32" OD brass tube axles. These tubes have inboard washers of brass which are a snug push fit on the tube and which have been slit in two places to allow for bending two tabs ⅛" apart, which are then drilled #60, making two lugs for the lower shock strut attachment. The axle tubes are inserted into these washers to protude about 1/16" on the lug side. Clean and flux the inside of each tube and the axle stub wires. Apply heat and Sta-Brite solder to the inboard wire, and the washer-to-tube joint. You can and should use the fuselage and dummy wood shock struts to get it all aligned. If the sandwich beam is used, be sure it is strung on the wires before soldering. Small wire wrappings soldered to the wire on each side of the aluminum lugs prevent sideways slippage.

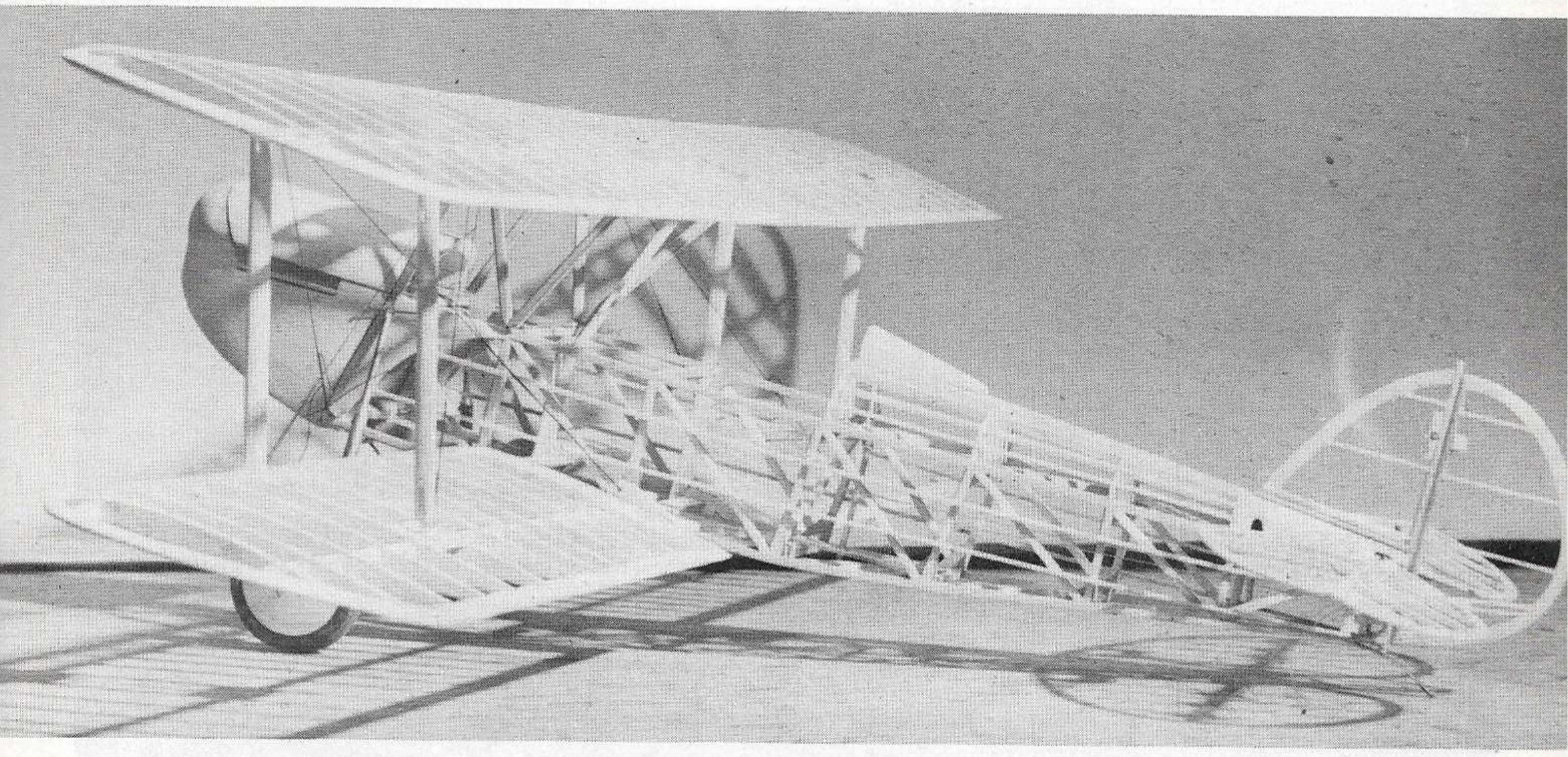
Bend the tailskid and mount it to the ply triangle. I soldered one dummy spring leaf of .010" shim brass to the top side of mine.

Wheels are laminated of ply and spruce, with discs cut from aluminum drink can bottoms epoxied in place along with 3/16 OD axle tubes. Wacos came standard with 26" x 4" wire wheels. Aluminum fairing discs were held in place with long stove bolts from disc to disc thru the wheel. Deluxe or special order airplanes came with 30 x 5 aluminum disc wheels which had brake drums. Williams Bros 1½" golden age wheels are just right for these.

After installing the wheels on the axles, add a ¼" OD washer and drill #60 thru the brass tube axle for a retaining pin.

Shock Struts

These items are functional and quite easy to make. The large cylinder is 7/32" brass tube with a ⅛" length of 3'16 tube soldered in one end as a bearing for the 5/32" piston tube which also has a short collar of 3/16 tube soldered at its supper end. I use Sta-Brite solder and flux. All these solder joints must have no solder outside the joint. Use flux only where solder is wanted and very small amounts of solder. All you want is a capillary film of solder *in* the joint. The upper cap for the cylinder is made of short lengths of tubing again with only capillary solder films in the joints. Its central core tube is slotted at the top end and a brass tab is soldered in the slot. This tab



is drilled #60 and then filed to shape. When assembled, a #60 hole is drilled through the cylinder and cap, for the final assembly common brass pin.

After cleanup, I sprayed mine with zinc chromate primer and then with color dope. Final assembly is made with ball point pen springs in the cylinder and the retaining pin is clipped and hot stuff touched to the head of the pin.

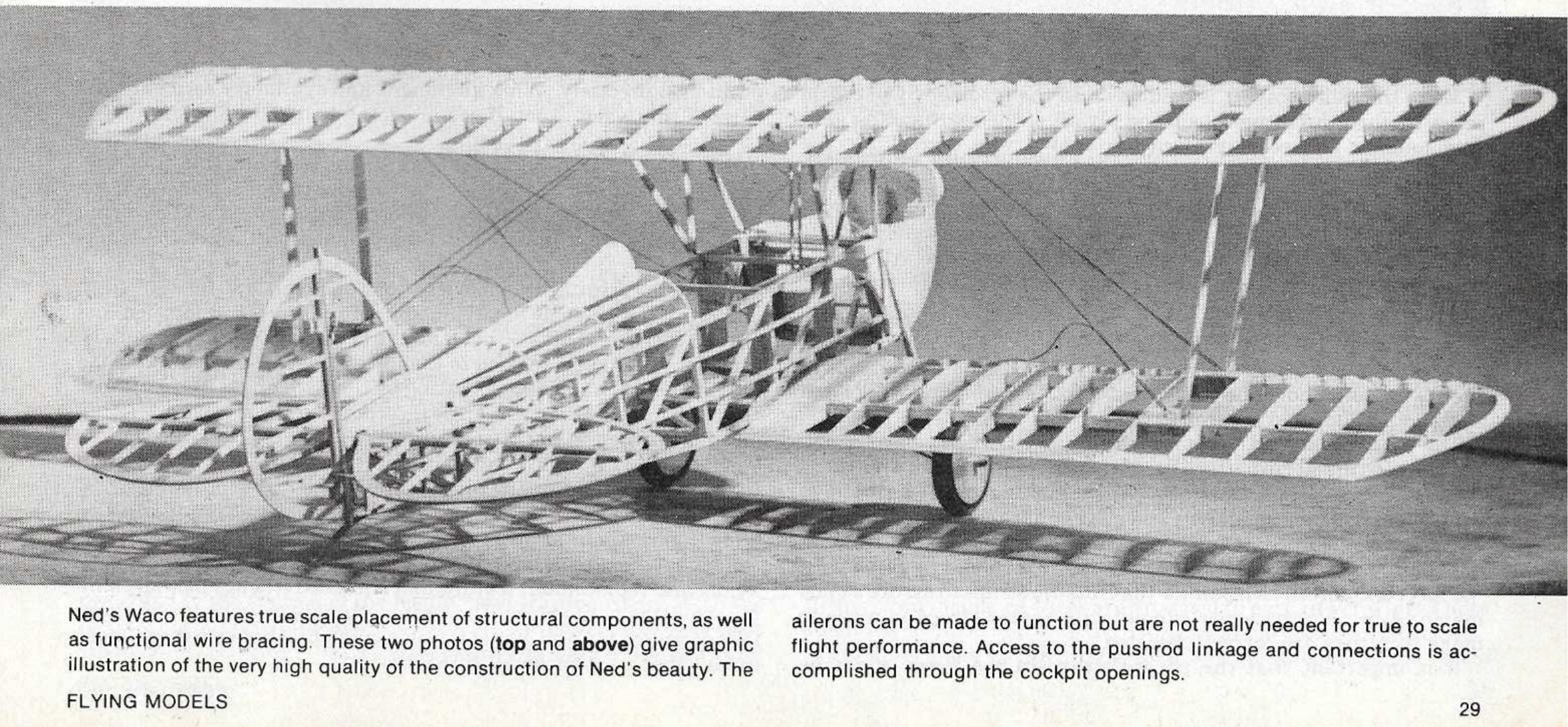
Control linkage

My model has a vertical shaft behind the rear cockpit instead of in the cockpit as drawn. Moving it forward will allow use of shorter push rods from the radio with easier access to connectors in the cockpit. The rudder is connected by monofilament cables to this shaft unit but the elevator uses a push rod in a forward guide or 1/32" cable and nylon tube. The drawing shows a balsa push rod and the rear elevator horn assembly of 1/32" wire and 1/64" brass.

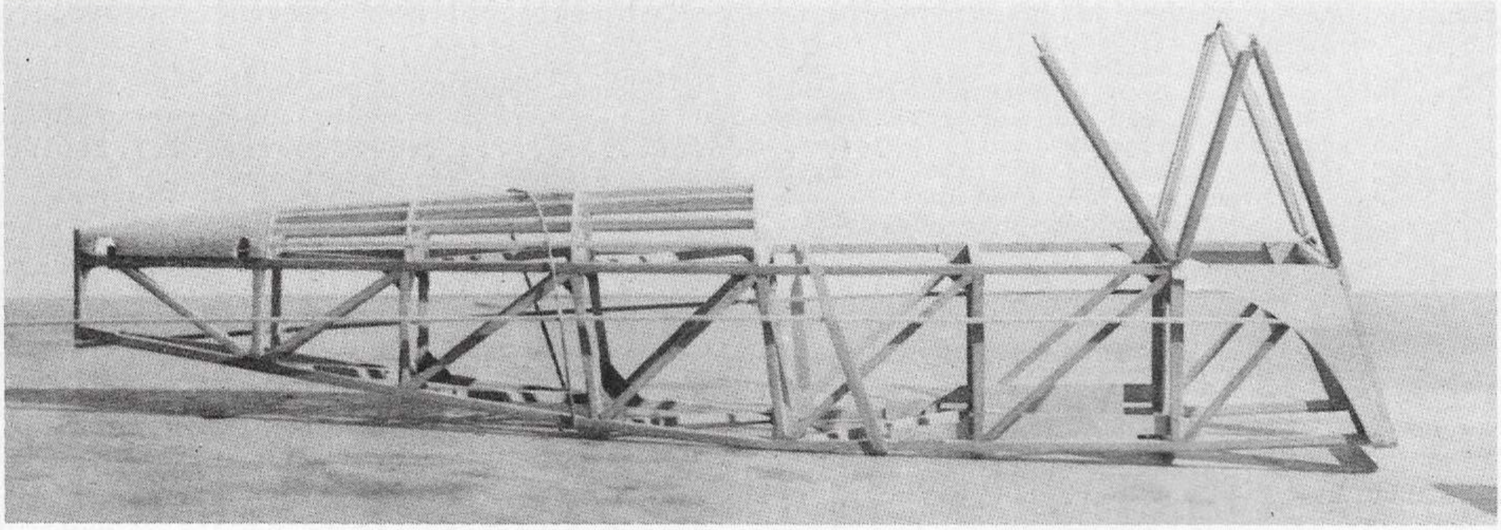
The elevator horn is bent of 1/32 music wire soldered to a brass lever. It is epoxied to the elevator spar dowel and laminated outline. Do this only after a trial assembly shows everything clears everything else. Install the elevator push rod and its forward guide. The stabilizer brace struts attach to mini hinge points cut short and epoxied to the stabilizer.

The fin/rudder hinging is similar to the stabilizer; one difference is that the fin spar tube must be slotted for the lower hinges and the fin spar dowel either slotted or cut off above the hinges. The rudder horn is connected by monofilament to the vertical jackshaft forward.

Carve an upper tail block of balsa, slot it for the stabilizer spars, drill it for the front fin dowel and then hollow it.

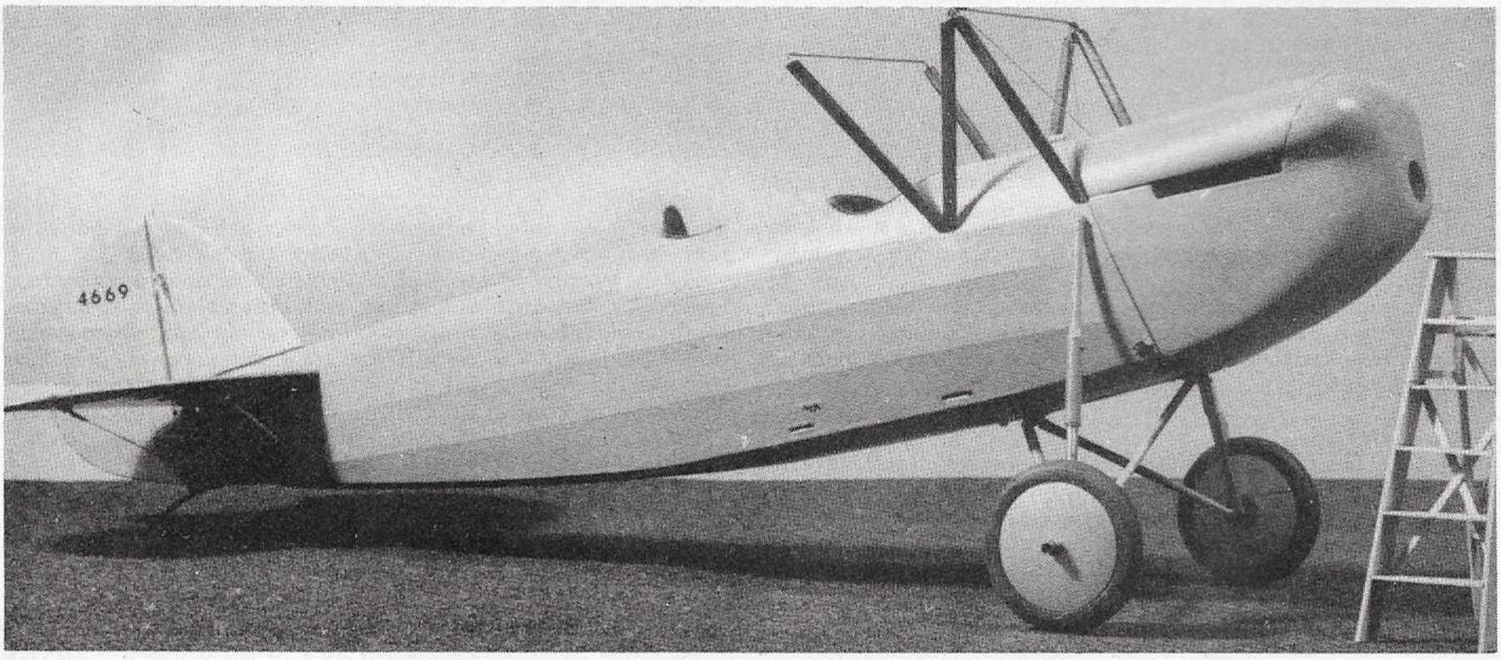


Ned's Waco features true scale placement of structural components, as well as functional wire bracing. These two photos (**top** and **above**) give graphic illustration of the very high quality of the construction of Ned's beauty. The ailerons can be made to function but are not really needed for true to scale flight performance. Access to the pushrod linkage and connections is accomplished through the cockpit openings.



The fuselage is constructed from balsa and spruce strips with plywood gussets providing the strength (**above**). Note the aluminum tail post.

The fuselage is covered and finished before the addition of the wings and monofilament bracing (**below**). The working shock strut evident here.



Make the radio tray. It is held down in the fuselage by one 2-56 screw up thru the corner block and ply aft of the rear landing gear attachment. The receiver location shown was correct for the airplane in the photos.

Install instrument panel details in the cowling, make cockpit cut outs and trim edges. Mount the center section strut assembly, binding and adding a bit of epoxy.

Wings

Laminate the wing tip bows from 1/32" balsa strip, using six strips. Now construct both upper and lower wings as continuous wings. This assures symmetry and minimizes errors. Do not install ribs in the lower wing under the center section. The lower sing will be cut apart to produce two separate panels.

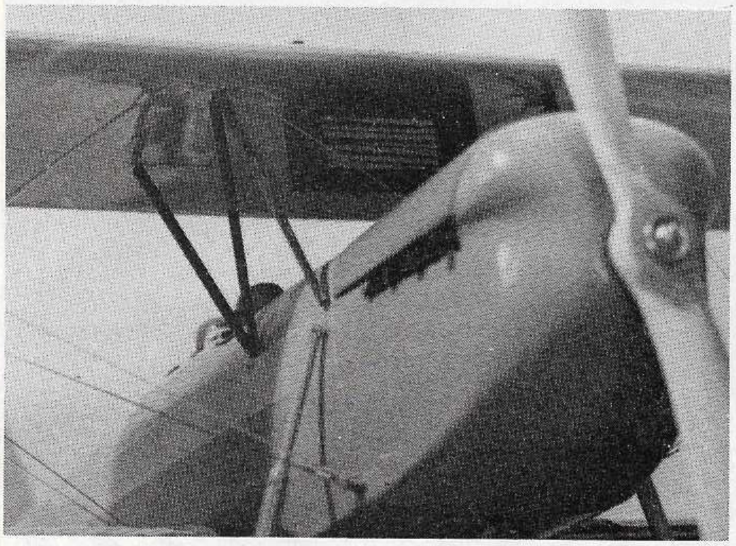
The wing ribs should be cut from medium to hard 1/16" balsa sheet. Make a good metal rib pattern first, with pinholes to permit marking the correct spar hole locations. When making pierced ribs it is convenient to drill a small hole and use a square coarse needle file to enlarge the hole until a sample of spar stock is an easy fit - snug but not tight. The lower wing inboard (butt) ribs should be faced with 1/32" ply ribs pierced as a pair for the cross-tie straps to assure a good match. Assemble the lower wing(s) with center straps in place to make sure they are correctly located.

It is important that the ply tie straps in the lower wings be positioned precisely. Wing alignment and symmetry cannot be assured if this is not exact. If you are going to install ailerons, now is the time. You're crazy if you do!

Add the ply strut-point doublers to the spars at this time and construct the upper center section strut wire troughs. Do *not* add the leading edge 'riblets' until just before final sanding and covering because they are fragile to handling damage until after the wings are covered.

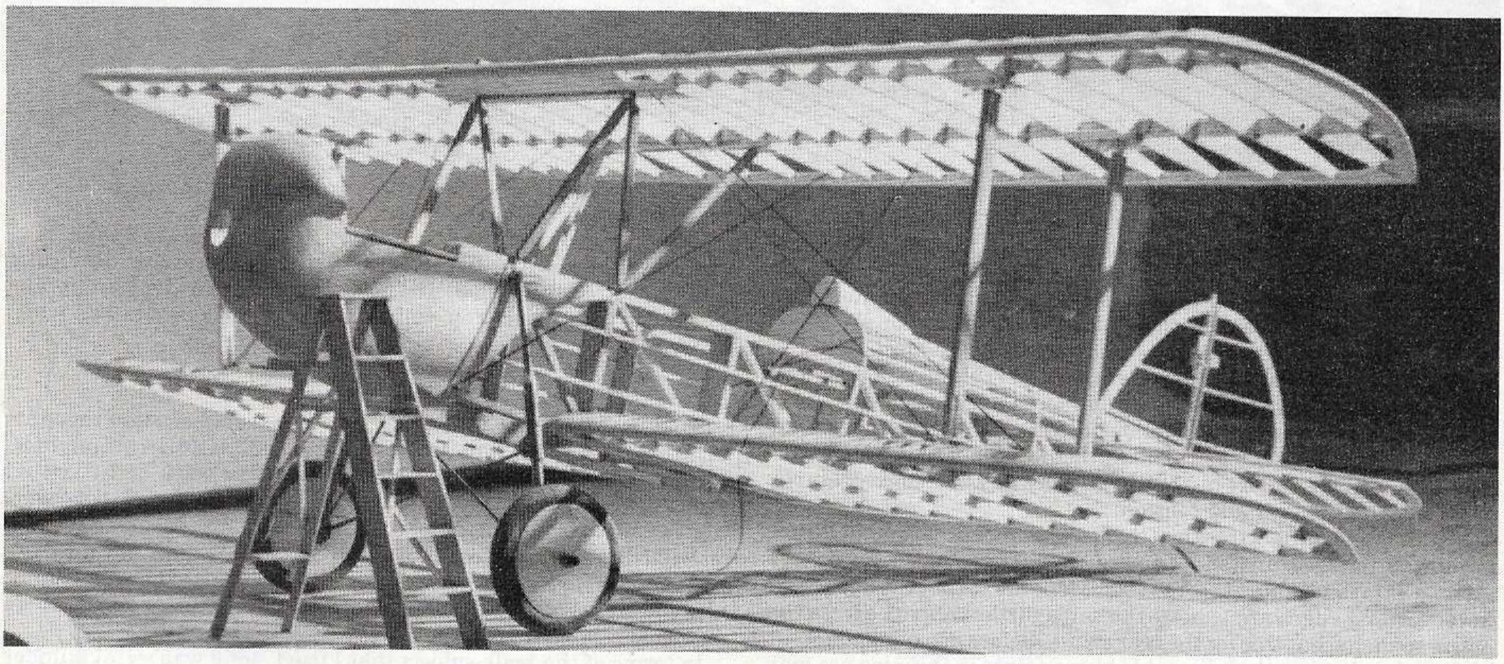
Locate the strut filling hole locations and drill #60 (or 1/32") first, enlarging the holes by small amounts until correct in location and size. At this time drill #60 holes for the brass wire rigging terminals. This wire should be epoxied to the ply doublers to increase its load bearing ability and prevent cutting by the wire under impact loads.

Adjustable strut length can be incorporated if you have a 1-72 tap and die. With these you can put threads on Robart Tiny Hinge Points and inside 3/32 O. D. Tubing. With short lengths of this tube epoxied in the spars, a strut fitting hinge point can be raised or lowered 1/72" at a time. This will make rigging adjustments very easy and will also allow replacement of strut ends that break. If you do not have or cannot get these tools, you can use the hinge points without the easy adjust and replacement feature that threaded fittings provide; simply epoxy them into place. This writer strongly believes the 25 bucks for a complete tap and die set is well worthwhile because there are so many other uses for small threaded parts.



The scale radiator is shown here (**above left**). Careful detailing is a must to achieve that "real" effect. Note the wire bracing fittings.

The addition of two scale pilots and a spinning propeller makes one imagine he is hearing the wind singing through the wires (**above right**).



The center section struts are made up from $1/32''$ music wire, with solder over fine copper wire binding at the joints. A jig is constructed and assembly of very accurately bent wire frames will produce a stong and accurate scale strut assembly. The strut wires are faired to streamline shape with plywood strips which are made up as tubes. This whole process (for this model) appeared as an article, "Center Sections and Cabanes" in the September 1978 issue of FLYING MODELS.

Mount, but do not cement, the upper wing. This is to let you make necessary alignment corrections. Shim strips of $1/64''$ plywood can be placed under the center section spars to adjust the upper wing incidence. When correct, the chord line will intersect the rudder spar $2\,9/16$ inches above the top longerons. Cut notches for the cross wires in the cockpit cowling edges at the front.

The lower wing now lacks any center ribs and has ply straps across the center. On these and the inboard spars the butt ribs and their ply doublers are still not cemented to spars or straps. These are cemented in position, using the lower fuselage as a spacer and alignment jig.

Use $3/32''$ ply temporary spacers to space the butt ribs away from the fuselage longerons on both sides. The butt ribs can now be cemented to the spars and the leading and trailing edges. With the lower wing panels defined by the butt ribs, the panels are ready to be cut apart at the center line of the fuselage. The wing walks and other detail work can then be completed, nose riblets installed, and after final sanding, covered.

Assembly and rigging

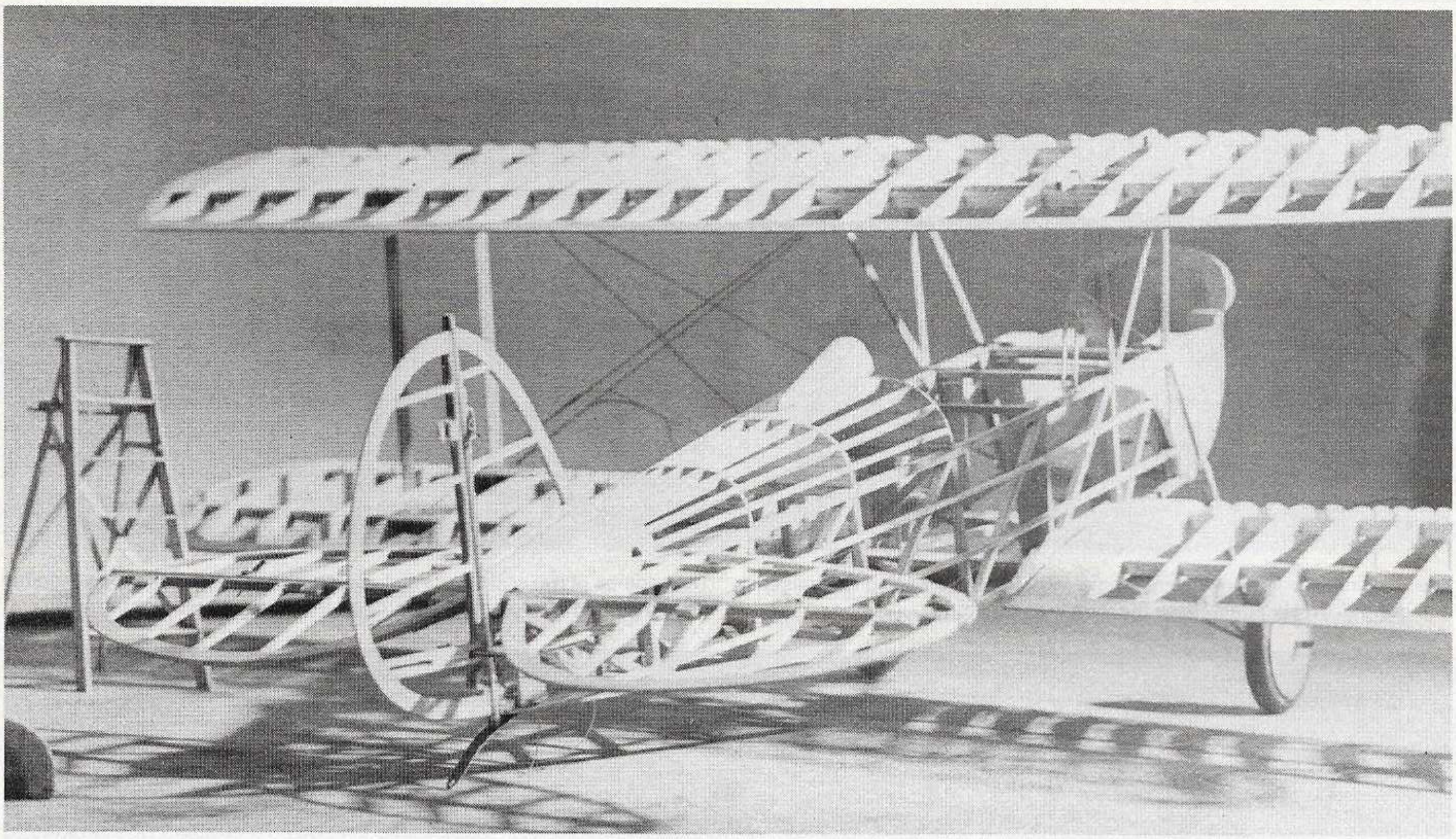
The wings are installed only when the fuselage, tail, and center section is completely assembled and painted, and front windshield, passengers and filler cap, are in place.

Start by inserting the lower wing tabs in the fuselage slots. The spar butts should be firmly against the basic fuselage frame leaving a gap between the inner rib and fuselage of about $3/32''$.

Check that the trailing edges lie on the same straight line and both trailing edges at the tips are equally distant from the tail post tube. Adjustment is made by careful sanding of whichever spar butt is too long. When the lower wing panels are correctly aligned remove them while the upper wing is similarly adjusted for alignment and incidence. When correct, place small amounts of epoxy in the ends of the spar trough. Take care not to smear the covering. Make final minor alignment adjustments before the epoxy cures.

When this has cured, cover the troughs and you can quit working in that constricted space. Attach two landing wires to the upper wing fittings at the center section and two lift wires at each fuselage fitting. Two incidence wires are attached to each upper wing. These should be crimped $1/16''$ from the fittings and the ends clipped neatly.

The interplane struts are made up over-length with mini-hinge



points epoxied only into the upper ends. The lower ends are going to be trimmed to set the gap. Use male points in the struts. Reinstall the lower wings and cement the ply tabs with connector ply strips which must hold the spar butts tightly against the fuselage.

Rigging is accomplished by leaving one ferrule loose enough to permit slippage. This slippage should not be too easy since we will tension the monofilament and allow it to creep or stretch overnight before final adjustment and really pinching the ferrule. Monofilament on impact stretches in a sort of gummy way but shortly returns to its installed length and tension.

Install the landing wires thru the lower wing pull loops but do not crimp the ferrules. Instead, use scotch tape to hold a temporary setting. Trim and adjust the front strut lengths so that the upper and lower leading edges are exactly the same distance apart across the entire span. Repeat this for the rear struts. Before epoxying the strut hinge points be sure the adjustable hinge points in the wing are four full turns from their bottomed position.

This airplane had no dihedral but models will look droopy if dead straight; so pull the front landing wire to produce 1/16" dihedral at the strut fitting. Now use the incidence wires to make the upper wing trailing edge parallel to the lower one. If all has been well done up to this point, only small adjustments should be needed.

At this point the rear landing wire is tightened to produce 1/8" to 3/16" dihedral at each strut station at the trailing edge. Now check that all previous rigging remains unchanged, readjusting where necessary. At the end of this round-robin of rigging adjustments the wings will be equally spaced, parallel, and there will be about 1/8" of washout at the wing tips.

The flying wires will of course require tension equal to landing wire tension in order that creep and stretch does not change rigging.

The author decorated his model to duplicate the shabby "ten" he flew. Factory finish however, was aluminum doped surfaces with a bright red fuselage, generally with an aluminum stripe. The Waco insignia was quite often placed on the baggage door.

Flying

Be absolutely sure that the C. G. is correct and that wing alignment and washout is exact. The old advice to test fly over tall grass still applies, as does the requirement for ground range radio checks. You will find *small immediate* rudder corrections as good as ailerons. Keep the wings level. It goes without saying that dead calm weather is recommended. The model has a low wing loading and relatively high drag. You will find this model durable and when necessary, repairable.

Afterthoughts

After building and flying this airplane a few random thoughts occurred to me that I want to share. First of all, 1/10th scale might be a better size. You could use the same wood sizes and it would probably fly very well with a Cox TeeDee .049. In the area of covering, I think that the plastic heat shrink coverings such as MonoKote or Solarfilm are too glossy for scale ships in general but they are light and strong. Using Coverite's Balsa Rite would be an excellent idea for all models in this size range. I used tissue for the fuselage and should have used it on the tail.

In terms of the scale subject that I used, 4669 was serial number 1740 according to my messy records. The fuselage was Berry Brothers Galatea Orange and the wings and tail were aluminum color. The struts were black. (It was some other colors before that.) The airplane was destroyed and burned in a fatal crash in 1936 or '37. The right hand cowl access door was blown shut in flight, it never had a latch of any kind.

Take your time building this ship and you'll really have something to be proud of for a long time.