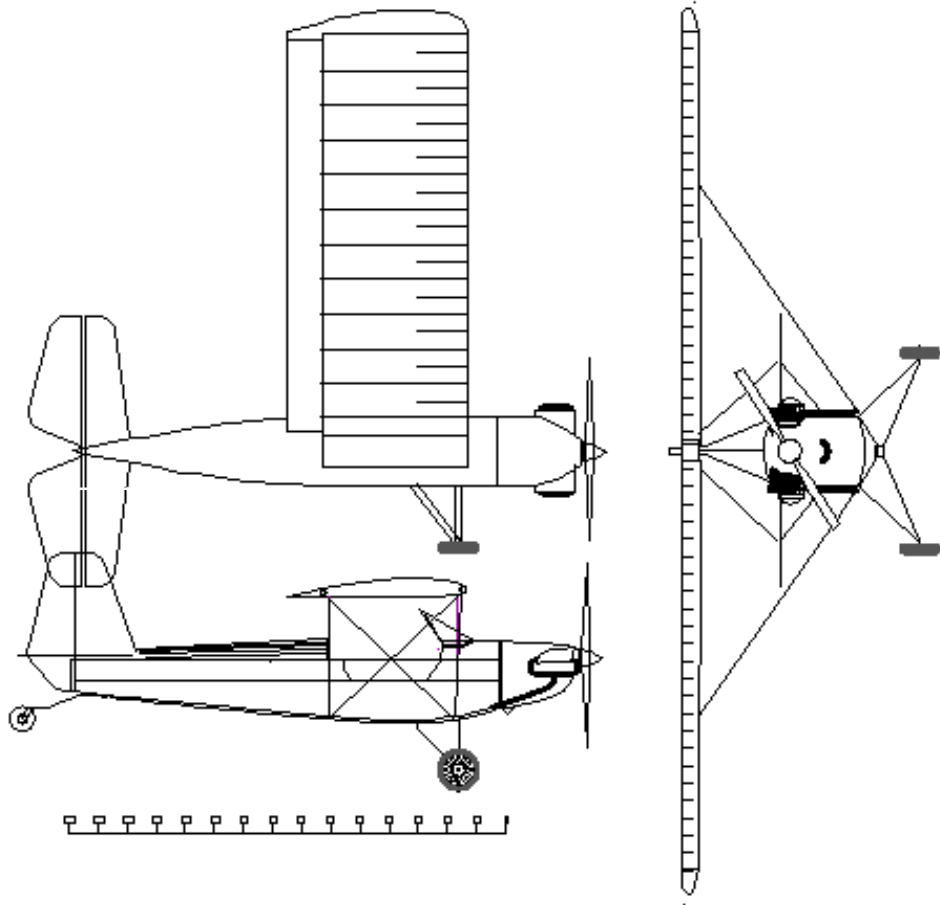


Texas Parasol

Builders Manual



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Aircraft operation involve various unique hazards. The pilot must assume final responsibility for aircraft operation.

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HISTORY

The Texas Parasol began as a quest for a simpler, stronger, less expensive alternative to the traditional "rag" ultralight airplane. Through the years, and much experimentation, the design has evolved into a truly nice flying, easy to build honest little airplane patterned after the Pietenpol Sky Scout of the 1930's. The construction, however, is thoroughly modern. Since 1980, over sixty of these little airplanes have been built by dozens of people.

Extruded 6061-T6 aluminum angle and AD type rivets make up the fuselage structure. This has proven to be so superior to pop-riveted tube in strength and ruggedness that most builders have vowed never to go back to pop-riveted tube construction. In fact, this has become the construction technique of choice around the San Antonio area.

Wings are built around aluminum tube spars with ribs routed from urethane, PVC, or Styrofoam sheets, and only take about a day to build from scratch.

The entire airplane is covered with light weight ceconite and traditional dope finishes like Randolph or Stits. Unlike the traditional covering practice, however, we are more concerned with weight than gloss. Enough finish is applied to seal the surfaces only.

Power plant options abound. Early airplanes mostly used Xenoa 2-stroke engines of about 40 horsepower. The power to weight ratio of the modern 2-strokers like the Rotax series makes them hard to beat for pure excitement, but some people still prefer heavier 4-stroke engines such as: Volkswagen, Subaru, Geo, Suzuki, BMW; you name it.



A plain-jane ultralight parasol powered with a 2 stroke water cooled engine.

DIMENSIONS and SPECIFICATIONS

Wingspan	26 ft
Wing Chord	4.6' (56-inch)
Wing Area	125 sq. ft
Aspect Ratio	5.8
Reynolds #	1.5 to 3 million
Empty Weight	252 to 350 lb.
Gross Weight	600 lb. max.
Useful Load	250 to 300 lb.
Wing Loading	6 LB/SQ. FT
Power	30 to 90 HP
Power Load	6 to 20 lb./HP
Fuel Capacity	5 to 12 gallons

PERFORMANCE

Stall	30 mph
Cruise	55 to 75 mph
Vne	100 mph
Rate of climb	depends on engine
Take-off distance	200 feet
Landing Distance	300 feet
Service Ceiling	over 12000 feet



Richard Lamb's VW powered Parasol, "Peanut Butter & Jelly"

TOOLS REQUIRED

There are not a lot of tools required to build this airplane. In fact, it can be built using mostly common hand tools. It certainly does not require an entire machine shop or the related skills. There are very few parts that need welding or machining, and these can be farmed out to local professionals for a few dollars. Some tools, such as a rivet gun and compressor, might be borrowed, or the project taken to someone who already has them. The following is probably a minimum requirement list:

Recommended Tools:

Flexible tape measure - 16 feet or longer
Carpenters square
Carpenters level
Metal snips
1/4-inch Socket wrench set
Open end wrench set
Vice Grips (Several small needle nose)
Assorted metal files
4-inch or larger bench vise
3/8-inch hand drill (not battery powered!)
Spring center punch
Clecos (mostly 1/8-inch) and Cleco Pliers
Hacksaw with metal cutting blades
Pop rivet tool

Have Access to:

Hand Router
6 foot Sheet Metal Shear
6 foot Sheet Metal Break
Drill press
Compressor and rivet gun
Paint sprayer
Welding torch
Metal Lathe
Metal Mill
Vacuum cleaner
Band Saw
Cut-Off or Chop-saw
Saber saw, metal cutting blades



Doc Harr's VW powered aerobatic "Lucky Lady"

FUSELAGE CONSTRUCTION

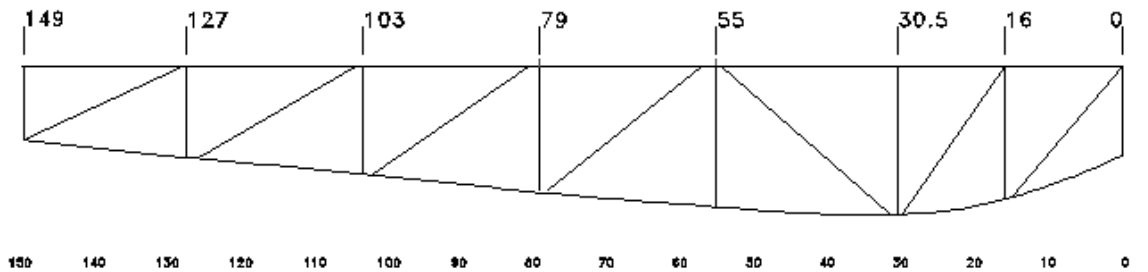
Building the fuselage structure begins with the construction of a worktable. The table should be 12 feet long and about 3 feet wide. 2x4s and plywood work fine. It doesn't have to be built like the Ark, but it should be fairly sturdy, flat, and level. Scrap plywood can be cut into triangles to brace the legs. Lag screws on the bottom of the legs make leveling the table easy. Assemble the table with wood screws so it can be disassembled when the airplane is finished.

Attach a pair of long straight 1 x 2's to the long edges of the table top with wood screws. These will be used as alignment guides to hold the top longerons in place while fitting the pieces of the fuselage. Select very straight pieces for these.

The top longeron is straight from station 0 (the firewall) to station ###.# (the tail post). All vertical members are perpendicular (90 degrees) to the top longeron. Measure aft from station 0 (the firewall) to locate the stations for the verticals. Draw the verticals the full width of the table.

While the fuselage sides look the same on paper, they are NOT interchangeable. There is a LEFT side and a RIGHT side. **The flanges of the angles face INBOARD and DOWN.**

One fuselage side is drawn and built on one side of the table, then, once constructed, the completed truss is flipped over to the other side of the table and traced. In this way, the side trusses can be built as mirror images of each other. Using this angle construction technique, it is just not practical to build both sides from one layout; but it's not really a problem either. Just make sure you don't accidentally make two left sides!



Fuselage Truss Layout

Measuring down from the top longeron at each station, locate the intersection with the bottom longeron. Use a builders square or a large drafting triangle to make sure the verticals are perpendicular to the top longeron. It is not necessary to draw the diagonals; they will not actually intersect at the verticals; rather, they attach to the longerons just aft or forward of the verticals. Carefully note where extra room is needed to allow access for cross pieces (intercostals), mounting bolts, etc. Also, pay careful attention to the direction each angle faces when it is installed.

Lastly, draw a centerline the length of the table. This will not be used for making the sides, but it will be needed to align the sides when it comes time to assemble the fuselage.

FUSELAGE SIDES

Fuselage stations are given in inches. Directions such as right, left, front, back, etc. are in reference to the pilot's point of view, even if the structure is upside down on the worktable! OK?

The aircraft datum point (station 0.0) is located at the firewall for simplicity of measurement. While the datum can be located anywhere (sometimes it is located at the tip of the spinner!), things are a lot easier to deal with if the datum is somewhere that can be easily found. The firewall serves this purpose admirably. The downside, of course, is that measurements forward of the firewall will have a negative sign (for weight and balance purposes only).

Cut the top longeron 149-1/2 inch long and lay it on the table with the vertical edge flush with the table's straight edge. Align the forward end at station 0, and secure the longeron in place with wood screws and large diameter washers screwed into to the table.

The bottom longeron is 150-1/2 inch long (i.e.: the remainder of a twenty-five foot piece of extruded aluminum angle). Obviously, this is one place you'll want to measure carefully to avoid wasting material.

Drive a few nails firmly into the table develop the curve of the lower longeron. Nail a few small wood blocks flush outside the curve of the aft section of the longeron to hold the proper curve.

Lay the station 0 (firewall) end in place and screw loosely it to the table. Pull the longeron around the forward nails and inside the aft block to meet the desired curve. You will notice that the curve causes the aluminum angle to try to roll away from the table. Drive a few wood screws with large washers into the table in the appropriate places to lock the longeron into place.

The vertical piece at the firewall is cut from 1-inch angle stock. Cut to size and file the ends to fit neatly into the radius of the longerons. Once the vertical member fits nice and flush on the longeron re-check the alignment and, when satisfied that the piece is OK, drill a #30 hole through the vertical and longeron and install a cleco.

Locate this first hole so that there is room for another hole to be added later to the same joint. Remember that all joints get two rivets. In some joints, this is going to be a bit close. Locate the rivet holes so that they are at least one rivet diameter from any edge. Also, don't get them so close that the rivet heads overlap!

Make up all of the necessary gussets before hand to speed the assembly task. Where a gusset is called for, slip it in place before drilling. It's fairly easy to drill one hole in each member, cleco it, then drill the next member and cleco it - until all the members of a cluster have been drilled and have a single cleco in them.

Then go back and drill the second rivet-hole in each member for the second rivet. It helps a lot to set your drill bit long enough to clear the clecos already installed. A short drill bit will cause the drill chuck to grind on the existing cleco - making it much harder to put the hole where you want it.

Repeat this process for the vertical members at all other stations. Remember that these verticals are perpendicular to the TOP longerons.

A carpenters-square or large drafting triangle works well for aligning verticals while drilling rivet holes.

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Always check which way the pieces are oriented at each cluster, and the proper placement of members of a cluster. For the most part, flanges of angles face IN and DOWN.

Once the verticals are in place, go back to station 0 and cut and fit the diagonals. Trim the ends to fit flush against the longerons. Note that the diagonals are not jammed up against the verticals. There must be room for cross-members, landing gear mount bolts, cabane mount bolts, etc. Remember, do not snug things up! If you place pieces too close together, you are going to have a miserable time trying to get a bucking bar in there!

Since there are varying thickness of metal to rivet, it may be necessary to trim rivets to the proper length before installing. Rivets should extend 1-1/2 diameters past the structure. Any less will cause the shop heads to be too small, any longer and the shop head tends to wander and bend over.

The clecoed truss should be sturdy enough to remove from the table if handled gently. An easy approach to the riveting job is to clamp the truss upside down between a pair of saw horses or the worktable. Use C-Clamps or Vice-Grips to lock the top longeron to the sawhorses. Rivets are installed from the outboard side and the shop head formed on the inboard side. That means the bucking bar will normally be held inside the structure. A small V shaped face on the bucking bar gives the bucker easier access to rivets hidden in tight corners.

The other fuselage side is built the same way, except for the orientation of the aluminum angles. Remember - FLANGES FACE INBOARD and DOWN. Place the riveted truss back on the table, but flipped over, with the top longeron on the other side of the table. Align the firewall (station 0) with the marks from the original layout so that all the other stations will fall in place. Trace around the curve of the bottom longeron and diagonals. Nail the form blocks in place and build the other side.

Riveting Note: There has been a lot of controversy about the double rivets per joint. Traditional aviation standards for thin sheet metal riveting dictate minimum edge margins and hole distances. In addition, engineers point out that the double rivets can actually fight each other, as one tends to be the pivot while the other one gets sheared. While all this may be true, we'd like to point out that there has never been a problem with a broken joint.

Still, if you'd prefer, a single 6/32 inch diameter rivet can be used in each joint.

FUSELAGE ASSEMBLY

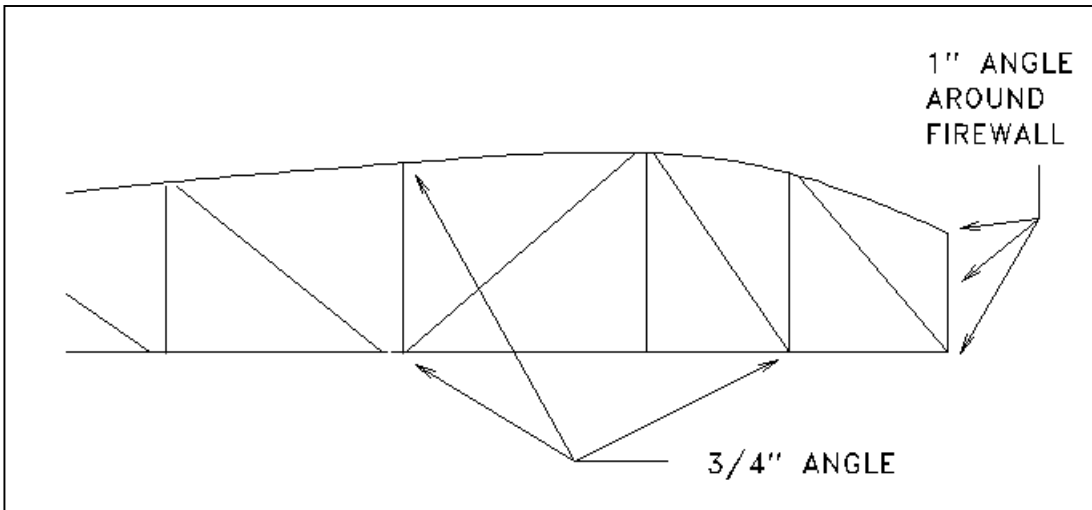
Fuselage assembly begins by standing the fuselage sides upside down on the table. Since the structure is upside down, we have a great opportunity to confuse ourselves by saying top and bottom.

In the following description, the term top refers to the top of the structure from the pilot's point of view - as if it were right side up - i.e.: as if you were sitting in it! OK?

Square the firewall end so that both sides are even with each other and parallel. The sides must remain parallel through the cockpit section. Make sure to keep the sides vertical. Clamp, nail, or screw them in place temporarily.

Cut and trim the following cross-members (these are all the same length):

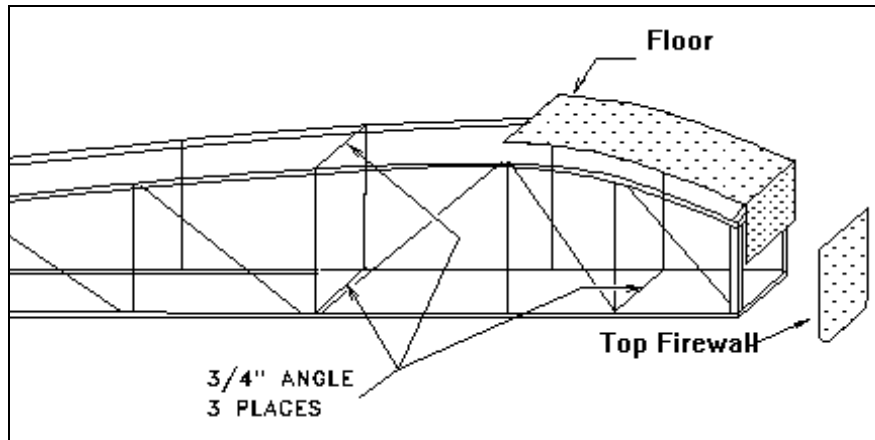
- Two pieces of one-inch x one-inch x 1/8-inch angles for firewall cross-members.
- Three pieces of 3/4-inch x 3/4-inch x 1/8-inch angles for cockpit area.



Location of First Fuselage Cross-members

Take careful note of which way each angle faces. Place the one-inch firewall cross-members in position inside the front of the fuselage sides (top and bottom). Place two of the 3/4-inch pieces at the top and bottom of the aft cockpit frame. The third piece of 3/4-inch angle goes across the top longerons in front of the instrument panel. Temporarily clamp these in place. Small vice grips, especially "needle-nosed" ones, will work great for this.

Next, move to the front of the fuselage and fit the firewall / cockpit floor sheet. Cut the sheet aluminum to width and make the 90-degree bend about 6 or 8 inches long for the bottom of the firewall. Put this in place on the lower firewall and line up the edges. This will help square the front end of the fuselage.



Sketch Showing Preliminary Fuselage Assembly

Double-check the alignment and fit of EVERYTHING. Use a large carpenter's square over the longerons to make sure each station is square, and make sure the sides are parallel.

Once you are completely satisfied that everything is in the proper place, you can start drilling and clecoing the cross-member joints. Also, drill and cleco the floor - firewall sheet metal. This is attached with AD470 rivets spaced every 3 or 4 inches to install the firewall and floor. Place filler strips of 1/8-inch thick wood or aluminum between the firewall sheet and the one-inch cross-members to keep the rivets from cratering the firewall.

Make the landing cross-members pieces at frame 3 from 1-1/4-inch x 3/16-inch 6061-T6 angle. Carefully locate the bolt holes for the gear cross-members in the longerons as it is easy to get them too close to the longeron flange which will make it difficult or impossible to get the bolts to seat properly.

The culprit is the radius inside the extruded angle and interference from other members of the cluster. Take a 3/4-inch wide strip, subtract two 1/8-inch flanges and you are left with only 1/2-inch to play with! (See Methods and Madness for more info).

Note where the bolt holes are located, and how much room is available around them. Fit the gear cross-members in place on the fuselage and clamp. Obviously, make sure these are centered and square to the fuselage. Locate where you want to drill through the longeron and drill there. Use the holes in the longerons to locate the hole positions in the cross-member angles. Then install the cross-members angles with AN-3 bolts.

Remember, you do not want to drill bolt holes through the center of the longeron! That will put the bolt head too close to the flange, and the bolt heads won't fit!

At this point, the front of the fuselage is aligned and squared, and will pretty well hold its shape. Next, we move to the tail and pull the fuselage into final shape.

Before installing the tailpost plates, mark the center of the cross pieces at the cockpit and firewall. These marks will be used to insure that the fuselage is straight.

Cut out the tailpost plates from .080 to .125 aluminum. The top plate has a one-inch hole for the tailpost to pass through. Clamp the tailpost plates to the longerons with vice-grips, and check the alignment with the string by stretching a string from the firewall to the tailpost. If the string hits the marks at the firewall, the center of cockpit, and the center of the tailpost hole, the fuselage is nice and straight! If not, adjust the longerons and tailpost plates so that it does all line up properly. Take your time with this operation. Once these parts are bolted, the alignment of the entire fuselage is permanently set.

When it is all as good as you can make it, drill the bottom tailpost plate and longerons for a 3/16 bolt on each side. This bolt, besides holding the tailpost plate in place, also serves as the attach point for the bottom stabilizer brace wires AND the tailwheel leg bracket. Bend a pair of stainless steel tangs to the appropriate angle, and bolt the tang, tailpost plate, and longeron together. The bolts will hold everything steady while you drill the bottom plate for 1/8-inch rivets.



Tailpost Plate and Elevator Mount Tabs

Flip the airframe right side up and install the top tailpost plate. The 1" hole for the tailpost can be cut in the plate first. Then put the plate in position and clamp. Make sure the edges of the 1" hole are at least 1/8" from the edge of the longeron to allow clearance for the vertical webs of the longeron material. Trim the ends of the longerons so that the sides align with the tailpost plates. When in proper place, clamp well and cut the 1" hole through the top flange of the longerons as well.

Drop the tailpost tube in place. Inspect it to make sure it is square and straight. Eyeball it from the firewall end to see that it continues straight up the aircraft centerline and not angled off to the right or left. From the side view, it should be square with the top longeron -- not swept back or forward.

Install the tailpost with its inner doublers and outer sleeves as shown in the drawings. Again, make sure it is vertical and square to the fuselage. Drill through the outer flange of the longerons from each sides—then run a long drill bit through both sides. Install with a long AN-3 bolt and washers on both sides. The washers will keep prevent the bolt head and nut from digging into the soft aluminum.

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Make the cockpit cross-members from 2" x 1/8" angle and bolt them in place. Later, the seat will be installed, but for now, the cockpit cross-member will serve to stiffen the fuselage tremendously. Before installing these, however, drill the cross-members for the necessary holes for the control stick torque tube and rudder cable fair leads!

Cut and fit the cockpit cross-members and bolt them in place. These are made from 2-inch x 1/8-inch 6061-T6 angle. Later, the seat will be installed, but for now, the cockpit cross-members will serve to stiffen the fuselage tremendously. Before installing these, however, drill the cross-members for the necessary holes for the control stick torque tube and rudder cable fair leads!

A single diagonal cross brace is located at frame 4. Make very sure the fuselage is square when measuring and fitting this piece as the structure suddenly becomes quite rigid.

Now, start fitting the intercostals (cross pieces on the top and bottom that go from one side to the other) at each frame. Watch the fit at the ends of the pieces -- match the angle of the longeron, and make sure to allow for the radius inside the longerons.

Square the cross pieces against the centerline (string) and clamp in place with vice grips, then drill and cleco. Remember that all joints get two rivets. Make double sure of the hole locations before drilling and riveting

Be careful not to put rivets where bolts or other parts will be located later.

Give the fuselage a careful inspection, then crawl in, and make airplane noises. When people start looking at you funny it's probably time to get back to work



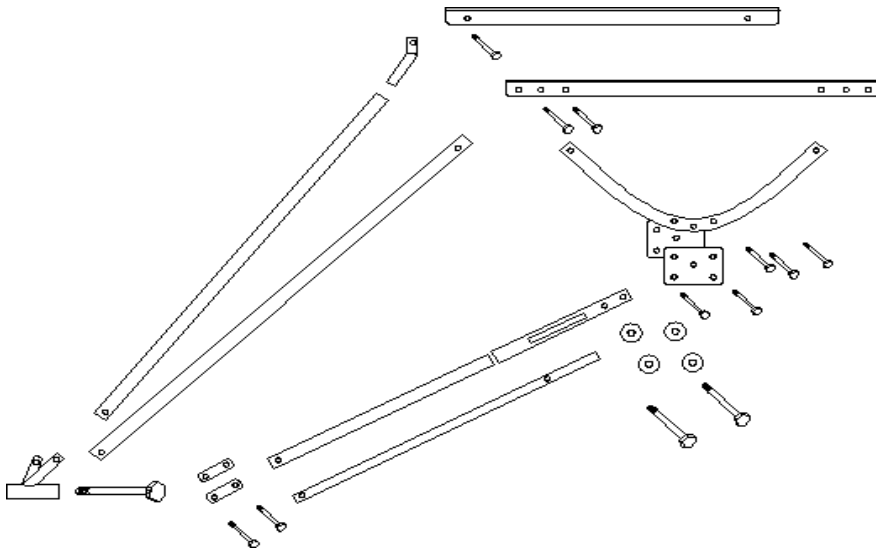
LANDING GEAR

The main gear is mostly bolted aluminum tube with heavy wall steel clusters at the hinge points. Only the center V section is bent. The remaining parts are all simple straight tubes.

The axle clusters are probably the most difficult parts to make as they each involve three separate pieces that must be held in rather accurate alignment. Next is the rear leg upper cluster, which has two pieces welded together to give the correct angle. These steel pieces slide inside the aluminum landing gear leg tubes.

We found it easiest to bolt the steel clusters in place on the fuselage and slip the leg tubes on them to visualize the angles. Cut and grind the rear top cluster parts to a mating angle that brings the lower end of the rear leg into place at the axle.

Run a long piece of all-thread through the axle tubes or block them in place on a long



Exploded View of Landing Gear Parts

straight board. Then cut and grind the axle cluster stubs to mate with the axle tubes. When everything is in place, tack weld the clusters to hold them in correct alignment. Then, disassemble the legs, and finish welding the clusters.

If you are going to install brakes on your airplane, weld a steel plate to the axle cluster to carry the braking torque. These won't need to be very big, but they do need to be fairly sturdy. Size and position will depend on the brake setup you use. While the torch is out, consider adding the mount plates for wheel pants if you are going to install them. The axle itself is made from a 6 1/2-inch (or so) long 1/2-inch diameter grade 9 bolt. (Use the size that matches the wheels you want to install).

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Carefully cross drill the head for a 3/16 bolt. Place a tang on each side of the head and attach with an AN-3 bolt. Since this joint will have some motion, use washers under both the head and nut. Snug the nut down to remove any play, but don't over tighten. The other end of the tang is bolted to the slider tube assembly.



Cutting the slot in the slider tube may present a tough challenge. It's really easy to do on a mill, and can be farmed out if desired.

Doing it with a drill and hacksaw is possible, however. Just be careful to get the slots straight and the edges smooth to prevent binding when the gear works.

When the whole thing is bolted together, wrap several turns of safety wire or rope around the bungee retainer bolts (AN5 or 5/16" grade 9) to secure the gear for the time being. Later, after the engine is installed, this will be replaced with bungee cord. It's almost impossible to guess what the right tension should be. Waiting until the engine has been installed will prevent having to re-wrap the bungees.

Final bungee installation is simple, but is a lot easier with two people.

Each shock cord is attached as follows:

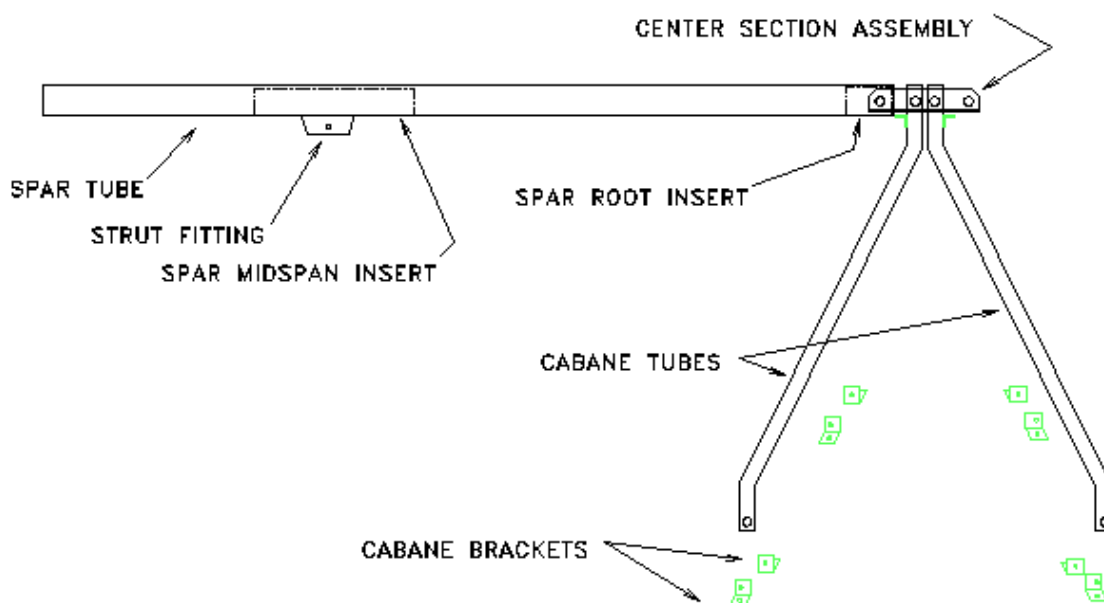
Four pieces of bungee are used (two on each leg). Double a piece of safety wire, take two turns around the bungee and leg tube, pull tight and twist normally. Pull the bungee tightly around the retainer bolts six turns and wrap the end with another doubled piece of safety wire. One bungee goes on front, another on the back. When finished, wrap both ends with another piece of doubled wire. It may sound crude, but works really well.

The tail wheel leg is cut from 1/8-inch 6061-T6 tube and bent per the drawings. The front end is bolted to a heavy attach bracket located inside the lower longerons. At the aft end of the fuselage the leg is held on with a retainer strap. Flatten the ends of a 5/16-inch dia. steel rod, drill 3/16" dia. Holes in each end, and it into a U shape. This retainer goes under the tail wheel leg and bolts through the lower longerons and tailpost. The tail wheel itself is an industrial castor with a steel tube welded on to act as the steering horn.

CENTER SECTION

Before installing the center section, decide on the engine that will be used. This is necessary because the wing is mounted in slightly different locations depending on the engine weight. Light two-strokers have the wing mounted as far aft as the center-section will allow. Heavy four-strokers need the wing to be located further forward. This dictates where the lift struts will attach to the fuselage also.

With the wing in the AFT position, the front lift strut should attach to the FWD main gear cross-members. With the wing FWD, an extra pair of 1x1x1/8 inch angles are added under the fuselage forward of the main gear cross-members for the lift struts. (See the photo of Doc's airplane on page 6.) The other option is to cut the forward lift strut plugs to match the angle required to mount the lift struts to the main cross-members – and I wouldn't wish that on my worst enemy!



Cut eight cabane brackets from one-inch angle. Match drill one side of each pair with 3/16-inch holes for the cabane mount bolts and drill the other side for longeron attach bolts. Mark the matched side so you don't accidentally install the thing wrong side up and have problems installing the bolts through the cabane struts!

Locate these on the top longeron, drill, and bolt in place. The front cabane strut is located about 16 inches aft of the firewall. When the airframe is level the front cabane will be directly above the front landing gear cross-members. The rear cabane strut is located 40 inches aft of the front strut. **LOOK UNDER THE LONGERONS BEFORE DRILLING!!!** **There must be enough clearance for nuts on both cabane brackets.**

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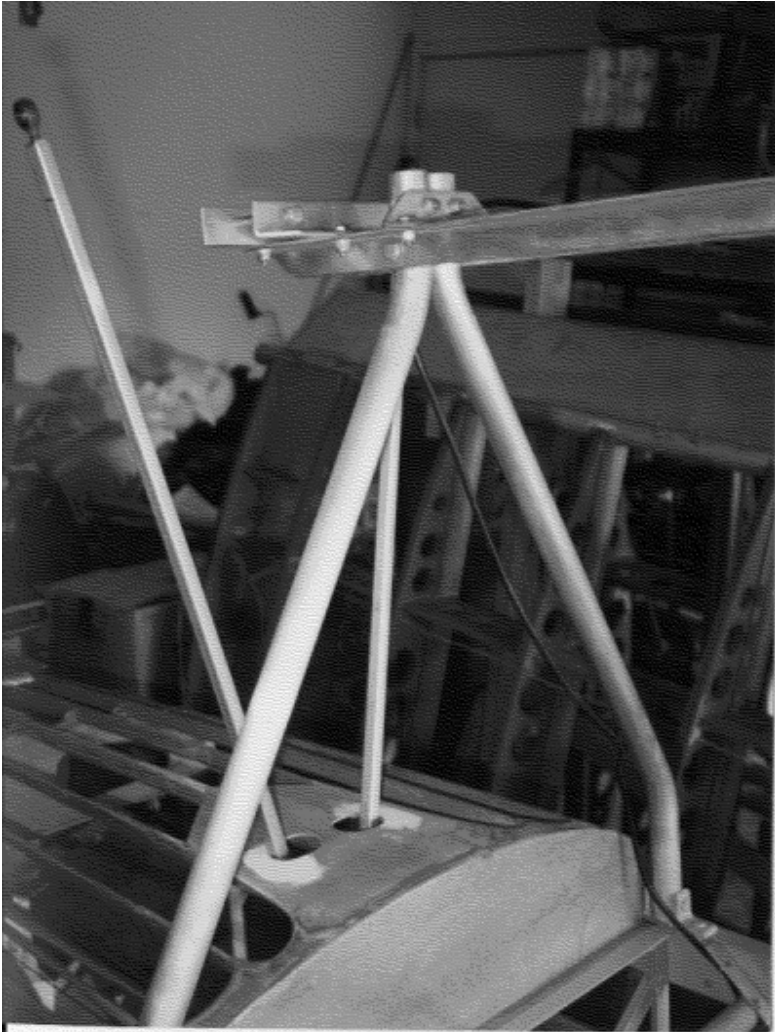
Cut and bend the cabane struts according to the drawings and bolt them in place. Make sure the cabanes meet at the aircraft centerline. Drop a plumb bob from the top of the cabanes to check alignment. Clamp a straight edge at the center of the firewall and eyeball the center of the firewall, both cabane struts, and the tailpost. The cabanes will move easily—side to side.

Don't worry if the tops don't come out exactly flush. Just get them centered. They can be trimmed flush later.

Layout the upper center section structure (for some reason this is called a "tree") according to the drawings (see D-WING2A for two-stroke engines or D-WING2B for heavier aircraft with four stroke - four cylinder engines).

Drop the top center section in place on the cabanes and carefully check positioning and alignment.

The center section will set the angle of incidence and the lateral alignment of the wing, so make sure it is level and properly positioned. Check with a level across the "ears" of the tree.



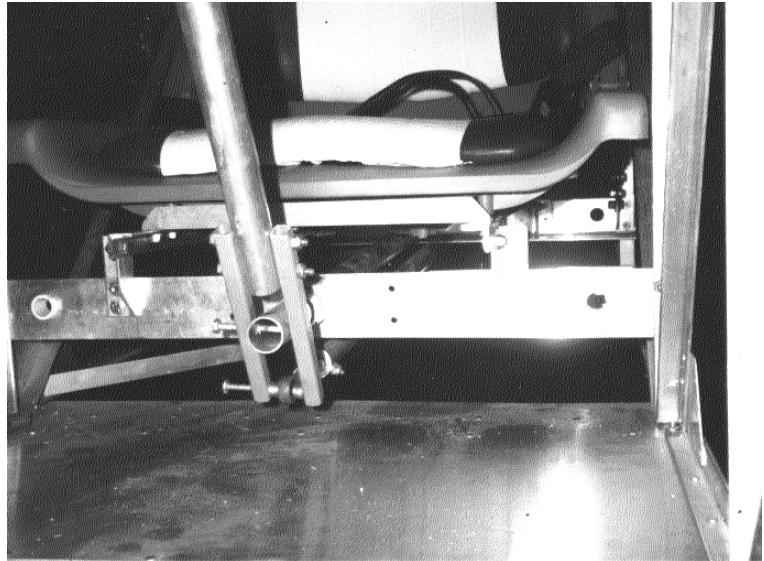
Set the front end about two inches higher than the rear end to provide the proper angle of incidence.

Drilling the center section and cabane struts is a lot easier if the center section assembly is marked, then removed and disassembled for drilling. The long pieces can be clamped together and match drilled with a 1/9" pilot hole. When reassembled and reinstalled, the assembly can be clamped to the cabanes and a 1/8" hole drilled in the cabane struts from each side. Use a long bit. When you can get the bit through the pilot holes on both sides, increase to a 3/16" diameter bit and drill straight through.

COCKPIT

• PILOT'S SEAT

A small plastic boat seat with a folding back makes for a comfortable and neat looking office. Remove the swivel (if it has one) and arrange the seat rails to meet at least four screws under the seat. It will probably be necessary to carve a bit from the underside of the seat to clear the control stick torque tube. A Dremel type motor tool and a 1/2 inch sanding drum does a neat job if the speed is kept low. Otherwise, the plastic melts onto the sanding drum and makes a mess.

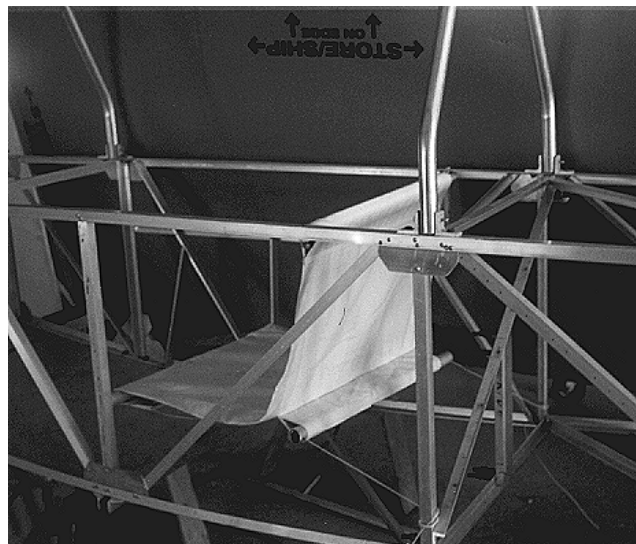


The seat rails for a "boat seat" are 1-inch x 1/8-inch angles attached to the 2-inch cross pieces by means of small brackets cut from scrap one-inch angle. These must be positioned according to the type of seat you intend to install.

Ultra-light builders need to keep a careful eye on weight. Either use the fabric sling type seat, or find a very light plastic or fiberglass seat. The sling seat shown here is made from 10 ounce duck. The seat is once piece, and the bottom aft loop is added as another piece. The sling is tensioned with cords through the grommets under the seat and a pair of 3/32" cables pulling aft and down.

If the cushions are removable they do not count for empty weight. Something to keep in mind.

A good place to tie in the seat belts is at the cockpit cross-member at frame 4. If an automotive seat belt is installed, it might be necessary to extend one side a bit since one side is usually short. Make the extension from 3/32-inch aircraft cable with a Nicopress thimble at each end. Put one thimble through the belt end fitting before squeezing the collar. Put the belt in place with the latch where you want it before making the other end so that the belt will fit properly.



INSTRUMENT PANEL

The instrument panel is cut from aluminum sheet (.032 to .050). Use a 3 1/8-inch and 2 1/4-inch hole saws to cut holes for standard aircraft instruments. Automotive instruments come in various sizes, but hole saws are cheap. Get one to fit your gages.

Bend two pieces of 3/8-inch aluminum tube to match the outline shape of the instrument panel. This fits just inside the edge of the panel. This tube is bent by hand, so be careful and go slowly. Check against the instrument panel blank often. Try to get as flush a fit here as humanly possible since any gaps or bulges will show big-time when the front deck is installed.

Pop-rivet one tube to the front side of the panel and the other to the back side of the firewall.

The front deck cover sheet will be pop-riveted to the framing tubes later.

- **FLIGHT INSTRUMENTS**

Flight instruments and radios can easily double (on in our case TRIPLE) the cost of the airplane as well as increasing empty weight. This is strictly a fun airplane for DAY - VFR flying. For experimental registration, the feds want you to have an airspeed, altimeter, and compass. Ultralights have no federal instrumentation requirements. Hand held radios and GPS navigation units do not count against empty weight.

- **TWO-STROKE ENGINE INSTRUMENTS**

An Exhaust Gas Temperature gauge (EGT) should be considered mandatory on all 2-stroke aircraft engines. It's really more important than a tachometer (although you'll probably want a tach too). If your engine is liquid cooled you will want to add a water temp gauge.

- **FOUR-STROKE ENGINE INSTRUMENTS**

For air cooled engines, a bare minimum would be a tachometer, oil pressure, and oil temp. Cylinder head temp (CHT) gauges are highly recommended -- otherwise, you just don't know. Liquid cooled engines need a tach, oil pressure, and oil temp. CHT gauges here are a waste of money and panel space.

FRONT DECK

To prevent costly mistakes, consider making a pattern for the front deck cover from poster board first. Make the front deck cover from .025 or .032 aluminum sheet. Note carefully where the slots for the front cabane struts will be located, and the angle of the instrument panel. A 1-1/4-inch hole saw makes a neat hole for the struts. Trim the rest of the strut slots with sheet metal snips. By slotting around the cabane struts like this, the front deck can be removed if necessary for maintenance.

The fuel tank neck will need to stick through the front deck somewhere. It is best to have the fuel tank installed before trying to guess where the hole will be located. Cut this hole with a 3 1/8-inch hole saw and file or sand the edges smooth. You'd be surprised how fast a raw metal edge will saw through a plastic tank.

Put the front deck sheet in place and wrap it around the panel and firewall to the top longerons. Trim if necessary until it looks good. Then clamp it in place and, starting in the center, drill through the deck sheet into the 3/8-inch tube frames - clecoing as you go.

Space the rivet holes about 3 to 4 inches apart, and try to keep a regular spacing. Later, when all the instruments and fuel tank are plumbed and wired this can be permanently installed with pop-rivets or sheet-metal screws through the longerons.

WINDSHIELD

The windshield is made from 1/16-inch thick Lexan plastic sheet. The major drawback to Lexan is that it will desolve instantly from almost any solvent - including gasoline. On the bright side, however, it's pretty tough stuff. Lexan can be cut with a band saw or saber saw using a fine tooth blade. The windshield can even be mounted with pop-rivets! Don't try that with Plexiglass!

Some people use small sheet-metal clips to mount the windshield. Others have used formed compound curved aluminum cover strips. A 1/2-inch aluminum tube can be bent into a bow and mounted to support the aft edge if desired. It's all up to how much work you want to put yourself through. Just remember to be very careful when refueling!

FUEL TANK

There is a long list of options available for fuel tanks and mounting. We've used just about everything that will hold gas at one time or another. For an ultralight, however, it's hard to beat a five-gallon plastic gas can. Cheap, easy to mount, and officially approved for carrying gas! For those with deeper pockets and a desire to innovate, there is enough room under the front deck for a custom aluminum or fiberglass tank of about nine gallons.

Rubber bushed metal tank fittings are available for very few dollars. These are ideal for fuel line installations. Some are available with built-in finger strainers, shut-off valves, 90-degree elbows, etc. Installation consists of drilling a 1/2-inch hole, inserting the rubber part, and then pressing the metal connector through the rubber. It doesn't get any easier, folks.

Another approach is to make your own custom aluminum tank. While this is considerably more involved (and expensive) it's probably the best way to get a nine to twelve gallon tanks that fits well. If you want to go this route, drop me a note or email.

CONTROL SYSTEM

• TORQUE TUBE

Bushings for the control stick torque tube are made from two sizes of PVC pipe with a telescoping fit (i.e.: one piece fits snugly inside the other). Cut and trim the pieces for a tight fit and install them in the cockpit cross-members with a generous application of PVC cement.

The rudder cable fairleads are made the same way from a smaller pair of PVC tubes. Note that these are installed in both the front and rear 2-inch cross pieces under the pilot seat.

Cut the control system torque tube and joystick from one-inch .058 wall aluminum tube. At the aft end of the torque tube is a 1/2-inch diameter hole for the aileron control horn. At the front end is a 3/16-inch diameter hole for the joystick pivot bolt. These holes need to be on a common centerline (i.e.: not rotated from each other).

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Drill 3/16-inch diameter holes near the ends of the aileron horn tube (1/2-inch dia. tube). Press the aileron horn through the torque tube until centered, and align the end holes parallel to the torque tube. Drill a 1/8-inch hole through the top of the torque tube and both sides of the aileron horn. Secure the horn with a 3/4-inch long #8 wood screw. The screw should go through both sides of the aileron horn tube, but not come out the bottom of the torque tube.

• **JOYSTICK**

Drill two holes near the bottom of the joystick. Cut a pair of pieces for the joystick fork. These are specified as 1/2-inch x 1/2-inch square aluminum tube, but 3/4-inch angle could be adapted if desired. Using the joystick as a guide, drill matching holes in each of the fork pieces.

If necessary, run a long drill bit through all three pieces to help align them for the bolts.

Bolt the fork arms to the joystick using a pair of long AN-3 bolts. Do NOT torque these bolts down tightly. Just get them snug. Washers may be added to the fork assembly to add a little extra clearance if needed between the fork legs. Add a tang to the top bolt for the elevator cable.

Install the torque tube by sliding it into the PVC bushings. A pair of large thrust washers and a short aluminum tube sleeve at each bushing take the pull of the elevator cables and keep the torque tube in place. These can be secured by drilling the sleeve and torque tube and installing the large thrust washers and cotter pins. Fit the joystick assembly on the torque tube and install an AN-3 bolt for the pivot pin. Tighten the bolts enough to remove any play, but not tight enough to cause binding or stiffness. The stick should flop around freely.

• **RUDDER PEDALS**

Rudder pedals can be made and installed now. Several dollars can be saved at the cost of a bit of extra work by making the rudder pedal hinges from 3/4-inch angle brackets. It's a lot easier, however, to use AN42 eyebolts.

Cut a piece of 3/4-inch angle to fit across the fuselage at the lower longerons. This will be the rudder pedal mount bar. For two-strokers, this piece usually goes under the fuselage, since it makes a convenient place to put the aft muffler clamps. For four-strokers, however, that's not really necessary, and the rudder pedal mount bar can go inside-- out of the breeze.

Drill the mount bar for your particular pedals. It's a good idea to use a washer between moving parts. Locate the position of the hinge parts accordingly, drill and bolt in place. Install the pedals on the mount bar with AN-3 bolts and washers. They should flop around freely, but without a lot of excess play. Locate the pedals at a comfortable distance from the seat and drill through the mount bar and longeron. Secure with an AN-3 bolt through each longeron.

Thread the rudder cables through the PVC bushings under the seat before installing Nicopress thimbles at both ends. They won't fit through the bushings afterwards. Best bet is to install the pedal end and leave the rudder end hanging until the rudder is installed.

• **ELEVATOR CABLES**

Elevator cables are routed under the seat through PVC guides attached to the torque tube. The bottom cable from the stick goes to the top of the elevator horn, and vice versa. They

should not come in contact with any structure anywhere. A tang Nicopressed to each end makes it easy to disconnect the cables when necessary. Make up and install the control stick end, but leave the elevator end bare until the elevator is actually installed. Obviously small diameter pulleys can be adapted if desired.

- ***AILERON PUSHRODS***

A pair of crossed push rods operates the ailerons. The pushrods have a ball type rod end connector at each end. The pushrods bolt to the aileron horn on the torque tube. One pushrod is bolted to the front side of the aileron horn; the other is bolted to the backside. This provides clearance between the pushrods where they cross each other. Cut the aileron pushrods to rough length. These will be trimmed to final length once the wing has been installed.

There are several ways to make up ball ends for the pushrods. Depends on what you have on hand or can purchase. A female ball-end that can be trimmed to fit inside the pushrod tube is perfect for the bottom end. These can be drilled and riveted or bolted in place.

For more flexibility in setting aileron droop/reflex, the top ends of the pushrods can be made adjustable. Make a piece of aluminum about 3-inch long that will fit snugly into the pushrod. Carefully drill a deep hole about half the length of the piece. Thread the hole for a MALE rod end. Insert these threaded plugs into the trimmed pushrod. Set the plugs where you have adequate adjustment range without unscrewing too much of the rod end from the plug. Leave room for a lock nut on the rod end. The trailing edge of the ailerons should ride about 3/8-inch above the bottom of the wing. Set the plugs, drill and rivet or bolt permanently. Now you can unscrew the top rod ends to reflex the ailerons, or screw them in to droop the ailerons. Just make sure you have enough threads inside the plugs to hold the ailerons securely.

FIN and RUDDER

The main spar of the fin should already be in place on the fuselage. Cut and bend the leading edge tube. Make a pair of brackets from 1 inch angle to attach the leading edge tube to the top of the last fuselage lateral. To align the fin, stretch a string from the center of the firewall to the tailpost. Center the attach brackets on each side of the string leaving a one-inch space between them for the leading edge tube. Match drill the leading edge tube for the attach brackets and bolt. Wrap a gusset around the top of the fin spar and rivet to the spar and leading edge tube. Gently bend the edges of the gusset in a bit to avoid cutting the fabric cover.

One-inch diameter tube ribs are installed on the fin. The bottom rib must be located high enough to allow the elevator and stabilizer to slide under. Fish-mouth the ends to mate snugly with the fin spar and leading edge tubes. Drill a single 1/8-inch hole on both sides of each joint and install with a single pop-rivet on each side.

The rudder consists of the spar, trailing edge tube, and two tube ribs. Bend the trailing edge tubes as shown and fit to the spar. Cut the ribs and fishmouth the ends to fit snugly against the tubes at both ends. Install the doubler in the bottom end of the rudder spar. Wrap gussets around the spar joint at each end. Drill and pop-rivet. Install the ribs with a single pop-rivet on each side of all joints.

Locate and mark the position for the rudder horn. Drill a 1/2-inch hole vertically in the rudder spar for the control horn. Press the control horn into the spar until it is centered. Drill a 1/8-

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inch hole through the spar and horn and secure with a $\frac{3}{4}$ -inch long number 8 sheet metal screw.

Rudder cables are made from $\frac{3}{32}$ -inch braided cable and are routed from the pedals through the PVC fair leads in the cockpit and on back to the rudder horn. Make up the pedal ends and install. Save the rudder end until the rudder is in place.

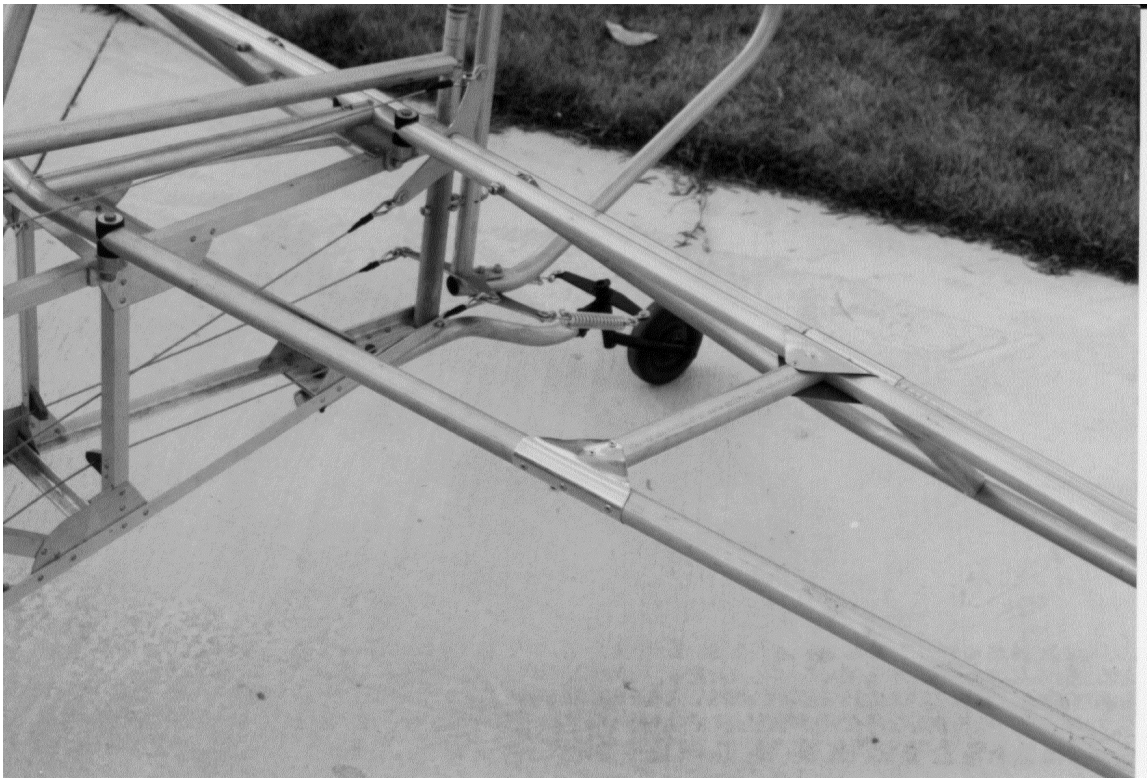
- **HINGES**

AN-42 eyebolts are often used for control surface hinges, but they are rather expensive -- especially when you need to buy so many of the little things. Twelve of these will run about \$50. A cheaper way to make hinges is to cut them from 1 inch by $\frac{1}{8}$ -inch aluminum channel -- about $\frac{1}{2}$ -inch wide. Round the open ends and drill for a number 8 clevis pin. Mount them with a pair of $1\text{-}\frac{3}{8}$ inch long number 6 machine screws and lock nuts on each piece. Align the halves so that they automatically keep the control surface from sliding around on the hinge pin. Use a Clevis pin and Cotter pin for the hinge pin (D-TAIL3).

STABILIZER and ELEVATOR

The stabilizer is built in one piece. Start by cutting the stabilizer spar to length.

The spars have internal doublers at the center. The doubler strengthens the spar to carry the torsional loads of the elevator control horn and center hinges. They should extend past the innermost hinge points. Drill a 1/8-inch hole at the center of the spar. Cut and debur the doubler and mark the center with a line around the tube. Slide the doubler into the spar tube until the center mark shows through the center hole. Then drill the doubler and install a pop-rivet to lock it in place.



Bend the leading edge frame tube in the center; then carefully bend the ends to shape. Trim the ends to equal length. Lay the spar and leading edge frame in place on the table. (Don't forget to insert the 7/8" OD spar doubler before assembling!!!) Wrap a gusset around each joint, drill and rivet in place. Cut the three one-inch diameter tube ribs to fit in their proper locations. Fish-mouth the ends to fit snugly in place and square with the spar tube.

Put the stabilizer in place on the fuselage top longerons and locate the position of the four mount tabs. Leave enough room for the elevator to mount behind the stab without hitting the fin spar. Make the mount tabs from one-inch angle and install with AD470 rivets or AN3 bolts. Center it carefully on the fuselage, then measure from the center of the firewall to each tip to insure the stab is square. Drill the stabilizer and tabs for an AN-3 bolt through each.

Bend the elevator trailing edge tubes as shown on the drawings; being careful to make them as close to the same as possible. Fish-mouth the ends that contact the spar tube. Put the

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spar on the table and lay the frame tubes in place. Place a wrap gusset at all four joints, drill, and rivet.

Make the one-inch tube ribs for the elevator and fish-mouth them to fit neatly. Drill and install a pop-rivet top and bottom at each joint or wrap and rivet gussets around each joint. Drill the elevator and stabilizer for the hinges and install them.

Make the elevator control horn from ½-inch diameter steel tube. Drill 3/16-inch holes at each end for the control cables.

Slide the elevator in place between the top of the fuselage and the bottom fin rib. Next, slide the stabilizer through and bolt it in place. Install the hinge pins so that everything is in place. Now, locate and mark the position for the elevator horn. Check to make sure the horn will clear the fuselage structure. Remove the elevator and drill a ½-inch hole vertically in the elevator spar for the control horn. Press the elevator control horn into the spar until it is centered. Drill a 1/8-inch hole through the spar and horn and secure with a ¾-inch long number 8 sheet metal screw.

The stabilizer mounts with eight plastic saddle fittings. Trim off and smooth one side of each saddle to prevent it from puncturing the fabric. Install the stabilizer to the airframe with AN-3 bolts and AN960-3 washers on top of the top saddles.

Make up the four stabilizer brace wires and install them. To reduce cost and weight, we generally omit turnbuckles on the brace wires. Install a tang on one end of each cable with a Nicopress thimble. Install the tangs but don't tighten the bolts down completely. Make up the other end in place by snugging the wires and squeezing the Nicopress collars. Then tighten the mount bolts. If you do this carefully, the wires will fit perfectly with the proper pre-load.

If you need to adjust a but, remove one end and twist the wire. Twisting in the direction of the lay of the cable will tighten the wire—twisting against the lay will loosen the wire.

Besides, for what aircraft turnbuckles cost, you can remake the cables several times if you feel the need!

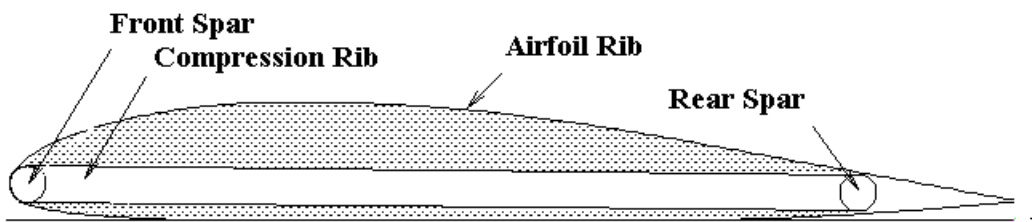
WINGS

• WING RIBS

Now, for the wings. Make a rib template from 3/4-inch plywood and drive in three or four long nails. Cut the nails off short enough that they don't stick through when the foam sheet is laid on. If you are going to install the nose ribs, put a couple of nails where the end of the nose rib will be so you have something to place the aft end of the foam sheet against.

Place a piece of foam over the template and press it down on the nails to hold it in place. Cut the rib out with a hand router. Move around the rib in the opposite direction of blade rotation to minimize the fuzzies. This turns out a finished rib in about 30 seconds each!

Make 26 full sized ribs plus two that have the upper curve and a straight bottom for the wing tip bows. If you are going to use the false ribs, make 24 of them about 12 inches long. One



false rib is installed between each main rib.

For an ultra-light, omit the false ribs. While this won't remove a lot of pounds, it will remove a lot of ounces—and ounces do add up!

• COMPRESSION RIBS

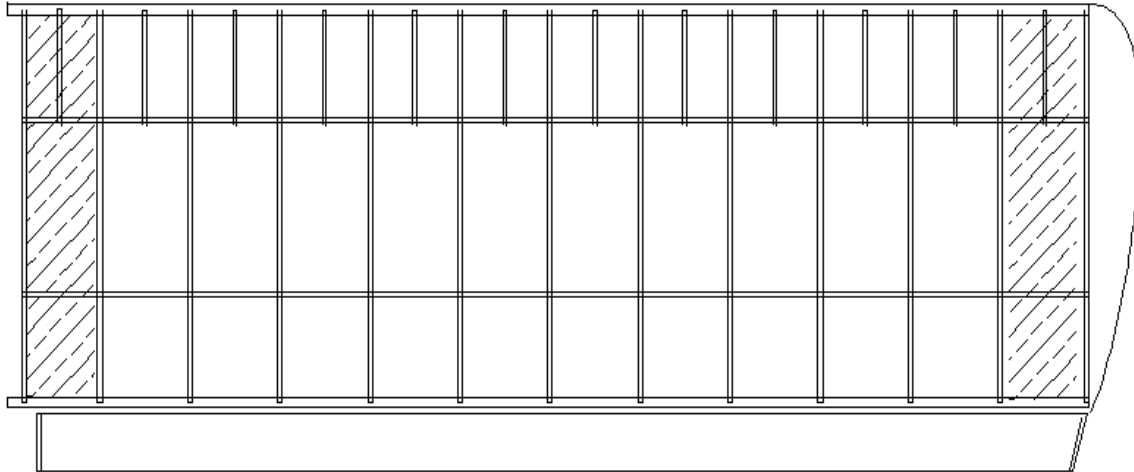
The compression ribs are light channels formed from .025-inch 6061-T6. There is a compression strut at each rib, plus a couple for the wing drag boxes. Cut 30 strips 48 inches long by about 2-3/4 to 3 inches wide. That leaves enough tab on the compression strut to wrap part way around the spar tube. Next, cut the ends with a 2-inch diameter hole-saw for the spars. The spar holes are 46 inches from center to center. While a two inch hole punch would be ideal, few people have one lying around. We use a 2-inch hole saw with an index bit. If you have a drill press, several strips can be stacked up, clamped tightly, and gang drilled.

If you have to cut these with a hand drill, take a few minutes to stack all the strips and gang drill a 1/8th inch pilot hole at the center of the spar holes to help hold the proper length. There are 60 of these holes in all. Gang drilling on a drill press or mill only takes a few minutes. Doing them with a hand drill is going to take quite a bit longer. Be very careful to hold the proper centers, as the compression ribs must all fit snugly against the spars.

Bend the flanges on each side 90 degrees. If you know somebody who has a bending brake, be real nice to him. The compression rib flanges can be bent by sandwiching the strip between two boards, but using a brake does it faster and probably neater. It's for sure a lot easier.

WING SPARS

The wing is primarily an aluminum ladder structure. Start by cutting the spar doubler inserts. These internal doublers go inside the spars at high stress points. Drill a 1/8-inch hole in one side of the spar tube at the center of the doubler location. Cut and debur the doublers and mark the centers with a line around the tube. Slide the doublers into the spar tube until the center mark shows through the center hole. Then drill the doubler and install a pop-riquet to lock it in place. Align the spars so that the doubler rivets face toward the inside of the wing (so they don't show).



Wing Planform

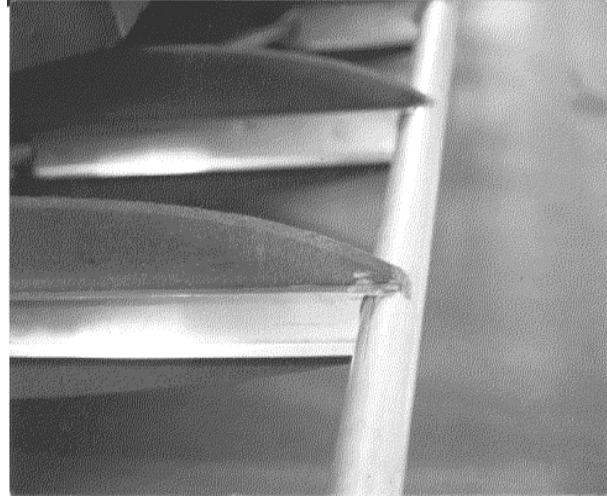
WING ASSEMBLY

Assembly starts by laying the spars on a pair of saw horses and blocking them in place. Mark the rib locations on each spar.

Most ribs are located on 12-inch centers and all compression ribs have their flanges facing the center of the airplane. Note, however, that the tip and root are a bit different. At each end of the wing is a large box structure formed by riveting skins to the top and bottom of the compression ribs in those bays. Therefore, the root rib faces outboard and is positioned outboard by the width of one rib. The next to last rib at the tip is treated similarly - it faces toward the tip and is offset by the width of the rib material. Slip the tabs of the compression ribs over the spars at each rib location. Square these up; bend the tabs around the spar. To pull the spars tightly into the compression ribs, place two or three straps with a ratcheting mechanism around the structure. Don't clamp them down so tight that you break something, but do pull them down very snug. All of the compression ribs should fit tightly around the spars. Check alignment and placement one last time before drilling and pop-riveting the compression ribs to the spars. Put one rivet through each tab.

Once the compression ribs and box skins have been riveted in place on the spars you might be surprised how stiff the wing ladder is - especially if you have any experience with wooden wings for very light airplanes. Obviously, you want to be sure you have the wings straight and flat when you build the ladders.

Run a generous bead of construction glue along the 2-inch wide face of the compression strut and on the spars where the ribs mate. Slide the ribs in place against the compression strut and clamp in place. Run a thin bead of glue around the junction of the rib and spar. Use your finger to make a smooth fillet, but do NOT build up a lot of glue here. That would just add unnecessary weight. The picture to the right shows the main wing ribs and compression ribs in place on the spars.



Except for the root rib, all wing ribs are installed on the outboard side of the compression ribs.

- **FALSE RIBS**

Slice up strips of foam about five inches wide for the false spars. Cut these to fit between each pair of ribs. Install the false ribs just like a regular rib except that the aft end butts against the false spar and is attached with glue and a couple of pop-rivet nails or toothpicks. Although the false spars won't show once the wing is covered, make an effort to keep them lined up properly. It looks better that way and they provide a great deal of lateral support to the airfoil ribs..

- **FALSE SPARS**

The false spars hold the aft end of the false ribs in place. They also provide a lot of support to the main ribs. Cut foam to fit snugly between the ribs. Bottom edge can sit on top of the bottom lip of the compression rib channel. Glue in place, and add a couple of pop-rivet "nails" through the ribs to pin them in place.

- **WING TIP RIBS**

Cut out the wing tip ribs from a normal rib but with a flat bottom. Sand a small angle on the straight edge to allow the tip ribs to angle up just a bit. Brace these in place with small triangles of foam glued and "nailed" in place against the last rib.

- **LIFT STRUT FITTINGS**

Finally, make the four spar fittings for the lift struts. Cut and drill per the drawings. However, don't install these until you are ready to install and rig the wings on the airplane. That way you will be sure of strut alignment.

Note how the brace wires attach to the strut fitting with a bent tang using the same bolt that holds the strut in place.

Also, this is a nice place to add a tie-down fitting. Drill another hole outboard of the strut bolt and add a bolt with a spacer tube between the flanges of the strut fitting.



Wing Strut Fitting.

- **LIFT STRUTS**

Lift struts are made from 1-3/8 inch .035 wall 6061T6 for ultra-lights, or 1-1/4-inch diameter .058 wall 6061-T6 tubes for heavier aircraft.

Short pieces of aluminum rod stock are cut to form the end plugs. The bottom end (fuselage end) fits between a pair of angles under the fuselage (lift strut cross-members). The top end (wing end) fits into the strut fittings on the wing spars. These have a nominal one-inch space inside the fitting. The top strut plug will need to be cut to fit into this one-inch slot.

For ultra-lights, make the end plugs from the next smaller diameter aluminum tube so the plugs fit tightly into the ends of the strut tubes. It saves a couple of pounds and is plenty strong for lighter planes.

The aft struts attach to a pair of 1x1x1/8-inch angles under the fuselage. These are located such that the aft struts run straight to the fuselage.

There are a pair of 3/32-inch braided cables in an X configuration between the front and rear struts. These serve as drag/anti-drag wires, as well as strut brace wires. They attach to the wing with bent tangs Nicopressed to each end.

Lately we've found some extruded 6061-T6 streamlined tube from Rans Aircraft in Hays, Kansas. The price is reasonable and the struts are heavy duty for this size plane.

Check the drawings for details.

AILERONS

The latest ailerons are made from a single 17-½-inch x 144-inch piece of aluminum sheet. Yep, that's a 12 foot section, folks! The aileron skins can be bent on a knife brake. Check around for an air conditioning shop that has a 12-foot knife brake. Of course, the ailerons can also be built up from shorter pieces. An easier way for less experienced builders would be to make a built-up aileron. See the drawings for this option.

We had problems with some of the early attempts because the brake operator forgot to grease the edges of the brake! This caused the break to drag the skin a tiny bit out of alignment and put a minor curve in the trailing edge bend! A bit of grease would have avoided this problem. Discuss this with your operator before bending your skins.

Place the bent aileron skin upside-down on a long flat table (with the topside down). Work the aileron skin down into place so that the open edges meeting flush. A long 2x4 and C clamps may be used to hold things in place. When the edges meet and the aileron is straight, drill and cleco the mating edges. Leave the hinge locations undrilled until later. Now, rivet the aileron together every 4 inches or so.

Cut a piece of ¾-inch angle to fit under the bottom surface of the aileron at the inboard end for the aileron horn. Cut and bend the root rib and install with pop-rivets. The flange goes on top of the aileron while the web extends down overlapping the ¾-inch horn piece.

Cut and bend the tip ribs to match your aileron profile. Install the aileron tip ribs with pop-rivets.

Make the aileron hinges from piano hinge stock. If the edge of the table is straight, you might slip the hinges under the aileron (they go on the TOP surface) and hang the free end down the side of the table to align the hinge pins. Otherwise, wait until actually installing the ailerons on the wings to mount the hinges.

WING INSTALLATION AND RIGGING

With all the pieces made up, it is time to install and rig the wings.

Level the fuselage by blocking the tail up until the top longeron is level. Hang a heavy paint can (or ?) on the tailwheel leg to prevent the airplane from nosing over while you work on it.

Slip the wing spars into their brackets on the center section and pin them.

Block the wings up in position with 4-1/2" of dihedral.

(we use five 5-gallon cans on each side - hence 25 gallons of dihedral???)

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- **LEVELING**

Chuck could set incidence very accurately with a carpenter's level, but that's a result of years of practice. Here is a very accurate and simple way for us mere mortals to use.



Make a water level from a plastic jug and a long pair of inexpensive plastic tubes. Mix a little food color (blue, green, or yellow is best) and dish washing soap in the water. Find a convenient place to hang the jug from (or install an eyebolt in a rafter?) and suspend the jug. Also, find a way to hang the ends of the tubes ABOVE the water level so they won't drain all over everything. Locate the jug near a wall, if possible, to keep it out of the way and maybe keep it from swaying. All that matters is that it can be raised to wing level.

Clamp or tape the ends of the tubes a foot or so above the front spars. Then raise the jug until the water in the tube is level with the spars at the wing root and secure the jug.

Measure the distance from the water line to the center of the spars at the wing tips and mark the tubes. Adjust the wings until they match.

Remember that the front spar should be about two inches above the rear spar to set the correct angle of incidence.

Do the same at the rear spars to set incidence and the wing is in place!

When you are happy with it, drill the struts and install all of the bolts.

BIPLANES

While the plans in this manual do not explicitly describe how to build a biplane, it is fairly easy to adapt these structures and techniques to a small two-winger.

Aerodynamically, there are a whole host of options of wing arrangements; stagger, gap, sweep, decalage. Determining where the combined center of pressure, and the resulting Center of Gravity envelope, can be – well - interesting at best.



A simple vertical arrangement of equal chord wings works out about the same as a single wing – as far as CG and loading goes at least. The cabin biplane (picture on page 4) has 54 inch chord wings. The top panels are 8 feet long, the lower ones are six feet. This open cockpit version has longer wings. Twelve feet on top, eight on bottom.

Lower wing attachment to the existing structure is done with simple brackets cut from 2"x 1/8" angle. A heavy gusset – usually made of 1/8" sheet – allows these attach brackets to be placed pretty much as desired. Rivet or bolt the gussets to the vertical and diagonal members of the fuselage. Bolt the attach brackets to the gussets. It's obviously better if you can bolt the brackets to some of the primary structure. Depends on what you are trying to do. If all else fails, design your own fuselage layout to match your needs.

Upper wings – at least unswept ones – can be mounted similar to the parasol arrangement using the inverted "V" cabanes. Alternately, you may want to have a separate center section with the cabanes running straight up, or angles out. All are do-able if care is taken to brace the structure in all three dimensions.

If you want to design something a little snazzier – swept wings; different chords, etc, feel free to work up your own.

COVERING

I'm not going to try to write a How-To book on covering. There are many on the bookshelves. Get several and study them. Better still, get in touch with someone who knows how and get some help. Covering is easy and vastly rewarding, but it is a skill that one learns mostly by doing. This section will just cover some general pointers on how we do it.

Use a good 1.7 ounce Dacron fabric - no heavier! There is nothing wrong with Stits products, except maybe the prices. We use Randolph fabric cement and dopes exclusively, so the instructions here are for that product. Randolph is used for fabric to fabric joints.

Get several tubes of 3M Plastic and Emblem adhesive. This is used for attaching fabric to metal.

- **TAIL**

The tail surfaces are covered with two pieces each - top and bottom. Start with a slightly oversized piece of cloth, wrap, and glue one edge to the spar tubes. Keep the weave parallel to the spar. Pull the other edge around the other side of the structure so that the fabric wraps most of the way around the tube. Pull the fabric snug and glue.

Put the bottom skins on first so that the overlap from the top skin is on the bottom where it won't be so obvious.

When both skins are glued and dried, come back and brush the seams with another wet coat of glue. Above all else, try to keep your fingers out of the wet glue.

- **WINGS**

The easiest and quickest way to cover these wings is with a sock. It will take two pieces of fabric to cover the wing. We generally plan on a seam running chordwise at midspan. Cut two pieces that wrap around the wing chordwise, fit the fabric loosely around the wing structure and mark for length. It should be loose enough to slide on the wing after sewing but snug enough that it will shrink taught when ironed. Machine sew the two pieces together to make one long piece, then fold the fabric spanwise and pin together to make the sock. Always double stitch these seams for a safety factor.



Slip the sock onto the wing and align the spanwise seam along the rear spar where it won't show.

Using clothes pins (or ?) secure the excess fabric to the wing tip so that it will stay put.

Start fitting at the root rib. Pull the fabric down over the rib and trim it so that it is a couple of inches past the rib. By carefully applying the iron to the free end of the fabric, the fabric can be shrunk smoothly over the edge and flattened onto the rib web. It is not necessary (or even desirable) to snip the fabric to make it lay down.

Trim the tip section the same way and glue securely. Do the bottom side first so that the top skin can overlap onto the bottom skin.

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Next, warm up the old iron for the first shrinking pass. **Do NOT try to iron one section smooth before moving on to the next.** Move the iron smoothly along the entire length of the wing on each pass so that the fabric shrinks uniformly and doesn't pull out of shape. Watch the weave of the fabric as it shrinks and you'll see what I mean. Turn the wing over and make a first pass on the other side.

Trim CLOSELY around the lift strut fitting only **AFTER** the fabric is snug. Cutting this before shrinking will cause the fabric will pull away from the fitting leaving a large hole to patch later.

Once the wing is covered, come back and cover the whole root rib with a piece of scrap fabric to tie the top and bottom surface together.

Turn the iron up a bit and re-iron the entire wing. Looks great, don't it!

The seam in the middle of the wing can be covered with a one-inch wide strip of fabric. To cut these strips (forget the scissors!) lay a long piece of scrap on a large piece of cardboard and using a long straight edge and a new razorblade, slice off the strips you need.

Fabric shops sell small bottles of liquid that prevent edges from unraveling. Just run a bead along the line you want to cut and let it dry before slicing. Lay the tapes into wet fabric cement and brush another coat of glue smooth.

Another way to cover the wings is to do the top and bottom separately. Start on the bottom side, and lay a piece of fabric full length on the wing. Wrap a couple of inches around the spars so that the fabric is smooth and start gluing. When the bottom is done, turn the wing over and do the top side. Overlap the top skin a couple of inches onto the bottom skin and glue securely. Once the fabric is in place, iron and finish normally.

• **FUSELAGE**

The fuselage is a rather large structure and is easiest to cover if two people are available. If you have to do it by yourself, go buy **lots** of clothespins.

We start by covering the bottom.

Set the tail wheel up on sawhorses (or ??) so you can get to the bottom without having to crawl around on the floor so much. Weigh the tail down so it doesn't fall over.

Rough cut a piece of fabric several inches oversized. Start clothes-pinning the fabric in place on one side, then go around and pin other. Try to keep the weave parallel to the centerline of the airplane while you snug the fabric. Place clothespins every few inches as you pull the fabric into place.

Once the fabric is all in place and snug, go back and start gluing. Glue the bottom skin to the outside surface of the longerons - not the bottom. Make sure you have the fabric glued securely, don't let the glue run all over the inside surface. Lap the fabric over the firewall about two inches and glue securely.

Once the glue has dried, use a sharp razorblade to trim the edges flush with the top of the bottom longeron. Then go back and brush on another wet coat of glue.

Next, the side skins are installed the same way by pinning the fabric to the top longeron and letting it hang to the bottom. Overlap the sides an inch onto the bottom skins, and wrap over and around the top longeron. Glue to the top surface of the top longeron - not the outside

Texas Parasol

surface - and trim along the inside edge. Again, overlap the fabric about two inches onto the firewall and glue securely.



Lastly, cover the top of the turtleback. Overlap one-inch over the side skins and glue. Since these seams will show, be extra careful to make them neat.

If there are places where a bulge appears when the fabric lays down - for Pete Sake - DON'T cut gores. Just use the tip of your iron to shrink the edge of the fabric where the bulge appears. You don't want to shrink anything but the bulging part, so go easy with the iron. The place where this will most likely appear is around the curved tips of the tail surfaces. By very carefully shrinking the just the edge of the fabric, it will pull right up to the tube and make a beautiful seam.

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- **DOPING**

Dopes and paints will not soak into the fibers of synthetic fabrics. The only way to make them stick is to encapsulate the strands of the fabric. To do this, the first coat has got to be put on pretty wet. Some people insist that this first coat be brushed on for that very reason. Ok, fine. We spray the first coat because we can't afford the weight (and time, and money) penalty necessary to build up enough dope coats to cover the brush marks. But whether brushed or sprayed, the first coat should be a very wet coat of NITRATE dope. This helps with adhesion, but be very careful when using nitrate dope, as the vapors are EXPLOSIVE, and the dried film is extremely flammable! (**Nitrate Cellulose is also known as GUNCOTTON, folks**).

After the Nitrate coat is dry, spray on a couple of coats of clear, then a couple of coats of silver, and finally the color of your choice.

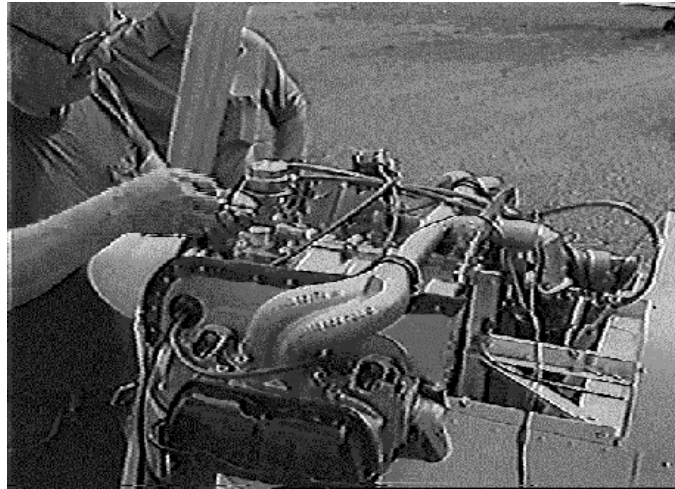
There are a few things to keep in mind while deciding what paints to use:

- Enamels work far better on metal and fiberglass than dope does.
- Dope and lacquer cannot be painted over enamel.
- Paint the trim details on fabric with lacquer instead of enamel.
- Pay attention to temperature and humidity. If they are not right, do something else.
- Always use fresh masking tape for paint lines. Old tape sucks!
- Newspaper usually has tiny holes that will leak paint onto the surface below.
- Overspray will travel at least twice as far as you think it will.
- The solvents in any of these paints will desolve Lexan windshields instantly.
- Make sure you have adequate fresh-air ventilation when spraying (why do you think they call it dope, dope?)
- Paint is HEAVY! Especially enamel and polyurethane. Weigh the can before spraying, and again after. The difference is the amount of weight you sprayed on the plane.

ENGINES

The high power to weight ratio of 2-stroke engines has made them the no-contest choice for ultra-light aircraft. In addition, they have been developed to the point where a properly maintained and operated engine can be as reliable as a 4-stroke.

The Rotax line of 2 cylinder, 2 stroke engines have become the industry standard for ultra-light and very light aircraft, but their prices have soared in the last few years. If you can afford one, a Rotax 503 may be the perfect choice.



Sonny Mosel timing a big-bore VW installation

But some people just have to have a 4 stroke motor. We have seen VW, Subaru, Geo, etc. used with varying degrees of success—depending mostly on how modified the engine became. Increasing horsepower and complexity almost always decreases reliability and engine life. (There ain't no free lunch!)

ENGINE MOUNT

Making an engine mount from welded steel tubing is a very critical job. Even a nice looking weld can lack the penetration necessary to develop adequate strength, and it is difficult to determine the amount of penetration without destroying the part. We prefer to use a simple bolted aluminum angle mount. They are rugged, lightweight, and use no welded joints.

Two-stroke engines generally use a cradle type mount with rubber shock absorbers to isolate engine vibration from the airframe.

This photo shows the basic mount truss.

A pair of aluminum angles are bolted directly to the bottom of the engine (D-ENG01). These angles fit between a pair of rubber donuts attached to the mount truss. A pair of braces are added AFTER the engine is installed. Place them to avoid contact with carbs, exhaust pipes, etc. The clips can be attached at odd angles to allow the braces to fit properly.

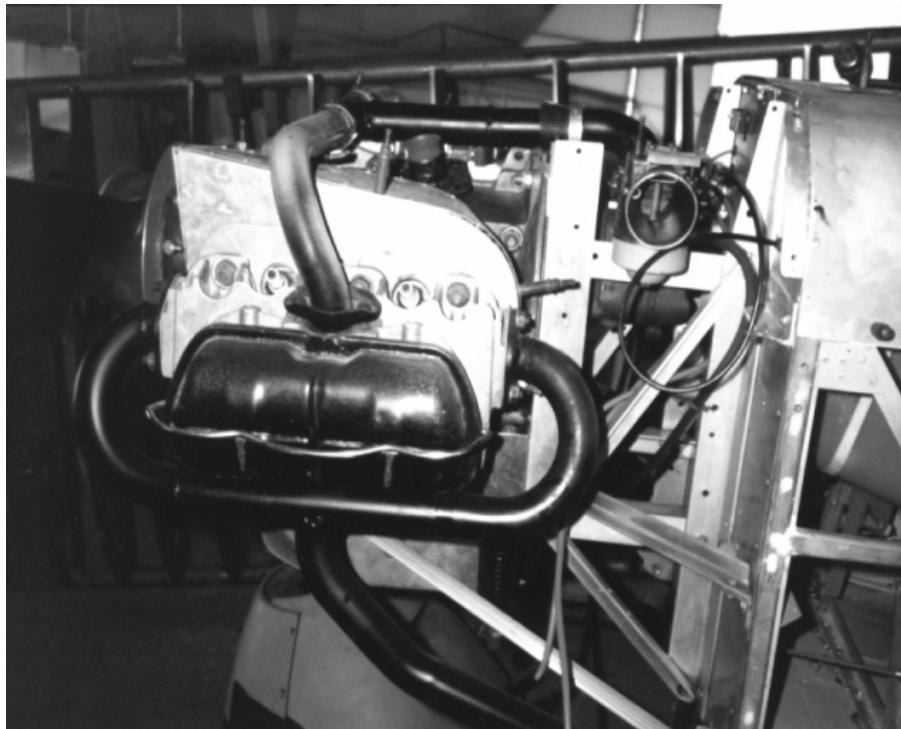
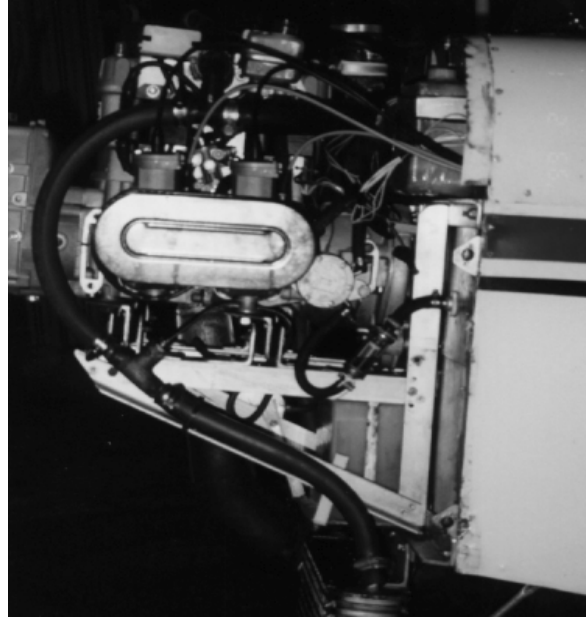


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This is a typical 2-stroke installation using a Rotax 582. If you look closely and you can see the rubber donuts between the ears on the bottom of the engine and the engine bearer itself. Also note the radiator installed below the engine.

Depending on the engine you intend to use, the actual measurements will vary. Adjust the mount so that the thrust line is about on the top longeron. We normally rig with no offset in any direction.

Four-strokers, however, are usually mounted directly to the structure without any shock pads. Due to the higher weight, the engine mounts are built a bit beefier.



Richard Lamb's 1600cc VW engine installation.

There is a horizontal piece of 2"x2"x1/8" angle behind the firewall where the bottom of the mount ties in.

Note that the vertical bearers extend all the way to the top of the firewall so that a pair of drag wires could be tied to the wing center section. Also note the side braces that tie into the horizontal 2" piece behind the firewall.

A Slick magneto is hung on the flywheel and a stock VW fuel pump was added to the bottom of the adapter. This mount places the engine eight inches in front of the firewall. With the wing mounted forward it works out just about right. This engine came in at 144 pounds.

This biplane was used as a test bed for the Rotax gearbox and Subaru EA-81 set up. This mount is built a low since the engine had a Rotax gearbox attached. Additional spacers are added to raise the engine an inch above the bearer arms. This allows the oil filter to clear the bearers.

A pair of top braces bolt to the aft end of the cylinders and the firewall frame to provide side to side support.

No problems have been experienced with this "hard" mounting (no rubber dampers). Two-strokes, on the other hand, really NEED isolation.

PROPELLER

In order to convert all this horsepower into thrust you need a propeller that matches the engine horsepower and RPM to the airplane's speed. Fast turning direct drive engines need short props to avoid supersonic tip speeds. This works out well on a fast airplane, but these are low and slow, high drag airplanes that need a long, slow turning prop. To run direct drive with a long prop means keeping the engine RPM down—usually below the maximum torque—with the resulting loss of horsepower and efficiency. The other option is a propeller speed reduction drive (PSRU). This will allow the engine to turn at its maximum torque RPM while the propeller turns at a more sedate and efficient speed. All 2-stroke engines use some type of PSRU. They have to. Otherwise, they could only turn a ridiculously short prop.

The choices are again pretty simple. Accept the reduced efficiency of direct drive, or add a PSRU. Well, it's your nickel, so you choose.

Something to keep in mind about propellers is that the props from different manufacturers will often perform differently - although they have the same numbers for diameter and pitch.

COWLINGS

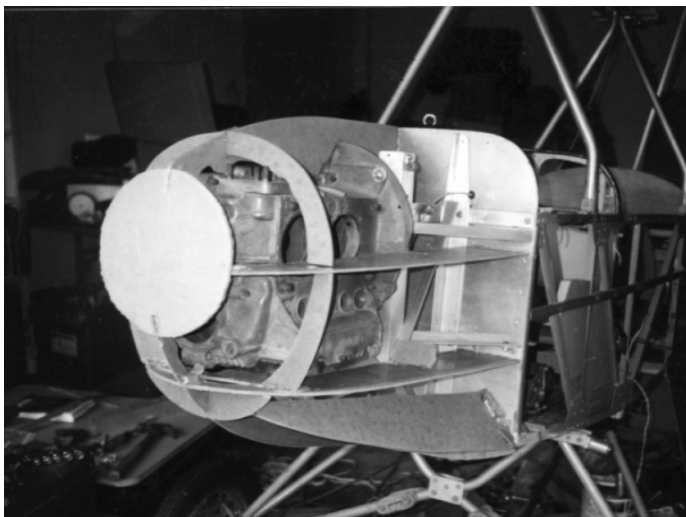
Several of the guys have built simple aluminum sheet metal fairings that look good and weigh very little. For an authentic olde-timer look, this is definitely the way to go.

Many people don't like working with fiberglass because of the itching caused by all the sanding needed to make a smooth surface. Sanding into the glass creates a lot of tiny glass particles -- with very sharp ends. It's almost impossible to wash off; and you end up itching for days. It's miserable.

If your idea of making a fiberglass part is to lay up a bunch of layers and grind it down to shape, you're gonna itch. My secret tip for an (almost) itch-proof fiberglass project is this -- don't sand so much! It's really that simple, and of course, it's not. But proper preparation will save a lot of scratching.

First of all, making fiberglass parts usually requires some kind of mold to give it shape. A male mold (also called a plug) makes a smooth inside surface because the part is laid up on the outside of the mold. But what we usually want is a smooth outside surface.

A female mold is used for production line work because it produces a smooth outside surface since the part is laid up on the inside surface. Female molds are made from the finished plug. The plug is carved to shape, smoothed to a beautiful finish, and thrown away after the female mold (called a splash) is laid up. In addition, different kinds of resins are needed to make a durable mold. Don't even think about using polyester (boat) resin. It shrinks too much as it cures, and won't hold shape reliably.



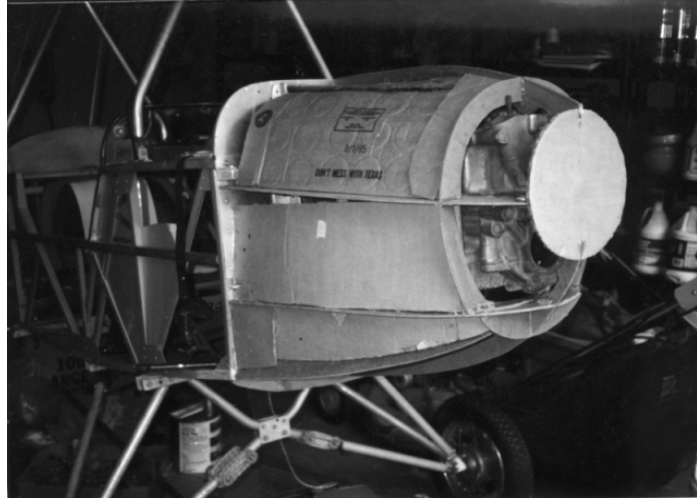
For one-off projects, however, the extra work and expense required to make a female mold is hard to justify. A male mold is all that is needed. But it needs to be as close to the desired finished shape and smoothness as possible.

This photo shows the beginning of the project. A junk engine block was mounted to keep from messing up my flight motor, but you might wrap your motor with heavy plastic sheet and duct

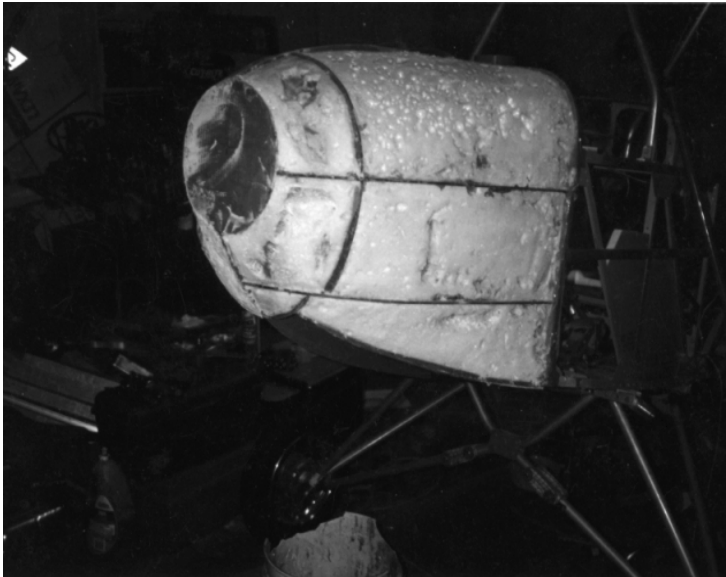
tape if you don't have a spare laying around. The framework was sketched onto corrugated cardboard and cut out. This is easy to assemble with a bit of tape. Trim and adjust until the shape gels. Remember that fiberglass gets it's strength from the shape.

Compound curves are not only easy to make, they strengthen the parts! Transfer the frame pieces to 1/8 inch thick masonite. It may help to make left and right parts at

the same time. Sand the edges smooth. Reassemble the framework. I used hot melt glue for this. Small pieces of wood are glued to the joints to hold the thing together. Realize that when it's all done, the plug will weigh quite a bit. This one ran over 50 pounds! You'll see why in a bit. Next step is to seal off the insides so we don't permanently glue the engine into the plug. This picture shows how pieces of cardboard and tape were used to close off the plug. For the following technique to work well, locate these dams at least 1/2 inch inside the framework. As you can tell, in places I left even more space, but it's not really necessary. In fact, that's where a lot of the extra weight and expense came from.



Duct tape was applied to the firewall and between the framework and the cardboard pieces. Around the nose, I taped a bunch of empty cigarette boxes to fill the odd shaped cavities. Hey, use what ever you have lying around! (Can't do that anymore cause I quit smoking!!!)

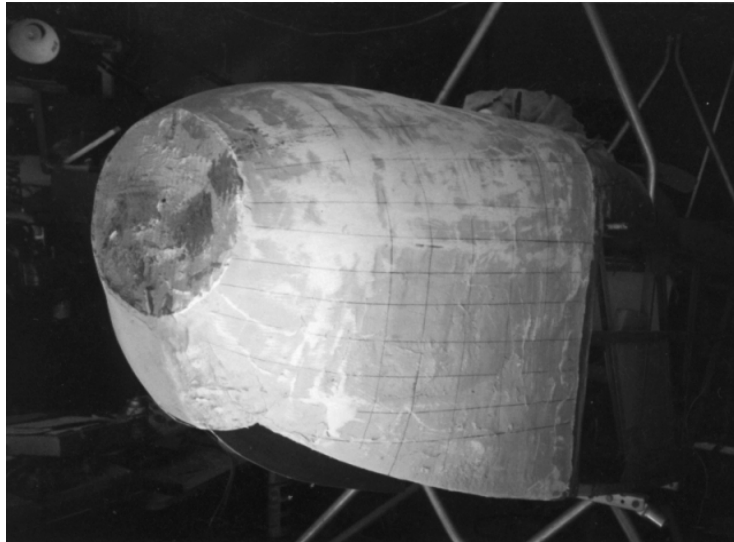


Now it looks like a mess, and it really was. I used a couple of cans of spray-in foam to fill in over the cardboard. A piece of poster board was taped to the sides and under the bottom. Otherwise the foam will just fall off and wind

up on the garage floor. After the foam has been sprayed in, leave it alone for at least a full day! Take the wife to a movie and dinner, watch football, whatever. But don't pester it for at least 24 hours (and a couple of days would be even better). This kind of foam cures on contact with air. The exposed parts will cure fairly quickly giving you the idea that it's ready -- but it's not!

If you are impatient (I was), when you peel the poster board off, a lot of wet foam is gonna come along with it. That's where all the big gaps in the surface came from.

Anyway, when the foam has (finally) cured, start sawing off the lumps with a long sharp knife. If the knife drags, the foam isn't done yet. I dug the foam down about 1/4 inch below the desired surface. It's easy to work, cleans up easily, and it doesn't itch at all.



The next step is to start building up a hard surface for the plug. I started off using Bondo, but quickly realized it was a mistake. Bondo costs \$12 or \$13 a gallon, and it became very obvious it was going to take a lot of gallons to fill in all the holes and build up a smooth surface.

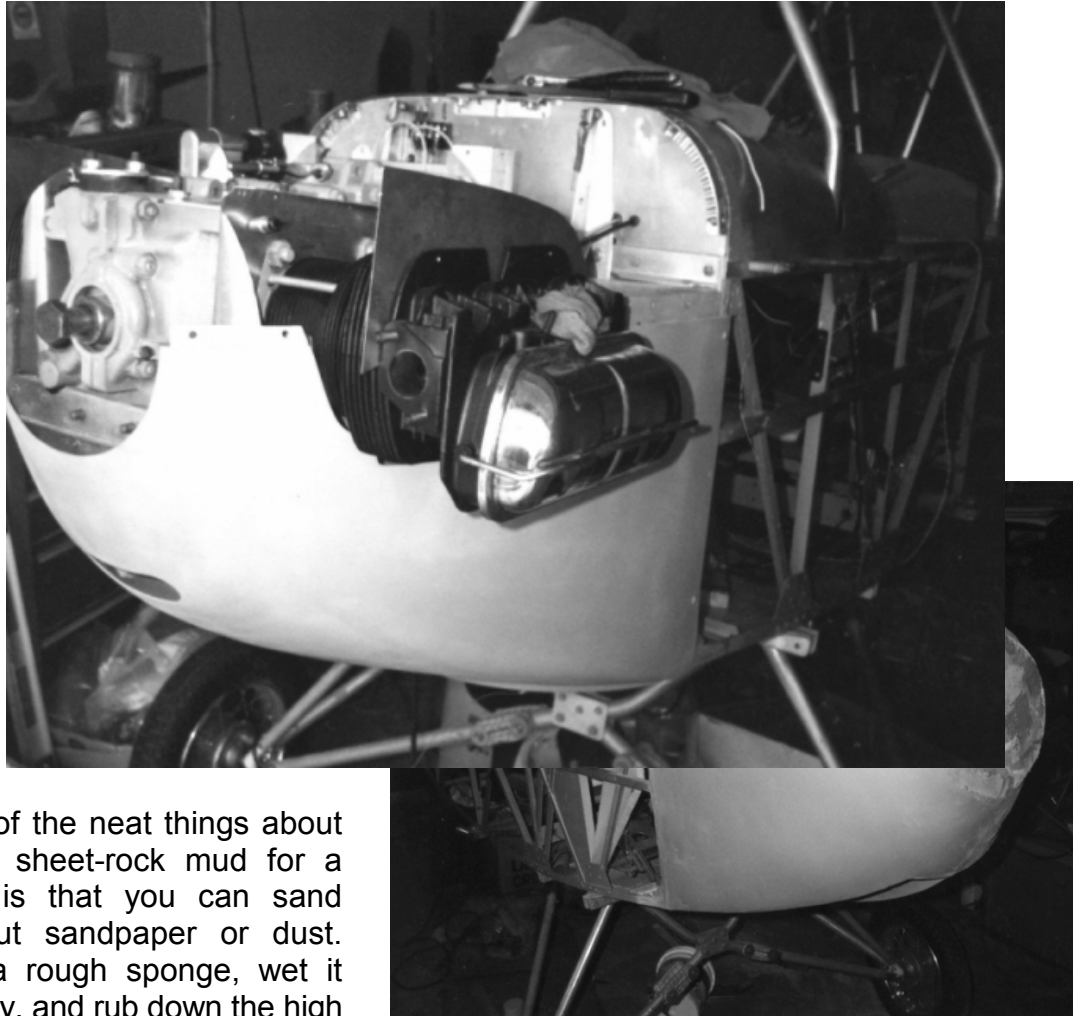
In this view, lines were drawn on the surface with a flexible straight edge and a soft pencil. Even in this photo, you can probably see the lumpy the surface. This photo was taken just before I gave up on Bondo.

In addition, the stuff cures pretty hard. That makes it a lot harder (sorry no pun intended) to shape. I wanted something cheaper, a lot less toxic, and much easier to work. Looking around the aviation department at WallMart, I came across a 50 pound bucket of sheet-rock joint compound for less than \$8. Commonly called sheet-rock mud, this stuff is basically powdered gypsum and water. Used alone, the dried mud is soft and breaks easily. As in sheet-rock walls, some kind of reinforcing is necessary. I used strips of paper sheet-rock tape, newspaper, and fiberglass screen in various places. Just remember to keep the reinforcing materials well below the surface. Where I sanded into the reinforcements, I had to dig out quite a way around the damaged area and refill.

The mud can be applied with a squeegee, a sponge, or even by hand if you want. Build up in thin layers so that it has time to dry thoroughly. Water in the mud seems to settle toward the bottom of the plug. It is easy to tell what condition the mud is in by feeling it. If it feels hard but cold to the touch it's still wet inside

Carving the mud to a smooth shape is unbelievably easy. A hacksaw blade with the ends taped makes a useful tool for fairing large areas. Hold the blade by both ends and at a thin angle to the work. Pull it towards you like you are shaving the lumps off. Pull a couple of strokes in one direction, then pull a few at a cross direction.

Sanding makes a lot of fine dust, which is a real health hazard without a dust mask. But carving with a hacksaw blade makes larger shavings that don't hang in the air like the dust does. Besides, sanding seems to make very smooth lumps -- which is *not* what you want.



One of the neat things about using sheet-rock mud for a plug is that you can sand without sandpaper or dust. Get a rough sponge, wet it slightly, and rub down the high spots. Since the mud softens with water, it makes a thick paste that can be worked from high spots into nearby cracks and low spots.

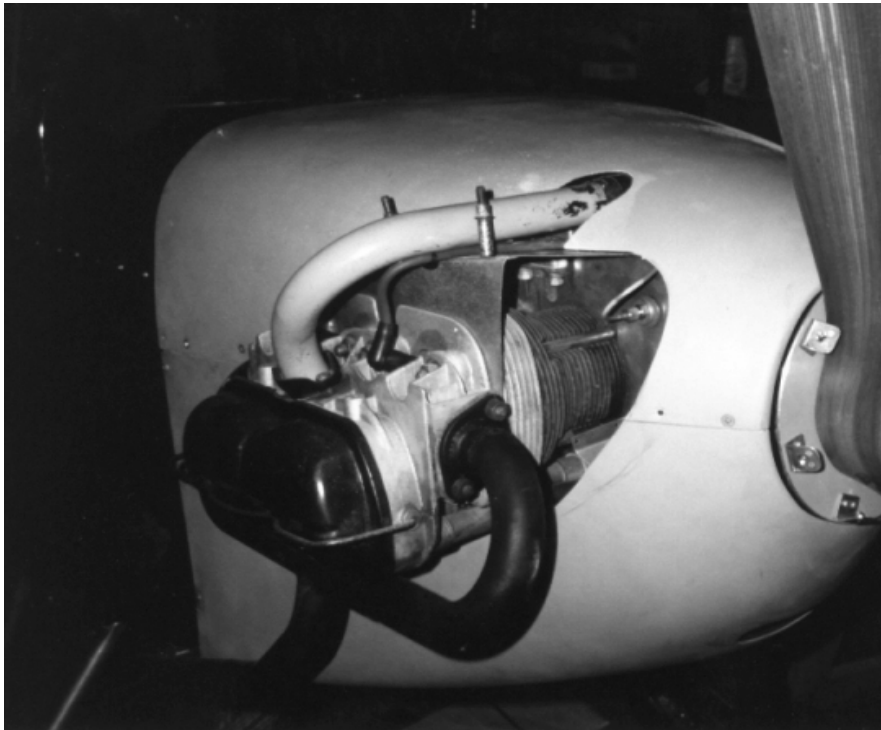
Lastly, before you can lay up the glass part, it is necessary to seal the surface to protect it from the resin. Otherwise, the finished cowling will have the plug glued permanently inside. I've tried a lot of different things to seal the surfaces -- paint, epoxy, etc. but the cheapest and easiest is a couple of coats of plain old spar varnish. It won't act as a mold release, but it soaks into the mud a bit and makes it

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hard enough to work with. Spray on a couple of layers of PVA (poly vinyl alcohol) for a mold release.

By now, you are probably saying “Yeah, yeah, but what about the itching part?” Well, since you are working on the outside surface, lumps and bumps will have to be sanded off.

Be aware of edges and seams. Don’t overlap seams if they can be laid side-by-side and made flush. Getting the plug as slick as possible means a whole lot less sanding; therefore less itch.



This cowling is split along the sides, so the fiberglass cloth could be laid on the bias and pulled smoothly over the top or bottom in a single piece without overlapping seams to lump up - - and sand off later. An aluminum backing plate is bonded into the top edge of the bottom piece. Trying to glue anything to aluminum is a waste of time. But drilling dozens of

holes in the aluminum strip lets the resin (and glass too – if you want) to pass through the metal and bond with the glass surface. Be generous with the contact area also. I riveted nutplates inside the aluminum lip and installed the top with a few 10-23 countersunk screws.

If your shape won't let you lay up in full single piece layers, butt the pieces together rather than overlapping them. Stagger the seams in successive glass layers and again, no lumps or bumps to grind off later.

Well, that's about it. The secret to (almost) itchless custom fiberglass is to put as much of the finishing work as possible into the mold rather than the parts. This makes lighter, stronger parts, and you don't itch near as bad. In fact, the only way easier is to get somebody else to do the work!

MATERIAL LIST

There are a lot of ways to skin a cat, my Grandma always said. For the basic structure, this rough list will get most of the metal in the plane. But note that there are small quantities of a lot of other stuff that are also needed.

Angle:	
3/4 x 1/8 6061-T6 Angle	7 PCS 25' long
1 x 1/8 6061-T6 Angle	2 PCS 12' long
2.00 x 1/8 6061-T6 Angle	5 feet?
1.25 x .3/16 60061-T6 Angle	5 feet ?

Tube:	
2.00 OD x .058 6061-T6 Tube	4 PCS 12' long
1-7/8 OD x .058 6061-T6 Tube	1 PCS 12' long
1.25 x 1/8 6061-T6 Channel	2 feet
1 x .058 wall 6061-T6 Tube	5 PCS 12' long
7/8 OD x .058 6061-T6 Tube	
1-1/4 or 1-3/8 OD x.058 6061-T6 Tube	4 PCS 8' long

Sheet:	
.025 6061-T6 sheet	2 pcs 4' x 12'

Fuselage:

Most structure	3/4 x 1/8 6061-T6 Angle
Cockpit Cross-member	2.00 x 1/8 6061-T6 Angle
Main Gear Cross-member	1.25 x .3/16 60061-T6 Angle
Tailpost Plates	.080 to .125 6061-T6 Plate
Tailwheel Bracket	2.00 x 1/8 6061-T6 Angle
Fuselage Gussets	.050 6061-T6 Sheet
Firewall	.025 6061-T6 Sheet
Cockpit Floor	.025 6061-T6 Sheet
Instrument Panel	.050 6061-T6 Sheet
Front Deck	.025 6061-T6 Sheet
Turtleback Formers	1/2" Foam or 1/4" Plywood
Turtleback Stringers	3/4 x 3/16 wood
Rivets	AD470 Type - various lengths

Wing:

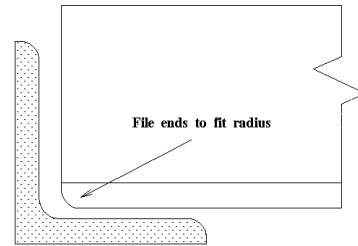
Spars	2.00 OD x .058 6061-T6 Tube
Spar Sleeves	1-7/8 OD x .058 6061-T6 Tube
Compression Struts	.025 6061-T6 Channel (bent)
Ribs	1/2" thick Urethane Foam
Strut Fittings	1.25 x 1/8 6061-T6 Channel
Cabane Struts:	1 x .058 wall 6061-T6 Tube
Cabane Strut Attach Fittings	1 x 1/8 6061-T6 Angle
Center Section	1 x 1/8 6061-T6 Angle
Strut End Sleeves	7/8 OD x .058 6061-T6 Tube

Lift Struts:	
End Fittings	1" or 1.25" OD 6061-T6 Round (?)
Strut Tubes	1-1/4 or 1-3/8 OD x.035 or .058 6061-T6
Tube	
Drag/Anti-Drag Wires	3/32 7x7 Braided Cable
Jury Struts	1/2" OD x .058 6061-T6 Tube
Straps	1/2" x .050 Stainless Steel
Thimbles	AN100-3
Nicopress	3/32" Collars
Shackles	AN115-21
Tangs	2 hole stainless steel
Control System:	
Stick	1" OD x .058 6061-T6 Tube
Torque Tube	1" OD x .058 6061-T6 Tube
Tail Spars and Ribs	1" OD x .058 6061-T6 Tube
Tail frames (bent)	1" OD x .049 6061-T6 Tube
Tail Surface Hinges	AN42-13 Eyebolts
Gussets for Tail Structures	.025 6061-T6
Elevator Cables	3/32 7x7 Braided Cable
Elevator Horn	1/2 OD x .049 4130 Tube
Rudder Pedals	3/4 x 1/8 6061-T6 Angle
Rudder Pedal Hinges	AN42-8 Eyebolts
Ailerons	.025 6061-T6 sheet 17 x 144 (bent)
Hinges	1 1/2" Piano Hinge (3 per wing)
Push Rods	1/2" 6061-T6 Square Tube
	AN- Ball Rod Ends (4 req'd)
Aileron Horns	3/4 x 1/8 6061-T6 Angle
Landing gear:	
Mains	
Arch Tube	1.00" OD x .058 6061-T6 Tube
Gear Legs	1.00" OD x .125 6061-T6 Tube
Outer Slider tubes	1.00" OD x .049 6061-T6 Tube
Inner Slider Tubes	7/8" OD x .058 6061-T6 Tube
Clusters	7/8" OD schedule 80 Steel Pipe
Axles	1/2" dia by 6 1/2" long Grade 9 bolts
Tangs	Stainless Steel - Two hole
Bungee Cord	3/8" OD
Tailwheel	
Leg	1.00" OD x 1/8 6061-T6 Tube
Retainer	1/4" Steel Rod
Tailwheel Wheel	Industrial Caster
Tailwheel Control Arm	1/2" OD x .058 steel tube
Tailwheel Springs & Chains	Door Screen Springs (compression type)
Shackles	AN-115
Tangs	Stainless Steel

METHODS AND MADNESS

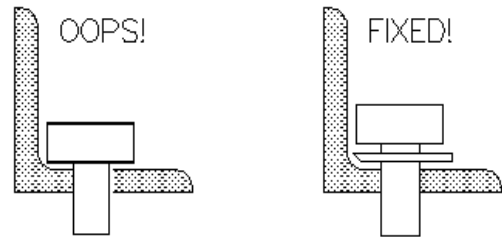
- **BUILDING WITH ANGLE**

With most extruded aluminum angle, there is a radius in the inside corner. Square ends will not fit tightly against the mating piece. Ends of the vertical members and diagonals will need to be filed down (rounded a bit) to fit the radius inside of the longeron.



- **BOLTS AND EDGE MARGINS**

Be careful when locating bolt and rivet holes in aluminum angle structures. It is real easy to get the holes too close to the flange. This will cause very serious problems when trying to install bolts or bang rivets. Remember that you must get a wrench or socket between the bolt and the angle! If you run into this problem with a bolt hole, you may be able to fix it by grinding one or two washers to fit into the radius under the bolt.

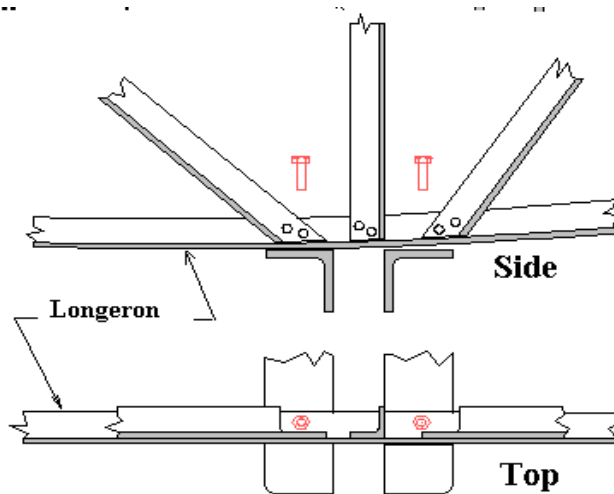


- **HOLE LOCATIONS**

This sketch shows the cluster on the lower longeron where the front main landing gear leg attaches. The top part is a side view, the bottom part is a top view. The heavy angles under the longeron are the landing gear carry-through.

Note the location of the mounting bolts and how much room there is for bolt holes.

If the hole is located in the center of the longeron there will probably not be enough room for the bolt head to clear the inside radius of the longeron!



Top and Side View of Landing Gear

Suggestion: Locate and drill the holes in the longerons first. Then, use the holes in the longerons to locate the holes in the carry-through pieces. That way the holes will be in the right place on the longeron and still line up with the carry-through.

- **BENDING TUBES**

Bending the 1-inch diameter tubes for cabanes and tail surface frames should be done with a bender that will pull the tubes around the bend. Conduit benders will usually kink the inside surface of the tube.

- **MARKING CENTERLINES ON TUBES**

When drilling holes through spar tubes, it is important that the holes go through the center of the tube on both sides. Here is a simple way to mark centers on tubes. Mark both sides of the tube with a Magic Marker. Clamp two tubes together so they can't move around. Then gently scrape both sides of the tube with a square held firmly against the table. This will leave a bright mark on the center line of both sides. Mark the desired hole location with a center punch and drill each side separately. Use a smaller diameter bit first, then re-drill with the correct size.

- **LAYING OUT PARTS**

Never use a scribe to draw bend lines on metal. Use a BLACK fine point permanent marker or a soft pencil. Never use a RED marker because the red ink will soak right through 60 coats of dope!

- **ANNEALING ALUMINUM**

Do NOT ANNEAL any aluminum parts on this aircraft.

- **WELDING ALUMINUM**

Do NOT WELD any aluminum parts on this aircraft.

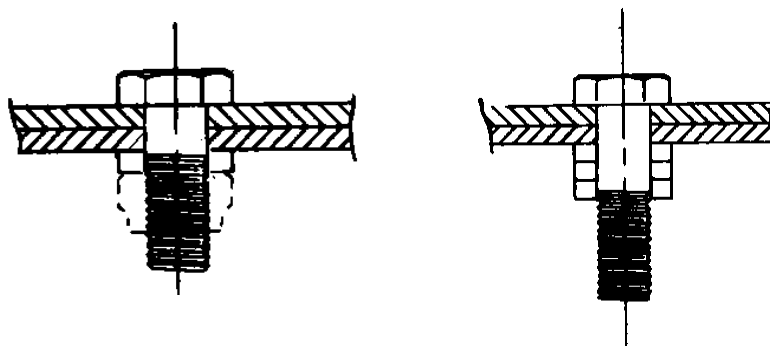
- **AIRCRAFT HARDWARE**

All nuts and bolts used in the primary structure are to be aircraft quality (AN, MS, NAS, etc). Do NOT use hardware store nuts and bolts.

- **BOLT LENGTH**

Aircraft bolts are not threaded the entire length. The "grip length" is the portion not threaded. The threads should not start inside the hole. Use up to 3 washers (max).

Always use a washer if there will be motion or rotation about the bolt.



TIPS FOR ULTRA-LIGHT BUILDERS

The arbitrary 254-pound empty weight limit imposed by the FAA is a real challenge for designers and builders alike. This is only about HALF the weight of the average street motorcycle!

Chuck built some early parasols that weigh in at 248 pounds empty and has received FAA part 103.7 approval as a legal ultra-light flying machine. These are sound, nice flying little airplanes—not flimsy contraptions that are just barely (if at all) airworthy. But to duplicate this, you HAVE to think LIGHT, build LIGHT, and resist temptation to add stuff that is not really necessary...

The following is a list of practical things to consider in building a legal ultra-light:

Note the options called out for ultra-lights in the plans. There are several places where lighter material can be used if the overall airplane is kept light.

Don't beef up anything just because it doesn't look strong enough. We've spent years evolving the structure to balance weight against strength. Making stuff beefier not only adds weight, and MAY overstress some other structure. (If it looks strong enough for a tractor, it belongs on a tractor.)

Use the lightest materials listed in the drawings.

For the diagonal braces in the aft fuselage, substitute 1x1x1/16 commercial aluminum extrusions (6063H532?). These parts are lightly loaded and the lighter material is perfectly adequate

For cockpit carry-through, use 1 x 1 x 1/8 angles instead of 2 x 2 x 1/8.

For some reason, 2-inch diameter .058 wall spar tubes cost a lot less than .049 wall tubes. When we buy spars for six or eight airplanes at once, the difference is noticeable. But even .035 spars are plenty strong enough and save about 6 pounds. Perfect for ultralights.

Use a 5-gallon plastic fuel tank instead of a steel or aluminum tank. It will save money as well as weight.

Consider blue Styrofoam ribs instead of urethane foam. (But remember to protect Styrofoam from solvents in the dope or the wing will wind up lighter than you want! Consider fiberglass-strapping tape over rib edges.)

Using 3/8-inch thick ribs rather than 1/2-inch thick.

Omit the nose ribs and false spars. They make a wing prettier, and it probably flies better, but we have that weight limit to deal with!

A Rotax 377 engine will fly the airplane nicely. True, a Rotax 582 makes it fly like a mini F16, but weighs more, costs more, weighs more, and burns more gas. Air-cooled engines are usually lighter by the weight of a radiator, coolant, hoses, etc.

Leave out the battery, starter, and alternator (unless it's built in like Rotax). Use a rope starter and a mechanical or vacuum driven fuel pump.

Make the simple sheet aluminum engine cowling rather than a heavy fiberglass one.

You don't really need a panel full of instruments to fly day VFR. Consider using multi-function combo gauges where needed. Nav lights and strobes are not necessary either—especially if it means you'll need a battery!

For ultralights, there are no instrument requirements at all! Get the plane covered and weighed before adding extra gauges.

Do you really NEED brakes? They generally add 8 or 10 pounds!

Don't use heavier fabric. 1.7 ounce (P106) fabric works fine. Also, go easy on the dope and paint. That stuff adds up fast.

Be stingy with paint. The stuff is HEAVIER than you think.

Use a minimum of lightweight stingers for the fuselage turtleback, or eliminate it altogether?.

A fabric sling seat can be made quite comfortable. Make extra cushions removable for different pilots. That way they are not part of the airplanes' empty weight.

Use a hand held radio if you must gab while you fly, and a hand held GPS for navigation. These will also be a lot safer at home than in the hanger.

Lighten up the heavy stuff. Wheels, motor, instruments, paint... Lightening the lighter stuff doesn't work near as well as lightening the heavy stuff.

Ed Heineman, designer of the Navy's A4 Skyhawk, had a sign on his door that said, "If it's lighter, simpler, cheaper, COME IN. In fact we WANT you here!"

If it isn't installed in the airplane, it won't add weight, it won't cost anything, and it won't break.

THINK LIGHT!
IT 'S THE ONLY WAY TO BUILD LIGHT!

OUR FAMILY PHOTO ALBUM



A Chuck-Bird "Flock-In" at Zuehl field.



Charlie Ramos has one of the oldest ChuckBirds - now 13 years old! This bird has a 50 hp 2-stroke engine and flaps. Charlie likes to drop the flaps and "park" a few hundred feet over the airport.



SE-5 replica with a 3-cylinder Geo engine and a Rotax gearbox



Sonny Mosel's 2-seat VW powered Das Fulgerhund



Sonny Mosel's VW powered "Patti-Cake" midwing.



This new pair of birds at Zuehl are patterned from the Pietenpol Sky Scout..



This is Chuck Beeson's cabin biplane. A Rotax 582 powers it. With all that power, and those short wide wings, this plane really scoots!



Roger Hopper and his bright yellow "Banana Bipe". Note the swept top wing, inverted "V" cabanes, and the fully rounded fuselage. It also has a slide over canopy ala the old Ercoupe.

AN HARDWARE

AN 2 THRU AN 20 BOLT-HEX HEAD

AN 21 THRU AN 36 BOLT – CLEVIS

AN 42 THRU AN 49 BOLT – EYE

AN 73 THRU AN 81 BOLT – DR HD (ENGINE)

AN 100 THIMBLE – CABLE

AN 115 SHACKLE – CABLE

AN 155 BARREL – TURNBUCKLE

AN 161 FORK - TURNBUCKLE

AN 162 FORK – (FOR BEARING)

AN 163 EYE – TURNBUCKLE (FOR PIN)

AN 170 EYE – TURNBUCKLE (FOR CABLE)

AN 173 THRU AN 186 BOLT – CLOSE TOL.

AN 210 THRU AN 221 PULLEY – CONTROL

AN 253 PIN – HINGE

AN 256 NUTPLATE – SELF LOCK (RT. ANGLE)

AN 257 HINGE – CONTINUOUS

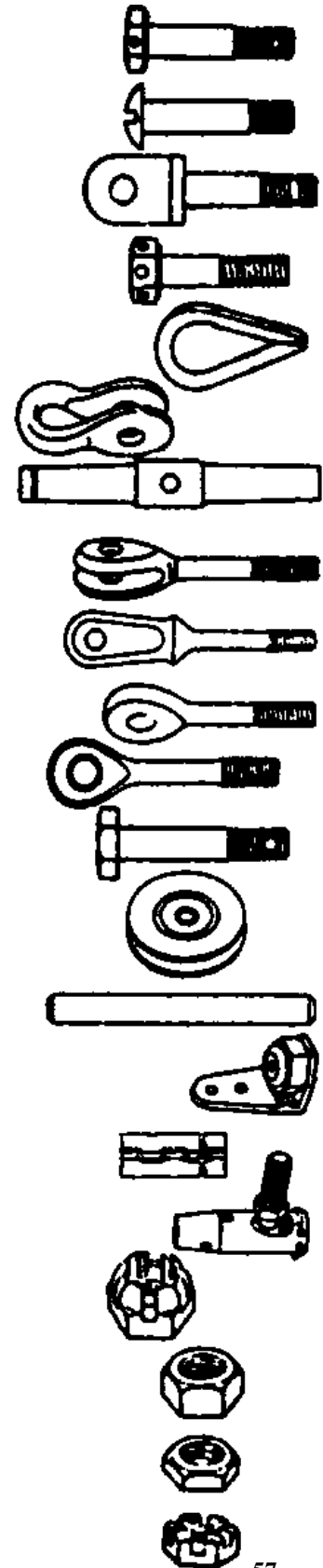
AN 267 JOINT – BALL AND SOCKET

AN 310 NUT – CASTLE

AN 315 NUT – PLAIN (AIRFRAME)

AN 316 NUT – CHECK

AN 320 NUT – CASTLE, SHEAR



AN 365 NUT – HEX

AN 340 NUT – HEX, MACH. SCREW

AN 341 NUT – HEX, BRASS, ELECT.

AN 345 NUT – HEX, MACH SCREW

AN 350 NUT – WING

AN 355 NUT – SLOTTED (ENGINE)

AN 360 NUT – PLAIN (ENGINE)

AN 362 NUTPLATE – SELF LOCK, (HI TEMP)

AN 363 NUT – HEX, SELF LOCK (HI TEMP)

AN 364 NUT – SELF LOCK, THIN

AN 365 NUT – SELF LOCK

AN 366 NUTPLATE – SELF LOCK

AN 373 NUTPLATE – SELF LOCK, 100 CTSNK

AN 380 PIN – COTTER

AN 381 PIN – COTTER, STAINLESS

AN 385 PIN – TAPERED, PLAIN

AN 386 PIN – TAPERED, THREADED

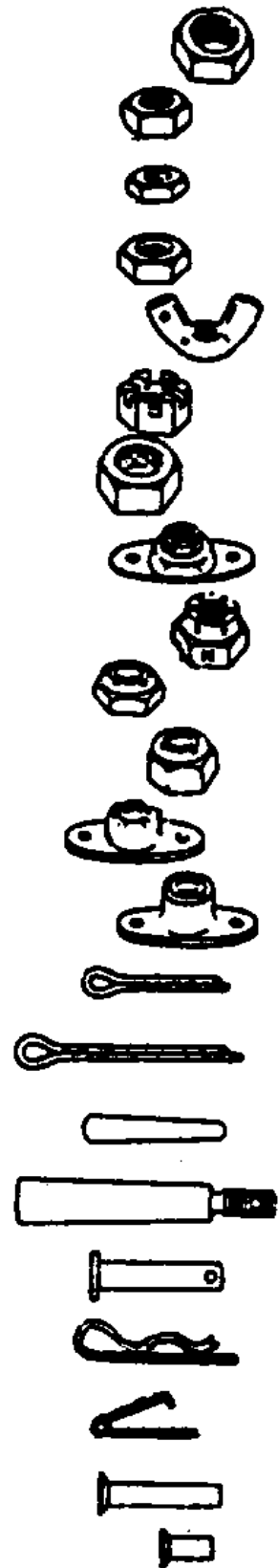
AN 392 THRU AN 406 PIN – CLEVIS

AN 415 PIN – LOCK

AN 416 PIN, RETAINING, SAFETY

AN 426 RIVET – 100 FLAT HEAD, ALUM AN

AN 427 RIVET – 100 FLAT HEAD, ST,
COPPER

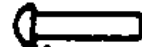


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AN 430 RIVET, RD. HEAD, ALUM



AN 435 RIVET, RD HD, ST, COPPER



AN 470 RIVET, UNIV HD, ALUM



AN 481 CLEVIS, ROD END



AN 486 CLEVIS, ROD END, ADJUSTABLE



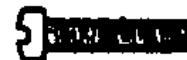
AN 490 ROD END, THREADED



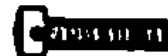
AN 500 SCREW, FILLISTER HD (NC)



AN 501 SCREW, FILLISTER HD (NF)



AN 502 SCREW, DR. FILLISTER HD (STEEL)
(NC)



AN 503 SCREW, DR. FILLISTER HD (STEEL)
(NF)



AN 504 SCREW, RD HD, SELF TAPPING



AN 505 SCREW, FLAT HD, 82 (NC)



AN 506 SCREW, FLAT HD, 82 , SELF TAP.



AN 507 SCREW, FLAT HD, 100 , (NF & NC)



AN 508 SCREW, RD HD, BRASS (ELECT)



AN 509 SCREW, FLAT HD, 100 , STRUCTURAL



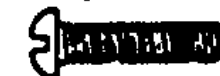
AN 510 SCREW, FLAT HD, 82 (NF)



AN 515 SCREW, RD HD, (NC)



AN 520 SCREW, RD HD, (NF)



AN 525 SCREW, WASHER HD (STEEL)



AN 526 SCREW, TRUSS HD (NF & NC)



AN 530 SCREW, RD HD, SHEET METAL

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AN 531 SCREW, FL HD, 82 , SHEET METAL

AN 535 SCREW, RD HD, DRIVE (TYPE U)

AN 565 SCREW, SET, ALLEN

AN 663 TERMINAL, CABLE, BALL, DBL SHNK

AN 664 TERMINAL, CABLE, BALL, SNG SHNK

AN 665 TERMINAL, CABLE, THREAD, CLEVIS

AN 666 TERMINAL, CABLE, THREAD, SWAGE

AN 667 TERMINAL, CABLE, FORK, SWAGE

AN 668 TERMINAL, CABLE, EYE, SWAGE

AN 669 TERMINAL, CABLE, T-B, SWAGE

AN 737 CLAMP, HOSE

AN 741 CLAMP, TUBE

AN 742 CLAMP, SUPPORT, PLAIN

AN 900 GASKET, COPPER, ANGULAR

AN 901 GASKET, TUBE, METAL

AN 931 GROMMET, ELASTIC

AN 935 WASHER, LOCK, SPLIT

AN 936 WASHER, STAR (INT * EXT)

AN 960 WASHER, FLAT, AIRCRAFT

AN 970 WASHER, FLAT, LARGE AREA

AN 996 RING, LOCK

