S-51 Fuselage Kit

Last revised 8/3/00

Introduction

The fuselage is much more complex to assemble than the wings for two reasons. First, most of the aircraft systems reside there, and these are left largely up the the builder. Second, parts of the fuselage require considerable trimming and fitting. This particularly applies to the scoop, cowling and cockpit floor. We recommend that those with little experience in sheetmetal aircraft construction begin with the wings. Unless you add auxiliary fuel tanks, the wings go together in a very straightforward manner.

The plans for the fuselage are less complete than those for the wing. In fact, no plans presently exist for some of the fuselage subsystems such as that for flap actuation. Fortunately, in most cases what needs to be done is fairly obvious. Nevertheless a close look at an project in a fairly advanced stage of construction will be very helpful in identifying how the parts go together. So after you get your parts inventoried and have a look at the plans, a visit with your local S51 wizard would probably be well worthwhile.

We will try to address most of the questions that arise in the course of the fuselage assembly in these notes. More recent builders will find that some of the comments are not applicable to their kits, due to either design changes or better documentation in the plans.

Most builders tackle the fuselage from front to rear. In these notes, we work from fore to aft on the top portion of the fuselage (above the scoop) doing the internal riveting, putting on most of the skin, and installing most of the control systems. Then we turn the fuselage upside down and spud in the tailwheel hydraulic lines, wires for the tail position light, trim actuators and and tailwheel microswitches. After that we fit the scoop, radiator and coolant lines. Lastly, we work on the tailfeathers and go back and complete as much of the interior as possible without mating the wings.

Begin by making a jig such as that shown in Figure 2.1 to hold the fuselage in a level attitude while you work on it. Nothing too elaborate is required. The example shown is made from 0.125" wall 2x2 tubing. The front part mates to the bottom of the fuselage at the forward wing attach fittings (5200-12). The rear part mates to the top of the fuselage at the forward horizontal stabilizer attach fittings (5200-75). Later on you will have to modify the rear part so that it supports the fuselage at the lift tube.

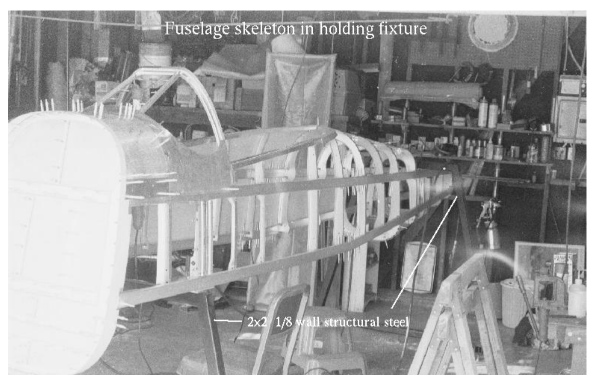


Figure 2.1. A simple fixture to hold the fuselage in alignment. Begin by supporting the forward end at the forward wing attach brackets and the aft end at the horizontal stabilizer attach brackets. Later on you will need to move the aft support point to the lift tube.

For now you can secure the fuselage to the tooling with clamps or bolts. Install the fuselage in the tooling so that the following criteria are met.

- The forward part of the lower longeron (e.g. before the bend) should be level. This levels the longitudinal (roll) axis of the airframe.
- The distance between centers of the forward wing attach fittings should be 25" (as specified in the plans).
- The forward wing attach fittings should be level. This levels the horizontal (pitch) axis.
- The forward horizontal stabilizer attach fittings should be level. This insures there is no twist in the fuselage.
- The forward wing attach fittings should be at least 32" above the floor to allow room for the scoop.

If you are sure that you will not need to move the tooling you can also mark the projection of the fuselage symmetry plane on the floor. Use plumb bobs at the front and rear to do this. You will really not have to use this line until you install the engine mount. Once you have the tooling aligned and the fuselage mounted, you're ready to begin work.

Firewall

Begin by removing the firewall and assembling it on the bench. The firewall is stainless steel and should be assembled with the Monel rivets supplied with the hardware kit. You can install the Monel rivets with a 4x gun and an extra heavy bucking bar, or you can build or buy a long reach riveting fixture (an Avery tool) and install them with a hammer. The Monel rivets have a tendency to tear up bucking bars that are not really hard, so it might not be a good idea to use your favorite bar.

The firewall should be sealed with a compound meeting MIL-S-38294, which you can likely get from the same source you used for your tank sealer. This stuff is a fibrous asphalt compound similar to roof patching material. It's not nearly as sticky as pro-seal, and so is much easier to work with. Use the sealer between the riveted parts so as to make the rivet holes and seams gas tight. You should also use the sealer where the firewall mates to the skin. Use enough so that it extrudes and seals the gaps where tabs are cut into the firewall. Inspect the job for gaps by darkening the room and backlighting the firewall.

The skeleton

Work your way from fore to aft installing the AN470 internal rivets. Most of this is pretty easy riveting. Some specific areas which require special attention are outlined below.

Canopy bow

You should use AN426 rivets in the aft side of the canopy bow (5200-30) where it mates with the canopy frame. This will make it easier to install the seal. Older editions fo drawing 5231 call for AN470's, but this has been changed. You will probably not be able to get a caged countersink inside the bow. Just use the plain 100° countersink on your deburring tool.

The angles (5231-6,7) which hold the sides of the center portion of the windscreen may warp if they are riveted with excessive force, The pieces here are small and the single rivet line is very close to one edge. This problem can be minimized by using the minimum rivet length and setting with the minimum amount of force.

The doghouse and instrument panel

You should not rivet in the doghouse (the structure that mounts the instrument panel) at this time. Most builders make modifications in this area so as to enlarge the usable panel space. Generally this involves reducing the depth of the doghouse and using vibration isolated standoffs to mount a panel that extends from the bottom of the upper longeron all the way to the glareshield. See the third issue of the Rivethead for an example. We will have more to say about this later.

Jim recommends against removing the doghouse completely, even though it was not used in strength analysis. If you cut it back to the minimum depth, you can get about 3-5/8 inches of clearance behind the panel just beneath the glareshield. This is not enough to install a sensitive altimeter, but will work for most airspeed indicators and the UMA vertical speed indicator. Many builders also move the cross-piece designed to mate with the bottom of the doghouse as far forward as far as possible. This will result in 3-5/8 inches of clearance behind the bottom of the panel; enough for engine instruments, switches, annunciator lights, etc. We suggest removing the doghouse and leaving crosspiece at the bottom pop-riveted in place for now.

Wing attach fittings

You can squeeze the wing attach fittings to the angles on the bench, then mate the assembly to the skin. On some of the very early fuselage assemblies, the fit between the angles and the skin was apparently poor. If so, be sure to install shims as done for the wings and bulkheads.

The tabs (5217-5,6 & 5216-4,5) that hold the attach fittings to the upper longeron were not furnished with some of the kits. They are installed with AN470 rivets; three per tab except for the center section of the rear fitting, which gets two. The riveting should obviously be done with the fittings clecoed to the skins. You will probably want to remove the excess material so that the tabs are flush with the inner edge of the longeron.

There are clips that secure the front and rear wing-fuselage mate fittings to the lower longeron. The front ones came with the kit, but the rear ones (p/n 5217-3/4) have been omitted in some cases. You can make them yourself from a piece of 2.5", 0.125 wall aluminum angle. 6061-T6 is satisfactory. See Figure A.4 for the fabrication and installation details.

Tailwheel mounting brackets

There has been a design change in the area where the tail strut assembly mates with the fuselage. This is described in the first issue of the Rivethead (the S51 builders newsletter), which I assume you have. If you have an old kit, check the Rivethead to see if yours incorporates the changes.

The rest

While working on the skeleton you can fabricate and rivet in the doublers at the point where the lift tube mates with the bulkhead at FS 191. See drawing M5545. You will not need to rivet in the gussets and crossmember that hold the rear seat back (M5110-5/6). This has been deleted from the design and the parts are no longer furnished with the kit. It's up to the builder to determine how to support the back of the rear seat and to anchor the rear shoulder harness. One possible solution is shown in Figure 2.2. For now you should omit the rivets in the doubler joining the lower longeron between 28.5 and 30.5" aft of the center of the rear wing attach fitting. These rivets are likely to interfere with the mounting of the rear seat frame. You will want to ream out some of these holes for AN3 bolts when you do the seat installation. You can put rivets in the remaining holes after you have the seat frame located.

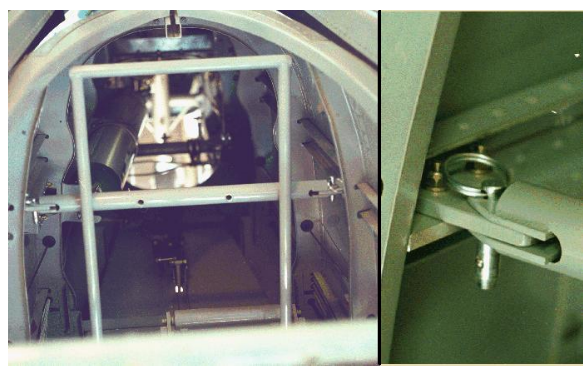


Figure 2.2. The cross-strut supporting the rear seat back. This arrangement is similar to that for the front seat. The strut attach brackets are riveted into the upper longeron.

Tailwheel

Strut

It's easiest to do the tailwheel installation before you rivet skins in that area. First assemble the strut. Jim has an illustrated write-up (Figure A.5) giving a step-by-step procedure. To that we add the following.

The tailwheel used with the kit was changed in the course of production. If you have a tailweel that will not fit on the axle, you will need to remove the axle that is welded into the fork and replace it with one fabricated from the bolt provided with the kit. The best way to remove the old axle is to grind the weld flush with the fork on a belt sander, then press out the axle. You will probably have to use a press to break the weld penetration. Then cut the new bolt to length and weld it in the fork.

Probably the most practical way to fit the clamshell clamp (Figure 2.3) to the outer strut is by using Dyekem (machinest's layout dye) to find the high spots, then removing them with a sanding drum or cylindrical stone in a die grinder. Don't be bashful; you have to take out quite a bit of metal. Once you begin to get a reasonable fit, make sure to put Dyekem on the lower lip of the fitting. You may have to remove material here as well.

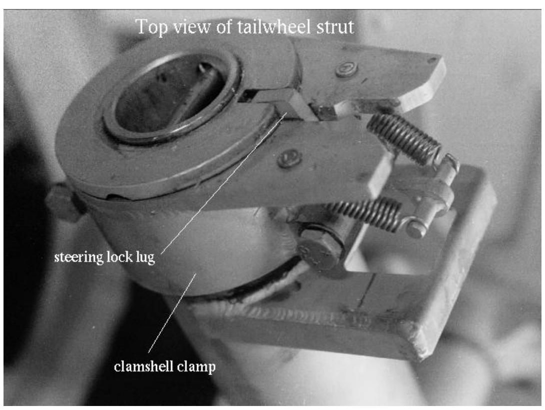


Figure 2.3. The clamshell clamp installed on the tailwheel strut. It is very difficult to get the tailwheel to turn freely with the clamp installed. Some builders modify this part to incorporate thrust bearings.

The small tabs welded to the exterior of the outer tailwheel strut hold an NAS383-1 pulley for the steering lock cable. The pulley OD may be too large to fit, provided that the pivot bolt is installed in the pilot drilled location. If so, you can put the pulley in a lathe and turn about 0.060" off the OD. Alternatively you could enlarge the bolt hole to 0.25" while moving it outboard.

Steering box

After you have the strut assembled and mounted in the fuselage, you can assemble and install the steering box as shown in Figure 2.4. Be advised that this assembly has one of the highest specific work requirements (the amount of work per unit size for non-engineers) on the aircraft, so don't be surprised if it takes awhile.

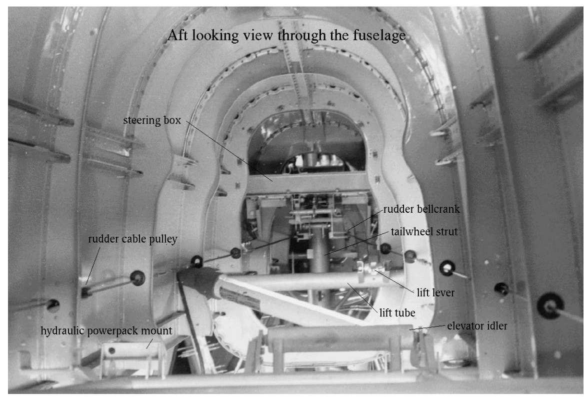


Figure 2.4. The steering box and related hardware viewed from the front. It already getting pretty crowded back there!

First you need to determine what you have in the way of parts and drawings. The problem is that the steering cable pulleys have been changed to a smaller size and this effects the dimensions of the pulley attach brackets. Presently NAS383-1 pulleys are supplied. On the other hand, some steering boxs were designed for MS20219-2 pulleys. To see what you have, consult the lower left corner of drawing 7203. If the bracket bend angle is 24°, you have drawings for the old MS20219-2 pulleys. If it's been changed to 17°, you have drawings for the new pulleys. Measure the bend angle on your box to see what you have. If you have an old box and old drawings to go with the new pulleys you have two choices; get the original pulleys (Wick's has them) or get the updated drawings and fabricate new attach brackets. The old pulleys are better quality (they have ball bearings instead of bushings).

There have been several changes made to the steering box design to address some cracks found in the prototype. These are all documented in the current drawings. Make sure that the angles (7203-6,8) on the top of the box mounting the downlock lever extend the entire length of the box, and that angle brackets (7203-19) that mate with the web of the upper longeron are shown in each corner. Most boxes do not incorporate these changes. If yours does not, you will have to add them.

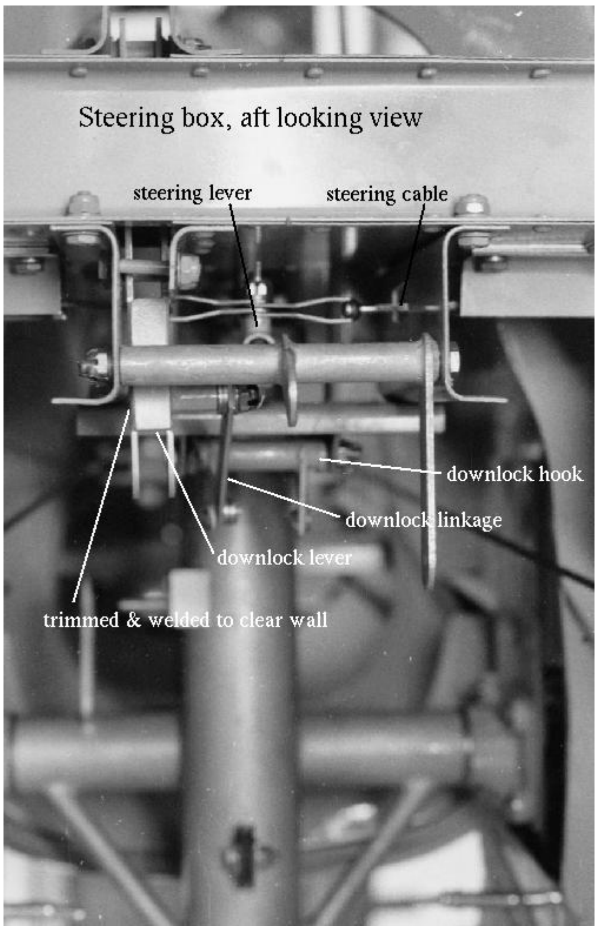


Figure 2.5. The downlock lever and associated hardware viewed from the front. The bolt extending between the downlock linkage and lever may need to be modified to fit correctly.

Begin by reaming the welded fittings for the pivot bolts or sleeves, as appropriate. Depending on the sleeve tubing you get with the kit, you may have to use an oversize (0.3775") reamer. The downlock lever (Figure 2.5) may require special attention. On some boxes the 0.25" OD, 0.187" ID tubing welded into the bottom of the lever (7202-5) protrudes too far on one side and interferes with the U-channel on the bottom of the box. If so you can trim the end off and rosette weld an AN3 bolt into it. This fastens to the linkage attached to the downlock hook.

Bench assemble the box, riveting in the forward crosspiece last. Leave the pulley brackets and the angles mating the pulley brackets to the box off for now. Put in the downlock lever before you rivet the box; it may be difficult to get in otherwise. Locate and mount all the welded fittings. Be sure you get the downlock stop and steering lever pivot (Figure 2.6) located in the exact center of the box.

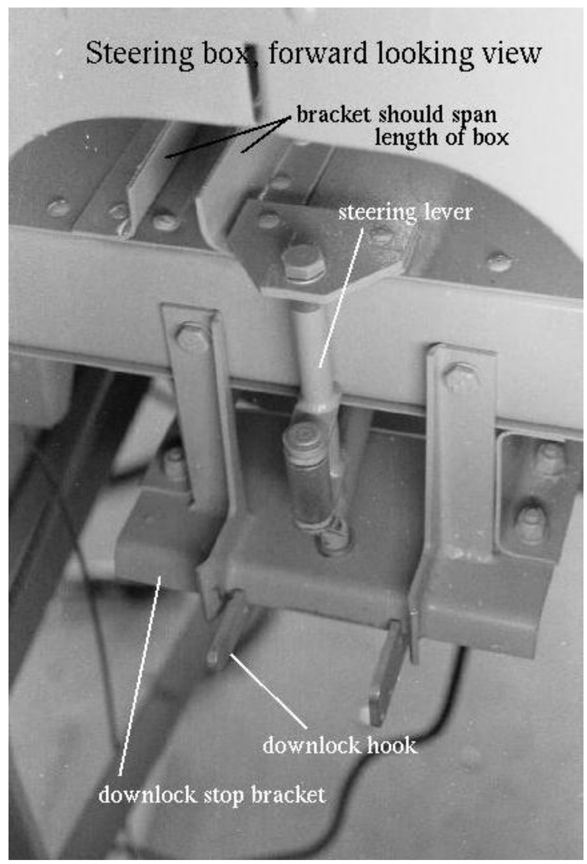


Figure 2.6. The steering box viewed from above and behind. Most builders use more than the 2 rivets called for in the plans on the bracket that holds the top of the steering lever.

The tubing furnished to sleeve the inside of the steering lever may be oversize. The design calls for the lever to turn freely on the sleeve, which is itself captured between the end fittings on the box. If your tubing is oversize you will need to turn down the OD and/or ream the lever ID until the parts fit freely.

Try mounting the box. Mark the location of the rear of the box on the upper longeron. The location is given in drawing 5200-2. The box fits better when installed on top of the longeron edges, Clamp the box in position. Rotate the clamshell clamp at the top of the strut so that the steering notch faces forward, them rotate the assembly to the down position. If you're lucky, the downlock hook will snap into position. If it does not, you need to move the box up or down slightly so that it will. If you need to shim the box up, be advised that you will likely have to shim the pulley brackets down by the same amount. You also may want to change the location of the pulleys within the brackets.

You can assemble the pulley brackets separately on the bench. The four flush rivets called for in the plans may not be pilot drilled, so don't overlook them. These are most easily installed by backriveting.

Take the box out and temporarily attach the pulley brackets. Locate and clamp in the pulleys to see how the cable will line up with the steering lever. If you have not needed extensive shimming, you should be able to use the pivot bolt locations in the plans (the correct plans, that is). If you have shimmed extensively you may need to adjust the bolt locations a bit in order to get the steering cable horizontal when mated to the steering lever on the box. Locate and mount the pulleys. Make some provision to keep the cable in the pulleys. The easiest method is to use a piece of mild steel strap or cotter pins.

Do you feel lucky today? If so, try fitting the corner brackets between the longeron and the box. The longeron is already pilot drilled for the skins, so you will need to pick up these holes. Hopefully they do not lie too close to the bend in the bracket. If they do, try mating the bracket with the inside of the box. If this still won't work, install one or more shims between the bracket and the interior of the box. You cannot shim the exterior of the box because you will have to be able to buck the rivets securing the skin (you would not want to use pulled rivets there, right). Locate the brackets and pick up the pilot holes in the longerons. Install clecos through the longeron to hold the brackets in position while you drill the pilot holes in the box.

Remove the box and rivet the corner brackets to the box. Then you can rivet or bolt in the box. Most builders use AN3 bolts. When you have the box secured, bolt/rivet the pulley brackets into place. This completes the steering box installation, so now you can go eat lunch!

Use 3/32" cables for the tailwheel steering. As shown in Figure 2.7, these clamp to the rudder cables a few inches forward of the steering box pulley. You will have to design and fabricate suitable clamps. See Figure A.6 to get an idea of what will work. Depending on how you terminate the cables you may need to enlarge the rectangular opening where the cables pass through the U-channel on the bottom of the box.

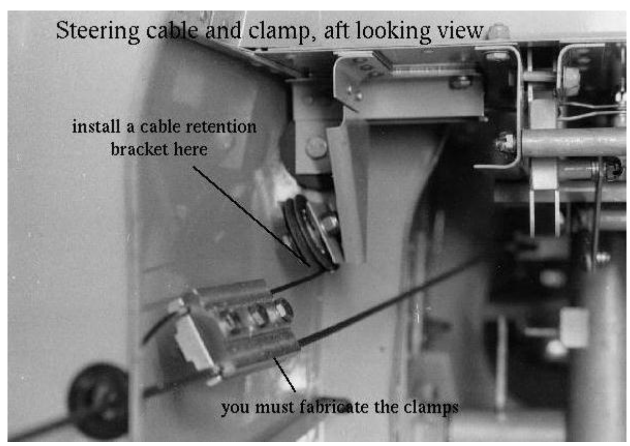


Figure 2.7. The steering cables are secured to the rudder cables with clamps. The retention brackets are not yet installed on the steering cable pulleys.

Some builders use and different way of routing the steering cables that eliminate the clamps altogether. In this design, the steering cables are routed aft from the steering box, around pulleys mounted aft of the rudder bellcrank, then forward to the rear of the rudder bellcrank.

The tailwheel actuator is installed between the downlock lever on the bottom of the steering box and the threaded rod welded to the outer strut. You can install it now. *Adjust the travel so that the actuator piston is bottomed out when the gear is in the up position.* You will need to insert a spacer between the piston and endcap to do this.

You will need to install a microswitchs for both the tailwheel uplock and downlock. The tailwheel downlock switch (Figure 2.8) mounts on the downlock hook with 2-56 screws. The holes should be predrilled.

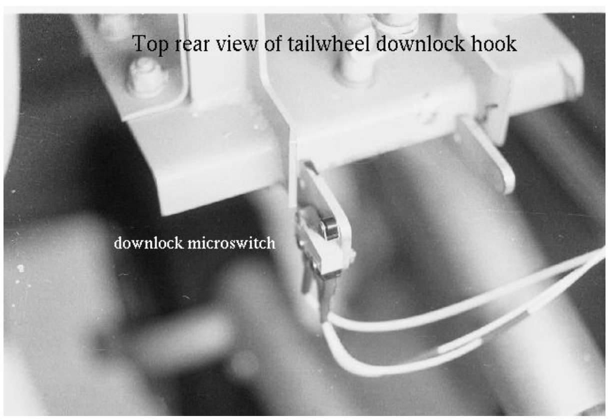


Figure 2.8. The downlock switch mounted on the downlock hook. In this clever arrangement the switch is activated only when the tailwheel is both down and locked.

This finishes the skeleton. Now would be a good time to spray the skeleton in primer if you're so inclined. The skins are attached next.

The forward fuselage skins

Most of the internal riveting is now complete, so you can begin the skin installation. Again it's probably best to work from fore to aft. The riveting is fairly easy compared to the wings. A lot of it can be done without assistance. Go ahead and ream, deburr and if necessary trim the skins forward of the aft end of the cockpit. Also install the structural screws securing the skins, longerons and engine mount brackets on the aft side of the firewall. The skin must be countersunk for #10 screws here; use a 3/16" 100° piloted countersink in a cage. You will probably want to clean, alodine and prime the skin interior.

It's important that you deburr the doublers inside the upper and lower longerons after you ream the rivet holes for the skin. This will require removing the firewall and drilling out the flush rivets securing the longerons to the bulkheads (these were installed at the factory). Once this is done you can slide the doublers out the front of the longerons and deburr them.

If you plan on using an engine in excess of 600 hp, you will need to add a length of 0.125" thick 2024-T3 strip inside the longerons. This is in addition to the strip that is already in the forward part of the longerons. The additional strip should run all the way to the tail. Doing this will require changes to the bulkheads where the longerons pass through.

With the skins removed, replace the doublers and remount the firewall. You can now fit the skins forward of the aft end of the cockpit, and install the rivets with the following exceptions.

- Do not rivet the small angle brackets (5200-78) located on the skin interior just aft of the firewall and below the top engine mount fittings. Wait until you do the rudder pedal installation for this.

- Do not rivet these skins to the lower longeron where the scoop will attach. It will be easier to fit the scoop if you can slide its top under the skin on the top part of the fuselage.

- Do not rivet the formed sections of skin (5500-8,9) at the rear of the cockpit. You may need to remove these when fitting the rear canopy track.

- The canopy crank mounts on the upper longeron on the right side with 10-32 screws (see drawing 5250). Four of the rivet holes will have to be reamed and countersunk for the screws. Identify these and omit rivets here. The crank can be moved slightly fore or aft of the design position if it is necessary to pick up the rivet holes.

- Similarly, you will be bolting the rear rudder pedal mounts to the lower longeron a few inches to the rear of the forward wing attach fitting. If bolt holes are drilled in the rudder mounting flanges, weld them up and pick up the pilot holes drilled for rivets in the lower longeron.

- Do not rivet the formed sections of skin at the bottom of the windscreen. These sections are best riveted after you have the doghouse riveted in and the side windscreen glass fit.

We recommend use of 3M 2216 structural adhesive as a liquid shim where the skins mate with the bulkheads and wing mounting brackets. See the notes on wing construction for hints on this technique. Where a gap in excess of 0.020" exists, you will need aluminum shims too. Be sure to use some firewall sealing compound where the skins attach to the firewall.

The holes for the screws that secure the instrument access plates (5500-10,11) located on the top of the nose can be dimpled for 8-32 screws. The plans call for 10-32's, but 8-32's look better and are strong enough. If you dimple the skin, you will have to dimple the mating doublers also and use countersunk platenuts.

The formed skin sections (5500-14,15) in the nose that mate with the canopy bow should overlap the skin just aft of it, as indicated in the plans. It's designed this way to make the canopy skirt flush with this section of skin when the canopy is closed. You will need to install AN426 rivets securing this skin section to the canopy bow. These must be double flush riveted. Use short (4-4) rivets and countersink both the exterior and interior surfaces. Wait until you install the windscreen glass to do this riveting.

Canopy tracks

Install the front canopy tracks according to drawing 5245. Use a countersunk 10-32 screw to secure each track to the canopy bow. Fit the rear canopy track in the channel provided in the turtledeck. Examine how the flange on the track mates with the bulkhead. On some of the early production tracks, the flange angle was not correct. If you have one of these you will have to cut the flange off and weld on a new one.

Before you install the tracks, examine the interior of the track in the areas where welds are present (e.g. underneath the studs for the forward tracks and in the area of the flange for the rear track). If any burn through has occurred, you will need to grind it *completely away.*

The cable and chain that closes and locks the canopy is on the right side. You will need to cut a slot in the fuselage for the cable pulley at the rear. If you install this pulley as shown in the plans, you will find that the brackets for the crossmember (see drawing M5320) will interfere with the cable. The best solution seems to be moving the pulley down as far as possible so that the cable, chain and turnbuckle pass beneath the crossmember bracket. If you put in everything as specified in the plans, you will probably have to put a piece of plastic at the leading and trailing edges of the crossmember bracket so as to get the cable, chain and turnbuckle to ride up over the top of the bracket. No big deal, but why do it if you don't have to?

The chain length is fairly critical in this installation; if the chain is a couple of links too long or short you will not be able to get full canopy travel. The length you need depends on where you put the crank, so don't cut the chain until you have the crank, trucks and canopy frame installed.

Rudder controls

It's easier to put in the rudder cables before you rivet on the skins aft of the cockpit, so we suggest you do that next.

Front and rear pedals

Install the front rudder pedals according to drawing 8022. The brake pedals are secured to the lever shafts with AN3 bolts. Do not install these until you can sit in the cockpit and position the brake pedals to suit you. The plans call for AN3 bolts to secure the rear rudder pedals to the lower longeron. These will be beneath the wing fairings, so they will not show.

You can install the pushrods (8022-5) connecting the front and rear pedals now. They install on the outboard side of the front pedals. You will have to cut a hole in the bulkhead just aft of the firewall through which the tube will pass. The pushrods should just miss the forward wing attach fittings if you install them with the tubing inboard of the tabs on the ends.

At this point the positions of the front and rear pedals can be easily changed if desired. If you move the rear pedals too far from the design position you may need to shorten or lengthen the rudder cables. Similarly, if you move the front pedals too far you may have to shorten or lengthen the pushrods and/or balance cable. You can wait to finalize the connection until you get the seats in and are able to try them out for size. Once you have them oriented so they are comfortable, proceed to the pulley installation in the next paragraph.

You may have to fabricate brackets for and install two MS20220-2 pulleys (Figure 2.9) on the aft side of the firewall for the balance cable linking the front rudder pedals. The Czech's shipped some kits without these parts. Use 10-32 screws to mount the assembly. You should put a couple of short pieces of U-channel (8022-12) on the engine side of the firewall where the pulleys mount. The balance cable (8022-10) is supplied with crimped terminations, but unless your legs are really short I expect you will need to shorten the cable.

Bellcrank

Next locate and install the rudder bellcrank (see drawing 8016). Ream the sleeve tubing to 0.250" and if necessary ream the bushings to the tubing OD. Assemble the bellcrank to the crosspieces and clamp the assembly in the fuselage frame. The *approximate* position is specified in drawing 8016. Attach the rudder cables to the pushrods at the rear rudder pedals and fix the pedals in the neutral position. Adjust the turnbuckles to mid-range. When the bellcrank is positioned correctly you should be able to attach the rudder cables with a bit of slack. The slack is necessary because the cables will eventually be routed straight back a couple of bays, then go directly to the bellcrank. One quarter inch forward of the location given in drawing 8016 should work well. When you install the rudder cables, the hole in the bellcrank for the rudder push-pull tube should go on the right side as viewed from the back.

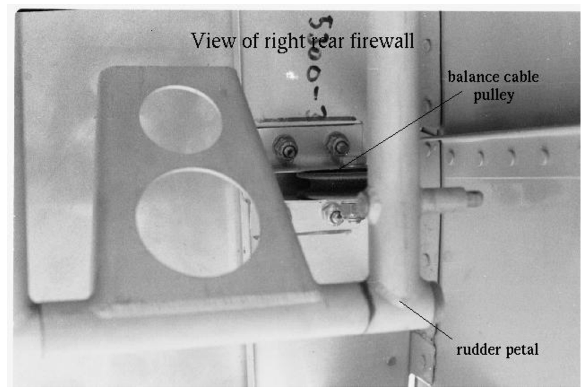


Figure 2.9. The balance cable connects the rudder pedals at the firewall. Two MS20220-2 pulleys are required. Shim them back from the firewall to allow the cable to clear the angles riveted to the aft side.

Cable installation

There are no plans for routing the rudder cables. The following method has the advantage of requiring only one pulley on each side. The only drawback is that the cables do not quite run straight into the rudder bellcrank. Because of this, the table tension will increase slightly when the rudder is moved from the neutral position. This does not appear to be a problem in practice.

The rudder cables come straight back (parallel to the aircraft's longitudinal (roll) axis) from the pushrod end through the second bulkhead behind the rear wing attach fitting (FS 151.5). The cable passes through the second bulkhead very close to the skin. As shown in Figure 2.10, install an MS20200-2 pulley just aft of the second bulkhead, where the lower longeron bends. The pulley brackets attach to both the bulkhead and skin. From there the cable runs straight to the bellcrank.

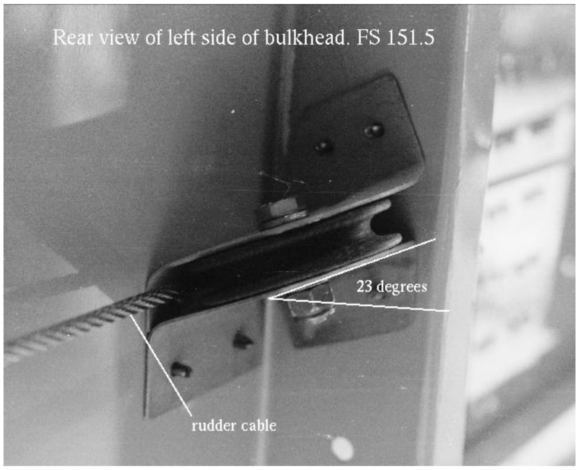


Figure 2.10. The rudder cables require installation of at least one pulley per side, at FS 152.27. Some builders use additional pulleys to route the cables straight into the rudder bellcrank.

For those who are mathematically inclined, here is the recipe for calculating the proper locations of the grommets or fairleads in the bulkheads. If you don't want to make the measurements and do the calculations yourself, you can try using the locations tabulated later. That should work if your pulley and bellcrank locations the same as those specified in the example.

Identify the cable position at the pulley just aft of the second bulkhead. It should be 4" above the top of the lower longeron about 0.25" from the skin. Make this the origin of your coordinate system. Measure the Cartesian coordinates of each bellcrank attach point with respect to this origin. Let z be parallel to the longitudinal (roll) axis, x be parallel to the horizontal (pitch) axis and y be parallel to the vertical (yaw) axis. The actual measurements of x and y are most easily made with respect to the fuselage symmetry plane and the floor (provided that your floor is level). Transform these to spherical coordinates in order to identify the angle α of the pulley with respect to the horizontal axis and the angle β that the cable bends from the longitudinal axis. The transformation is

$$\alpha = \arctan(\frac{y}{x})$$

and

$$\beta = \arctan(\frac{\sqrt{x^2 + y^2}}{z})$$

Arctan is probably denoted $\tan^{-1}$ on your calculator. Now measure the z coordinate for each of the intervening bulkheads. Alternatively you could take them from drawing 5200-1 and correct the origin. The corresponding x and y coordinates for the cable are given by

$$x = z \tan\beta \, \cos(\alpha)$$

and

$$y = z \tan\beta \, \sin\alpha$$

where both x and y are with respect to your origin. To lay out the points, you will probably want to measure x relative to the fuselage symmetry plane and y relative to the floor.

In the present example the pulley angle is $\alpha = 22.7°$ and the cable bend angle is $\beta = 7.4°$. The corresponding cable coordinates are given in Table 2.1. x is the distance from the fuselage symmetry plane, y is the distance above the cable height at the pulley and z is the FS. All are in inches.

Table 2.1. Rudder cable coordinates

location	z	x	y
pulley	152.27	11.37	0
blkhd	165.00	9.88	0.62
blkhd	178.88	8.20	1.32
blkhd	191.00	6.71	1.93
blkhd	206.50	4.91	2.69
blkhd	219.76	3.31	3.36
blcrnk	222.50	3.00	3.50

Note that the cable passes inside the last two bulkheads, but close enough to the bulkhead at FS 206.50 so that you will probably have to install a strip of Teflon or rubber molding to protect against chafing.

If you use only one set of pulleys the cable will bend where it joins the swaged eye fitting at the bellcrank. If this bend is too severe, you will need to fix it. The easiest and cleanest fix is to replace the eye fitting with a swaged stud mated to a spherical bearing. Unfortunately this will require replacing the aft end of each cable. If you route you cables as in the example, this should not be necessary.

The aft fuselage skins

Once you have the rear canopy track, steering box and rudder bellcrank installed you can install the skins aft of the cockpit. This is pretty straightforward. You will probably have to shim extensively (up to 0.20" in places) where the skin joins the tailwheel mounting brackets, where it joins the bulkheads reinforced for the horizontal stabilizer attach fittings (FS 219.76 and 234.76), and at the bulkhead at FS 178.88. Apparently the fit of the latter bulkhead (Figure 2.11) is a chronic problem. The only rivets which are particularly difficult are those inside and beneath the lower longeron at the tailwheel attach fitting and those in the upper longeron inside the steering box. You will probably have to make special bucking bars for the lower longeron rivets. The rivets in the upper longeron can be reached through the top of the steering box with more conventional bars, but when you do the turtledeck you will be working totally by feel. Try not to mash your fingers any more than necessary. It will make this riveting easier if you wait until you have the fuselage inverted for the scoop installation.

Right side of turtledeck at FS 178.88

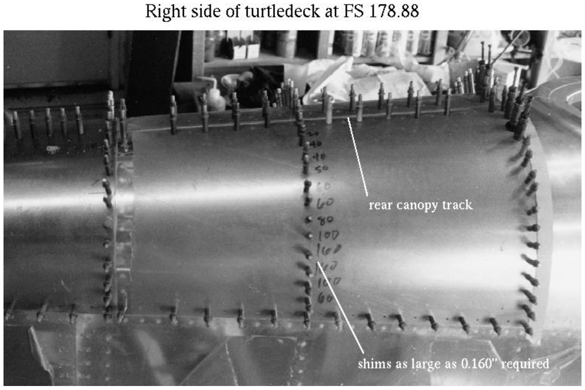


Figure 2.11. The fit of the turtledeck skin to the bulkhead a FS 178.88 is unusually poor. You may have to shim some rivet holes as much as 0.160". This is an extreme example. Most parts fit much better than this.

You will need to make or purchase fittings for the static ports and rivet them in. Based on data from completed kit aircraft, the static port location specified in drawing 5500-2 seems to be satisfactory.

Some builders install a baggage shelf in the turtledeck behind the rear seat. If you need to put a battery in the tailcone, you will likely end up putting it here. Fitting such a shelf is less difficult if done before the turtledeck is riveted in. Don't put it in yet as you will be spending considerable time wedged into the tailcone. It's best to put the shelf in with screws, so that you can get it out if necessary.

Most builders paint the interior. If you want to do this, it will be easier to do the top and bottom (scoop) sections separately. You may as well do the top now.

Seat frames and elevator/aileron controls

It's easier to take care of a few preliminary jobs on the bench before you bolt in the seat frames. First, you may have to replace or extend the bolt tabs on the aft end of the rear seat frame. They often need to be extended about 0.125", and the bolt holes need to be moved outboard about the same distance. You can grind off the old tabs and weld on some new ones, or weld some additional metal to the ends of what is supplied. Do not drill the bolt holes for now. If you add metal to the ends, weld up the old holes and reface the tab surfaces.

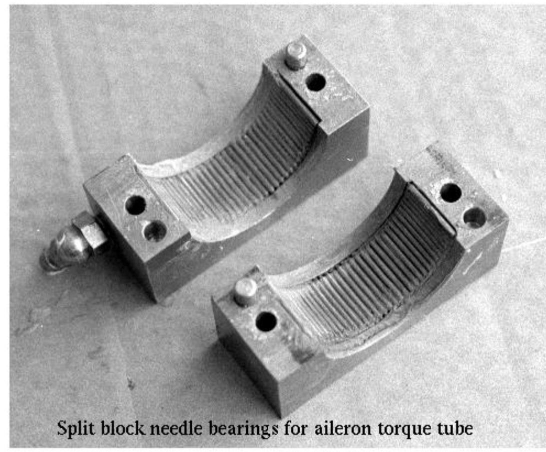
The front and rear control sticks mount to a torque tube which is fastened to the bottom of the front seat by means of split aluminum bocks. These blocks also serve as the bearings for the tube. Rotation of the tube controls the ailerons, so if you want to feel the airloads you will want to minimize the friction in this area. Usually the mounting pads for the bearing blocks warp when they are welded to the seat frame. As a result, the ends of the pads typically angle upwards. The best solution for this is to put the seat frame in a milling machine and face off the bottom of the mounting pads. If you do not have access to a mill, or have to take off too much material (around 0.025" is typical), you can install shims instead. In either case you will probably need to ream the 3/16" bolt holes in the pads oversize to allow the bearing blocks to self-align.

If you shim, you will have to determine the shim thickness and placement by trail and error using Dyekem to find where the shaft binds in the bearings. This is much more easily done on the bench. When you've shimmed as best you can, grease the bearings and see if you're satisfied with the result. If you are, we recommend gluing in the shims, because otherwise you're unlikely to get them back in the same place. Use a rigid adhesive such as Devcon Type A. Most builders also cut grease groves in the bearing blocks and install grease fittings.

If you still have an unacceptable amount of friction, you will need to come up with a better bearing arrangement. This is not very difficult if you have access to the right equipment. You may also need to grind the bearing surfaces on the torque tube round. They are often slightly out of round. Then you can make new split steel blocks and bore them for needle bearings. The blocks (Figure 2.12) should be pinned for alignment before boring the bearing race. Each block requires approximately seventy two 0.0625" diameter needles. The cheapest way to get the needles in this quantity is to dissemble (e.g. crush) eight Torrington B-812 bearings. This common part should be available through any bearing supply house. This modification adds a day or two of work, but essentially eliminates friction from this part of the control system.

Once you have fit the torque tube you can mount the torque / push-pull tubes and sticks to the front seat. Many builders use a 3/16 quick release pin to hold the rear stick in its receptacle. If you have ever scrambled in and out of the rear seat you will understand why.

Before you bolt in the seats, make sure the distances between the sides of the fuselage and wing attach fittings are correct. You want 25.0" between centers for the forward attach fitting and 24.5" for the rear. See the upper right corner of drawing 5200-1 for the fuselage dimensions at the bulkheads. If you bolt the seats in at the locations specified in the plans, the front seat frame will interfere with the installation and removal some of the bolts in the rear wing mate brackets. If so, these will have to be installed before the seat frames.



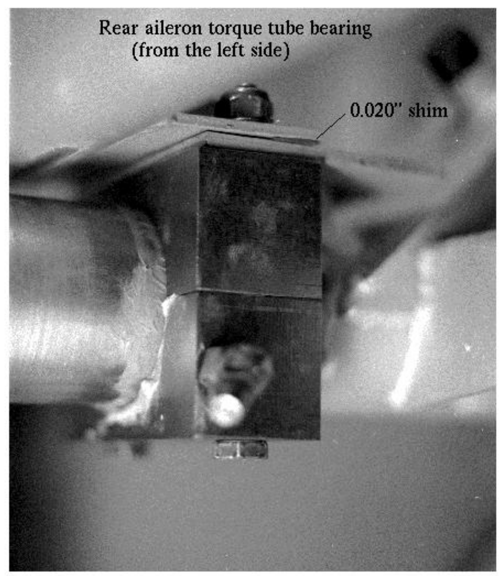


Figure 2.12. A fabricated needle bearing for the aileron torque tube. You can use the parts furnished with the kit, but considerable fitting (possibly involving some machine work) will be required to reduce control friction to acceptable levels.

The aft end of the rear seat mounts just forward of the joint in the lower longeron. There is a doubler inside the longeron here, so the height of the aluminum crush block (M5110-7) that fits inside will have to be reduced accordingly. Further, you will probably want to pick up the holes in the longeron which have been pilot drilled for rivets. The spacing is unlikely to be the same as that in the block. The easiest solution (here I'm assuming you have welded up the bolt holes in the seat frame mounting tabs) is to turn the spacers sideways and drill two new holes using the pilot holes in the longeron bottom for a guide.

Next you need to install the lift tube (8023-12). You will have to grind the ends of the lift tube to fit it inside the fuselage. Use a grinder, belt sander or cutoff wheel. Install the doubler on the bulkhead if you have not already done so, then drill and ream for the four AN3 bolts that secure the lift tube to the bulkhead and lower longeron. Cleco into place and mark the OD of the tube on the interior of the skins. Remove the tube, measure the diameter of the marked circle and use that to find the approximate point at which the lift tube axis intersects the skin. Drill a small hole (1/8" or so) in the skins from the inside at this point. Reinstall the lift tube and check to see how well the holes are centered. One way to do this is to stick an allen wrench through the hole and use it as a feeler gauge. Or you can illuminate the interior of one skin and check visually through the hole in the opposite skin. Ream out the hole to 1/4" (if necessary do this in stages while moving the hole towards the center). Select a hole saw or chassis punch of the proper size and cut holes in the skins. You can use 1-1/8" if your guide holes are well centered. Use a half-round file to finish opening up the holes to the ID of the lift tube.

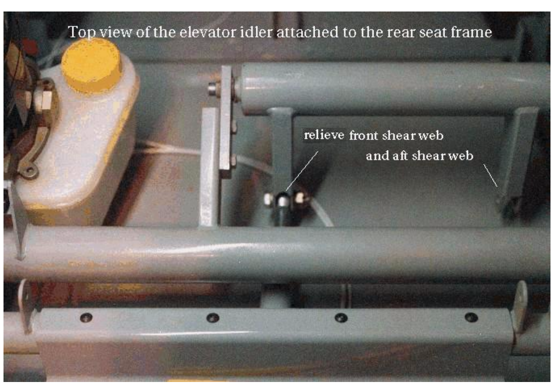


Figure 2.13. You will probably have to trim a bit from the webs of the elevator idler arms in order to eliminate interference with the rod end bearings.

Mate the elevator idler to the back seat frame and mate the lift lever to the lift tube. The small tab machined into the lift lever goes above and aft of the pivot bolt. This is where the tailwheel steering lock cable attaches to the elevator control system (see Figure A.7). On the elevator idler (Figure 2.13) you will probably find it necessary to relieve the front shear web of the right arm and the rear shear web of the left arm in order to prevent interference with the rod ends. You will likely also need to radius the interior aft edges of the slot which accepts the rod end on the lift lever (Figure 2.14). This is necessary to provide for enough side movement of the aftmost elevator push-pull tube, which angles towards the center of the fuselage where it attaches to the elevator horn. Install the elevator push-pull tubes as shown in the plans. The plans call for installation of the shorter of the two in front (between the rear stick and the idler). According to Jim, it's easier to rig the elevator controls if the lift lever is vertical when the stick is neutral. At present, the aft push-pull tube is too long to accomplish this, even with all the rod ends screwed in as far as possible. If you have access to welding equipment, you may want to shorten the rear tube about 1.5". As a guide, you must provide for a minimum of 1.50" of forward (pitch down) and 2.75" of rearward (pitch up) travel at the top of the lift lever. These distances are with respect to the position of the lift lever when the stick is in the neutral position. Full movement of the lift lever should translate into 30° up elevator travel and 20° down. The forwawrd stick travel is limited by the instrument panel. Many builders find the rearward stick travel required to move the elevator over its full range to be excessive. They reduce it by changing the ratio in the lift lever, typically by moving the bottom attachment point upwards.

Tailwheel gear doors

Installing the doors is pretty easy. Cleco the hinges to the doors and then clamp the assembly to the fuselage. The doors are too short to cover the entire opening in the fuselage bottom; they should be positioned flush with the *aft* end of the opening. Pilot drill and cleco the hinges to the fuselage, then mark and trim the doors to fit. It is easiest to trim before you rivet the doors to the hinges. If you have access to a shear, most of the trimming can be accomplished in a few minutes. Some builders use a brake to put a little more bend in the lip that extends from the inboard side of the left gear door. When everything fits, rivet up the gear doors. You will have to add a small piece of skin at the forward end of the gear doors, but wait to do this until you have the scoop installed. *When fitting the gear doors, check to see if they match the contour of the fuselage bottom at the forward edge.* Nearly all of them have too much bow at the forward edge. You will probably need to progressively flatten the doors as you go from the aft end forward. To do this you will have to move the pilot holes in the doubler in the door interior.

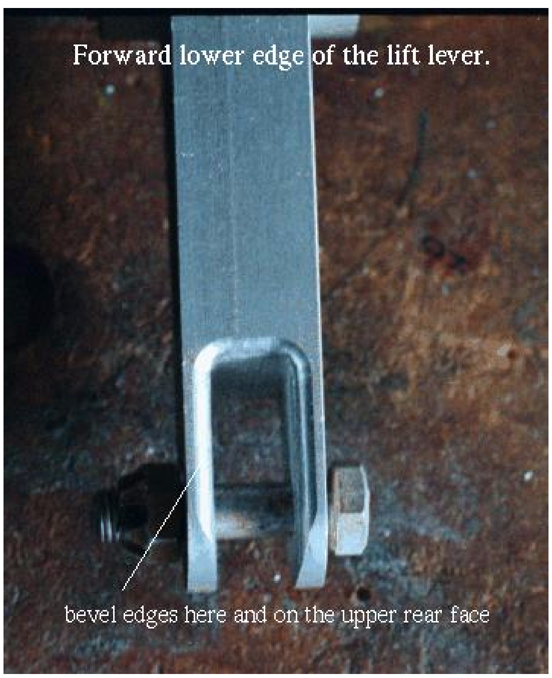


Figure 2.14. You will probably have to bevel the inside edges of the lift lever to prevent the rod end bearings from binding at the extremes of travel.

Drawing M7205 has been changed. The push-pull tubes and female rod end bearings depicted in the original drawing longer used. Male 1/4-28 rod end bearings are used instead.

Engine mount

Note that the distance between centers of the upper and lower engine mounts on the firewall is not the same. In assembling the engine mount, you will have to *bend the upper segment of each arm inboard to account for this difference.* As shown in Figure 2.15, this requires putting a slight bend in the doubler that mates the upper and lower arm segments near the mid-point of the mount. The bends should be 3.7° and should be made along the top of the lower arm segment aft of the joint. The original plans were (to put it mildly) not very clear about this, as evidenced by the fact that the Czechs pilot drill the part incorrectly. This has been flagged in the current edition of drawing 6000-1.

In order to get the incorrectly positioned pilot holes to clean up when reamed to 5/32, some care is required. Drill out the pop rivets securing the arm segments together, then mark and bend the doublers as described above. Do not drill or ream any additional rivet holes for now. Reassemble each arm on some sort of jig so as to enforce difference in the distance between centers for the upper and lower mounting flanges. The jig should insure that the lower segment of the arm will be *vertical when mated to the firewall* (e.g. you do not want to cant the lower arm segment to make things fit on the firewall). Canting the lower arm segment (6000-2,3) will cause difficulty later when you mount the engine. As illustrated in Figure 2.16, clamp the lower arm to a flat table, then use a spacer to set the proper angle of the upper arm (6000-4,5). The bends in the doublers will cause the pilot holes in those areas to no longer line up properly. Clamp the doublers in position *so as to distribute this error over both the upper and lower arm segments.* This way when you ream the holes to 5/32", they will (barely) clean up completely. Drill, ream and deburr the rest of the rivet holes. Some rivet lines are apparently not being pilot drilled, so be sure to consult the plans. Do not drill or ream holes for the rivets which attach the cradle to the arms. Also, do not ream the four aftmost pilot holes in the top of the lower arm segment. These should not have been drilled at the factory, but cause no real difficulty.

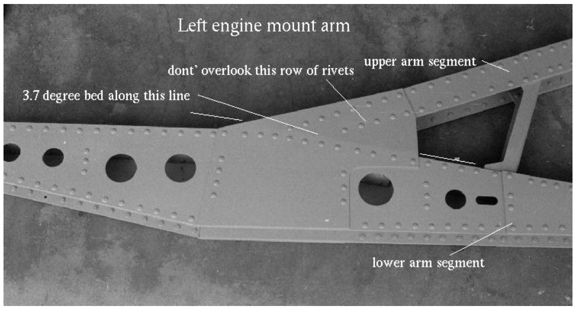


Figure 2.15. A 3.7 degree bend in the engine mount is required if the lower arms are to be vertical when installed on the firewall. This is extremely easy to overlook, and is not done in the parts furnished with the kit. If you install the mount with the lower arms canted inwards it will cause some difficulty when you mount the engine.

You will be installing AN3 bolts in this area when you mate the mount to the firewall using the pattern pilot drilled into the attach fittings. You will likely end up simply plugging most of the pilot holes in the arms with double flush #3 rivets. Finally, *do not ream the pilot holes or install rivets where the engine mate fittings attach, particularly the forward fittings.* Have a look at the section on cowling installation and see Figure A.8 if you are unsure of what we refer to. You will again be using AN3 bolts here.

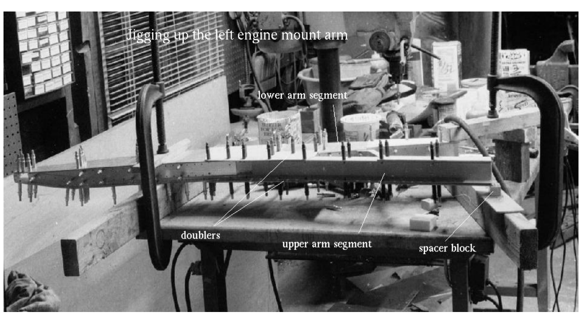


Figure 2.16. The easiest way to insure the proper angle between the planes of the upper and lower arms is to block up the upper arms when you ream the rivet holes to 5/32.

You can rivet the arms together now. For some reason the hardware kit does not include the required AN470AD-5 rivets. You will need about 1# of 5-6s, 1/2# of 5-7s, 1/4# of 5-9s, 1/2# of 5-12s and 1/4# of 5-13s (or longer). Assuming you want to avoid using pulled rivets, the easiest method is to do the job in separate steps. The order is not important until you get to the final assembly. Most of the rivets can be squeezed if you can find a squeezer that will handle #5s.

- Rivet side skins (including the doubler plates) to the small internal ribs in the lower arm segment
- Rivet the upper and lower halves of the upper arm segment together
- Rivet the top of the lower arm segment to the stack of 0.125 internal doublers
- Rivet the bottom of the lower arm segment to the stack of 0.125 internal doublers, making sure not to install rivets where the cradle will attach.

Insert the top and bottom of the lower arm segment into the side skins and rivet everything together. Rivet the upper arm segment to this assembly. This completes assembly of the arms.

Construct the cradle in a similar manner. Rivet the top and bottom skins to the internal ribs, and assemble the forward and aft ends of the cradle separately. Cleco the assembly together but *do not rivet in the fore and aft ends.*

Mating the cradle to the arms requires the use of some sort of jig. It's easiest just to use the firewall itself. Begin by reaming out the attach fittings to 0.250" so that you can use 1/4" bolts instead of the metric bolts furnished with the fuselage. The engine mount attach bolts should be oriented parallel to the longerons. You can make a 9° drill guide and used that to get the hole axis aligned correctly in the firewall and rear fittings.

One batch of forward attach fittings (part numbers 6502-3-6) have the pilot holes for the thrubolts were drilled perpendicular to the rear face of the fittings, which is not correct. Past runs of these parts did not have this problem, and hopefully future runs will not.

In the parts with perpendicular pilot holes, either the bolt holes will not come close to aligning or the rear face of the fitting will not sit flush against the firewall. Note that the bottom fittings are installed with the arms vertical (recall that the bottom arm segments are vertical). In this case the pilot hole should be angled 9° off perpendicular in the plane of the arms *measured with respect to the fittings rear face* (the one that mates to the firewall). The pilot hole orientation in the top fittings is a little more involved because, as described previously, the upper arm segments are supposed to lie 3.7° off the vertical. In this case the pilot hole angle should again be 9° off perpendicular in the vertical plane, but *after the 3.7° rotation.*

If you have a fitting with incorrectly drilled pilot holes and to not have the equipment to fix them (a milling machine is required), consult with PAE. If the pilot holes line up, you can bolt the forward attach fittings to the firewall and clamp the arms into them (Figure 2.17). Use bolts corresponding to the hole size, and locate the arms as far aft in the lower attach fittings as possible. Orient the arms so that the top of the lower arm segment (forward of where the upper segment joins) is *angled* 1.5° *downward* with respect to the longerons. Adjust the arms in the attach fittings so that they are level in the aircraft's pitch axis. This should cause the arms to fit into the attach fittings pretty well. If necessary, you can relocate the top fittings slightly by reducing the pilot bolt diameter by 1/16".

You probably have a copy of drawing 6000-1 which calls out a distance of 8.82" between the lower arm and the extented centerline of the upper longeron. This dimension is incorrect; just ignore it. Angling the lower arm downwards 1.5° from the upper longeron makes the correct distance close to 10".

Cut a 17.5" wooden spacer to set the distance between the forward tips of the arms. You can use a bungee cord to hold it in place. Snap a line on the floor along the symmetry plane of the fuselage and use a plumb bob to make sure the tips of the arms are centered on the line. Once the arms are located, clamp the cradle into place, pilot drill, Cleco and ream the rivet lines. Make sure the arms are completely seated in the cradle before you drill. Remove the forward and aft ends of the cradle to buck the rivets securing the cradle to sides of the lower arm segments. You will have to reach through the access holes in the exterior sides of the arms to buck the rivets in the corner clips securing the cradle to the bottom of the lower arm segment. If this is too difficult you can always use structural pulled rivets here. Close out the engine mount by riveting in the forward and aft ends of the cradle.

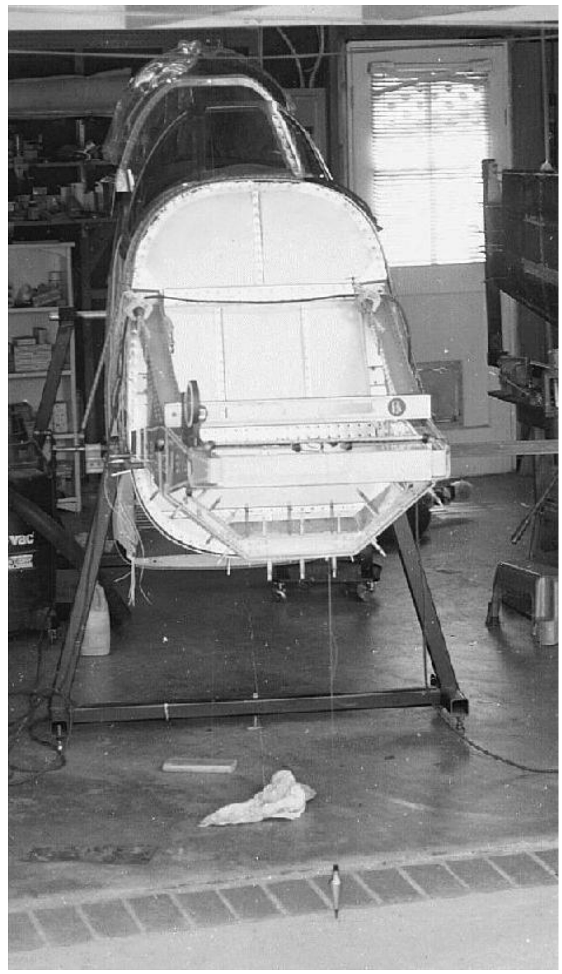


Figure 2.17. The engine mount lower arms should be symmetric with respect to the fuselage centerplane and angled downwards 1.5° with respect to the upper longerons. The distance between the tips of the lower arms should be held at 17.5".

Remove the assembled mount from the attach fittings and ream the lower fittings for the AN-7 attach bolts. Use your drill guide for the aft fittings and ream the forward fittings with a drill press. Remate the mount to the firewall and re-check the alignment. If everything is still OK you can drill and ream the holes for the AN-3 bolts that secure the mount to the forward attach fittings. Complete the installation by drilling and reaming upper attach fittings in place for AN-8 bolts. If your pilot holes are oriented correctly you might consider using a piloted counterbore instead of a drill.

Cockpit floor

You will find it easier to fit (but not rivet) the cockpit floor before you attach the scoop to the upper fuselage. This is a pretty straightforward job, although it does involve quite a bit of measuring and trimming. For example, compare the parts furnished with the kit with the corresponding trimmed parts in Figure 2.18. Again, work from front to back. Do yourself a favor and think before you rivet any of the floor components. Smart builders put in most of the floor with screws. 6-32 button head cap screws look particularly nice.

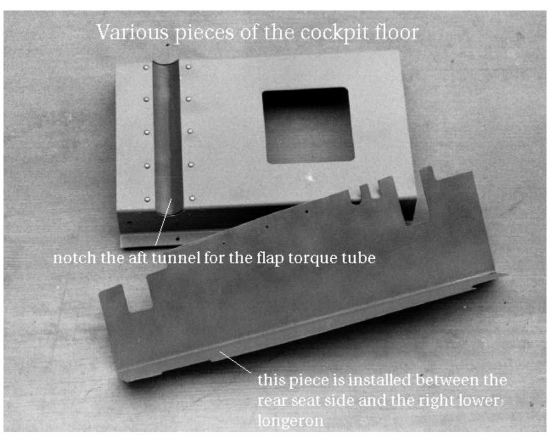


Figure 2.18. Some examples cockpit floor pieces after fitting and trimming.

Begin by fitting the step brackets (5210-10,11) that attach the floor to the lower longerons forward of the front seat. Make cutouts for the forward wing attach fittings and aft engine mount fittings. Pilot drill the rivet holes which attach the step fittings to the lower longerons on approximately 2 inch centers. The fittings (and the remainder of the floor) should rest inside the lower lip of the longerons. Cut the floor to clear the fittings on the firewall and hang it between the step fittings. The parts in the floor kit labeled -22 (2 angle brackets which are bent somewhat less than 90°) are used to support the floor from the bottom at the firewall. These parts do not appear on the assembly drawings. Make sure the floor is level, then pilot drill the firewall for the rivets holding the -22 fittings.

Make sure the distance between centers of the forward wing attach fittings is 25" (your jig should hold this dimension), then pilot drill the rivet holes which secure the floor.

The tunnel fits in between the vertical angle brackets (5300-9) on the firewall and between the tabs welded to the front of the front seat frame. Use these to locate the tunnel sides and the angle brackets which mate the sides to the floor. You can pilot drill the angle brackets, floor and sides. The angle brackets and sides can be riveted together now.

The top of the tunnel needs to be cut into two sections. The cut is probably best made just aft of the avionics console (which extends from the bottom of the instrument panel to the top of the tunnel). If you angle the avionics console 11° from the vertical, you will need to make the cut 8" from the aft end of the tunnel. The aft portion of the tunnel top needs to be cut for the front stick and should be attached with screws. Most builders also attach the forward part with screws.

Work your way back to the parts (5210-12,13) that mate to the sides of the front seat frames. The tab welded to the right side of the front seat frame is where Jim mounts his emergency hydraulic pump on the prototype. If you are not going to use an emergency pump (the gear is designed to free fall), you can simply cut this tab off. Make sure the distance between centers of the aft wing attach fittings is correct before you drill any holes in the lower longeron. The seat frame material is pretty soft and thin, and according to Jerry it's easy to strip the threads if you use sheet metal screws to attach the floor and pans. Some attach the floor components and seat pans to the seat frames using 8-32 button head cap screws. These builders weld threaded studs into the seat frames to accept the screws (you could use hardware store stainless nuts just as well, and avoid a lot of work).

Start the installation of the aft portion of the floor with the tunnel (5210-14). This sits in between tabs welded to the front and rear seat frames. Position the tunnel so that its bottom is level with the bottom of the lower longerons and drill and cleco it to the seat frames. Then proceed with fitting the remainder of the parts. The tunnel section should be attached with screws, not riveted. You will have to notch the aft tunnel for the flap torque tube.

You need to wait until you have the wings mated to the fuselage and the main gear installed to locate and install the sheet (5210-3) that extends below the floor between the wheelwells.

Scoop and Radiator

First separate the scoop (drawing 5400) and the duct (drawing 5410) and set the duct aside. You will have quite a bit of fitting to do in this installation, and in our experience it works out better to *first fit the scoop to the fuselage, then fit the duct to the scoop.* The fit of the fuselage and scoop is obviously important if you want a structurally sound and good looking airframe. Except in a very few areas the shape of the duct is unimportant, and it's not a structural part. So feel free to nip, tuck, bend, patch and shim as necessary to get the duct in the scoop. The result may not be especially pretty, but since most of the duct is buried inside the scoop and/or underneath the floor, you will not have to look at it.

It is much easier to fit the scoop with the fuselage upside down. If you have enough riveting done on the skins so the fuselage will not twist, simply supporting it on sawhorses as in Figure 2.19 will work fine. Make sure the width of the fuselage is correct at fuselage stations aft of the rear wing attach fitting. The necessary dimensions can be found in the upper right corner of drawing 5200-1. Clamp some lengths of wood between the sides of the bulkheads to hold the proper dimensions. At each bulkhead (and also at the joint in the lower longeron) precisely measure the distances between the middle of the upper and lower longerons (e.g. the seams in the skins), then tape the skin at the lower longeron to protect it from scratchs.

Figure 2.19. Fit the scoop with the fuselage inverted and with internal braces installed as necessary to control the fuselage width.

Place the scoop on the fuselage with the forward bulkhead (FS 125) against the rear of the aft wing attach fitting. The scoop skin will overlap the skin on the fuselage. The only critical dimension on the scoop is the 21" from the scoop bottom to the bottom of the lower longeron at the forward edge. Check this, adjust if necessary and clamp the scoop to the fuselage at the forward edge. Center the scoop on the fuselage and mark the centerline of the scoop. You can use the joint between the radiator access panels and the two pieces of skin on either side of the tailwheel gear doors as guides. Mark a preliminary trim line on the sides of the scoop by measuring from the seam at the upper longeron. Be sure to mark the position where the trim line changes direction. Mark a trim line on the aft end of the scoop too. Use a transfer punch to locate holes in forward scoop bulkhead for the two lower aft bolts in each of the aft wing attach fittings.

Remove the scoop and trim somewhat short of the lines, say about 0.5". Measure the length and width(s) of the radiator door and lay out the opening on the scoop with respect to the centerline. The hinge pin on the door should be about 2.125" aft of the front of the bulkhead at FS 165. Note that the radiator door cut extends through the aft end of the scoop. Cut out this opening, leaving about 0.5" on the sides and about 1" in the front. A cutoff wheel in a die grinder works great for this. Drill and ream the 0.250" holes for the wing attach fitting bolts in the bulkhead at FS 125.

Hopefully, you have not yet riveted the fuselage skin to the lower longeron. If so, you can reinstall the scoop, this time with the scoop under the fuselage skin. Install a couple of bolts through the forward bulkhead and the rear wing attach fitting to secure the front of the scoop. Progressively mark and trim the aft end of the scoop until it fits. You will likely need to use something to hold the scoop down in the back while checking the fit. A ratchet takeup strap will work nicely. When the fit is satisfactory, secure it by crawling inside the turtledeck, picking up the pilot holes in the bulkhead at FS 191, and installing clecos. Next carefully mark the final trim lines on the sides. This will be easy if you have the scoop underneath the fuselage skin. You can also lay out and pilot drill rivet holes securing the scoop to the lower longeron. *Do not drill any holes in the access panel(s) between WS 138.5 and 151.5.* You will be using platenuts here, at least on one side. With the PAE engine, you will need platenusts on both sides.

You can now demount the scoop and do the final trim on the sides. Next you need to install the bulkheads. First see if your kit includes the modification to the bottom of the bulkhead at FS 138.5 designed to raise the bottom of the duct 0.625". This is change C in drawing 5400. Jim added this so as to insure adequate clearance between the radiator box (in the duct) and the radiator access panels in the scoop. The Czechs apparently ignore this change. If it's missing, fabricate and install the part in accordance with drawing 5400, and be aware that you will also have to modify the duct (which hopefully you have not riveted yet). In some kits the Czechs also neglected to bend the bottom of the bulkheads at FS 151.5 and 165 to conform with the duct bottom. The upper lip should be bent 110° from the vertical. If this is not done, get out your seaming pliers and do it now. Unless your scoop was shipped with the radiator door cutout already made, you can scrap the doubler between the skin and the bottom of the bulkhead at FS 165. Kits are presently shipped without the door cut. You can prepare and rivet in the bulkheads with the exception of the that at FS 138.5. You will need to cut holes in this one for the radiator coolant lines before you rivet it in. Be aware that you must install doublers between the side skins and the bulkhead at FS 125 for attachment of the duct inlet fairing. This does not appear in the plans, but is shown in Figure A.9. You can install the platenuts for the radiator access panel(s) now. Dimpling works better than countersinking. The fairing will extend approximately 13" below the top of the scoop in this area, so there is no need to use flathead screws in the upper portion of the sides of the scoop.

Next install the duct and check the fit. The duct should be located as far forward as possible, so that the front of the radiator box lines up with the rear of the bulkhead at FS 138.5. Make sure the duct is seated against the bottom of the bulkheads, particularly FS 125, 138.5 and 165. If you have had to incorporate change C, you will find that the duct will not seat. In this case the simplest fix is to cut 0.8" out of the bottom of the duct just forward of the radiator box flange and replace the flange with a piece of aluminum angle riveted to the duct bottom and the radiator box. As shown in Figure 2.20, this will cause the duct forward of the radiator box to angle downwards enough to make up the required distance. This change also requires trimming the sides of the forward duct section at the radiator box. Whatever you do must end up satisfying the following criteria

- the duct must bottom against the bulkheads at FS 125, 138.5 and 165
- the duct top must be approximately in line with the aft end of the scoop
- the front of the radiator box must line up with the rear of the bulkhead at FS 138.5.

These are the only important components of the duct geometry.

Next check the duct width. Compress the bulkhead sides against the duct and secure in position using clamps, straps, etc. Measure the width of the scoop at each bulkhead and compare with the fuselage widths given in drawing 5200-1. If the scoop is too narrow, you can always install shims. If the scoop is too wide in places (which is typical), you will either have to cut some from the bulkhead or the duct. The cleanest fix is to simply move the sides of the duct in the required distance, as in Figure 2.21. If you have already riveted the duct, you might instead consider trimming away the sides of the bulkhead and installing angle aluminum doublers.

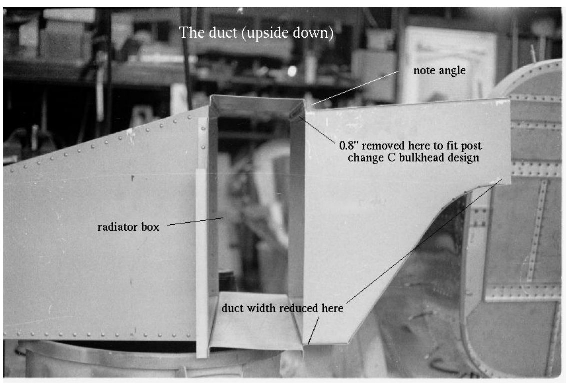


Figure 2.20. Change *C* in drawing 5200-1 can lead to some change in duct geometry. This is relatively easy to fix, but not pretty to look at!

Place the scoop and duct assembly on the fuselage and make sure everything fits OK. While you have the assemblies mated, check the fit of the radiator inside the box. The radiator should fit flush against the top and front of the radiator box. Mark the locations where the coolant tubes pass through the bulkhead at FS 138.5. The radiator drain valve is supposed to be located on the back surface. However, radiators from at least one production run have the drain valve in the front. If you have one of these you will need to cut an additional hole for the drain valve, so mark that location too. Also, the radiators are supposed the have a purge port at the top. Almost all of the radiators were manufactured without this. If it's missing, you will have to add it. When everything fits OK, you can ream the pilot holes for the scoop / fuselage attach rivets.

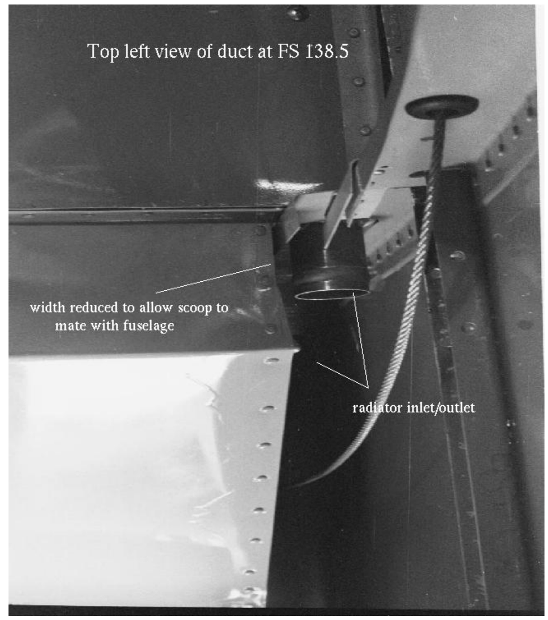


Figure 2.21. It is usually necessary to reduce the duct width slightly at the top of the radiator box. All this gets covered by the cockpit floor.

Demount the scoop and cut holes for the coolant lines (and if necessary the drain valve) in the the bulkhead at FS 138.5, then complete riveting the bulkheads to the scoop. You can remove the duct and rivet it on the bench.

The duct can be attached to the scoop with structural pulled rivets. If you use pulled rivets you can wait until the whole assembly is again mounted on the fuselage to install them. For now, mark on the duct the locations where the duct mates with the bulkheads and pilot drill these lines for rivets on approximately 2 inch centers. Do not drill the bulkheads themselves.

Next you need to get the radiator door assembled and installed. You will have to use structural pulled rivets somewhere in the door assembly, preferably on the back side. Clamp the hinge and the strip that mates it to the scoop together and pilot drill the bolt holes. This strip was not included with some kits, but is trivial to make. Ream the holes and install platenuts on the bottom side of the door hinge. The plans call for AN4 bolts here, but AN3s are acceptable. Jim may have changed to AN3s in the plans by now.

With the duct removed, lay the door inside the scoop, mark the trim lines on the scoop interior and trim to the line. Use a cutoff wheel or snips and take the last 1/8" with a file. With the duct removed, assemble the scoop to the fuselage. Clamp the door and hinge strip assembly to the bottom of the bulkhead at FS 165 and check the fit of the door. You will probably have to trim a little more at the aft end of the door cut. When the position and fit are satisfactory, install a few countersunk rivets to hold the hinge strip to the bulkhead.

If necessary, fabricate the angle brackets (5400-22,23) that secure the duct to the scoop along the radiator door cutout. These were not included in some kits. Unless you have a shrinking tool, you will need to use fluting pliers to get the the correct contour. Make sure these brackets line up with the tailwheel door cutout at the aft end. When you have the brackets fit, pilot drill and cleco them to the scoop, but not the bulkhead at FS 178.88.

Remove the scoop from the fuselage, mark and trim between the aft end of the radiator door and FS 191 using the angle bracket as a guide. Rivet the brackets to the scoop (but not the bulkhead). Assemble the duct and scoop to the fuselage, drill and ream the bulkheads for -4 rivets using the pilot holes in the duct for a guide, and install pulled rivets. You should rivet the duct to the bottom of the bulkhead at WS 165 on 1" centers, since this joint also secures the radiator door. Use pulled rivets to fasten the duct to the angle brackets along the door cutout. Use flush rivets in the area above the radiator door. Finally, you should seal the seams of the duct. Hardware store RTV works fine.

This completes assembly of the scoop except for the radiator door linkage and actuator. Before you rivet the scoop to the fuselage you should definitely fabricate and install the radiator door actuator. You may want to stub in the tailwheel hydraulics and run wires for the tailwheel uplock and downlock switches, rudder and elevator trim servos and the aft position light. You may also want to install the tailwheel uplock release cable. *It will be much easier to work back in the fuselage before you rivet in the scoop, so do everything you can now.*

Most of the radiator door actuator hardware was missing in some of the kits. If you're in this boat, it's all easy to fabricate and install according to drawing 5413 (Figure 2.22).

The next step is to fabricate the small skin section that goes between the rear of the scoop and the front of the tailwheel gear doors. The bottom of the bulkhead at FS 191 is too flat to make the contour of this skin section match that of the gear doors. This is likely a problem with the doors (not the bulkhead), and hopefully you fixed this before you riveted the doors. Even so, you will probably have to shim the center of the skin up at least 0.2" to match the leading edge of the doors.

Now you can rivet in the small skin section and the scoop, and install platenuts where the radiator access panel mates with the lower longeron. The forward section of the longeron contains the 1/8" doubler. This section is inside the fairing, so there is no need to countersink or dimple the skin. Screw holes aft of where the doubler ends should be dimpled. This area is still under the fairing, but very close to the edge. Be advised that the nuts securing the radiator retention straps to the lower longeron will be in about the same area where you will probably want to put the forwardmost platenut. You can save yourself some difficulty if you first locate the holes for the radiator retention brackets, then put the platenut between them.

Next you might as well install the radiator. The rubber chafe strips (6420-7) that go between the straps and radiator should come with the kit, as do the 4 rubber vibration mounts (6420-8). The rest of the parts (the straps, brackets that mate to the lower longeron and the baffles) often do not. Again, they are not very difficult to fabricate. You can use galvanized steel for the straps (6420-4) and a piece of 1/16" SS plate for the brackets (6420-9). First bolt the brackets and vibration isolators into position.

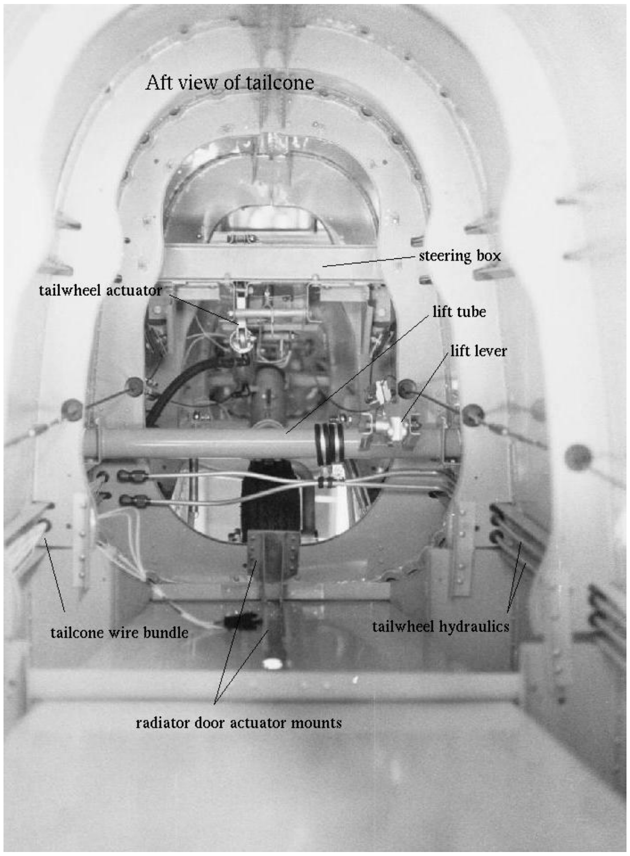


Figure 2.22. It's getting crowded back in the tailcone. Crawling back here to install parts is not a fun job, especially if the canopy is on. The radiator door actuator mount is shown in the lower part of the picture.

Make sure you put the bolt holes inboard enough so as to provide adequate clearance between the doubler inside the lower longeron and the nuts. Lay the chafe strips and straps over the radiator and drill and cleco one side to the bracket. Tension the other side as much as possible and mark the location where the strap meets the bracket. Installing the second bracket 1/4" below the mark (towards the scoop bottom) gives a satisfactory strap length. Disassemble and rivet the straps to the brackets. Before you install the radiator permanently, put a generous bead of RTV along the front of the radiator where it mates with the radiator box in the duct. You need an especially large bead on the bottom. Reinstall the radiator, straps and brackets. Fabricate the baffles that seal the sides of the radiator box as shown in the plans. Install them with screws and use RTV to seal everything up, as in Figure 2.23.

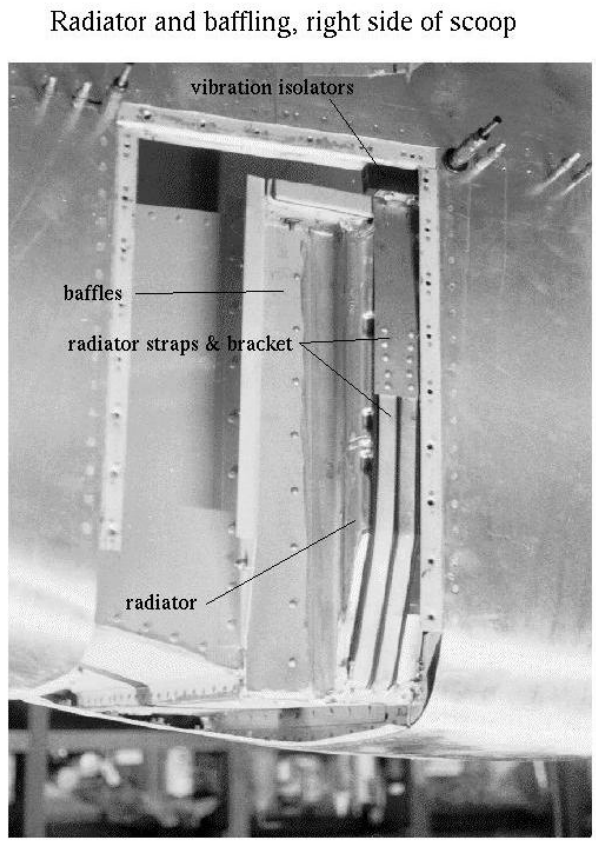


Figure 2.23. The radiator installed in the duct as viewed from the right side. Bend up the baffles from sheet and install them with screws and RTV.

One final thing to think about here. If you want cabin heat or air, the best place to get it is probably from the duct. The prototype has no heat, but takes cabin air from am inlet in the diverging section of the duct below the rear seat. Some builders intend to take hot air from the duct downstream of the radiator for cabin heat. In the example shown in Figure 2.24, a GM automobile heater core is mounted on the diverging section of the duct and valved into the coolant lines. With this arrangement, simply valving off the coolant introduces outside (cool) air through the heater ducts.

Figure 2.24. Heater plenum installed on the duct. This example uses a GM aluminum heater core, and controls the coolant flow with a butterfly valve. The ducts route air (heated or unheated) separately to the cabin and windshield defroster. If you want to use this arrangement, keep in mind that you may eventually want to put the battery in this same general area. This might make for a tight fit.

You may also want to provide an access panel for the hoses just forward of the radiator, as shown in Figure 2.25. This is an easy modification to make, but be sure the panel and the associated doubler do not interfere with the cut you will have to make in the scoop for the flap actuator bracket (3400-45,47). If you do not install an access door you will have to remove part of the cockpit floor to inspect the hoses. If you have a radiator with the drain valve on the front instead of the back, this door will also provide access to the valve.

Coolant tubes

Kits sold by PAE come with stainless steel coolant tubes. These conform to the modifications made to the cooling system for use with the PAE engine. Earlier builders were never furnished coolant tubes, only some 90 degree bent sections of 1.5" aluminum tubing. Builders had to fabricate the tubes, either by welding in straight sections of tubing or chucking what's furnished and starting over. Several builders have had some one-piece tubes formed from 0.049" wall 303 stainless steel (Figure 2.26). This was done by Advance Tube Engineering in Huntington Beach, CA. (714) 847-7888. They charge $120/set plus a $150 set-up fee for small runs, so any builders that want to go this way should try to coordinate your orders with others. They still have the patterns; talk to the owner (Fiddy Alvarez) and ask for a set of S51 coolant tubes. If you make your own, be sure to put a joggle in your pattern so that the left tube will clear the aileron pushrod linkage lever.

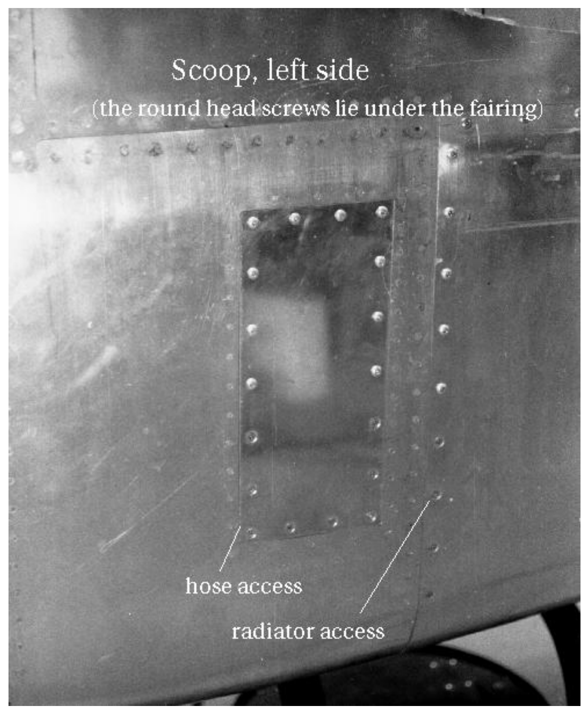


Figure 2.25. The coolant line hose connections are very difficult to inspect or replace unless an access panel is added.

You will find it much easier to install and remove one piece coolant tubes if you *install the coolant feedthrough flange (6406-1) on the forward face of the firewall with screws instead of rivets.* The flange will have to be modified slightly to do this. Many builders cut an inspection hole in the cockpit floor so that the hoses on the forward end can be inspected easily. If you cut the cockpit floor, remember that you will have to work around the vertical aluminum sheet that separates the wheelwells.

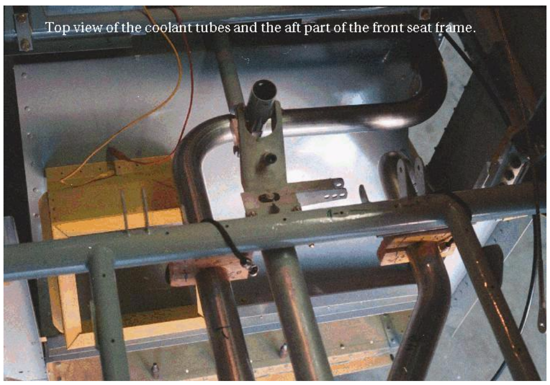


Figure 2.26. Advance Tube Engineering one-piece coolant tubes being installed in the aircraft. Note the joggle to clear the aileron controls.

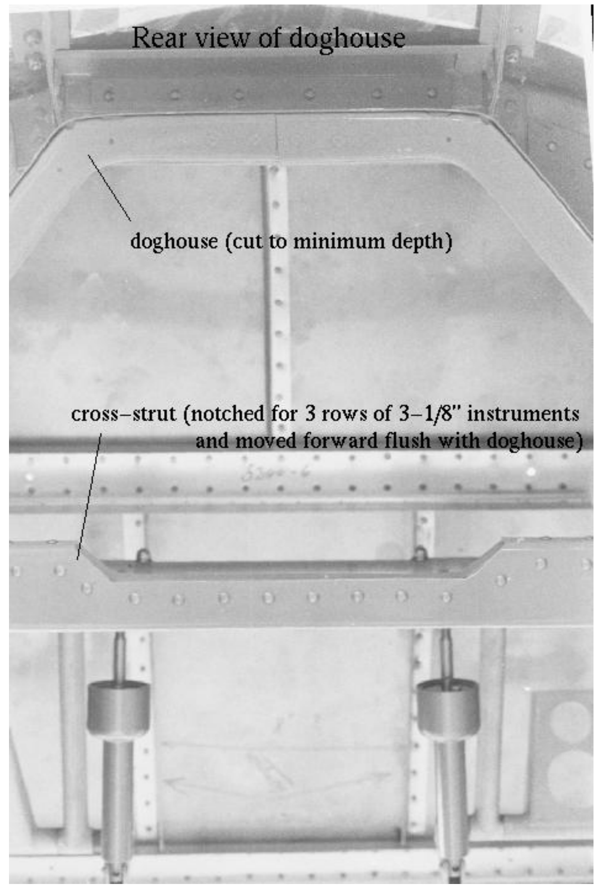


Figure 2.27. The doghouse and cross-strut support the original instrument panel. Most builders are replacing the original panel and modifying the doghouse and cross-strut to provide as much space as possible behind the panel. Here the doghouse is cut to minimum depth and the cross-strut is notched to provide clearance for deep instruments.

Windscreen and canopy

Before you tackle the windscreen and canopy you should decide what you're going to do about the instrument panel, doghouse and the associated cross-strut (Figure 2.27). *Any work you have to do in this area can be performed much more easily before you rivet in the formed skins (5500-14,15) that constitute the lower part of the windscreen.* The best way to trim the Plexiglass is with a cutoff wheel, A belt sander can then be used to smooth and bevel the edges. This seems to work well (but be very careful not to get Plexiglass dust in your eyes). You will need to ream screw holes in the Plexiglass oversize to allow for thermal expansion. The manufacturer recommends 0.125" oversize in diameter, but that's clearly more than necessary for the size screws we are using. To be safe, you should grind the drills you are going to use on Plexiglass to zero rake angle, so that they do not have a tendency to grab and dig in.

Windscreen

The windscreen installation (Figure 2.28) is pretty straightforward. You will probably need to trim quite a bit off the bottom of the center section of windscreen glass. Fitting the windscreen side glass is much easier if you can remove the formed skins that constitute the lower part of the windscreen (or at least loosen them at the top). Hopefully you have not yet riveted these in. I had to trim the windscreen side glass sections, and even then some bending was required to get the glass to fit. Be sure the plexiglass is at least room temperature before you try bending it. You can minimize the degree of bending required by trimming the proper edge(s), so give this some consideration. Typically most of the trimming is from the rearward facing edges of the side glass. You will also have to notch the glass where it extends below the bottom of the cutout in the canopy bow.

Figure 2.28. The windscreen being installed in the frame. You will have to bend the sides a bit, so do it on a warm day or use a heat lamp.

Most builders countersink the screw holes for the glass in both the skin and mask. You will definitely want to countersink the 0.050" skin (5500-14,15) that mates with the bottom of the side glass, but dimpling the skin and countersinking the glass works better for the mask (5230-3,4). Read on.

If you countersink the mask and drill out the screw holes in the side glass 1/8" oversize (as the canopy manufacturer recommends) it's very likely that you will run into difficulty installing the vertical parts of the mask that retain the sides of the center and side glass. The screws are the only things that hold these pieces in position, and with the grossly oversized holes these pieces will want to move laterally on you. This will result in a poor fit with the top of the mask, and will make the screw heads canted in the holes instead of flush. The best solution to all this would be to dimple these holes. If you insist on countersinking, we suggest partially ignoring the recommendation to greatly enlarge the screw holes in the glass in this one area. You can ream the holes overside most of the way through, leaving about 1/16" of the original (#19 drill) hole at the outer surface of the glass to hold the screw in alignment. If you don't like this fix but still want to countersink, you have enough material to cut joggles in these pieces at the top and bottom to keep them from moving laterally. This should eliminate the problem.

Some builders use Hylok fasteners in place of the screws in the windscreen area. If you're not familiar with Hyloks, they are basically steel or titanium rivet like fasteners with the shank end threaded and with an allen socket cut into its end. You thread a special nut on the end and tension the fastener using a allen wrench from the inside. As a result, you have what appears to be a countersunk rivet from the outside, but which is easily removable.

Parts 5230-3,5 must be *double flush riveted* to the canopy bow. Countersink both surfaces, use very short rivets (about 4-3) and oversqueeze them.

Canopy bubble

Begin by taking apart the canopy frame and installing platenuts for the canopy trucks (5241-1). When the platenuts for the side trucks are installed you can put the frame together and install the *top row* of rivets in the curved skin (5240-23) that forms the aft interior of the frame. *Do not install the any rivets on the bottom row, and do not rivet in the split flanges (5240-10,11) that secure the leading edge of the canopy to the frame.* You will be installing platenuts for the screws that secure to bubble to the frame, which will require removal of the bottom of the frame (5240-2). Fitting the bubble is much easier without the split flanges installed.

You will need to make a pair of angle brackets to attach the rear truck to the frame. The Czechs are installing a doubler attached to the aft bottom of the frame with 4 screws and platenuts. Keep the doubler and install the brackets beneath it, picking up 2 screw holes for each bracket. The 0.25" plate that holds the rear truck bearing sandwiches between the brackets with the bearings oriented forward. Reassemble the frame bottom with clecos and mount the assembly on the canopy tracks. Notice that when the canopy is closed the rear truck bearing is nearly out of the rear track. According to Jerry, this is how they are supposed to fit (or at least how they fit on the prototype). Some builders turn the plate around so that the bearing is oriented to the rear, giving more engagement when the canopy is closed.

Install the rear truck and put the frame in the tracks. Move the frame forward and examine how it mates with the canopy bow. All the frames shipped so far seem to be slightly too short. You will probably have to move the horseshoe (aftmost) section back 0.50-0.75" to get the canopy to close properly when the rear part of the skirt is installed. If you assembled the frame as is it pilot drilled, you will very likely have to shim the bottom of the rear skirt back 0.50-0.75".

Note that the canopy is opened and closed by a drive chain connected to the right truck. When the canopy is closed against an opposing force (the rubber seal which you will eventually install where the bows mate), the canopy frame will want to cant slightly to the left. This occurs due the unavoidable slop in the tracks. According to Jim, the solution to this problem is to make the left side lead the right by about 0.25". This can be done by splicing in a doubler where the forward and aft sections overlap; about 2/3 of the way from the front. The approximate location is shown in Figure 2.29. Go ahead and do as you see fit, make sure the angle of the canopy bow matches that of the windscreen where they mate, then install the doublers and brackets mating the frame segments (except for those that would prevent you from removing the bottom).

With the split flange (5240-10,11) on the bow removed, place the bubble on the frame and trim it to fit. Let the forward edge of the bubble overhang the bow and trim the rear section to fit. When the rear and sides fit well, trim the front as necessary and mate the split flanges to the bow. Make sure the bows on the canopy and windscreen are approximately parallel before you trim. Use pop-rivets to attach the split flange so that you can close the canopy all the way. Also, replace the clecos on the frame exterior with pop-rivets so that you can fit the skirt. With the canopy closed locate the side skirts (5251-2,3) on the bubble and frame. At the front, the bottom of the skirt should match the jog cut into the fuselage skin. At the rear, the top of the skirt should be even with the top of the frame. Mark the skirt position, open the canopy and C-clamp the skirt into place. You want to drill the skirt, bubble and frame for 8-32 flathead screws on about 2" centers, installing clecos as you go. The drill size you use will probably be dictated by the pilot on your platenut jig.

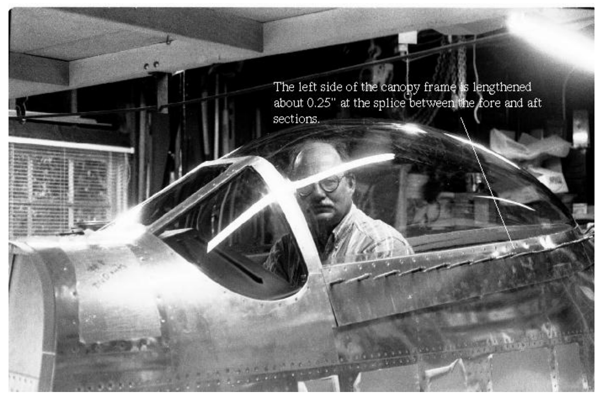


Figure 2.29. The canopy bubble and frame with the skirt installed. Most builders have to lengthen the frame to get it to fit correctly. The left side should be lengthened more than the right, causing the left side of the bow to lead the right slightly.

After you have drilled the holes, remove the bubble from the frame, then remove the frame from the fuselage (you can use the emergency release on the front trucks to do this). Cleco the skirts to the frame and use the top of the frame to mark trim lines on the skirt. Jim also recommends picking up every other rivet hole in the frame exterior. You can drill the necessary pilot holes from inside the frame using a stub angle drill. Take the frame apart and install platenuts, ream the holes in the bubble oversize and trim the skirts. Dimpling the screw holes in the skirts usually works better than countersinking. If you dimple you will have to countersink the bubble, of course.

Reassemble everything and go through the same procedure for the rear skirt section (5251-1). This has to be formed to the fuselage skin contour (see Figure 2.30). It's annealed (2024-0), so it can easily be formed by planishing. The material furnished with the kit is contoured, but the contours do not conform to the drawings. You should definitely *cut the material to Jim's pattern (drawing 5251) before you begin forming.* In any case, be prepared to stretch the aft end of the skirt a considerable amount. Just take your time with it and it will come out very nicely. You want to make the aft skirt contour match the skin (with the canopy closed, of course) and you want to get the skirt to fit tight against the bubble. This may result in a considerable gap between the skirt and canopy frame at the aft end. This is normal; just make sure you use shim where necessary when fastening the aft skirt to the frame. Finish by sanding out the small hammer marks left from the planishing.

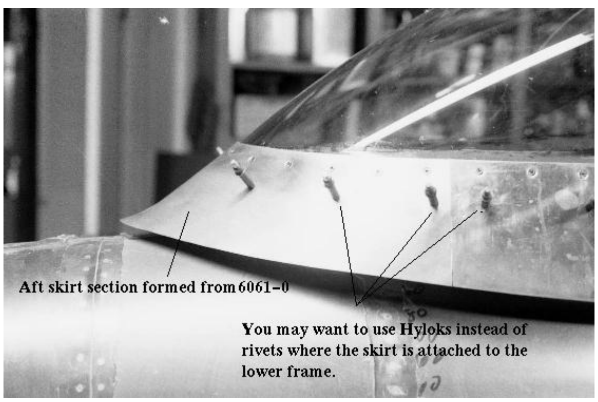


Figure 2.30. The aft part of the canopy skirt must be formed by the builder.

Fit the skin and drill the holes for the screws. Finish trimming the skirts, install the remaining platenuts and finish riveting the lower part of the frame (except for those the go through the skirt). Complete the installation by reinstalling the bubble with RTV, flush riveting the split flange to the bow (use pulled rivets), gluing Velcro strips (use the fuzzy side) to the underside of the skirts to protect the skin, mounting the skirts and installing the screws and remaining rivets. You may want to use Hyloks instead of rivets in the skirt. That way you will not have to drill out rivets if you ever need to replace the bubble.

Breaker box

Where you put the breakers or fuses is up to you. Some builders design and fabricate a breaker box similar to that shown in Figure 2.31, but others put the breakers on the panel. Breaker boxes are typically installed on the right side, just aft of the forward wing attach fitting and below the upper longeron. The box cannot be so deep as to interfere with the push-pull tube that connects the front and rear rudder pedals. Also, try to minimize its protrusion into the cockpit. Most builders appear to end up with something about 2" thick. You could reduce that if you can find Klixton breakers at a reasonable price (e.g. military surplus). If you use Potter-Brumfield's you can not do much better than 2".

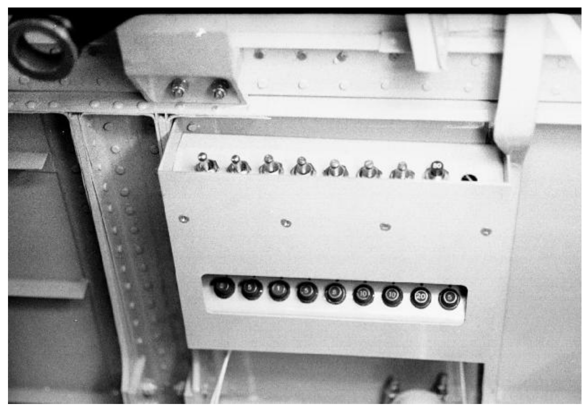


Figure 2.31. The breaker box is normally mounted on the right side just aft of the forward wing attach fitting and below the upper longeron.

Instrument panel and avionics console

Size, design and location of the instrument panel of course.varies greatly between builders. The panel in Figure 2.32 is at the same FS as the factory panel, but extends from the glareshield to the fuselage sides and to the bottom of the upper longeron. The cutouts for the trim and radiator door position indicators and a number of switches and annunciator light on the bottom row are not shown. Machined aluminum shock mount fittings (Figure 2.33) sit inside the upper longeron. The idea is basically the same as described by Rod Bower in the third issue of the Rivethead. The panel is supported at the top with shock mounted rods attached to the corners of the doghouse. The doghouse is moved as far back as possible, which results in about 3-5/8" of usable space between the doghouse and panel. This is not enough to put a sensitive altimeter in the top row of instruments, but you can put in the airspeed and vertical speed indicators.

Figure 2.32. This instrument panel is fabricated from 0.125" 6061-T6.

The cross-strut at the bottom of the panel forward so that it is flush with the doghouse. It is notched to make room for 3 rows of full size (3-1/8") instruments. Rubber moulding is used on the top and sides of the panel. This protects your legs from the panel edges and also makes it easy to get an excellent fit between the top of the panel and the glareshield. With this panel arrangement you can get enough room for a full IFR complement of instruments, but not with the conventional layout.

If you want to change the factory panel layout, keep the following in mind.

- Be cautious about extending the panel below the upper longeron, especially if you have long legs. This can make it hard to get in and even harder to get out, particularly if you are in a hurry.
- If you move the panel aft very much you will interfere with the canopy crank and the forward travel of the stick.
- Although it's tempting to remove the doghouse altogether, Jim recommends that this not be done.

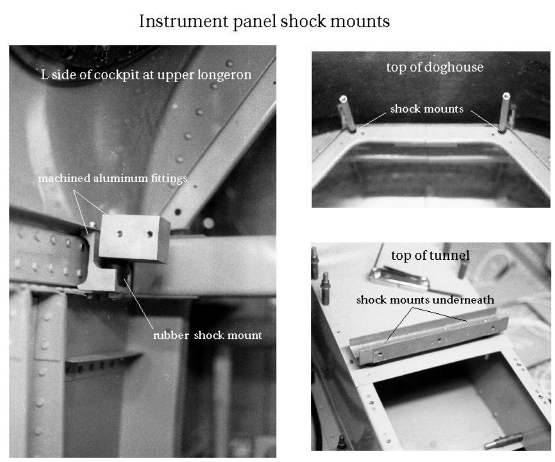


Figure 2.33. Instrument panel shock mounts McMaster-Carr has a good selection.

Do you want to install windscreen defrost?

If you plan to fly in the winter or in instrument conditions it would probably be a good idea to install a windscreen defrost system. The system shown directs hot air at the side windscreen panels, but not the center. The reasoning is that in takeoff and landing the view from the sides will be more useful than that through the center. Where ice is the concern defrost air will also be more effective on the sides due to the thinner Plexiglass. You also might want to avoid placing defrost hardware in the center portion of the glareshield if you intend to install a GPS. Directly under the center of the glareshield seems to be the best place to install a GPS antenna of standard dimensions.

As shown in Figures 2.34-35, slots are cut in the ridges moulded into each side of the glareshield and an aluminum plenum is glued into the bottom of each.

Figure 2.34. View of the defroster slot in the right glareshield looking down through the side windscreen. The defrost air is directed towards the side windscreen sections only.

Depending on how you arrange your instrument panel, the plenums may need to have a low profile. They lie only an inch or so in back of the panel.

Console

The landing gear selector console (Figure 2.36) furnished with early kits served two purposes; mounting the landing gear control lever and mounting the manual trim controls. Almost everyone is replacing the manual trim with MAC-4A electric servos in order to avoid installing the cables, so in the current kits manual trim is no longer even offered. Nevertheless, the console has not been redesigned, and so is considerably larger than it need be. Some builders are relocating the gear control lever and are going with a completely different mounting scheme. Some leave it more-or-less as is, but convert the top, aft portion to another use, some of which are pretty imaginative. Before you get carried away making plans, remember that the rudder pedal push-pull tube runs right through the console. This limits what can actually be done with the space.

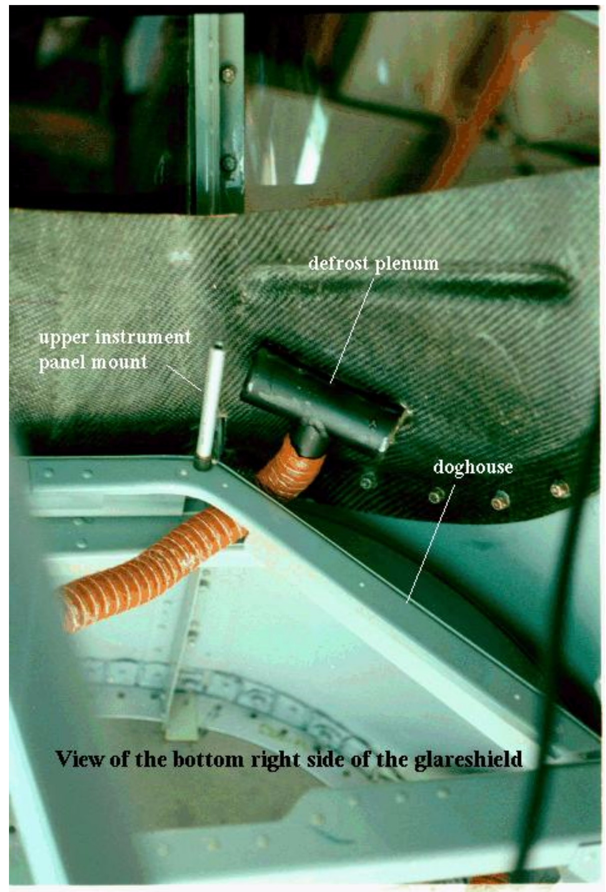


Figure 2.35. View of the right side plenum from the bottom. The scat tubing runs through the coolant tube tunnel to the heater box on the radiator duct.

The flap switch should be placed where it is easily reached with the left hand. The top of the console is one logical place. In this example the remainder of the console is used for environmental controls (heat, ventilation and defrost). The vertical part of the console that mates with the bottom of the instrument panel contains the pressure regulator and gauge for a constant flow oxygen system. The topmost part of this space is unusable since the mixture control push-pull cable passes through it.

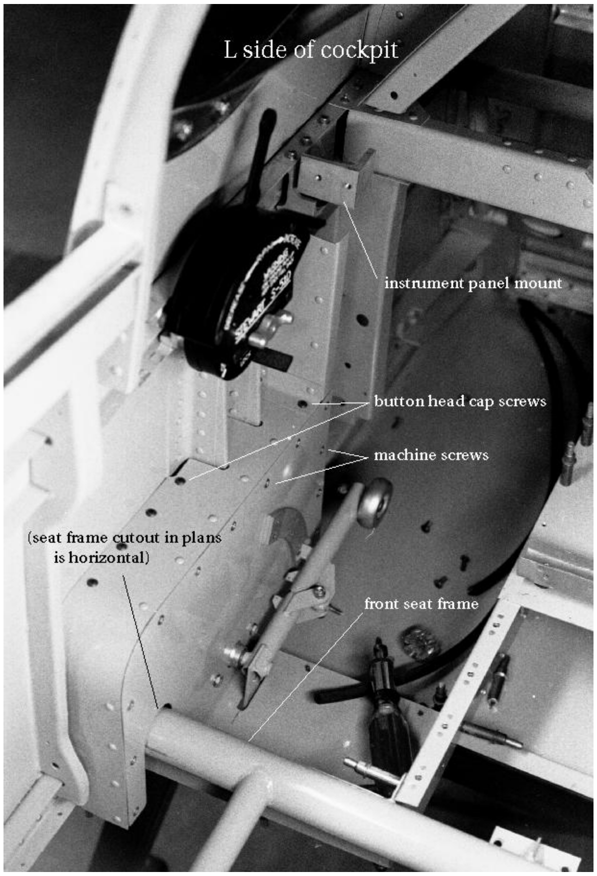


Figure 2.36. The landing gear selector lever normally mounts on the console. The cut-out for the front seat frame on this one does not conform to drawing 8141. You have to be able to remove the console to get the seat frame out, so it must be installed mainly with screws.

If you intend to install the console, you should wait until you have the floor, seat frames, and instrument panel fit. Assuming the console and breaker box are in the same positions as in the prototype, be aware that you cannot get the front seat frame in and out with both installed. *You need to make provision to remove and replace one or the other.* The console is the obvious choice. The console should be as depicted in drawing 8140. Early ones made according to drawing 8141 will not fit. The forward edge of the console is designed to mate with the crossmember which supports the bottom of the original instrument panel. If you have changed the panel or its location, you may have to modify or relocate the console accordingly. Depending on where you choose to locate the throttle quadrant, you will be running engine control cables through the forward part of the console just below the panel and through the lower part of the panel itself. Better give this some consideration too.

Trim servos are not included in the kit, but if you tell Menzimer you are an S51 builder they will give you a 10% OEM discount. If you use the usual 4PST coolie hat switch on the stick grip you will need to buy a relay for each servo. You may also want to use one of Menzimer's position sensors to monitor the radiator door.

If you have a console made according to the current version of drawing 8141 you will have to cut out most of the U-channel doubler forward of the flange that mounts the gear select lever. If installed as depicted in the drawing it will interfere with the forward wing attach fitting.

The rest of the fuselage (aft of the firewall)

By now you should have the major components of the fuselage aft of the firewall pretty well finished. If you have not yet climbed aboard and made airplane sounds, by all means do so now. Seriously, if you have not already done so you need to Cleco in the forward part of the floor, install the instrument panel, throttle (Figure 2.37), front stick and seat frames and try out the front seat for size. You need to get the rudder and brake pedals set so they are comfortable, and figure out where you want to put the cross-strut that fixes the position of the back of the front seat. Once this is done you can install the rudder pedal balance cables and the cross-strut (Figure 2.38). You need to design and install some sort of structure to support the back of the rear seat. In the prototype this is a section of U-channel attached with gussets to the upper longeron. You may also want to install some sort of stop to keep the tailwheel gear doors from opening so far with the gear extended, and will definitely need to install a hefty spring to extend the tailwheel in the event of a hydraulic failure. As shown in Figure 2.39, two springs are required; one to extend the gear and another to compress the actuator so that the downlock will engage.

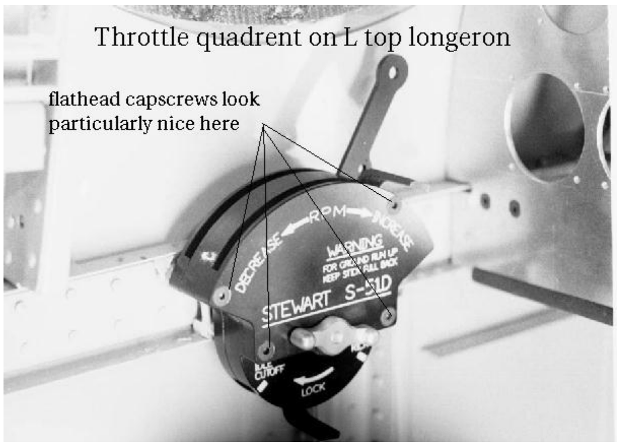


Figure 2.37. The P51 replica throttle quadrant is provided with the kit. You have to back-fill the recessed lettering with white paint. Be forewarned; If you leave it laying around the hangar it may end up in somebodys RV4!

Figure 2.38. The cross-strut supports the back of the front seat and anchors the pilot's shoulder harness. Use a pin in one side so it can be pivoted out of the way for back seat entry and egress.

Horizontal stabilizer

First, which is the top and which is the bottom surface? As installed on the fuselage, the center hinge of the stabilizer is offset slightly to the left when viewed from the rear. Also, the flange of the center rib should be on the left side when viewed from the rear.

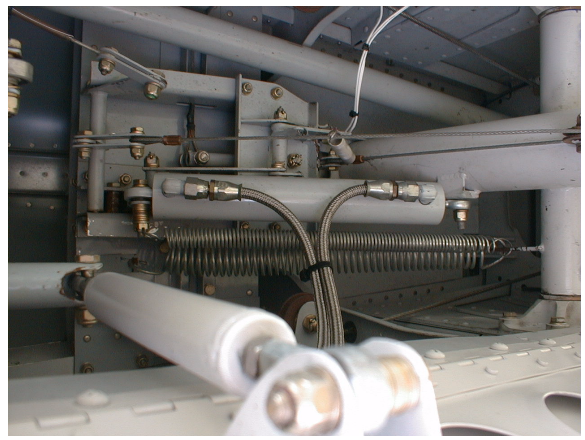
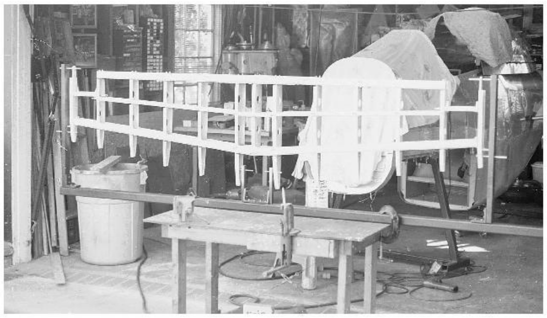


Figure 2.39. Bottom view of steering box. Two springs are required on the tailwheel; one to pull the strut down an another to compress the actuator so that the lock will engage.

As for the other flying surfaces, you will need to make a jig to hold the horizontal stabilizer in position while you rivet it. An example is shown in Figure 2.40. The jig should hold the end ribs to prevent twisting and should also hold the interior ribs at the leading edge. You should be able to remove sections of the stabilizer and later restore them to their original positions in the jig. When you set up the stabilizer in the tooling, confirm that the stabilizer is free of twist and that the the hinge line is straight. Then mark the position and orientation of the hinges. You can then drill out all the pop-rivets, replacing them with Clecos where necessary. You can remove the hinges and ream them to 0.7500" for the spherical bearings. The procedure is exactly as described for the flaps and ailerons.



Horizontal stabilizer in jig. I used 3/8" drill rod for the locating pins.

Figure 2.40. The horizontal stabilizer in the assembly jig.

Assembly

It is not difficult to build the horizontal stabilizer without resorting to pulled rivets in any exposed area. Here is the recipe. First remove the fore (4311-3) and aft (4311-2) spars from the jig and rivet them on the bench. Rivet the spar caps to the shear web, but *do not install rivets where the ribs attach.* You should secure the interior hinge brackets to the aft spar with AN3 bolts. Use platenuts instead of nuts. The hinges brackets on the end ribs are installed with 470AD-4 rivets. You will probably want to alodine and prime the skins and possibly the skeleton too.

Reassemble everything on the jig, attaching the ribs to the spars with #4 Clecos. Cleco the ribs to the spars *from the aft side.* Ream the leading edge skins for #4 rivets, then disassemble as necessary and deburr all of these holes. If you are using glue, apply it to the interior ribs and reinstall the leading edges. *Do not glue the leading edge to the forward spar or the inboard or outboard ribs.* Once the glue has cured, remove the leading edges and interior ribs from the jig and rivet them together on the bench. Reinstall the leading edges and use pulled rivets to attach the ribs to the forward spar. You should be able to squeeze most of the rivets which attach the leadings edges to the forward spar. You can rivet in the inboard ribs if you want, but *do not rivet in the outboard ribs.*

Do the top skins next, riveting/gluing in the interior ribs and forward spar, but *not the aft spar or outboard ribs.* You should be able to do this in the jig. Do not rivet the skins to the inboard ribs. Before you do this you will need to locate the machined fittings that mate the spars to the fuselage and bolt them into position, then install the center skins. This will come later.

Next reinstall and ream the bottom skins. You should not use glue on the bottom skins because you will need to remove the stringer (4311-9) and peel back the skin to buck the rivets. To rivet in the bottom skins, first remove the aft spar so that you can reach into the interior. Begin riveting at the forward spar and work towards the rear. If you peal back the skin and leave the stinger out as long as possible, you should be able to reach all of the rivets from the rear. Again, you should be able to do all this riveting in the jig.

Once you have the skins on you can squeeze the rivets in the aft spar caps. Use pulled rivets to attach the ribs to the shear web. Now you can rivet in the end ribs, first riveting the end hinges if you have not already done so. Remember to put in the doublers (4300-7) that mate with the stabilizer tips before you rivet the end ribs. Also rivet the inboard ribs at the leading edge if you have not already done so. If you want, you can use AD470 rivets in the inboard ribs as they will be hidden beneath a fairing. This completes the assembly except for the skins which cover the top and bottom of the center bay. Wait to install these until you have the the stabilizer - fuselage mating hardware located and bolted into place.

Mating to the fuselage

The current factory specification for the horizontal stabilizer angle of incidence is 1.5° *above* the plane of the upper longerons. The horizontal stabilizer airfoil is symmetric, so the cord line just extends between the leading edge and the elevator hinge line. According to Jim, 1.5° may be more than is necessary; anything from 1.0 to 1.5° will probably work fine. The angle of incidence is positive due to the downwash of the propeller.

The stabilizer is attached to the fuselage by eight machined mating brackets; 2 pairs for each spar. You have probably already installed the four that mate with the fuselage. To locate the remaining fittings on the stabilizer spars, first make sure that the fuselage upper longerons are level in both the pitch and roll axes (this should also make the wing attach fittings level in the pitch axis). Place the 0.125" wishbone shaped plate (4311-24) that mates with the vertical stabilizer spar between the attach fittings and the rear spar, then clamp the fittings so that

- the stabilizer is right side up, e.g. the center hinge should be offset slightly to the left when viewed from the rear
- the stabilizer axis is perpendicular to the roll axis
- the stabilizer span is level (e.g. parallel to the pitch axis)
- the angle of incidence is between +1.0 and +1.5° with respect to the upper longerons
- the clearance between the stabilizer bottom and the upper longerons is approximately 0.25"

The longer fittings (4311-7) attach to the forward spar. You will need to trim a bit out of the turtledeck to get the horizontal stabilizer to come forward far enough. This trim is completely hidden under the fairing, so it need not be precise. When everything is correct, drill and ream the attach fittings, installing AN3 bolts as you go, then drill and ream the attach fitting pairs for AN4 thrubolts. Mark the projection of the upper skin of the stabilizer on the plate 4311-24. You can now demate the stabilizer and fuselage, trim the stabilizer center skin sections to obtain adequate clearance for the attach fittings and rivet the bottom center section into place. You can use AN470 rivets on the center skin sections as they will be covered by fairings.

It is somewhat easier to complete assembly of the fittings before you rivet on the top center skin. You need to put a 10° bend in the vertical stabilizer mating plate (4311-24) and counterbore the forward stabilizer attach fittings (4311-7). The bend in the mating plate should be completed within 0.75" of the horizontal stabilizer skin line you marked previously. When you counterbore you must radius the corner to prevent stress concentration. Remember, these fittings hold on the tail.

Once you have completed this you can reassemble the front and rear attach fittings and install the top center skin section (4300-5), using pulled rivets if necessary.

Elevators

There have been a couple of changes made in the elevator design that may not be reflected in your drawings. Change "C" to the 4000 series drawings offsets the elevator horn and hinge 1 inch to the left to keep it from interfering with the center rib of the horizontal stabilizer. In some sets of plans, this is reflected in drawing 4000-2, but detail A in 4000-4 still has the old dimension. Other changes which may not be reflected in the drawings derive from the elimination of mechanical trim. Specifically, there is no need to cut holes in the front spar and leading edge of the left elevator to pass the trim cable.

Assembly

The elevator assembly closely parallels that for the ailerons. All of the elevator skins are 0.025", so they should be dimpled. Begin with the front spar. Some spars are missing quite a few pilot holes, so be sure to install all the rivets called for in 4000-3. As for the ailerons, you will probably want to secure the hinge brackets to the spar with platenuts. This will simplify riveting the lead edge D-sections later.

The left and right elevator torque tubes (4000-8,9) telescope inside one another and are mounted to the rear of the spars, The short torque tube mates to the left elevator, the one with the trim tab. The torque tubes must obviously be aligned with the symmetry plane of the elevators, and the position along the span must be correct if the hinges are to line up. You can use the following procedure to locate the torque tubes on the spars. First lay out the spars on a large table, mate the torque tubes together and and center them on the root ends of the spars so that the inboard flange of the torque tube is flush or slightly outboard of the root end of the spar. To insure that the symmetry planes of the spars are aligned, sandwich to top and bottom between 2 straight edges and adjust the spar position until the outboard ends are centered between the edges. When everything is lined up, clamp it in place and drill and ream the spars for the rivets and bolts that secure the torque tubes.

The rest of the assembly for the right elevator is straightforward. You will have to install the trim servo inside the left elevator, so have a look at that section before you begin the left side. Rivet from the trailing edge forward, as for the ailerons. Use pulled rivets to attach the ribs to the forward spar and to attach the inboard ribs to the torque tube assemblies. Close out the elevator by gluing the forward spar, skins and the D-sections together. (Unlike for the ailerons, here you will have to dimple the D-sections.) You can use the same type of long bucking bar as described in the notes on aileron construction to set the rivets in the D-section. The Czech's are apparently in the habit of leaving out a number of pilot holes for rivets securing the skins to the main spar caps. Make sure you install all the rivets shown in drawing 4000-4, especially in this area. Note that the plans call for securing the skin to the spar with double flush rivets in the outboard bay where the counterweight box mounts. Be sure to use the structural screws specified in the plans to attach the counterweight boxes as these joints are highly stressed. In some kits the counterweight boxes are trimmed to short. This leaves an unsightly gap of about 0.75" between the forward edge of the box and the horizontal stabilizer. The best solution to this problem is to reskin the box.

Installing trim tab and servo

You will probably find this a bit of a pain in the butt. The cure for this is to think about running all those cables associated with mechanical trim. Then it will not seem so bad.

Use the following procedure to fit the trim tab. First lay the tab in position without any trimming and mark on it the location of the top rear row of rivets which passes through the rear spar cap. Remove the tab and pilot drill these holes. Cut a piece of 0.025" aluminum to fit the gap on the top of the spar cap and place it in position. Position the trim tab over the top of it, carefully align the trailing edge with that of the elevator and use the hole pattern in the tab to pilot drill and cleco the top of the spar cap. Mark a trim line on the bottom of the tab about 0.375" aft of the rear spar and trim to the line. Reinstall the tab, lay the hinge in position from the bottom and mark the trim line on the top of the tab. Also note the taickness of the tab. It's not unusual to find that it is about 0.2" too thick at the leading edge. The best solution for this is to bend up a new spar. You can now remove the tab, install the actuator brackets, spar and hinge (make sure you use the proper orientation) and rivet it up on the bench (use 426-3s). *If you use electric trim you will need to change the actuator bracket location from the 7.75" specified in drawing 4000-1, so read the next paragraphs before you drill the holes.* You will also need to trim the bottom cap of the trim tab spar to match the bottom skin of the tab. Lay out and pilot drill the rivet line in the surface of the hinge that mates with the rear elevator spar. Finally, reposition the assembly on the elevator and drill the rivet line in the rear spar shear web. Once you have the tab fit, you can assemble the remainder of the left elevator pretty much as you did the right.

Servo installation on the prototype

Figure A.10 shows the installation of the elevator trim servo in the prototype. This was installed after the 1998 rebuild, and replaced the original manual elevator trim. Note that the servo is mounted externally, e.g. the servo base replaces a skin section. If you do this the servo base will protrude about 0.1" below the skin surface. If you mount a MAC-4A servo so that edge of the the base is flush with the web of the rib, you will need to position the push-pull bracket on the trim tab so that the distance from its center to the *inboard edge of the trim tab cutout in the elevator* is about 7". Jim mounted the halves of the trim tab actuator lever flush against each other and pinned the push-pull lever around them, hence the forks on both ends of the push-pull lever.

The servo should be positioned so that the actuator will produce mostly up trim. Very little down trim is required on the prototype. Jim recommends extending the actuator to its full length, then installing it so that the trim tab is approximately 0.25" above the elevator at the trailing edge. This could change depending on your CG and particularly on how you set the angle of incidence on the horizontal stabilizer, but it's probably a good place to start. If you need to change, just make a new push-pull lever.

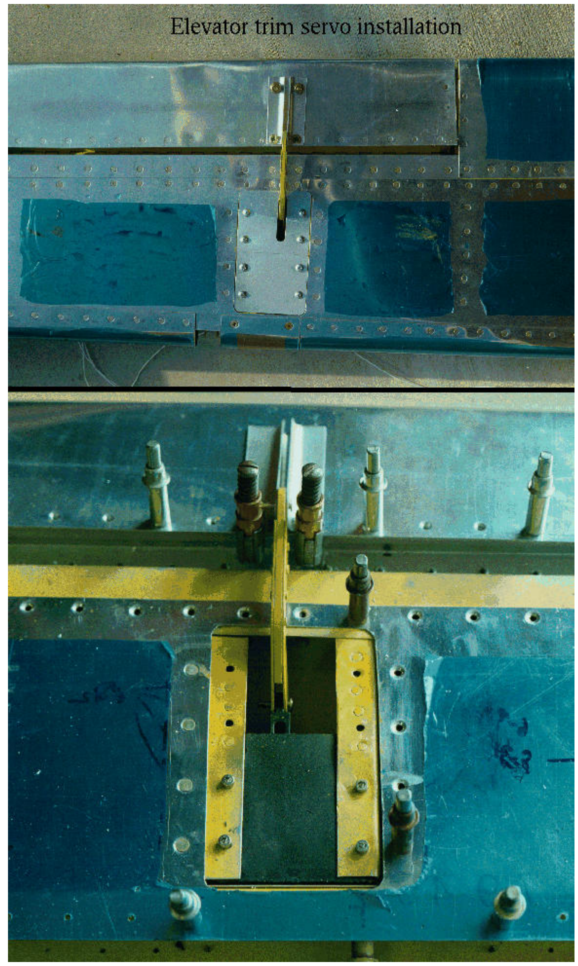


Figure 2.41. Two views of the elevator servo and linkage from the bottom. The cover plate is split into two sections. Platenuts are installed on the servo body to secure the rear section.

Recommended servo installation

It is almost as easy to mount the servo internally by bolting it to the top of the rib flange and an added aluminum angle with a piece of 0.040" sheet on the bottom. See Figure 2.41. We think this results in both better appearance and structural integrity. Doing this will cause the servo to sit higher and further forward in the elevator, so the dimensions of the push-pull lever will change. If you use the dimensions in Figure 2.42 and put the base of a MAC-4A servo up against (or at least very close to) the main spar, the trim tab movement should be in the range Jim specifies. You can use 6-32 pan head screws to install the access covers and to secure the servo, picking up the original pilot holes in the rib cap. The forward 2 holes on each side secure the servo and its cover plate. The aft 2 holes secure the plate slotted for the push-pull lever. You can use regular 6-32 platenuts for the aft holes. You will probably not be able to easily reach the forward holes to get nuts on them. One solution is to install platenuts on a piece of aluminum, then secure this with glue to the upper surface of the servo base. Install the push-pull attach fitting on the trim tab with a 0.125" gap (as in drawing 4000-1) and extend the 0.125" central laminate of the lever to fit inside it. Use structural adhesive as well as #3 rivets in joining the laminates.

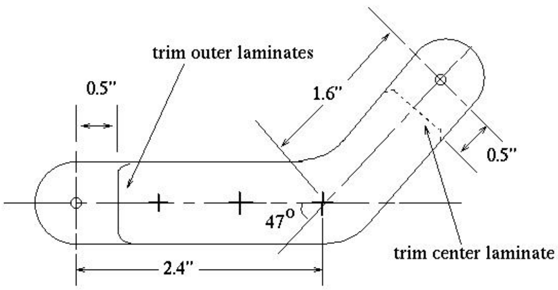


Figure 2.42. If you mount the servo as in Figure 2.41, the dimensions for the linkage given above should be about right.

Counterweight boxes

According to the plans, the counterweight boxes (4000-7) should be mounted flush against the outboard edge of the elevator D-section. The ends of the counterweight box ribs (4000-46/47) should seat against the forward edges of the elevator skins, so that the boxes go on square with the forward spar. Before you install them this way, check to see if this will make the counterweight boxes will fit comfortably inside the cutouts in the horizontal stabilizer. In some cases the boxes need to be moved slightly outboard. As mentioned previously, they also may be too short. One final thing you might watch out for is the fit of the shims at the aft end of the box (parts 4000-22 and -25). If these extend too far forward you will not be able to seat the box properly against the spar and you may get it on crooked. In some cases these shims needed to be trimmed a fair amount.

The recommended balancing procedure is to determine the necessary mass by laying weights on top of the counterweight boxes. Then make a form to cast the lead in a rectangular block which will fit inside the box. In theory, you should then install the bulkhead that contains the aft end of the counterweight so that it fits tightly against the weight. According to Jim, the rivet line that secures the bulkhead is not supposed to be pilot drilled. If it is predrilled at the location specified in the plans (as mine was), you need to cast the weight to that length and vary the other dimensions of the mold to make certain it will hold enough lead. You should need about 6 lbs of lead in each counterweight box.

Vertical stabilizer

The drawings for the vertical stabilizer are accurate but incomplete. The only change you might want to make is to attach the inspection plate plate on the righthand side with rivets instead of screws and platenuts. This plate was put into the original design so that the pulleys associated with the manual trim cables could be inspected and serviced. If you are using electric trim *and putting the actuator in the rudder*, then there is no real need for access to this area. Plan before you do this. You may want to install the rudder trim servo in the stabilizer and connect it to the tab via a push-pull cable. See the section on the rudder.

Assembly

Assembly is via the usual sequence, e.g. from the leading edge back. First rivet the spars, omitting rivets where the ribs attach. You will need to install 10-32 platenuts on the rear spar (and on the rib where the middle hinge bracket attaches). The bottom of the forward spar (4100-2) needs to extend below the skin line, as shown in the drawings. The forward and leading edge skins are often not trimmed in accord with drawing 4100.

First glue and rivet the leading edge to the forward ribs. You may need to shim extensively at the leading edge of most of the ribs. Do not glue in the forward spar as you will have to remove it to buck the rivets in the ribs. Before riveting in the forward spar, be sure to check the fit of the leading edge skins against the forward spar. The skin contour changes where the leading edge and rear skin panels meet at the forward spar. In some cases it is impossible to get the leading edge skin to lay down against the spar caps using clecos. The rear skin panels do lay down, so if you let this go you will have an unsightly mismatch in depth where they butt together. You can first use an edge forming tool (popular among RV builders) to break the edge of the forward skin. This helps lot, but it still may be necessary to use clamps and glue to get the edges down completely. You can attach the forward and rear rib sections to the forward spar with structural pulled rivets. The rest of the assembly is straightforward. Don't glue in the rear spar because you will again have to remove it to buck the rivets in the last section of skin.

Some stabilizers have no pilot holes drilled where the skin attaches to the rear spar (probably because none are shown in the drawings). The skins should be riveted to the spar caps using the usual AN426AD4 rivets with a 1 inch pitch. Wait to rivet the rear spar into the vertical stabilizer until after the assembly is fit to the fuselage and the rudder trim actuator is installed (if you are putting it in the stabilizer, see below). You will likely have to trim the skin where it rivets to the upper longeron, and this is a bit easier to do without the spar attached. When you are ready to complete the assembly you can use pulled rivets to attach the ribs to the spar. You will need some 4-6 Cherrymax rivets where you have to go through 0.25" plate, such as the top hinge bracket. A lot of vendors do not stock Cherrymax rivets this long, but Aircraft Spruce does (at $0.90/ea, ouch!). The lower and middle hinge brackets attach with AN3 bolts.

Mating to the fuselage

You say you can't find any plans which show how the vertical stabilizer attaches to the fuselage? Well, that's because there aren't any! Fortunately Jim has a sketch (Figure A.11) which shows roughly how they go together. The symmetry plane of the vertical stabilizer should be aligned with the symmetry plane of the fuselage, and rudder hinge line should be perpendicular to the upper longerons. Use 2 plumb bobs; one hanging from the top rudder hinge bracket through the middle bracket and a second hanging between the dorsal fin attach doublers at the leading edge of the stabilizer.

According to Jim the vertical stabilizer forward spar really does attach to the "wishbone" plate mated to the rear spar of the horizontal stabilizer with only one AN4 bolt. Jim could not remember why it is supposed to be installed a quarter inch off center. The mini-spar in the vertical stabilizer (4120-17) is riveted to the stabilizer skins and also at the bottom to the web that spans the top of the upper longerons. The lower hinge bracket bolts through the extended rear spar to the aft bulkhead of the fuselage. The top bolts will probably come very close to interfering with the bottom of the top longeron. If necessary, you can cut away a bit of the bottom longeron cap and install platenuts. You may also need to shim the spar extension back a little in order to get the hinge line vertical.

Installing the tip

The fiberglass vertical stabilizer tips are currently furnished in 2 halves. The tip has a joggle cast into it which will be trimmed off. Use eight 6-32 flathead screws to attach the tip to the doubler. Put 100° countersunk washers between the fibergalss and screws. You can get them from Aircraft Spruce. Mount the tip on the stabalizer, then glue the two halves together. When the glue has set, remove the tip and laminate the interior of the joint with fiberglass. The file and sand the seam to shape. The elevator and horizantal stabilizer tips are fit similarly.

Rudder

There is relatively little riveting to do on the rudder because it is mostly skinned with fabric. The biggest problem is what to do about the rudder trim servo. We suggest you read that section (below) and decide what you want to do before you do any work on the rudder.

You may have noticed the considerable effort to reduce weight in this part of the structure. This is because the rudder counterweight box will barely contain enough lead to get the rudder into balance. If you run out of room in the box you will have to screw a lead filled channel to the D-section, as for the ailerons. It's probably a good idea to put some platenuts on the D-section before you rivet it in, just in case.

Frame assembly

Note that, except for the main spar, most of the rivets here are AN470AD3's. According to Jim flush rivets are not required (except in installing platenuts) because the whole thing will be covered by fabric. All of the edges will be taped when the fabric is put on, and this will do a pretty good job of hiding the rivet heads. Nevertheless, many builders are using flush rivets everywhere. The hinge brackets should be attached with bolts so that they can be removed to buck the rivets in the leading edge D-section. The plans call for a mixture of rivets and bolts. Just replace the rivets with AN3 bolts, using platenuts for the center hinge. Riveting order is not critical since, without the skin, access is easy. In some cases a few of the pilot holes in the forward part of the ribs are missing. Note that the plans call for 4 rivets along each side of each rib. The Czechs occassionally omit some of these.

Be sure to use only epoxy primers on any part of the skin that will come in contact with the fabric cover. The glues and sealers used with Vinyl-polyester systems such as Stits or Ceconite will attack most non-epoxy based primers.

Trim tab and actuator

Unfortunately the MAC-4A servo is slightly too wide to fit in the rudder trim box (the area covered by 4200-39). You have several choices:

- Cut slots in the ribs so that the baseplate for the servo can extend beyond the ribs.
- Enlarge the trim box to fit the servo by moving the top rib upwards. This will require forming at least one new rib and moving the pushrod attach bracket on the trim tab upwards.
- Mount the servo in the horizontal stabilizer and connect it to the tab with a high quality push-pull cable.

Most builders appear to be using the second method, as illustrated in Figure 2.43. Jim recommends the last method (Figure 2.44) although it's probably more difficult to implement than the first two. Mounting the trim servo in the vertical stablizer eliminates any need to modify the rudder structure. It also helps keep the rudder light. It's not difficult to mount the servo in the horizontal stabilizer if you fabricate and install the brackets before the main spar is riveted in. The existing access port in the vertical stabilizer is in about the right place too. Note that the supporting structure does not need to be too strong as the maximum servo force is only about 40 lbs, but it should be very rigid. Drawbacks include greater overall weight, some added expense and possibly some added maintenance requirement.

If you do remote the servo, be sure to use a high quality push-pull cable; one with 10-32 threaded ends similar to what is used for the throttle, mixture, etc. You will have to have a short one specially made for this application. Also, be sure to anchor the cable shield securely at each end. Only cables that secure the shield with a bulkhead nut or the more common notch and fork should be considered. *You definitely do not want this to come loose at 300+ mph!* Standard push-pull cables have a 3" travel and a maximum compressive force of 25 lbs. You will only need an inch of travel, and possibly as much as 40 lbs of compressive force. Cablecraft (253-475-1080) makes cables with a 1 inch stroke that will tolerate 45 lbs in compression.

Figure 2.45 shows some of the details of the installation depicted in Figure 2.44. If the MAC-4A servo is placed as far forward as possible in the stabilizer, the assembly (cable, clevis fork and spherical bearing) will need to be about 20 inches measured from center to center. Cablecraft will make a 19 inch, 1 inch stroke cable for you (the rod end fittings account for the last inch). A 3 inch threaded rod and sleeve is on the end which connects to the trig tab. You need a long rod on this end so that the sleeve can be secured to structure inside the rudder. The actuator end has the standard 1 inch rod and sleeve. This gives about 4 inches of flexible cable between the terminations. The sleeves are mounted with bulkhead fittings. If you want this cable, the Cablecraft part number is 580-700-046.

Here are a couple of suggestions for the cable installation. First, as shown in Figure 2.46 you will probably want to mount the forward end of the cable on a removable bracket, otherwise you will have to get the cable in and out by working through the access port in the vertical stablizer.

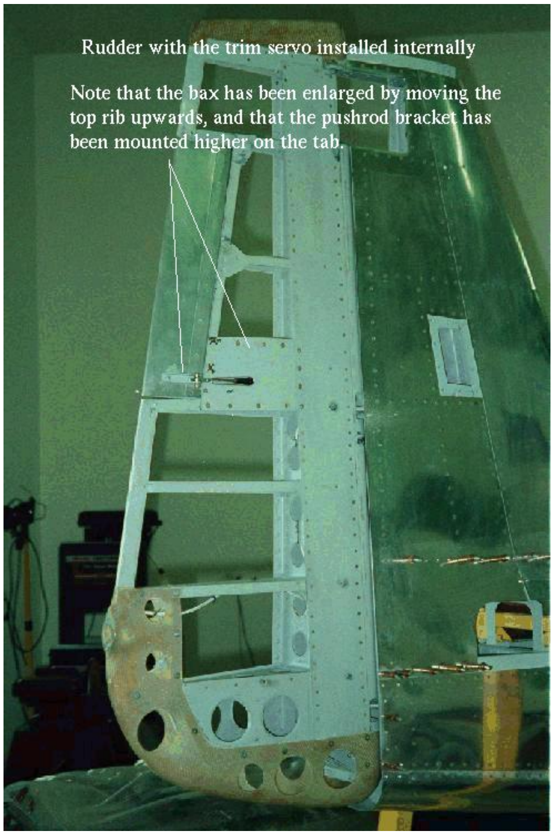


Figure 2.43. An example showing the actuator installed in the rudder. Note the the trim box has been enlarged by moving one of the ribs upwards, and that the pushrod bracket has been moved from the location specified in the plans.

The port is small enough and situated far enough from the rear VS spar so this will probably be very difficult to do. You can make a bracket that bolts to the forward side of the VS rear spar, and put platenuts on the bracket. That way the bracket can be demounted and the cable and bracket moved forward so the the bulkhead nuts are easily accessible through the access port. The other end of the cable is anchored to a bulkhead that you will have to make, locate and rivet inside the rudder (see Figure 2.47). Use an Aurora MW-3 spherical bearing rod end to attach the cable to the trim tab.

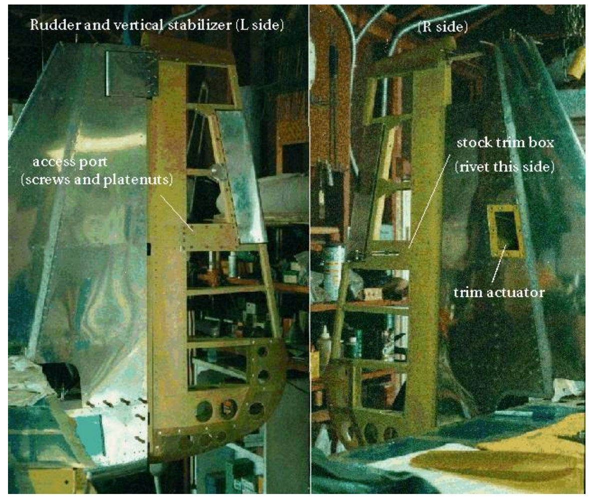


Figure 2.44. Here the actuator is installed in the vertical stabilizer and a push-pull cable is used to move the trim tab.

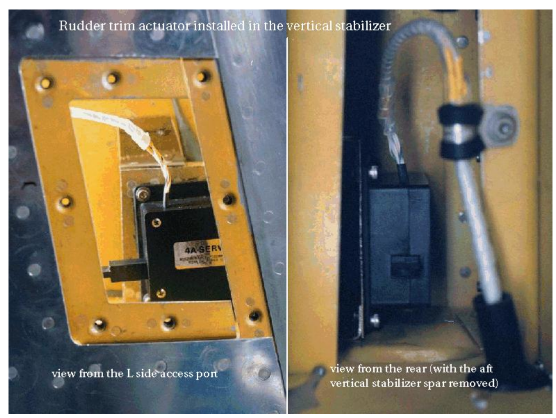


Figure 2.45. The trim actuator installed in the vertical stabilizer.

According to Jim you should allow for more right trim than left in rigging the system. This means that the tab should be displaced somewhat to the left (as viewed from the rear) when the actuator travel is centered.

The fiberglass parts

The tip and bottom are fiberglass castings. They are usually installed with large heap 0.125" pop rivets. The dimension from the top of the tip to the bottom of the top hinge in drawing 4200-4 is a lot closer to 2.75" than 3.5". Just make it match the tip of the vertical stabilizer. The fiberglass part that goes on the bottom is not stiff enough to resist deformation when covered with heat shrunk fabric. You should glue in some internal bulkheads to add stiffness.

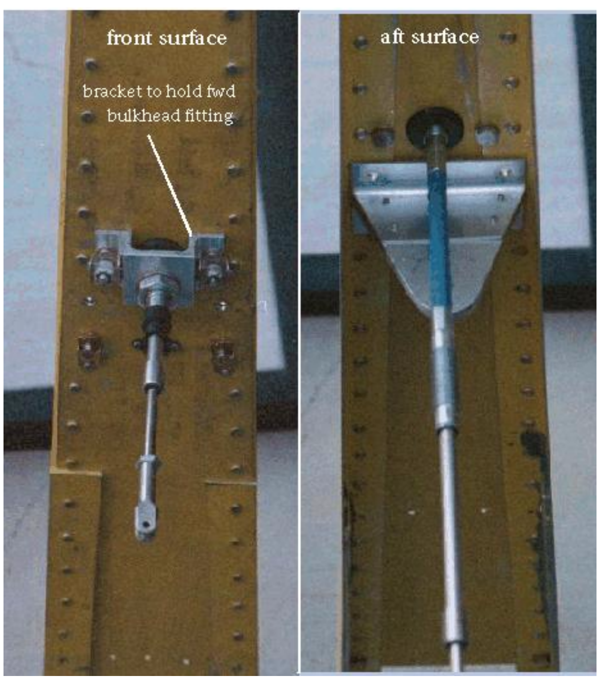


Figure 2.46. The trim actuator cable is mounts on a bracket which bolts to the front of the rear VS spar. The bracket and cable can be easily removed for servicing from the rear of the vertical stabilizer.

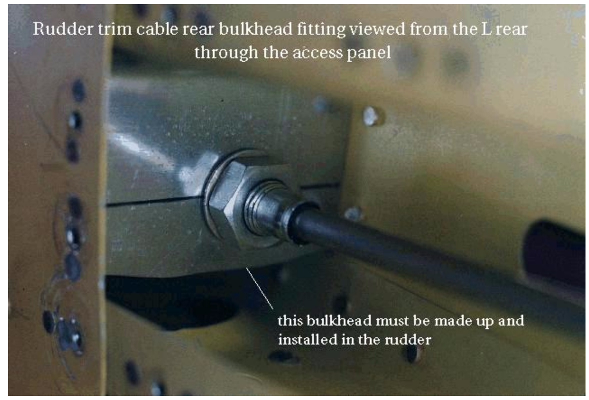


Figure 2.47. The rear of the trim cable is anchored by a bulkhead added to the rudder.

Fabric covering

You should use a synthetic covering (not cotton and dope) since the result will be much lighter. Remember, weight is a consideration here. Unless you have done this before or have some experienced help, we suggest you get the Stits Polyfiber or Ceconite manual are read it thoroughly. Aircraft Spruce or Wicks should have both in stock. You should use medium or heavy weight fabric. You will probably use screws to secure the one side of the trim box skin so that you can get access to the servo (or cable). The fabric should cover the entire rudder assembly except for the counterweight box, trim tab and actuator box access cover. Most builders wrap the fabric around the front and glue it to the trailing edge. Jim used large heap pop-rivets in place of rib stitching, but stitching with a 1" pitch will also work. If you have troube with runs or drips after sealing the fabric weave (e.g. applying Polybrush in the Stits process), lay aluminum foil over the blemish and iron it out.

Counterweight box

The counterweight box is somewhat too narrow to match the profile of the vertical stabilizer. Since more counterweight is typically needed than will fit in the box, many builders enlarge it by shimming the bottom rib out 0.125" on both sides and the top rib out 0.080" on both sides. That will make it match the vertical stabilizer considerably better.

Dorsal Fin

Install the dorsal fin after you have permanently attached the vertical stabilizer and put in the skin at the aft end of the turtledeck. When you rivet it to the turtledeck, make sure that you do not drill into the flanged edges of the stringer that runs along the spine. The you will have to trim away some of the flanged surface in the raised area above the horizontal stabilizer when you install the fairings. See the section on Final Assembly.

Cowling Installation

Why is the cowling not pilot drilled and pop-riveted as for the rest of the kit? Although this would make life easier if you were doing a "standard" engine installation, until recently there has been no such thing on the S51. As you no doubt realize by now, it's far better to have no pilot holes than ones that are placed incorrectly for the particular installation. While it's a pain to get everything aligned and clamped, it is lot easier than building from scratch. You are still getting considerable value for your buck, so no whining.

As you can probably tell from the length of this section, the cowling installation is pretty complex. Here is one important hint: *Avoid installing permanent fasteners (e.g. rivets and particularly Dzus fasteners) in the cowling until you have all the sections fit.* Use #3 Clecos instead.

The first step in installing the cowling is to get the engine located on the bed mount and the mating fittings installed. This is necessary because the forward bulkhead of the cowl must line up with the spinner. Once you get the forward cowl bulkhead located you can work backwards from this to the firewall, first fitting the skeleton then the skins. Fore towards aft and top towards bottom, that will work best.

Mounting the engine

Begin by preparing the tips of the bed mount. Figure A.8 shows what is necessary. You need to make a pair of 0.125" doublers and install them on the outboard tips of the arms with AN3 bolts. 6061-T6 will work fine for this.

It is not necessary to have the whole engine assembled; *the job if somewhat easier if you work only with the bare block, the Florida Airboat Power PSRU and possibly the propeller hub.* Assuming you are working with the actual block you are going to use (rather than a scrap block), the next step is to locate and mate the PSRU to the block. Dave Bogue's installation instructions are given in Figure A.12. If you want, for now you can just bolt on the PSRU without the Dowl pins. Install the upper mounts on the engine. Note that the holes on the front mount are quite a bit oversize. It is a good idea to sleeve these back down to 0.375" if you can do so conveniently. If not, according to Jim everyone is just installing them as is with no apparent difficulty. Position the engine and gearbox on the arms of the bed as shown in Figure 2.48. The centerline of the crankshaft should lie in the plane defined by the top edges of the arms. One way to hold the engine in this position is to make some slats that span the arms. The pair shown in Figure 2.49 have a step in them so that crank center is in the correct plane with the engine's oilpan rails sitting on the slats. Technically, on most if not all blocks the oilpan rails lie a little below the crank center (about 0.130" on the Merlin block shown). A discrepancy of this magnitude can be ignored. With the engine sitting on the slats it is easy to move it around to the correct alignment. Move the engine fore or aft until the centerline of the forward mount is 1 inch aft of the tip of the arms. Move the block laterally so that the crank axis lies in the symmetry plane of the fuselage. If your bed mount was installed properly the crank centerline should angle downwards 1.5°. If it does not, shim as necessary so that it does.

The forward mounts are typically about right for depth, but the angle on the outboard sides is too large. Only one batch of these fittings has been produced, so they are all like this. You should orient the forward lower fittings flush with the tip of the bed arms and with the inboard edge flush against the interior of the arms.

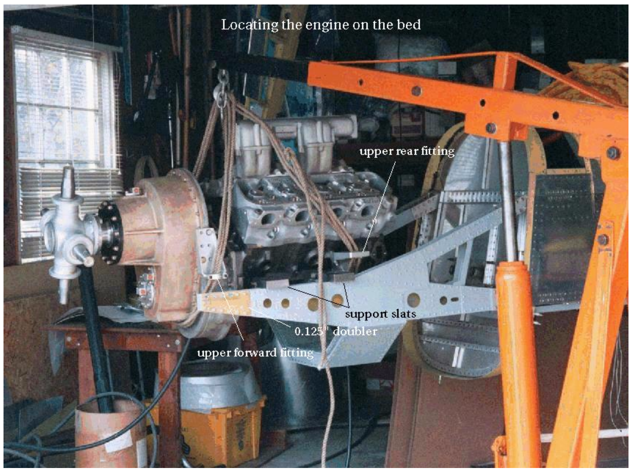


Figure 2.48. The block, heads and intake manifold sitting on the bed mount. The intake manifold obviously requires major surgery.

Then transfer punch the lower fittings through the upper fitting and Lord mounts and drill and ream them for the AN8 mounting bolts. Later on you will need to make a tapered shim to take care of the misfit on the outboard sides, but don't worry about it for now.

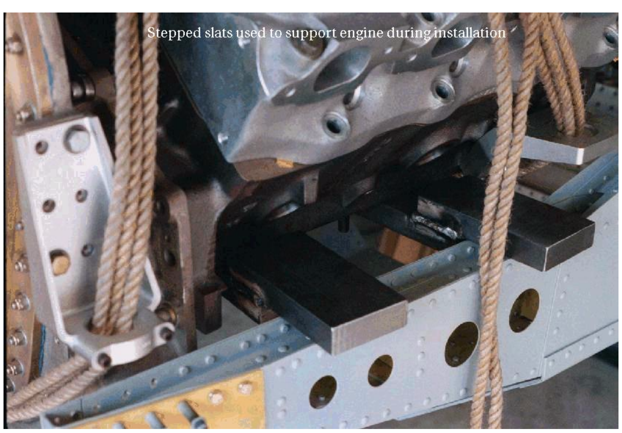


Figure 2.49. With the engine resting on the slats, it is easy to move it into alignment.

As shown in Figure A.8, you must make some 1.88" spacers which control the degree of compression of the Lord mount halves. You can easily make these by reaming heavy wall tubing to 0.5" ID. These spacers will result in 0.110" of squish when the engine mount bolts are torqued. Install the spacers between the Lord mount halves and bolt the front upper and lower fittings together. Torque the bolts to take up the squish. The lower forward fittings should now be held in the correct position. You have to figure out some way of picking up the inside holes in the arms and transferring them to the lower fitting. If you have reamed the pilot holes to 5/32 this is extremely difficult to do. If you have left them at 3/32 you have considerably more room for error. If Jim has stopped the Czechs from pilot drilling these holes (which he is supposed to do), then of course this step is not necessary. Use a piece of appropriately sized drill rod which is accurately ground to a point on one end to pick up the holes in the arms. With a jury rigged clamp you can easily put enough pressure on the on this punch to leave an indentation in the interior surface of the lower fitting. This can then be pilot drilled from the inside with a pancake drill and stub bit. Once you have a couple of holes on each side you can make templates from the arms and use them to locate the forwardmost holes (which you will not be able to drill from the inside, even in the unlikely event you figure out how to mark them). Once you have the bolt holes located and reamed you can fabricate and install tapered shims at the outboard mating surface. These can be made by filing down pieces of 0.125" plate.

The rear fittings are much easier. Since they fit inside the arms, picking up the holes is not a problem. If you have rear fittings from early production runs you will find that they are not nearly deep enough to get adequate edge distance for the AN3 attach bolts. The solution is to install a very thick shim (Figure 2.50) so that the fitting sits lower in the bed mount. You may need as much as 0.625". To preserve the shear strength of the original design, a spacer this thick should be held to the fitting by more than just the AN8 mounting bolt. At a minimum, use an additional bolt on each end. Later runs of the rear fittings are deeper, and only relatively thin shims (if any) will be required.

Use AN8 bolts and all metal locknuts to secure the engine to the mounts. It will make engine installation and removal easier if you secure the nut to the underside of the lower mount. We are not aware of any source for -8 platenuts, but you may be able to find some surplus half inch nut cages that serve the same purpose.

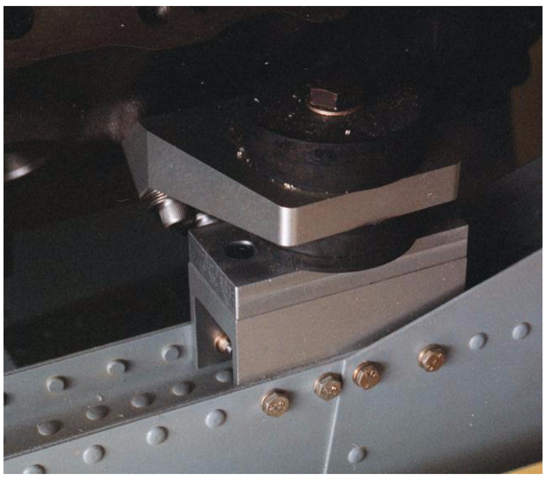


Figure 2.50. The left rear engine mount. It will be necessary to install a spacer between the bottom engine mount bracket and the lord mount. You will probably need something about 5/8" thick. If your lower arms are not vertical, you will have to modify the mounting hardware a little.

Mounting the spinner

The next step is to assemble and mount the spinner, or at least the rear section of it. Drill, ream and rivet up the forward and rear spinner bulkheads as per drawings 6101 and 6102. Note that the plans call for structural adhesive as well as rivets in the rear bulkhead, and that the outermost rivets are -5s instead of the usual -4s. Do yourself a favor and drill and ream the holes for the bolts which attach the rear bulkhead to the propeller hub accurately (e.g. with a milling machine equipped with a rotary table or digital readouts). These are the 0.250" holes on the 6.875 bolt circle. Note that the rivets that pass through the aluminum spacer in the rear bulkhead are AN426's. These must be installed with the factory head forward because the bulkhead is designed to mate with the hub from the rear. The bulkheads attach to the spinner with structural adhesive and AN426-4 rivets (approximately 1 inch pitch).

You will have to get the split flange backing plate adaptor that mates the prop hub to the rear bulkhead from Hartzell. Make sure you get the Hartzell C-3492 flange, the one with uniform 30 degree hole spacing on the 6.875" bolt circle (the more common Hartzell C-3404 adaptor has hole spacing slightly greater than 30°; it will not work). BTW, you are not going to believe the retail price for these adaptors; $684, as of April 1, 1999. Fortunately, you should be able to find some used ones at a prop shop or salvage yard for much less than the list price, say $50-100. The adaptor attaches to the hub with special bolts available only from Hartzell. They are 5/16-24's but have a 0.3281" shoulder. You may as well get these too.

If you want to put off the expense associated with the prop and hub, you can mount the rear spinner half to the gearbox as shown in Figure 2.51. You must space it out 0.50" to account for the thickness of the hub flange. Eventually you will need to trim the rear spinner section one inch forward of the joggle. The trim line is scribed on the part at the factory. In in order to preserve the circular cross-section of the spinner, we suggest not doing this until you are ready to mate the halves. Use 10-32 screws and platenuts to secure the spinner sections at the joggle. Jim suggests using 4 screws between blades (remember to allow for the blade cutouts). Jerry has made a template of the cutouts used on the prototype (Figure A.13) which may be of some help. This was FAXed to us with no dimensions, so we cannot vouch for its accuracy. We put a couple of dimensions on what was furnished so that those that users can resize it appropriately. Printers and printer software being as they are, you should check both dimensions to insure that the aspect ratio has not changed.

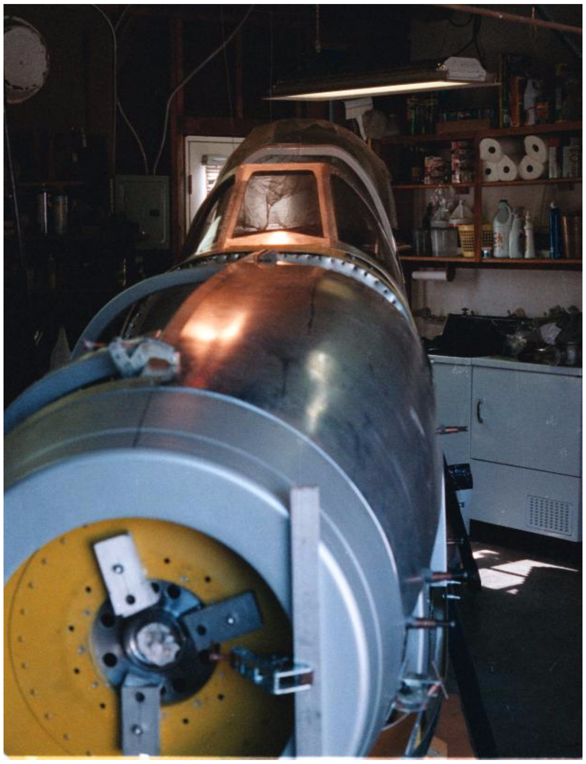


Figure 2.51. The aft part of the spinner mounted on the prop hub with some crude clamps. The forward cowl bulkhead gets clamped to the spinner backing plate and locates the front of the cowl.

When you think you have everything installed correctly, have someone spin the gearbox shaft. Stand back and visually check the spinner for excessive wobble or runout. If you have done a reasonable job of centering the ring flange on the plate you should not be able to detect any runout with your eye. If necessary you can remove any wobble using shims between the plate and hub adaptor.

Inletting the spinner for the blades

Although you can complete the cowling without installing the complete propeller, or even the spider (the part of the hub the blades mount on), you can avoid making clamps if you can at least acquire the spider. Because of a recent AD, you will probably find a pile of red-tagged spiders at your prop shop. Probably you can get one for the asking.

Before you can install the complete propeller, you will need to inlet the spinner for the blades. You can start with a hole saw, then gradually enlarge the holes to fit the blades, using rotary file and die grinder. Work on the back part of the spinner first. Place the prop on blocks with the hub side up and the backing plate adaptors installed. Put a couple of lengths of 0.25" drill rod in the holes which mate the backing plate adaptor to the rear spinner bulkhead. These serve to index the backing plate on the hub. All you have to do is lower the rear bulkhead on the drill rod onto the hub as far as you can, mark the spinner by moving a pencil along the blades, remove the spinner and trim. This procedure is repeated until the rear bulkhead seats on the hub. At this point you have the proper trim for the blades in course pitch. The cutouts can be enlarged for the fine pitch blade orientation in the same manner. You can easily change the blade orientation (between the stops) by removing the pins that hold the pitch adjustment arms to the hub (not to the blades). For each arm you will see 2 screws that are connected by a strap and safety-wired together. The head of one should appear to be peaned. This one holds the pin to the strap. Cut the safety-wire and remove the other screw only, then the pin and strap will lift out. Now you can easily move the blades by hand. You can turn the prop over, mount the rear part of the spinner and inlet the front part of the spinner as you did the back.

Installing the skeleton

The top stringer (the one that goes down the symmetry plane of the cowl) is 2" wide as currently furnished. This is not wide enough to install the 2 rows of #5 flush Dzus studs called for in the plans. Jim is aware of this and has increased the width to 3" for parts made in the future. However most builders will need to increase the width. either by cutting it along the web and riveting in additional material, or by forming a new stringer. The latter is probably easier (and certainly cleaner) but you will need access to a 5 foot shear and brake.

The forward cowl bulkhead (6802-2) is furnished as a ring flange and circular plate. First mark the plate in quadrants, clamp them together and pilot drill the rivet holes along the circumference. Then cut both the flange and plate in half. Rivet the upper half of the ring flange and plate together. Insert the flanged surface of the fiberglass chin scoop between the plate and ring (making sure the quadrant axis passes through the symmetry plane of the chin scoop), then rivet the lower assembly. You will need to install platenuts on the front surface of the bulkhead assembly for the 6 10-32 screws which hold the halves together. *These screws must go in from the rear.* When the assembly is complete, install it around the PSRU gearbox and clamp it to the spinner with the parting line horizontal and the remaining quadrant marks at 12 and 6 o'clock. You will probably have to make some simple clamps to do this. Jim recommends leaving a 3/8 to 1/2" gap between the spinner and the forward cowl bulkhead. *Note: The quality of some of the fiberglass parts is, uh... "not so hot". New builders will get all this stuff in aluminum, and these parts will apparently be available to current builders through PAE.*

Locate the fuselage symmetry plane at the top of the firewall and where it intersects the top of the spinner. (The easiest method is to use a snap-line and plumb bobs, as you did when mating the bed mount to the firewall.) Clamp the top stringer (6802-12) into position between these points. The plans show a distance of 60" between the front bulkhead and the rear of the stringer (or the front of the doubler just forward of the firewall). This is a nominal dimension; yours may differ slightly. Take the other dimensions off the plans, e.g. make up any difference in total distance in the rearmost section of the cowl, where the curvature is the least. Secure the top stringer to the firewall doubler using a aluminum strap and flathead screws (not rivets). *You will need to be able to remove the top part of the skeleton to get the engine in and out.* If at all possible, be sure to keep the strap and screws clear of areas where Dzus studs will eventually be installed (this remark applies to all the riveted and screwed doublers in the cowling).

Install the two sets of skeleton ribs as shown in drawing 6802. You will have to trim a bit off the bottom of the aft set of ribs and lesser amount from the forward ribs. Trim an amount off the inboard edges corresponding to half the amount by which you increased the width of the top stringer. The pieces labeled -3 and -4 in 6802 are actually subassemblies consisting of a -13 sheet reinforced with either a -14 or -19 formed stiffener. The Czech's are apparently labeling the -14/19 parts as -14R/14L. Curiously, what they label -14R goes on the left, and -14L goes on the right. *The more curved ends of -14L/R should go towards the front.* You will have to trim off the rear part of the formed stiffener. Apparently this results from a change in the plans to which Czech's have not yet adapted. In the prototype these stiffeners extend all the way to the firewall. However in the production kits the engine bed is wider and there is no room to extend the stiffener very far aft of the rear set of ribs. In addition to trimming the stiffeners to length, you will have to remove part of the horizontal section at and just aft of the forward engine mounts, as shown in Figure 2.52. If you do this you should be able to bend the front edge of the -13's in enough to mate with the chin scoop. The forward edge of the -13's should be trimmed flush with the aft edge of the chin scoop. The aft edge should be trimmed flush with the forward edge of the firewall doubler. Again, use screws to fasten these assemblies to the firewall doubler.

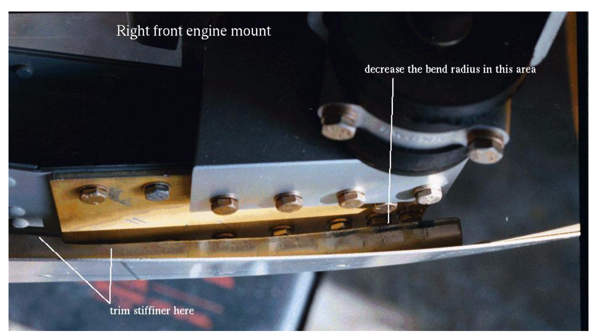


Figure 2.52. This view of the right lower engine mount arm shows how the stiffener on the lower cowl stringer must be trimmed to eliminate interference with the mount.

You are no doubt missing 6208-20. This part results from a design change made at the suggestion of some of the early builders. The actual parts were never produced, so current builders will have to fabricate them from the drawings.

That finishes the skeleton, at least for now. Next you can begin fitting the skins.

The top skins

The top of the cowl is formed with too much curvature in it. This appears as a hump near the nose, but most of it can be removed with little difficulty once you split the skin section down the middle. If you have access to one, a large industrial bandsaw will work nicely. A very thin cutoff wheel should also work OK. *Remove as little metal as possible when making this cut and cleaning up the edges, e.g. use a thin blade and cut straight.* When the curvature is removed the front edge of this skin will not fit evenly on the forward bulkhead. Move it forward and trim as necessary. The fit between the skin and the ribs typically improves as the skin is moved towards the front. Therefore most of the trimming is from the forward edge. Trim the aft just enough to get rid of the stretch marks. Mark the center of the top stringer and trim the inboard edges of the left and right skins until they are straight and mate evenly along the line. *Do not trim off any more than necessary.*

Before you drill any holes in the top skins, it would be a good idea to make sure they clear the engine heads, #1 intake valve rocker and valve cover. It is often necessary to modify the left valve cover to reduce the height at the forward outboard corner. With a tall deck block, the forward outboard edge of the head is sometimes very close to skin. Some heads (e.g. Brodix) have raised exhaust ports, and this in combination with the tall deck may cause the flange for the front exhaust stack (one of the dummy stacks) to lie just outside of the cowling surface. A standard block and heads fit better. Fit in this area is not a problem if you fabricate and install a stainless steel shroud around the stacks. If you use a tall deck and Brodix heads you should count on having to do this. In any case, if you need a little more room inside the cowl you may be able to get it at this point by shimming the ribs out a bit. Typically, the forward spinner bulkhead needs to be shimmed out about 0.1" at the sides to get the cowling skins to blend well with the spinner.

When everything fits you can drill and cleco the top skin sections to the top stringer. Be sure to allow adequate edge spacing for the #5 Dzus stud dimple. *In locating the Dzus fasteners on the ribs, take care to avoid the flutes.* The front rib flange may be bent at too great an angle to get the skin to lie down at the rear edge. If so, you can decrease the bend angle of the flange by reducing the depth of the flutes.

Tools to form dimples and install the grommets for the Dzus fasteners are available from Skybolt. We understand that the dimpling tool they sell does not do a very good job. Rod Bower has a very nice set of prototype dimple die made by Cleveland Tool. You can rent them for less than the cost of the Skybolt dies. See the section on final assembly. In any case, you should not install the Dzus fasteners now.

You will have to trim quite a bit from the outboard (bottom) edges of the top forward skin sections in order to remove the area where it was gripped in the stretch forming process. The exact position of the trim lines will depend on where you install the stainless skins which lie below. *Wait until you have these located before trimming the outboard (bottom) edge.*

The aft part of the top skin (6800-3) is formed from a 24"x48" section of sheet. The similar looking part (6800-6,7) formed from a 18"x48" section goes on the bottom. It's easy to get these parts confused because they are pretty similar and both will eventually be trimmed to under 18" length. These can be reliably distinguished only by the slight difference in the length of the straight sections extending laterally from the centerplane. *This section is slightly longer on the bottom skin.*

Locate the correct piece of skin and split it down the middle as before. Because this section is rolled instead of stretched, you have much more material to work with on the edges and no particular care is necessary to minimize the width of the cut. As with the rest of the fuselage, the cowling skins take most of the load. Therefore, *when fitting and installating these pieces, be sure that the front bulkhead is oriented properly with respect to the spinner.*

The side skins

The upper side skins (6813-7) are 0.030" stainless. Each is furnished in one piece which must be cut and fit around the exhaust stacks. After you have them located they should be cut along a line extending from the split in the forward bulkhead and angling upwards 1.5° to the firewall. The cut should lie about 18.25" from the top centerline of the cowl as measured along the circumference at the forward rib. At the rear rib the corresponding distance should be about 23". With a tall deck block this should come very close to passing through the center of the exhaust stacks. Install these skins with the top edges even with the bottom of the removable access panels just aft of the firewall. You should be able to do this if you were careful to remove little metal in parting the top skin sections. If you removed too much you will find that with the stainless skins in this position you will be unable to trim away the gripped section at the bottom of the cowl top. In that case you will have to mount the stainless skins higher (and pay a small penalty in appearance).

To get a good fit you will have to form the stainless skins a bit, particularly where they mate with the forward bulkhead. As unformed sheet, you will be unable to get the edges to lay down properly. Forming stainless takes some specialized skill and equipment that most of us do not have. One fellow that does a nice job on these uses a shrinker on the forward and top edges and finished them up with a power hammer. If you cannot find a sheetmetal wizard in your area you can try Fred Muehlenhort (Racetec; (805) 486-6500). He still has templates from previous jobs, and his parts fit pretty well and look great. It seems to work best to form the skins before they are cut for the exhaust stacks, then use a Beverly shear to spilt them.

You will need to make a doubler to join the skins along the split between the forward bulkhead and the front rib. Drawing 6800 shows two Dzus fasteners here, but this seems impractical. Usually the doubler is riveted to the lower half and a Dzus fastener used in the upper. Mike VadeBonCoure installed a section of U-channel along the joint running from the firewall to the rear rib. See the Rivethead Vol 2, No 4 for a picture. This is superior to a simple doubler, but it has to be installed so that it can be removed. You will also have to trim away portions of the flanged surface to avoid interference with the top engine mount fitting at the firewall.

The lower side skins (6813-3) are supposed to be 0.040" aluminum, but the Czechs cut these parts from stainless in some kits. You can go ahead and use the stainless. The downside of this is a little extra weight, the necessity of trimming an additional stainless steel edge and some increased difficulty in forming the forward edge to mate with the chin scoop. Many builders are extending the edge of this skin section forward so that it mates with the front bulkhead along its full depth, as in the real P51. This requires trimming away the top part of the fiberglass chin scoop that Jim currently provides. A brief description of this modification and a picture can be found in the Rivethead interview with Mike VadeBonCoure. Jack Peck has also done this. See the picture at the beginning of this write-up. *If you want to do this you must lengthen 6813-3 to about 59.25" and of course omit the notch in the front.* Actually, it's a good idea not to cut the notch in any case until you see how the formed skin will fit with the chin scoop. As for the upper side skins, the lowers will have to be formed too, particularly if you trim away the top of the chin scoop.

In installing the stainless skins you want to plan so that wherever possible you trim the adjoining aluminum skins instead of the stainless. The following procedure works pretty well. Clamp the skins into position with no doublers installed. Mark the trim lines at the overlap and trim about 1/16" short of the line. Then layout and pilot drill the rivet line securing the doubler to the aluminum side. If you Cleco the doubler to the aluminum skin, the edge of the stainless will come closer to laying in the same contour when the two are mated. This should enable you get a better idea of where the final trim should be made. You can then remove the doubler and file away the high spots on the aluminum edge until you get a good fit.

You will need to trim the forward edges of the side skins on a radius. I suppose you could do this with a saw and file, but the job can be accomplished much more easily with a Beverly shear (kind of a large, pedestal mounted tinsnip). You should be able to find one at a sheetmetal shop.

Chin scoop

Install the chin scoop on the bottom of the forward bulkhead if you have not already done so. The edges of the fiberglass parts are likely to be uneven and asymmetric, so find the center of the smile and put that at 6 o'clock. You will have to trim the top and sides of the chin scoop, then make and install an aluminum doubler between the scoop and adjoining skins. The doubler should be flush riveted *and glued* to the chin scoop. use a couple of rows of 426-3's and the usual 3M 2216 structural adhesive. As for the rest of the cowling, you should not install the doublers permanently (e.g with rivets and glue) until all the fitting is complete.

The bottom skins

The bottom skins to relatively difficult to install, primarily because you cannot develop much confidence that any one of the 3 sections is oriented correctly without *all* of them in place. We therefore strongly suggest that you read this entire section and think a bit about the big picture before you begin cutting metal. The following narrative assumes that you are working from front to back, but the opposite sequence could probably be used equally as well.

The first step is to install the air tunnel leading from the chin scoop to the firewall. Before you do this you should install rivets every couple of inches along the seams. According to Dan McGarry, the seams tend to open up after a hundred hours or so due to the combined effects of ram air pressure and vibration. Pop-rivets with backing washers or soft (non AD) solid rivets will work best. The top of the tunnel should be flush against the bottom of the engine mount cradle section. You will eventually have to put an rubber pad in here to prevent chafing and fabricate and install a pair of straps around the bottom of the tunnel which bolt to the cradle. For now you can use duct tape or baling wire.

To begin the fitting process you will need to lay the bottom skin sections over the middle skins. Where necessary you can replace the Clecos in the overlap area with temporary pop-rivets. First trim off the section of the forward bottom skin (6812-2) where it was gripped for stretch forming at the upper rear corners. Layout a centerline and clamp the skin to the lower stringers and chin scoop. Adjust the position as necessary so that the centerline lies in the symmetry plane of the fuselage. This section seems to fit the chin scoop better with as small a radius of curvature as possible. Therefore the skin is typically clamped to the chin scoop just far enough forward so that the grip marks at the front may be trimmed away. This puts the forward edge of the (untrimmed) skin slightly behind the forward edge of the chin scoop. If you do this, you will end up trimming a lot off the back. We will warn you that this may cause some curvature mismatch where the forward and middle skin sections join. The bottom line is that no matter how you go about it you are probably going to have some mismatch somewhere. Hence you will again need to do a little metal forming.

There is no firm dimension as to how far any of the lower cowl skins should extend below the bottom stringer. All you really want is to get a smooth line between the aft edge of the chin scoop, the bottom of the firewall and the front spar of the wing, and of course allow room for the air tunnel. If you have the wings mated you can use a thin wooden spline to get an idea of the proper curve. If not, you still use the spline and pick up the following reference points aft of the firewall. A dimensioned sketch of the forward extension of the butt-line zero rib as it is installed in the aircraft constructed by Mike VadeBonCoure (an especially nice one) is shown in Figure 2.53. The part (5210-3) we refer to is the one that extends below the floor from the front wing spar to the firewall, separating the wheelwells. Use the trimmed dimensions to get an idea of the proper skin contour from the firewall to the front wing spar. It might also help to compare your lines to those on a completed aircraft, for example Dan McGarry's (Figure 2.54). As a guide, the gap between the bottom of the air tunnel and the aft edge of the forward lower cowl skin is typically about an inch. When you have a pleasing contour along the bottom, mark trim lines on the sides. *You will want to trim about an inch short of this line for now.* Read on.

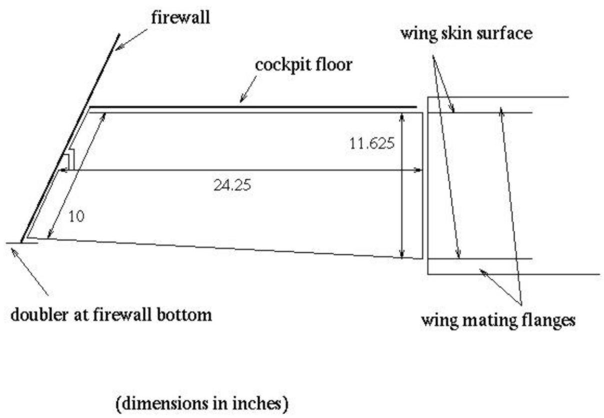


Figure 2.53. The dimensions in this sketch of the divider plate in Mike VadeBonCoure's project should help in determining the contour of the lower cowl.

You can use Bungee cords to hold the skin sections lapped against one another while the trim lines were marked. This can exert considerable upward pressure on the lower skins, so if you use this technique you will need hold the lower skins firmly along the sides. *By far the best way to do this is to leave enough material along the outboard edges so that the lower skin sections can be lapped under the middle skins deep enough to pick up the Clecos securing the middle skins to the lower stringers.* See Figure 2.55.

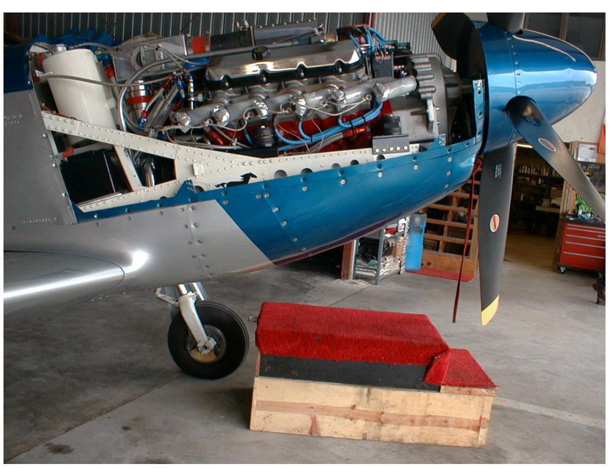


Figure 2.54. The lower cowl on Dan McGarry's aircraft.

Figure 2.55. Fitting the forward and middle sections of the lower cowl. Although the plans call for Dzus fasteners here, builders who are presently flying tell me that the joint could be riveted without sacrificing any convenience. You will have to do some forming at this joint to get the skins to match well. *The best way to temporarily secure the lower cowl skins is to lap then under the upper skins far enough to pick up the clecos in the upper skin.*

Pick up Clecos as described above to hold the rear edge of the forward skin in place. Use a Bungee cord to secure the front to the chin scoop. Assuming you have not glued or riveted the doublers to the chin scoop, remove them and mark the forward trim line from the inside. Again trim a bit short of the line, as it may become apparent that you need to move the bottom contour up or down as you fit the remaining skins. If you want you can drill and Cleco the forward edge at the bottom of the chin scoop doubler, but not along the sides. You may well need to do a little forming to get the sides to fit well. If you do, leave that for later.

Next you need to layout and cut the rear edge of the forward section. This is cut on an angle (the lengths at the top and bottom are in the plans). Use a cardboard template as shown in Figure 2.56 to lay out this cut. Trim just a bit short of this line, then identify the high points using any flat surface and file them away.

Figure 2.56. Preparing to trim the aft end of the lower forward cowl skin. Just mark the plane of the cardboard and trim along the line.

The middle lower skin section (6812-3) is fit much as the forward was. Layout a centerline on the middle section, then lap the outboard edges under the middle skins at the lower stringer. Move the center section fore and aft in an attempt to get the curvature to match at the rear of the forward skin section. Typically the skin is moved as far aft as possible and even then the middle section has too little curvature. You will probably have to do some shrinking and stretching to get the joint to fit. Use the spline to orient the aft end and secure the sides with the Clecos in the middle skins.

You can lap the forward edge either under or over the aft edge of the forward skin and lay out the trim line. Trim to the line. Install the doubler (6812-4) at the rear of the forward skin section with Clecos. The doubler furnished with the kit may not fit. If so, toss it out and make a new one. Butt the forward and middle skins against one another and secure the middle skin with a Bungee cord as shown in Figure 2.55. Refine the trim line on the middle skin as necessary. You may have to iterate several times on this, You should have plenty of excess material on the aft edge, so just keep cutting away the high spots and moving the skin forward until it fits. The plans call for installation of Dzus fasteners along the forward side of this joint. The few people currently flying completed aircraft tell me that this joint is never disassembled in practice. It's apparently more convenient to take the forward and center sections on and off as a unit. Hence, if you are not concerned with authenticity you could save some effort by simply riveting this joint.

The aft skin section is installed in three pieces, although it is furnished as a single section. The exterior pieces (6812-5,6) are mounted flush with the firewall doubler and lower stringer. They underlap the lower middle skin section along their forward edges and also underlap the interior part (6812-7) of the aft skin section. See drawing 6812 for the details. The outboard pieces are recessed in order to make the forward edge of the wing root fairing blend smoothly into the cowling. The interior piece is not recessed. The fasteners required for aft skin section are in some cases not specified in the plans. The outboard pieces are supposed to be riveted to the lower stringers using doublers. They attach at the rear to the firewall doubler using doublers which should be riveted inside the firewall doubler. The outboard pieces attach to these doublers with flush head machine screws so that the skeleton and outboard pieces can be removed as a unit. Dzus fasteners are to be installed at the forward edge so that the middle skin section can be easily removed. The interior part butts up against the aft edge of the middle skin section where it overlaps a doubler. The inboard piece is riveted to the doubler and the middle skin section is attached to it with Dzus fasteners. At the rear it overlaps the firewall doubler and ends in the plane of the firewall. This piece is secured on the sides and at the rear with flush head machine screws and platenuts.

You will not be able to get all three pieces of the aft section out of the part furnished with the kit. You need at least 1.25" of overlap between the interior and outboard pieces for #10 screws, and the part furnished is not wide enough to account for this and an adequate cut allowance. Use the formed part furnished with the kit for the two outboard pieces and fabricate the interior piece from sheet.

Begin by holding the (uncut) lower aft skin in place with Bungee cords. Check the bottom contour and see if you can improve the fit and/or appearance by adjusting it. At this point you should still be able to do so. When you have the geometry the way you want it you can use the leading edge of the aft section to mark a trim line on the aft end of the lower middle section. If you use the 11" dimension shown in 6812 for the length of the middle section at the lower stringer, you should find that the trim line is roughly even with the aft end of the rear set of ribs. Once you have this line marked you can slide the aft section forward to get the required overlap at the joint between the middle and aft sections. Drawing 6812 calls for 1", but that is really not adequate for Dzus fasteners. You should have plenty of material to make it 1.5". With the rear section held in this position (Figure 2.57), mark a rough trim line at the forward edge of the firewall doubler. You can also mark the outboard edges of the forward and middle sections and at your discretion trim them to butt up against the middle skins. Remove the aft section now and cut it into the outboard pieces (-5,6). You can also trim the rear edge of the middle section (-3) to the line. The geometry is now set, so you can finish up all the skins.

You will need to form 6808-20 yourself or wait for the Czech's to get around to it. You will probably need a shrinker because the bend radius at the bottom is a little tight for fluting. You can attach it to the lower stringers with rivets.

This finishes up all the sheet metal work that you can do on the fuselage without the wings mated. There is still a little more to do on the bottom of the fuselage between the front wing spar and the firewall, but you need the wings in place for this. We cover this in the notes on final assembly. Before you mate the wings you should install as much of the hydraulics and wiring as possible. As you progress towards final assembly access will only become more difficult.

Some comments on wiring

Here are a few things you may want to consider when you decide where and how to run your wires. First, you will probably have less trouble with noise (the electrical kind, I expect nothing will help with the audible kind) if you run power cables down one side of the fuselage and the antenna co-ax and audio cables down the other. The power leads usually run down the right side because the breaker box is on the right. Second, by now you have probably noticed that once the aircraft is assembled it is not going to be easy to work on anything up near the firewall. Some of this can be done through the access ports just forward of the windscreen, but reaching down either side of the tunnel is going to extremely difficult unless you can you can easily remove the avionics console.

Figure 2.57. View of the lower aft cowl section from the lower right. This skin section is cut into three pieces. The outboard pieces underlap the middle skin section. A minimum of 1.5" should be allowed at the lap joint to install Dzus fasteners.

It is really not good practice to use the airframe as a ground (although it's certainly done a lot on metal aircraft). You may save yourself some time chasing down noise sources if you run ground wires, at least for equipment that draws lots of current or is sensitive to voltage drop.

Be sure to label each wire at each end and keep good records of where each goes. Good circuit diagrams can easily reduce the time necessary to diagnose and repair electrical problems by a factor of ten. Writing labels on light colored heat shrink tubing works OK. If you use a very fine tip pen you can write legibly on heat shrink as small as 3/32 diameter. You may need a magnifying glass to read it once it is shrunk onto the wire!

Figure 2.58. Here the cowling is nearly ready for installation of Dzus fasteners. You may need to do a little forming where the lower cowl mates with the chinscoop. This shows the joint before "adjustment". The fit can be improved by cutting the chinscoop further aft, but then it will be impossible to get all the Dzus fasteners called for in the plans installed.

You should use shielded, twisted pair cable for your audio and microphone connections, especially if you are not using a switching panel. The wires from the alternator to the main power buss, from the master switch to the voltage regulator, and from the mags P-leads (if you use them) to the ignitions switch should all be shielded.

Suitable locations for a GPS antenna are very limited on this aircraft. Probably the best choice is inside the aircraft, directly forward of the instrument panel and under the glareshield. Be sure to allow room for the antenna connector between the instruments in the top row. An alternate location is on a strip of metal at the extreme rear of the cockpit. You will probably have to remove this strip to get the canopy on and off.

Some builders have placed the ELT antenna in the rudder. This apparently works OK. Just put rubber grommets in the ribs so that the antenna does not short against the frame.

Com and transponder antennas are typically mounted under the wing. With the flaps removed, you can get access through the lightening holes in the rear wing spar.

There is really no good place to mount a nav antenna. Probably the bect choice for a conventional antenna is under the fuselage aft of the tailwheel. If you use fiberglass wingtips, you can put an Archer antenna in them if you extend them abuout 3". This is not very difficult to do.

Instructions on installing the remaining system wiring (e.g. flaps, hydraulic powerpack and gear microswitches) are given in the section on final assembly.