Building the Bearhawk®

Builder's Assistance Manual

for the
AviPro Aircraft, Ltd.
Quick-Build Bearhawk Kit

WING ASSEMBLY

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Wings: Getting Started

When the wings come to you, after you've drilled out the pop rivets installed for shipping, this is what you have: nearly completed wings needing only the systems installed and the top sheet riveted down between the spars. You'll have to come up with a system of curling the sheets back so you can work on the inside of the wings. This builder used 1 x 2 wood with finishing nails in the end that will fit through the rivet holes. Others use PVC pipe or long pieces of wood suspended via wire to the bench.

What To Do And When to Do It

Note: this is a very rough guide that outlines the major steps to be taken and the order in which they should be taken. This is not cast in concrete, but is a suggestion.

1-Remove pop rivets and inventory parts shipped inside wings
2-Prepare table or resting place for wings
3-Remove wings from crate
4-Check all pre-installed bolts for correct length and torque .
5-Install stiffener at lower back edge of wing skins, fla area (if not already in place by factory)
6-Install flap actuation system, flap springs, torque tube, etc.
7-Install aileron bellcranks, pulleys and actuation system
8-Run aileron cables
9-Install back ribs at tip/root, root back skin.
10-Position wings on fuselage
11-Set incidence, drill fuselage and wing fittings
12-Set dihedral
13-trim and drill struts
14-Remove wings
15-Install flaps and ailerons (then remove)
16-Finish flaps and ailerons (can be done later), except trailing edge.
17-Install main fuel tanks including cutting hole for filler neck
18-Install tank bay stiffeners (optional)
19-Cut hole in bottom skins for aux tanks (if applicable)
20-Install aux tank straps, pump and plumbing
21-Fabricate aux tank cover, install nut plates
22-Run conduit for aux tank pump and nav light wiring
23-Install pitot system
24-Install inspection door frames and nut plates
25-Rivet top wing skins down
26-Back-rivet tank bay stiffeners into place
27-Install aileron well pocket rib skins
28-Install main tank covers
29-Install wing tips
30-Finish flap, aileron trailing edges
31-Install wings
32-Finish running aileron/flap cables
33-Fabricate wing-to-fuselage/windshield fairings.

Some Thoughts on Working Aluminum

Compared to the fuselage, the wings are a piece of cake in terms of the amount of time they

A set of easily made dollies for your wing crate makes them much easier to handle. An alternative are Harbor Freight furniture dollies.

will take to complete. However, because you're working with aluminum, it's necessary you make a special effort to be as careful as possible to avoid scratches, sharp edges, etc. Where steel is quite tolerant of such things, aluminum isn't. Each scratch that can be felt with a fingernail needs to be Scotchbrited out because it is a stress riser and the possible starting point for a fatigue crack later in life. This isn't meant to scare anyone but to point out the necessity of taking special precautions to protect the material, especially the outside skins.

The biggest sources of scratching on aluminum structures is accidentally laying it on something seemingly as harmless as drill shavings or a stray rivet. The best way to protect against that is to cover your work surface with deep pile (not shag) carpet and vacuum it periodically.

Work Tables

The hot ticket for building wing tables is to make them from the shipping crates. Turn the crates upside down on a set of saw horses (bolt or clamp them down) OR, if you're a welder, use the steel from the crate top to build legs for the crates.

If you want, you can just take the foam out of the crates and use it to pad the top or screw some plywood onto the frame. When you're finished with the wings, you can use the steel in the wing tables to build racks from which to hang the bazillion small parts you'll have to paint.

The table have to have a hole in the middle to accept the strut attach straps that stick out of the bottom of the wings

Unpacking the Wings

Don't try to open the crates by yourself: the tops are too awkward and it would be really easy to lose control for a second and dent something. The tops aren't even remotely heavy (25-30 pounds), but have an extra set of hands ready to help.

The flaps and ailerons are packed on top of the top wing and covered with foam. Because the foam is so light, don't attempt to unpack the wings in a wind because it'll pick up the big pieces of foam even as you try to get them out of the crate.

From this point on, remember that everything in the crate is super easy to damage, so treat the contents as if they are eggs.

When it comes time to lift the wings out of the crate, two people can easily handle the wings but be paranoid about the way the vertical parts of the crate are sticking up just waiting for you to slip and drop the wing on them.

Each piece of wing skin has a couple of aluminum pop rivets that need to be drilled out. USE A #40 DRILL, NOT A 1/8", to remove them because the rivet holes are for AN3 rivets. You don't have to drill all the way through. Just drill enough to remove the head and, if they start to spin, grab the butt with a pair of pliers. They should come out very easily, when pushed with a punch.

Once the skins are free, remove and inventory all the small parts packed in the gas tank bay.

Curling the Skins Back

To work inside the wings you'll need a method of curling the skins back and holding them there in a solid manner. The opening picture shows pieces of wood with finishing nails in them. Another way to do it is by running boards (2 x 3) or PVC pipe spanwise under the skins and tethering them to the ceiling or the back side of the work bench so they can't move.

It's important when setting up your skin restraint system that it be infallible because should one skin break free and try to come down, it can put dings in the edge of the sheets where they overlap.

IMPORTANT: CHECK BOLTS

Before doing another thing, go through the wing and check the bolts that were installed at the factory. They should not be considered "ready to fly" until you have checked each one for being the right size and length, the requisite three threads are free of the nut, that the nut is the appropriate type AND THE BOLT HAS BEEN PROPERLY TORQUED.

Bolts	Nuts Used	Max Torque	Nuts Used	Max Torque
	AN365/ AN310	Inch-lb.	AN364/ AN320	Inch-lb.
10-32 (3/16)	20-25	40	12-15	25
1/4-28	50-70	100	30-40	80
5/16-24	100-140	225	60-85	140
3/8-24	160-190	390	95-110	240
7/16-20	450-500	840	270-300	500

On Building A Wing Rotisserie

Although a rotisserie is a long way from being necessary, we thought we'd share what one builder fabricated to make his life easier, and it would indeed do that. A day with a hacksaw and MIG welder, gives you a way of handling your wings that can't be beat and allows one man to do many tasks, including turning the wings over, that would require another body to help. This is an excellent use for one of your crate tops.

The wings don't weigh very much (150 pounds), but they are not only awkward but very easily damaged. Plus, you're always wishing you could get at the other side.

The construction uses 1" x 1/16 tubing as is used in security gates and can be found everywhere. Better yet, there's enough steel in the top of one of your crates to build the dolly.

A locking mechanism doesn't get any simpler than this. The wing just lays in the pivot and the locking knob screws through a nut welded to the frame.

When it comes time to paint the wings, a couple dollies like this would guarantee a better paint job because you would always be painting down at an angle with no vertical passes.

Wings: Installing Flap Skin Stiffener

The small stiffener at the back of the bottom wing skin isn't difficult to install but paying attention to a few details, especially squeezing rivets through a thick piece of aluminum angle, will improve the

There are any number of places you could start on the wings, but to get you into the aluminum process with a minimum of hassle, the stiffener that lays in the open area behind the rear spar in the flap bay is a good place to start, although it has been done by the factory in later kits.

The goal here is to attach the stiffener and have the back edge of the sheet metal remain perfectly straight. The reason we mention this is because, when a rivet is driven, it expands the hole very slightly and, unless you plan ahead, it's possible to get distortion in the skin. It will manifest itself as a wavy or slightly recurved skin. However, with just a little fore planning, this can easily be avoided.

There are actually two stiffeners, one top and one bottom and they overlap the flange of the rear spar and are flush, or very close to being flush, with the trailing edge of the skin.

Wings have been supplied in several different degrees of completion in this area, as the kits were improved. The different configurations include:

1. Bottom skin and spar are drilled and dimpled but the stiffener is not.

2. Bottom stiffener is completely installed and finish riveted (all later kits)

3. Top skin and spar flange are drilled and dimpled but the line of holes behind the spar is neither drilled nor dimpled and the top stiffener is NOT drilled or dimpled for any of the rivets so it needs two lines of holes drilled and dimpled.

4. Top skin and flange have both lines of holes drilled and dimpled and the stiffener has matching holes and dimples

Drilling the Stiffener (if it isn't drilled)

In most of these cases, the stiffener has no holes in it, but both the spar and the skin are drilled and dimpled but an additional line of holes and dimples needs to be made between the spar flange and the edge of the skin. Use the front row of holes as guides to drill the stiffener and hold it in place while drilling the rear holes. To visualize what you're trying to do, look at Drawing No. 9.

You can drill the holes either direction, meaning have the wing right side up and drill from the bottom up (with the edge hanging off the work table) OR turn the wing over and drill down. Most people are more comfortable drilling down, but that's up to you.

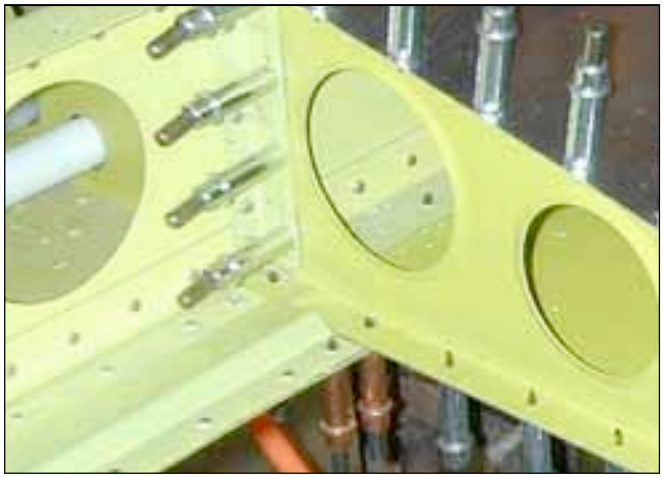
Clamp the Stiffener in Place

What follows is a general instruction of how to drill and install the stiffener. It is assumed the stiffener has no factory-drilled holes in it, nor is the second, rear-most line of rivet holes drilled in the skin. In most later kits the stiffener and all holes in the top skin and spar flange will have been drilled and dimpled. The bottom stiffener may also be finish riveted. If that's the case, much of this can be skipped.

The first step is to position the stiffener so it's flush with the trailing edge (or close to it) but the front edge overlaps the holes in the spar flange enough to give a distance from the center of the holes to the edge of the stiffener of at least twice the diameter of the rivet or 3/16".

Once you have a couple of holes drilled you can hold the stiffener in place with clecos and it won't move while you drill the other holes. HOWEVER, getting those first holes in without the stiffener moving takes a little forethought (doesn't everything?): the stiffener must be clamped in position until you have at least four holes drilled in it to accept clecos. They should be at each end and spaced through the middle.

To clamp the stiffener in place the best solu-



The stiffener at the bottom, front of the flap bay is finished differently depending on the vintage of AviPro kit you're building. However, when finished, they all look like this.

tion is about half a dozen side-grip clecos. Or pad a couple pair of Visegrips or small C-clamps with masking tap to prevent marking the aluminum and clamp the stiffener in place.

Drilling the Holes

Make a back-up block out of a six-inch piece of two-by-four or something similar that will be held against the stiffener and drilled into. This will keep the stiffener from flexing while being drilled.

You'll use the existing holes in the skin and spar flange to drill the front holes in the stiffener. Drill a couple of holes in the middle of the stiffener. Put clecos in the holes, then space out three more holes evenly spaced down the length of the stiffener. Make sure none of the clamps have slipped.

Once you have those clecos in place, the stiffener definitely isn't going to go anywhere so go ahead and drill the rest of the holes.

Don't start at one end and work to the other end as the stiffener will creep. Start at the middle and work our way out.

Once the holes are drilled, debur them and, if they aren't already dimpled, dimple using a squeezer, but don't squeeze too hard or you'll get distortion. .

Riveting the Stiffener.

While it is entirely possible to simply drop the rivets into the holes and whack away with a squeezer, chances are you won't be satisfied with the result because it's hard to keep the trailing edge straight and from recurving: the rivets expand and push the aluminum around. However, there is a way to prevent that.

Buy a heavy, extruded aluminum angle (1/4" thick, 2" or so wide) and squeeze the rivets using the angle as both a straight edge and as an interface between the squeezer the heads of the rivets.

The procedure is as follows:

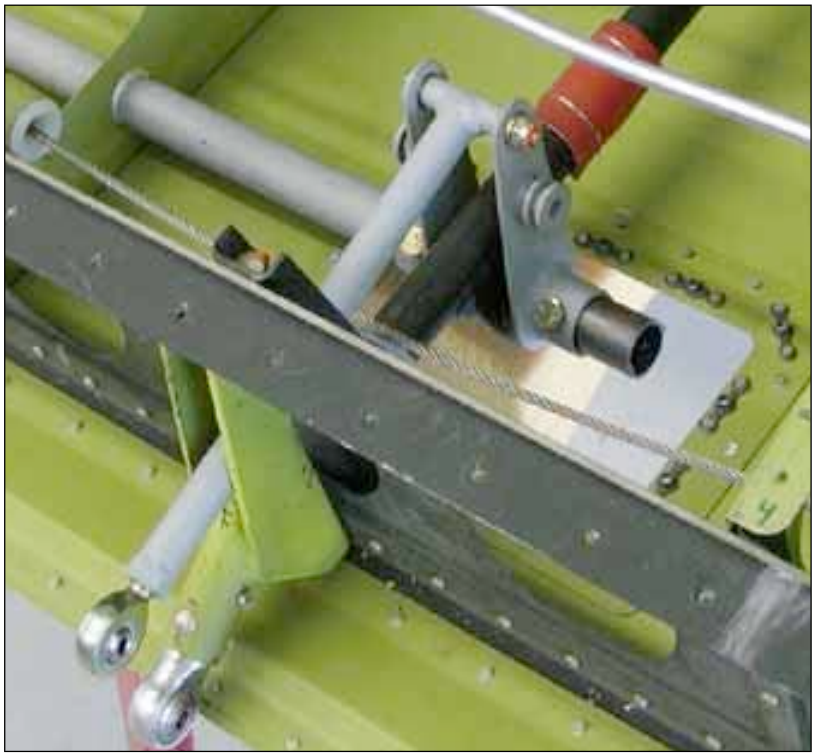
1. Drop all the rivets into the holes.
2. Position the stiffener over the rivets.
3. Lay the angle down over the rivets.
4. Clamp the angle and stiffener together. Make sure it's clamped tight in about a dozen places.
5. Adjust your squeezer to properly compress the rivet by squeezing the angle against the rivets.
6. Don't rivet in a straight line. Do several in the middle, the end rivets, then every third one starting in the middle and working out. Then come back to the middle and, working your way out, finish the rest of them. Using this technique you won't drive the expansion all one direction and will limit distortion.

A few wings were produced in which the stiffener was too long and it interferes with the root rib. Trim off about 3/4" with a Dremel tool being careful not to cut the skin. Protect it with scrap aluminum.

Mis-matched Stiffener/Rib Intersection.

A few wings were shipped with the lower stiffener riveted in place but it is about three-quarters of an inch too long and has to be trimmed to let the flap bay root rib fall in place. Just drill out a couple of rivets and cut three-quarters of an inch off the inboard end of the stiffener. A Dremel tool is the easiest way to cut it. Protect the wing skin beneath by inserting a piece of aluminum scrap.

Wings: Installing the Flap Actuation System



The actuating pushrod is trapped by two actuating arms, both of which have a spring (not shown) going forward and holding the flaps up.The torque tube (going to the left) must be drilled to hold the arms

Understand the Concept

Before doing anything on the flaps system pull out drawings No. 12 and No. 14. They will give you a good familiarity of how the different parts relate to one another and how they work. Also, study the photos in this section. They will clarify any questions.

The flap system is quite simple in that it is nothing but a torque tube coming in from the root with an actuating arm at each end. At the root it is attached to a cable and at the other end a push rod is attached to the middle flap hinge and pushes the flap out. The flaps are held in the up position by the long springs included in the later kits or available from AviPro for the older kits.

The procedures we'll use to install the system include:

1. Install torque tube
2. temporarily slide actuating arms into position on the torque tube
3. Position and drill outboard actuating arm.
4. Install inboard actuating arm, but don't drill.
5. Install springs

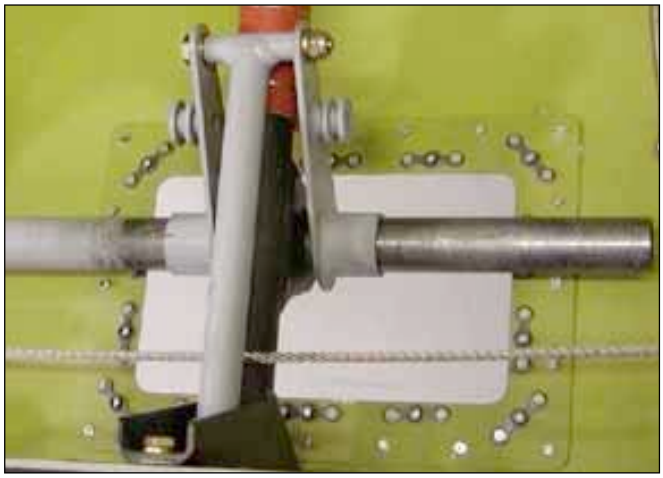
Install Torque Tube

The torque tube slides through the steel stand-off bushng at the root and through a similar bearing stand-off at the mid-wing cross member. Before sliding the outboard end into the bearing note that one of the outboard arms has to be slid in place first (see photo).

Because both the torque tube and the bearings have been painted, it's a good idea to remove the paint from both the inside of the bearings and the area on the torque tube where the bearings will ride. This not only makes it much easier to slide the tube into position but greasing the metal-to-metal contact makes for much smoother operation.

Drilling the Actuating Arms

Each torque tube has three actuating arms, one at the root and two that perform as one and clamp the push rod between them (see pictures). A hole needs to be drilled through the base of the arms and through the torque tube to accept AN3 (3/16" bolt) to stop the arms from rotating on the torque tube..



Paint must be removed from inside the arms and off the torque tube to ease getting the actuating arms on the tube. Note how the pushrod is sandwiched between two actuating arms.

It is best if these bolts have a snug fit, so rather than drilling with a 3/16 bit, drill with an 11/64" and ream to size to eliminate any possibility of slop in the holes.

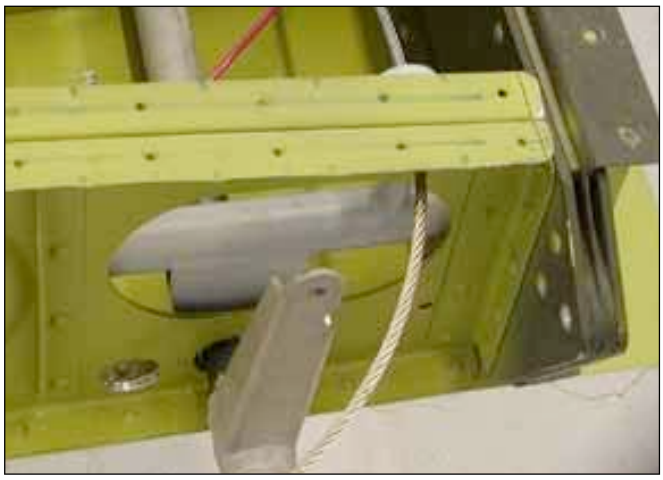
On the outboard arms, first bolt the short

flap push rod between them to hold them in alignment. Then clamp the top end of the push rod where it bolts to the arms down to the crossmember tube to keep it from moving while drilling it.

The root actuating arms have to be mounted at a specific angle on the torque tube to give the flap cables the most efficient angle for pulling.

With the outboard actuating arms still clamped against the fore and aft tubing crossmember, position the inboard arm as per Drawing No. 14.

Sand the paint off the inside of the pivot bushing and the tube and it'll be easier to insert it and it will work much easier.



The actuating arm at the inside end of the torque tube uses a 1/4" shackle for connecting with the flap cable and it is bushed down to 3/16" with 1/4" x .028 tubing.

Because there is limited room between the fuselage and the wing root, it is essential that the flap actuating arm be centered in that gap. For that reason, it's advisable to drill the hole through the actuating arm and torque tube AFTER the wings are on the airplane to ensure no interference occurs. IT S RECOMMENDED THAT THE OUTBOARD ACTUATING ARMS BE DRILLED WITH THE WINGS ON THE AIRPLANE.

Come in from the bottom (or turn the wing over) and center punch where you'll drill the hole in the arms. Then drill one arm with a fresh 1/8" bit (make it fresh, so it cuts cleanly and easily). Using that as a guide, drill with the 11/64" and ream. Then put a bolt in place to keep it lined up.

Do 1/2 of the outboard arms at a time, so one of them is finished and bolted in place, which will hold the other one in position and eliminate minor mis-alignments and wallowed-out holes. These will be bolted with Nyloc nuts.

If you want, you can install the flap springs now, which will help hold everything under tension and keep everything from moving.

A Note About Drilling

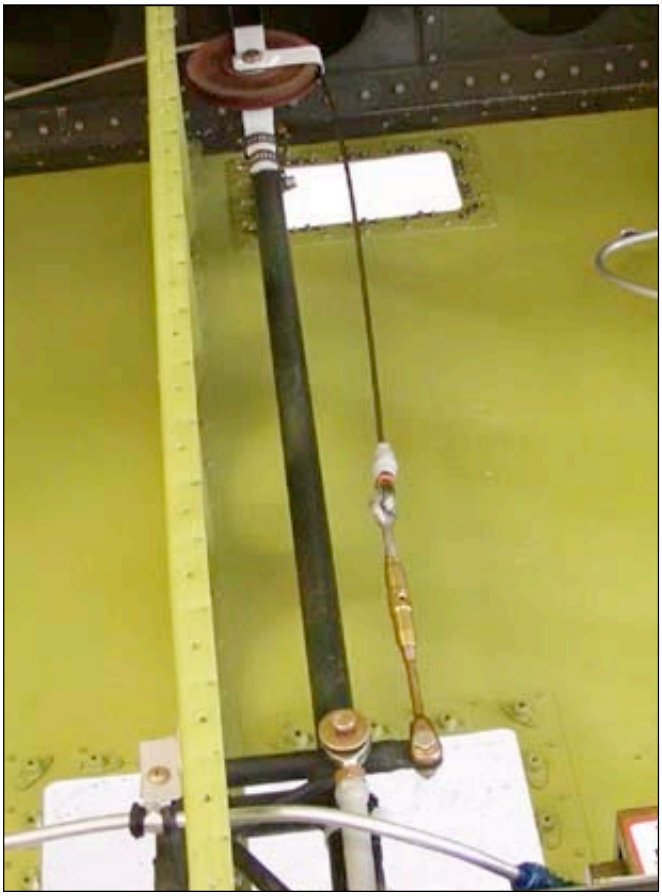
The back side of every hole you drill is bound to have at least a certain amount of burr standing up. The burr will be less if you use a sharp bit and don't push too hard, but you'll still get a burr. Your life will be much easier later on, if you file off every burr you can reach, including those inside the actuating arms. Not only does this produce a nicer looking unit with fewer stress risers but it makes putting the torque tube in and out much easier. This is where a Dremel tool with a little sanding drum on it would come in handy for those inside burrs.

The Flap Actuating Cable

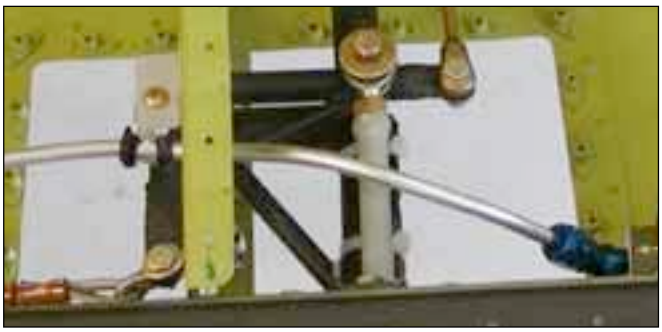
Later, after you put the wings back on the airplane semi-permanently and position the actuating arms and drill the mount bolt, you're ready to attach the actuating cable. The flap arm was delivered with a 3/16" hole (AN3) hole, however you use a 1/4" shackle rather than a 3/16" shackle to give a longer distance at the arm, which increases cable clearance from some structure.

A 3/16" (AN3) bolt will be sloppy in the shackle so bush it down with short pieces of 1/4 x .028" tubing. If you can't find that size tubing, contact AviPro. The only charge is for shipping. Later kits have six inches of the tubing supplied.

Wings: Installing the Aileron Actuation System



Right wing, looking forward. The cable at the front goes down through the strut. Just off the bottom of the picture, another cable goes to the left and across the top of the airplane.



Aileron bellcrank. Here you can clearly see the cable at the bottom of the picture that is connected to the other wing. At the lower right you can see the fuel pump and the transfer line.

The Concept of the Aileron System

The aileron control system has no push rods in it other than a short one that transfers motion from the bellcrank in the wings to the aileron itself. Otherwise everything happens as part of a "closed loop" cable system.

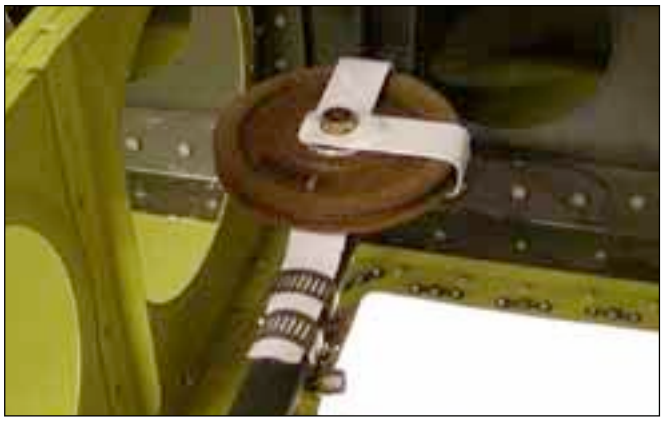
By closed loop we mean there is a gigantic loop of cable that essentially goes from one wing to the other with the control stick spliced into one leg of it and imparting motion. The cables, which are all 1/8" stainless) attach to the end of the control stick push rods, run up inside the lift strut into the wing, around a pulley at the top of the strut that routes the cable back to the aileron bellcrank, then back toward the fuselage where it continues all the way across the inside top of the fuselage and into the other wing where it makes a similar "U" turn. The cables are joined in the top of the fuselage by a turnbuckle that allows adjustment of the tension.

Adjustment of the aileron neutral position is accomplished by adjusting the push rod that connects the bell crank to the aileron. It's an extremely simple system and easy to install and maintain.

Notes About Working With Cable

First, get a cable cutter. Aircraft cable is extremely hard and difficult to cut. It can be cut with a cold chisel on an anvil but a dedicated cable cutter does a much better job and you're going to be cutting a lot of cable in this airplane.

Also, get a Nicopress machine AND a go/no-go gauge. The gizmo that compresses the Nicopresses isn't really a machine and can be either a pliers-like crimper or a set of steel blocks squeezed together by tightening bolts. **Either way you want to get a go-no-go gauge and *check each and every Nicopress*.** Go to the Bingelis books and read and re-read what he has to say about setting Nicopresses. They aren't difficult to set, but many parts of the control and flap system in this airplane depend on Nicopresses to work so we don't want one to slip anywhere in any of the systems.USE ONLY AIRCRAFT NICOPRESS SLEEVES NOT THOSE FOUND AT A HARDWARE STORE.



Front aileron pulley . Note the cable guard.

Cable Guards

It's not unheard of for a control or flap cable in an airplane, any airplane, to run off the pulley. For that reason, every pulley in the control/flap system should have a cable guard on it unless, as with the three in the belly of the Bearhawk, the structure stops a cable from walking over the edge of the pulley. These guards are available from a number of sources including AviPro.

Cable guards aren't supposed to turn with the pulley. They are supposed to be fixed. Since they are attached to the pulley by the pivot bolt, they want to pivot too. For that reason, they must be fixed to something that doesn't move or at least have a tab that contacts structure and stops rotation. See the photos.

Install the Bellcrank

The aileron bellcrank pivots on a bolt that goes through the fore-and-aft steel support tube that's bolted between the two spars. This bolt goes through two KP bearings, one inserted into the top of the bellcrank and one that goes into the bottom. They do not come with the kit but are part of the Wicks hardware kit. They are meant to be inserted into the pivot tube of the bellcrank where they rest against the lip formed by a short piece of tubing that's inside the pivot tube. You may have to sand a little paint out of the inside of the tube to get them to slip in. They should have a snug fit, as they aren't supposed to turn in the bellcrank.

The bellcrank pivots in such a way that one of its arms goes through a hole in the rib next to it. In a few early kits there was a little interference there so you may have to open up the odd-shaped hole right there. If you do trim it, take as little away as possible and make sure the edges are filed and sanded smooth. At the same time, make absolutely certain there is plenty of clearance: the last thing you need is the aileron bellcrank hanging up.

The bolts used *everywhere* in the control system, including the pivot bolts for the bellcrank and those attaching the cables to it, are drilled bolts using castellated nuts and cotter pins.

Routing the Cables

When routing the aileron cables through the wing you always have to be aware of any clearance issues with structure or components.

Where the cable comes off the front pulley and goes down inside the lift strut, it's possible you might have to file a little off of the edge of the strut to get clearance. This isn't critical other than making sure the bottom of any notch you cut is well rounded and smooth. Sand it with 320 grit paper and slightly round the edges to remove stress risers.

The hole in the wing skin is approximately two inches aft of the rear steel strap strut attach and 5/8' outboard of the main strut/wing attach bolt. Again, smooth the edges.

Watch for Cable clearance

Where the cables come off the bellcrank and go down the wing and toward the fuselage

Hole in the bottom of the wing where the cable comes out.

early kits have a number of places where ribs need clearance notches cut or holes elongated. Specifically, on ribs #7 and 8 the holes may need to be ovaled out. You want the cable to pass1/4" to 3/8" above the flap mechanism support tube that runs between the two spars. Any enlargement of the holes should leave at least 1/4" between the hole and the large lightening hole. If it is closer than that, make the hole a "slot" off the big lightening hole. Again, make it a smooth notch that's shaped like a finger tip.

Attaching the Cables

The cable that comes from the front of the bellcrank and down the lift strut should be attached with a turnbuckle (AN130-32S w 1/4 x .028 bushing)) to allow adjustments on that part of the cable circuit.

The cable that comes off the back of the bellcrank toward the fuselage can be attached with a shackle and thimble. A turnbuckle (AN140-22S) will be inserted in that cable in the middle of the cabin roof where it transitions over to the other wing.You'll be attaching 1/8" cable with thimbles (AN100-4) that are each Nicopressed (Wicks #428-4-VM)).

Wings: Installing Tip and Root Ribs

Left wing root. Notice how the bottom skin stiffener abuts the flange. You'll use the plywood template for aligning the ribs with

Wing Template Use

You received a plywood wing template that is cut in the outline of the upper surface of the wing. This is your guide for establishing the correct profile for everything that will be attached to the rear of the wing. This includes flaps, ailerons and,

The supplied plywood template is the key to establishing the vertical placement of both the ailerons and the flaps.

in this case, the root and tip ribs. If you utilize the template for alignment, you'll find everything is nicely lined up and the airfoil is accurate.

Root Ribs

Attaching the root ribs is quite straight forward, although there are several possible peculiarities depending on when your kit was produced.

The shortening of the bottom stiffener has been mention, but we'll discuss it again in relation to the root rib. Briefly, in a few airplanes, the bottom flap bay stiffener is 3/4" too long and must be shortened to allow attaching the root ribs.

Use the wing template to align the root rib and clamp it against the vertical stiffener in each of the root rib positions. Drill four #40 holes through the rib and the angle that's riveted to the rear spar. Before drilling, make absolutely the rib is flush against the wing template.

Cleco both ribs to the spar attach angle and slide the pre-bent aluminum skin over the ribs and under the skin and above the flange. Notice on Drawing 2 that the rivets between the two root ribs going through the skins and the spar are AN426-4's, NOT AN3's.

On some older kits, if the supplied metal is flushed to the fuselage-side of the root ribs, it hangs into the flap bay by about 1/4" and partially covers one of the holes in the lower rear wing skin. If this happens, slide the sheet metal toward the middle of the airplane enough that it is flush with the flanges of the root rib in the flap bay and clamp it in place in preparation for drilling the rivet holes.

Use a rivet spacing fan to layout an even row of rivet holes. After they have been drilled, remove the ribs and the trailing edge skins and deburr and dimple all holes.

Trailing Edge Tip Rib

Because it is rather fragile, you can hold off installing the outboard, trailing edge rib until much later, when you've riveted down the top skin of the wings and are ready to install the wing tips. The wing tips will protect the trailing edge rib.

An alternative is to install it temporarily by clecoing the wing skin down and drilling all of the tip attach holes in the ribs, skin and tip, so the wing tip protects the rib. Then remove it until ready to close up the wing.

Regardless of which direction you go, install the tip rib the same way you did the root ribs: use the wing template to guarantee proper alignment and fit the fiberglass wing tip to the tip ribs, not the other way around.

Wings: Hanging the Wings

Hanging the wings is definitely MVP (major visual progress), however we're going to install them only temporarily. Notice how this builder is using sheetrock lifts to get his wings into position with a minimum of hassle. Crate foam protects the wings

A Caveat Before we Begin

Don't let all the following words make you nervous. Everything being described is both intuitive and easy. None of it is life threatening, but it takes a lot of words to describe what must be done. It sounds more complicated than it really is.

Overview of Installing the Wings

At this stage we're only installing the wings temporarily because it's easier to handle them before they get additional weight in the form of fuel tanks, control surfaces, etc.

The procedure we're going to follow is designed to get the same angle of incidence for both wings. The goal is to have no more than .2 degree cumulative difference, left to right, as measured by a digital level. So, one wing can be .1 degree up and the other the same amount down or any combination as long as they don't total more than .2 degree. This represents a dimensional difference in height of .100" accumulated difference front to rear spar (.050 per side or any combination that totals less than .100").

Leveling Fuselage

Before we can install the wings or do any measuring, the fuselage must be leveled fore and aft AND left/right.

Fore and aft leveling can be accomplished by measuring the angle of the top of the front door frame. Because of the hinge bushing being in the way, you may have to space the level out.

Leveling right and left shouldn't be done with a digital level because it's always possible that there's a welding-induced difference in part of the structure so it shouldn't be used for measuring over such a short distance.

The important points to be leveled right and left are the holes in the front wing fittings. This is best done with a water level, which is not only easily made but the water level will also prove useful in setting the dihedral.

There is no more accurate way to level a fuselage or determine dimensions than a water level. It is more accurate, if you put a pinch of laundry detergent in the water to break the surface tension. This lets the water lay flat in the tube. Here a sharpened rod is put in the fittings holes to give an exact center.

The Water Level

Using a piece of flexible 3/8" clear tubing at least 25 feet long (a shorter one can be used for the fuselage, but the extra length is needed for setting the dihedral of the wings.), two spring clamps are modified via duct tape to hold the ends of the tubing where we want it.

The tubing is filled with a mixture of water and red (or blue, if you like) food coloring. Add just a hint of dishwasher detergent to help lower surface tension. We'll explain why later.

Fill the tubing most of the way full and clamp one end so the surface of the fluid exactly matches the bottom of the hole in one fitting. Clamp the other end to the other side of the fuse-

lage and keep messing with shims under the landing gear until the other hole lines up with the surface at that end of the tube. Rather than using the center of the holes, which will have to be estimated,use the bottom edge of each hole. We're only worried about them being the same,not dimensions are involved.

If no dishwashing detergent is used the surface of the fluid will be curved (the meniscus) and difficult to read accurately. The detergent relaxes the surface tension and lets it lay flat.

Make sure that when the fuselage is level, it is clamped or blocked in position so it can't move. As it is, after the wings are attached and before starting to work on the wing struts, you'll re-check to make sure nothing has moved.

A Note About Wing Fitting Hole Quality

Before you start reading all of the following about drilling out the holes in the fuselage wing fittings and the wing holes themselves, you should understand one thing: the bolts holding strut braced wings in place aren't nearly as critical as those on a cantilever wing. We are going to try for perfectly drilled holes with matching angles and zero slop, but, in reality, if they aren't perfect, it has absolutely no effect on the safety of the finished product.

We're not saying this so you think you can get away with lousy craftsmanship. We're saying this so you aren't daunted by all the following verbiage. Try for perfect regardless.

Several points worth mentioning.

1. Use new, or newly sharpened, high quality bits for these operations.

2. After drilling everything to size, ream the holes to clean them up inside.

3. If you want them perfect (always a good goal), drill 1/64" undersize and ream.

Getting the Wing Angles the Same

The procedures in the following sections are aimed at getting the left and right wing mounting angles exactly the same. Summarized they are:

1. Measure fuselage fittings to determine any difference left to right

2. Correct the angles to match by ovaling out the wing fittings in the right direction prior to drilling to size

3. Measure position of holes in wing spars to determine if any difference exists.

4. If FRONT wing holes are within tolerance, drill them on the bench. Do NOT drill rear wing spar. That's our final adjustment.

5. Mount wings on fuselage: if front hole has been drilled, use a bolt, if not, clamp in position.

6. Clamp both front and rear fittings to hold wings in position. Put undersize bolts or rods in the holes so the wings can't accidentally fall.Shim the rear fitting to the spar is tight.

7. Adjust wing angles until they are the same left and right and the wing spar holes are as nearly centered in fuselage fittings as possible.

8. Match drill wings to fuselage using special drill guides available from AviPro.

9. Ream all holes to clean up.

Fuse fittings with rods in them being measured.

NEED, NEED, NEED

We'll measure the angle of the fittings by inserting a rod BETWEEN the fittings and engaging only the inside holes. Chances are you'll have to oblong the outside holes with a chain saw file to let the rod pass through, which is okay as we'll want to align the holes anyway.

Measuring Fuselage Fitting Differences

We're going to first determine how much, if any, difference exists in the left and right wing fittings on the fuselage. Welded structures move around considerably due to the heat so it is possible a small amount of difference exists, although they are most often exactly the same.

In early kits, the fitting holes are both 1/4". Get several pieces of 1/4 rod and run them through the BACK hole of the front fitting and the FRONT hole of the rear fitting. In a perfect world, the rod will slide through both holes in both fittings, but this is definitely not a perfect world. It is possible that due to welding distortion that the holes in the front and back of a given fitting may not be point-

ing at the same angle. We'll address that later, but for the purpose of measuring the fitting angles, just having the rods bridging the distance between the two inside fitting holes will suffice.

After leveling the fuselage, measure the angle of these rods using a digital level. What we're looking for is the difference between the two sides. Ideally, we want them to be exactly the same. For that reason, you could use a bubble level and block up one end so it puts the bubble between the lines for one of the fuselage sides. Then, if necessary, we modify one, or both sides, until a level with a shim taped to one end indicates level on both sides.

The two sides will probably be well within tolerances. If they are within 0.2 degrees (two tenths of a degree) of being the same, you can, if you want, drill them to final size now, however they are easy to correct to get the exact same angle, ***which will make life easier later, when fitting the wings***. If, for some reason they are not within tolerances, or you want them exact, correct one side to match the other using the following procedure.

If the holes in your kit were drilled to full diameter, 3/8" front, 5/16" rear, at the plant, ignore the following section because those holes are all in the exact place required.

There will be a minor misalignment in the rear ear of the rear fuselage fitting, but this will be corrected in the drilling opera - tion described in the text

Correcting the Fittings

Before correcting the angle of the holes (which is a simple process), let's do a little filing on the holes so the rod will pass through. That will accurize the angles of the holes in each fitting.

Slide the rod toward the other side of the fitting and see where it hangs up, which, if it hangs up at all, it will probably be the top of the front hole in the front fitting and the bottom of the back hole in the rear fitting. Using a round file, file away just enough of the offending metal to let the rod pass though.

To correct the actual mounting angle of the wings, we're going to correct the angle of the holes in the fittings on one side of the airplane by filing them into ovals of the appropriate dimension and let the final drill bit make them round. In so doing, the wing angle, as determined by the fuselage fittings, will be the same left and right.

FYI-if a bit is fed into an oval hole, it automatically finds the center and cuts the hole around that center.

Take a round file (chain saw sharpening file) or a Dremel tool and cut the bottom or top of the front hole, the distance required to correct the angular difference (.050" is .1 degree). You'll cut the rear fitting hole the same distance but ***in the opposite direction.*** This spreads the required angular change between the two fittings.

By making the holes oblong and moving one edge (top or bottom) up or down the full amount required to correct the angle, the final-size drill bit will center on the oval, which cuts the vertical change in height in half, e.g. moving the top of a hole up .050" only moves the center up .025. The most you can correct by moving the rear fitting only is 1/16" (.063) because the original hole is 1/4" and the final size is 5/16", so if in the following steps you see it needs more than that, you'll have to split the adjustment between front and rear fittings and maybe right to left wings too. This is

The plywood fastened to the bottom of the wing forms a datum from which to measure vertically to the edge of the bolt holes. We're looking for comparative measurements between the two wings. We don't care what the exact measurement is.

highly unlikely because the fittings are generally well within tolerances.

If, after drilling the holes to size, some angular difference still exists, it can be corrected when drilling the wing spar holes to size in the next steps.

NOTE: In all probability, you won't have to do any of the foregoing. So far, virtually every fuselage that has been measured has needed very little, or no, adjustment.

After doing all the foregoing, the holes in both sides of your fuselage will be final sized and at the same angle.

Measuring Differences in the Wings

Here too, in all likelihood, your wings are going to be close to being identical, but to be on the safe side, we're going to measure them and make sure because, with the fuselage fittings correct and nearly perfect, when mounting the wings, we can make changes in wing position to correct for any wing differences.

The closer both wings come to being mounted at exactly the same angle, the easier rigging will be when you get it flying.

It should be mentioned that even wings on certified airplanes have a surprising amount of deviation, one to the other. Our goal here is to make them as identical as we can make them.

To make accurate measurements on the wings, we need to create a stable surface from which measurements can be taken. The first step in that direction is to cut a piece of 5/8 or 3/4" plywood 31" long (the distance between the spars). Make it wide enough that it goes from the second rib on the wing to just beyond the wing fitting holes.

Clamp this wood to the bottom of the wing, centered between the spars and protruding out from under the wing and under the spar bolt holes. This will become the datum you measure your holes from.

Measure exactly vertically from the surface of the wood to the bottom edge of the front spar hole ON THE BACK FACE OF THE SPAR (we're using the edge of the hole because it's more exact than estimating the center). This is most easily done by using a square block of wood and marking the dimension on that, then measuring the marks.

Do the same thing for the rear spar BUT MEASURE THE HOLE ON THE FRONT FACE OF THE SPAR.

Now, repeat exactly the same process on the other wing and compare the two.

If you zeroed out the differences in the fuselage fittings and the accumulated difference between the left and right wing spar bolt holes is less than .100", you can drill both front and rear spar holes on the bench (3/8" front, 5/16 rear).

If you want the angle of incidence to be "exactly" the same left to right, OR the differences exceed .100", then the holes have to be drilled on assembly. We'll clamp the wings into position and use the fuselage fittings to locate the drill bit.

Understanding the dimensions

It's easy to get confused on how to apply the differences between the two wings, as indicated by the dimensions, so use the following procedure.

1. Pick one wing as the master wing, i.e. that right wing. We'll compare everything to that wing.

2. After measuring both wings, clearly mark how far above, or below, the right wing the left wing is. Meaning, is the front spar on the left above or below the front spar on the right? Same thing for the rear spar. Establish a numerical difference.

3. Try to picture what the numbers are telling you. Are they saying the left wing is nose up or nose down compared to the right wing or do they indicate only that one wing is higher than the other because the differences on the rear spar cancel out the differences on the front spar. Example: If the spar on the left is .050" BELOW the spar on the right (nose down) but the rear spar is .025 below the right rear spar (nose up) they partially cancel each other out and the cumulative difference will be .025 or half of one/tenth degree (0.05 degree). 0.100" is 0.20 degree, remember? .

If the left is .050" ABOVE the right spar but the rear is .025" BELOW the right spar, then the differences add up to .075, making the angle much higher and putting the left wing at one and a half tenths of a degree (0.15 degree) of a degree higher angle of incidence than the right, which is still below the maximum allowable difference of 0.20 degree.

In summary, if the differences, front and

Although bench-drilling the holes in the wing spars can be done free hand, a simple drill block, as described makes it easier. Also, under-drilling and reaming gives a better hole.

back, both go the same direction e.g. up or down, then the rear difference is subtracted from the front difference because it cancels out part of the angle.

If the differences are opposite, then the rear difference is ADDED to the front difference and the total for the two wings must be under 0.100".

Whew!!

Drilling Wing Spar Holes

If you decide your wing spar holes are all within tolerance and you want to drill the front to size on the bench, do it in the following manner.

1. Make up a 90 degree drill guide, which will be nothing more than a 1" x 3" piece of garden variety iron plate no thinner than 5/8" (the thicker the better) with a 3/8" hole drilled in it on a drill press that has been checked for square. Sand the back side smooth. You're going to clamp this to the spar face so it keeps your drill bit square to the face. Remember to pad the clamp faces with masking tape to prevent scratches. For flawless holes, rather than using a 3/8" bit, drill the block for a 23/64th bit and ream to 3/8".

2. LOOSELY clamp the block in place with the 3/16 hole in the spar as close to center as you can make it.

3. Barely start the bit into the aluminum far enough that it is centered on the hole. Let the block move so it self-aligns.

4. Tighten the clamp firmly. this will align the block with the hole. Tighten as much as necessary to keep it from moving. Ream the hole after drilling.

Position Wings on Fuselage

One of the easier ways to handle the wings in this situation is to rent some sheet rock scaffold-

Even when using sheetrock lifts to handle the wings, it is still very much a two-man job.

ing (some places call them "lifts") and use that to get the exact height needed. Don't forget to pad the scaffolding to prevent scratching. This is a good application for the foam that the wings were packed with. Or use cheap moving mats or last year's carpet. If you can't find the lifts, make up some 2 x 4 "T"s to hold the wing tips up

By now you've figured out that moving the wings is a two-man job and sometimes three. This will especially be the case, when you start having to lift them over your head.

For the purpose of fitting the wings, it sometimes helps to have a couple of extra 3/8 and 5/16" AN bolts. Grind the ends to a smooth taper to make it easier to get them into the holes. Also, don't use hardware store bolts for this application because many zinc-plated bolts are slightly oversize and won't want to go into the holes as they should.

Before putting the wings on the scaffolds, draw an accurate pencil line on the rear face of the rear spar that runs vertically through the rear bolt hole. This will help in keeping the rear bolt holes lined up as you move the wing tip fore and aft after the front bolt is in place.

The concept in the way we're going to drill the wing (details are in the following paragraphs) is:

1. Push wing into approximate position so, if it wasn't drilled to size on the bench, the 3/16 holes in the wing are visible in the fuselage fitting holes.

2. Slide a 3/16" piece of rod through the holes or use long AN# bolts. This eliminates any

possibility of dropping that end of the wing, if something should let go. Put a washer/spacer inside the rear fitting before the rod goes into place.

3. Center the 3/16" rod/ in the middle of the fuselage fitting holes.

4. Clamp fittings closed on the spars from the bottom with Vice Grips padded with tape.

5. Measure angle of both wings with digital level bridging both spars (see later notes about measuring).

6. Tap rear spars up or down to make them match using a block of wood and small hammer.

7. If there isn't enough travel in the rear fitting to make up the difference, move the front one too.

8. Once the angle is the same, right and left, tighten the clamps so the wings can't possibly move in the fittings. RE-CHECK THE ANGLES AFTER TIGHTENING

9. Using the drill guides available from Avipro, drill the front hole on one side.

11. Put a bolt in the hole

12. RECHECK THE WINGS FOR ALIGNMENT.

13. Drill the rear spar hole and insert a bolt.

14. RECHECK THE WINGS FOR ALIGNMENT

15. Repeat on the other wing making sure the angle matches that of the first wing.

Clamping the Rear Fitting

The following assumes the front spar hole was drilled on the bench. However, if you decide to make both wings exactly the same, the process of clamping and drilling the front spar on the air - plane is essentially the same as is described below concerning the rear spar. If both holes in the wings are drilled after the wings are on the air - plane, you clamp and drill the front fitting, as well as the rear fitting, on assembly.

We are going to want to squeeze the rear fitting tight against the spar to hold it in place while the spar is match-drilled to the fuselage fitting. However, the rear fuselage fitting is purposely wider than the spar is thick to allow for differences in the welded structure. So, move the wing forward against the rear fitting and put a washer, or washers, in the gap. Ideally, the spacer will fill the gap completely, so, when the fitting is squeezed by a big pair of Vice Grips, it won't be bent. There's a high probability the front fitting will be tight enough that it will determine where the rear wing spar goes and you may need a spacer on both sides of the rear spar to fill the gaps.

We're going to use the drill jig available from AviPro to guide the drill bit through the spar. Instructions for its use are in the caption.

The wing spars MUST be tightly clamped so they can't possibly move or the bit will try to follow the existing hole. We want it to ignore the aluminum and go from rear fitting leg to front fitting leg in a straight line, thereby eliminating misalignment. Reaming before the clamp is removed will clean up the holes and guarantee alignment.

Grab the fittings from the bottom with a healthy pair of Vice Grips. Pad the fitting with masking tape so it isn't scratched by the pliers. Squeeze them down tight and then try to move the wing. If it moves, it's too loose to drill.

To get an accurate measurement, don't just lay the level on the skin. Make up a measuring "platform" from 1 x 2" wood that has been planed absolutely straight. Glue small "feet" on each end that will held against the centerline of the two spars. This gives a more accurate measurement. Mark it so you use the same end forward on both wings. This builder used a bub - ble level as his measuring platform. Note the digital level taped to the end.

Measuring the Wing Angle

In theory the angle of the wing is measured on the mean chord line, but that's nearly impossible to do on the finished wing. So, we'll settle for a approximation by laying the digital level across the bottom of the wing chordwise so the ends of the level rest on the center of the rear and main spars. As we've said, the actual angle is unimportant. It is only important that we measure it the same way on both wings so we can get them the same.

In most cases, the level won't be exactly the right length, so make up a very straight board with short pieces of 1 x 2 glued to the bottom at each end. These stand-offs will be positioned in the middle of each spar and the measurement taken off the board between.

If using a bubble level, make the blocks at the end of the board the dimensions required to put the bubble between the lines on one wing.

Positioning the Wing

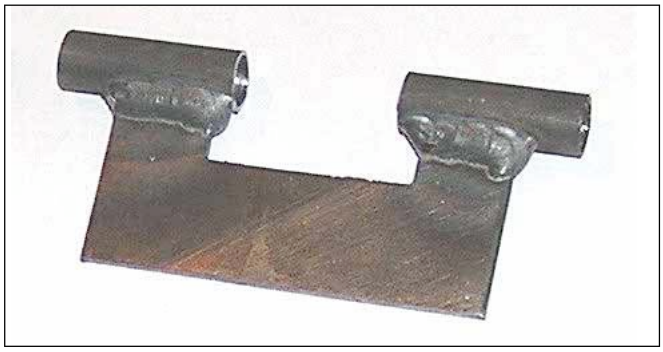
With the front hole either bolted (if you predrilled it) or perfectly centered and tightly clamped, tap the rear wing spar up and down until the spar holes are as centered as you can get them in the fuselage fittings. At the same time keep the vertical pencil line in the middle of the rear fuselage fitting hole. To aid in centering, slip a bolt through the wing spar fitting of the appropriate size and get the space around it in the fitting hole even.

When finished, the angle we actually get on the first wing is used as the target for the second wing. This assumes the front hole is either centered or bolted and the rear wing spar bolt hole (3/16") is entirely within the fitting hole so it will be entirely removed when the wing spar is drilled to size. *If that's not the case, adjustments can be made on the front spar (if it hasn't been drilled) or adjustments made on the other wing*.

All we're trying to do is get the angles to be the same left and right, which will greatly simplify rigging later on. At the same time we want the distance from the rear of each wingtip to the tail post to be the same within 1.0".

wing clamped in position
and ready for drilling.

Center and clamp, or bolt,the front fitting in position and change the angle of incidence by moving the rear up and down. The entire hole in the rear aluminum spar stub must be visible, so when the hole is drilled, it is completely removed. If it's not, move the front spar stub to compensate.



These drill guides are available from AviPro at no cost although we'd appreciate them being returned when you're finished, so we can send them on to others. Put a drill bit of the appropriate size in one bushing but put it in backwards with the smooth end going through the bushing and into the wing fitting. Have a helper hold the pin in place while you're drilling through from the other end. The bit will automatically seek the other bushing and align with it.

Drill the Rear Wing Spar Hole

You'll need an extra set of hands for this operation: Someone needs to hold the drill fixture in place and make sure the drill bit you're using on the front side to index in the front hole stays in place. This is extremely important.

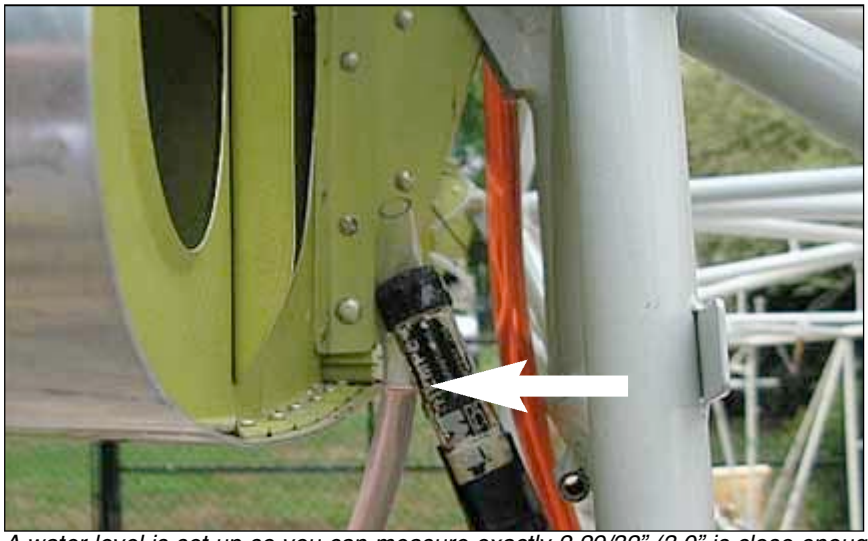
Briefly, what the jig does is index one piece of tubing in the front hole of the rear fitting while you are drilling in from the rear hole and through the spar. It is available from AviPro at no charge. You'll do it the other way around on the front fitting and run the bit in from the front.

The helper will insert a drill bit of the size being used BACKWARD into the guide opposite to the side being drilled. This pin will index the guide into the fitting. The drill bit will index the opposite guide tube. The helper's job is to make sure the pin remains in place until the drill bit pushes it out as it comes through the spar.

Use one of those 18" drill bit extensions available at hardware stores. It'll make it much easier to drill into the space between the fuselage and the wing. Use a new, or freshly sharpened, bit and don't rush. Turn it slower than normal and let the bit do the work while you concentrate on keeping the bit square to the fitting, although the drill jig will take care of most of that.

As soon as the bit is through, immediately ream the hole. Once all the fittings are reamed, put the proper bolts in them with finger-tight nuts and it's time to start working on the lift struts.

Wings: Setting the Dihedral and Making the Struts



A water level is set up so you can measure exactly 2 29/32" (3.0" is close enough) rise, root to tip. Measure at the edges of the bottom skin where it comes across the bottom of the main spar.

As with setting the angle of incidence, the goal of setting the dihedral isn't so much that you hit exactly one degree but that both wings be as close to being exactly the same as possible. Everything having to do with rigging the airplane after you get it flying is made a thousand times easier, if the airplane is symmetrical about the centerline.

Order of Operations

Once the wings are in place on the fuselage, as in the last section, the steps to be taken are:

1. Double check the fuselage for being level in both directions.
2. Set the wing dihedral on each side
3. Trim the strut material to length
4. Squeeze the strut ends down to accept the fittings.
5. Temporarily hang struts on airplane
6. Mark fittings
7. Remove and drill holes for bottom fitting in one side of strut only. ALL HOLES ARE ON ONE SIDE OF STRUT ONLY UNTIL LAST OPERATION.
8. Put back on airplane with bottom fitting bolted to outside of strut but top fitting clamped. Recheck lengthwise position of fitting.
9. Remove, drill one hole for top fitting and bolt.
10. Reinstall and clamp top fitting in position and mark.
11. Remove and drill another hole for the top fitting.
12. Reinstall for one last check
13. Remove, drill rest of holes in one side of strut only.
14. Insert fittings inside strut and use fitting to guide drill through other side of strut.
12. Insert final bolts and you're finished.

Level the Fuselage

Yeah, we know, we leveled it in last section but level it again. The accuracy of your dihedral, which also determines your rigging, will depend on having the fuselage level. We're going to recheck it several more times during the process of building the wing struts.

Set the Dihedral

The plans call for 1 degree of dihedral, which is 2.9" (2 29/32") difference from the root to the tip. But the truth is it doesn't have to be that exact. In fact, round it up to 3.0" to make measuring easier. The easiest places to measure that and be accurate are at the edges of the lower skin where it hits the main spar at both ends.

Set the water level up with one end right at the lower skin next to the fuselage and the other end suspended from the outer end of the skin with a clamp of some sort. Just tape the tube to the clamp and adjust things until the water at the inner end is exactly level with the bottom edge of the skin.

An excellent alternative to the water level is to use a 3' bubble level with a 5/8" block at one end. Set it on the top skin, over the main spar.

ALL OF THIS ASSUMES YOU HAVE THE FUSELAGE EXACTLY LEVEL. IF IT'S NOT LEVEL, NONE OF THIS WILL WORK.

Using the sheet rock lifts or a 2 x 4 "T", adjust everything until there is exactly 2 29/32" between the level of the water in the outer end of the tube and the skin at the spar.

So you aren't driving yourself nuts trying to

read a ruler or dial caliper in mid-air, cut a piece of aluminum sheet to 3" and use it as a gauge on both wings. It'll be easier to read with less interpretation on your part.

Make sure you're measuring from the same part of the skin, meaning, the lower, outer surface right on the edge. Don't measure one end of the wing to the outside of the skin and the other to the inside as that will introduce a .025" error.

Also, make sure that the support you're using to hold the wing in position can't shift, while you're working on the wing. If it's a "T" put some PVC packing tape between it and the wing and between the "T" and the floor, making sure to curl one end of the tape back on itself so you can easily pull it up, when finished. Then, when the dihedral is exactly right, smear some Bondo around the edge of the wood onto the tape. When you're finished, knock it loose and peel the tape off.

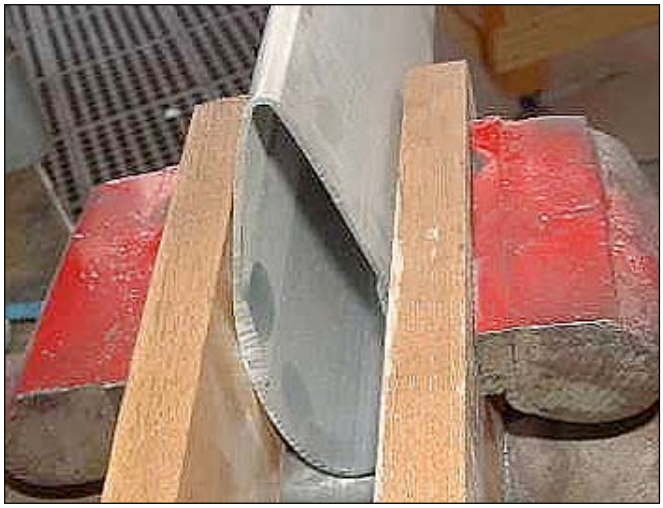
As we get into the various operations concerning the strut, we're going to re-measure the dihedral distance several times just to make sure nothing has moved.

Trim the Strut Material to Length

The plans call for 1.5" between the attach bolt holes and the end of the strut, so measure between the bolt holes and subtract 3". The dimension should be about 79 1/4".

To make your life easier, it helps if the cut you make is square so your subsequent measurements are accurate. So, whatever method you use (chop saw, horizontal hacksaw, hand hacksaw) make sure you are working to a line you marked all the way around the strut. A fine point felt marker or a pencil works fine, but don't scribe the line unless you remove the scribe mark completely when cutting/filing to remove the stress riser it represents.

Mark a center line on both sides and both ends of the strut.



Be careful when squeezing to make sure the axis of the strut is squared up with the jaws of the vice. When you have the strut down to the dimension that will barely accept the fitting, insert the fitting and really hog down on the vice to square up the flats inside.

After trimming the struts go back and smooth the cut surface, first with files, then with sand paper getting it down to at least a 320 grit finish, Then Scotchbrite it. At the same time, slightly "break" the edges inside and out and make sure any burrs left from cutting are gone. Sharp edges and burrs are all stress risers and raise the spector of fatigue cracks.

Mark Centerlines

Mark a centerline on the outside of both sides of the strut at both ends. <u>This line should be lined up with the center of the flat spots on the inside of the struts.</u>

When the strut is squeezed to dimension, the fittings should barely slide inside with a minimum of tapping.

Step One: bolt the fittings to the fuselage and wings and clamp the struts to the bottom of them. We'll position and drill the bot - tom fitting first. Position the strut so it is equidistant from each bolt. Make certain the fitting is aligned on the centerline and using a transfer punch in the outboard hole, as shown firmly center punch it for drilling.

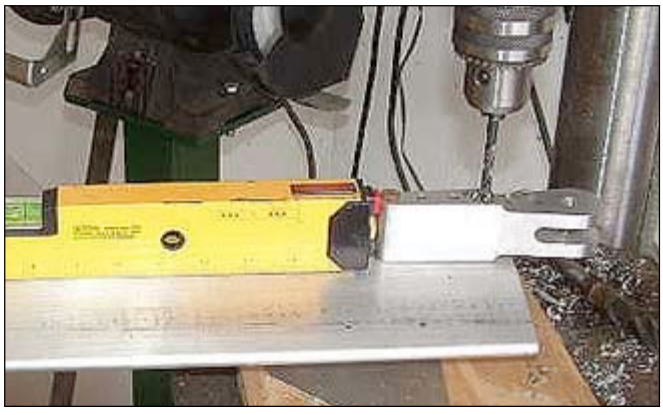
Here's another approach to making sure the initial holes are drilled square to the strut. The center punched hole is done the same way as the pix at left and a wood, screw-together cradle made for the strut to ensure being square.

Squeeze the Struts Snug to Fittings

The internal dimension of the strut material is slightly wider than the fittings so the last four inches at the ends of the struts must be squeezed down so the fittings will slide in with a snug fit. This is normal with struts on many aircraft.

The squeezing will be done in a vice with a piece of hardwood on both sides of the strut to keep from leaving marks and to keep the pressure even. Make certain the strut is square in the vice, as indicated by the flat spots on the inside of the strut, before squeezing.

Make up a spacer that's about 3/16" thinner than the fittings and insert inside the strut while



If using a drill press make sure everything is level and square.

squeezing. This is to make sure the flat surfaces inside the strut remain parallel. Just tighten the vice until the opening is a little too small to let the fitting slide in. Release the pressure on the vice and see how much the strut springs back by sliding the fitting in. Keep repeating that process until, with no pressure on the vice, the fittings slide in with a snug fit. We don't want them so tight we have to hammer them in as that could leave marks.

Position Fittings on Struts

To determine where the fittings will be positioned in the struts and to get ready to drill the holes,we're going to bolt the fittings to the fuselage and wing attach points and clamp the strut to the fittings with the fittings laying on the top surface of the strut.

The fuselage fitting (bottom one) is to be parallel to the centerline of the strut but the top one has a slight angle. We'll first determine the position of the bottom fitting, drill and bolt it in place on the outside of the strut and then finalize the position of the top fitting before final drilling it.

Put your spacer blocks back inside each end of the strut so sufficient clamping force can be exerted without crushing the strut.

With the strut clamped to the top of the fittings, move it lengthwise until it is centered between the bolts. That should leave 1.5" between each strut end and the respective bolt.

Using an extremely sharp pencil, mark a line across each fitting where the strut crosses it. That will determine the position of the fittings in the struts in a lengthwise direction. As an alternate, use a transfer punch in the outboard hole to establish that hole position. If you use a punch, make absolutely certain that the centerline marked on the strut goes right through the middle of the holes in the fitting before punching it.

Make sure each clamp is tight and remove the strut.

Once one bolt hole is drilled square and the fitting bolted in place on the outside, the rest of the holes may be drilled through ONE SIDE OF THE FITTING ONLY. By using the fitting as a drill guide, there is little opportunity for the holes to be anything but square to the surface.

Drill Bottom Fitting Holes

Center the bottom fitting with the strut centerline clearly seen to be going through the center of the holes. MAKE CERTAIN THE LENGTHWISE POSITION IS CORRECT AS INDICATED BY THE LINE PREVIOUSLY MARKED ON THE FITTING.

Clamp tightly and recheck alignment. DOUBLE CHECK THAT THE FACE OF THE FITTING IS PARALLEL TO THE FLATS INSIDE THE STRUT. **Be careful**: it is very easy to clamp the fitting at a slight angle on the strut because of the curved surfact. So, before drilling any holes, check and double check that the fitting is parallel to the flats. Otherwise, your first holes will be at a slight angle, which will result in a twisted strut that can't be installed on the airplane.

Use two clamps to hold it in place, leaving access to the hole closest to the outboard end of the fitting for drilling.

Drill the first hole THROUGH ONE SURFACE ONLY, NOT THROUGH THE ENTIRE STRUT, and put a bolt through the one side and reach in side to put a nut on it. Snug it down.

An alternate approach is to use a drill press to drill the first hole, BUT IT IS CRITICAL EVERYTHING BE SET UP SQUARE! Level the drill table and level the strut exactly.

When drilling these holes, use a fresh bit and let the bit do the work and let the fitting guide the bit. Don't force it.

Recheck it for alignment, re-clamp and drill the last hole inboard. Put a bolt in it and snug it down.

The bottom fitting is now secured with two bolts and we can do the top fitting.

Drill Top Fitting Holes

As a last minute check to make sure nothing moved, put the strut back up on the airplane with the bottom fitting bolted to the outside of the strut and the top fitting still clamped to the outside.

The top fitting with one hole drilled and bolted. The bottom fitting is aligned along the centerline but the top one has a slight angle, so it is better to attach it to the wing, as shown, carefully mark it, AND CLAMP IT FIRMLY, then bring it down and drill the other holes.

RE-CHECK DIHEDRAL MEASUREMENT. This is the last chance you'll have to correct anything.

Re-check the line you drew across the top fitting. If it's not right, correct it.

Remove the strut. Center the outside fitting hole over the centerline that you marked lengthwise on the strut making certain the fitting doesn't change position lengthwise, as indicated by the

It is not necessary to use a drill press to drill the holes all the way through the strut. In fact, it is highly advisable that a clamp be placed between the two outboard holes and tightened as much as possible. With locating bolts in the outboard holes, this guarantees that the fitting squares up with the flats inside. Then, when the two outside holes are drilled and bolted, they hold the fitting square so the balance of the holes can be through-drilled.

pencil line across the fitting. Clamp it in position with the clamp over the outside hole, make sure it is square, and drill the second hole in. Put a bolt in that hole and put the strut back up on the airplane.

Clamp the fitting in place so it can't pivot on the bolt. Using a short, very sharp pencil, so you can reach between the wing and the strut, carefully trace the outline of the fitting on the strut.

Remove the strut, verify that the pencil lines indicate nothing has moved, and drill the hole at the other end of the fitting through just one side of the strut. Put a bolt through that hole, snug it down and put it up on the airplane one more time to check that everything is right before drilling the rest of the holes.

If everything is right, you now have a strut that has both fittings bolted to it with two bolts. Repeat this process on both sides of the airplane continually checking and rechecking the dihedral. Once both struts have the fittings secured with two bolts, go ahead and drill the rest of the holes THROUGH ONE SIDE OF THE STRUTS ONLY.

Before taking everything apart, make identifying marks on both the fittings and the struts so you can easily determine which fitting goes with which strut and what direction they were facing when they were drilled. That's just good insurance.

Drill the Rest of the Holes

Reach inside the struts with 320 grit paper and knock down any burrs from the drilling operation.

Slide the fittings inside the struts and index them in position with a couple of bolts (the bolts can't go all the way through the strut because there are no holes on the other side yet). Using the biggest camps you own, clamp down on the middle of the fitting between the two outboard holes. Make the clamps super tight because we're trying to pull the strut together forcefully enough that the flats inside the strut lay flat on the fittings assuring that everything is square.

Drill completely through the strut in the the open holes, put bolts in those holes and through the struts. Put nuts on them and tighten them up, then drill the other holes.

Once all the holes are drilled, clean out the inside with 320 and Scotchbrite and lightly chamber the outside edges of the drilled holes by twirling a large diameter bit in the holes with your fingers. You want to just barely break the edges.

Hey, guess what? You're ready to bolt them together permanently. Congratulations on a job well done! Your wings are now ready to be attached permanently, any time you choose.

Now it's starting to look like an airplane, isn't it!

Wings: Install Flaps and Ailerons

Although the flaps and ailerons are essentially finished, you still must install the hinges, align them, install the trailing edges permanently and lined up, as well as balance the ailerons. Be as precise as possible and it will make the rigging easier later.

Remove the wings and sit them on the table flat side down. We're going to install the flaps and ailerons, which could actually be done after the wings are finished and closed up, but it is much easier, when you have access to the backside of the spars where the hinge bolts are accessible.

Hanging Flaps and Ailerons

First, and most important, refer to plans numbers #2 and 9 through 14 to establish & understand the relationship between the flaps/ailerons & the wing.

You'll need: wide flat table, ten 2" C-clamps, very sharp lead pencil, felt tip pen, drill motor, bit.

You do this entire process with an eye towards aligning the aileron/flaps with the top and bottom surfaces of the wing and spacing them correctly spanwise to each other (even gaps at each end and in the middle), while at the same time trying to eliminate as much gap between the wing skin and the control surface as possible. 3/16" -1/4" is good.

Before doing any of this, number each of the L-shaped hinge pieces and mark corresponding numbers on the aileron/flap spars so you don't mix them up after you have everything marked and ready to drill. When ready to paint the parts, if you used a Sharpy to make your marks, make sure to remove the marker ink or it will bleed through the paint. On later kits, the hinges are painted and already have pilot holes.

Before you can begin hinging the flaps and ailerons, you'll have to remove the gussets that have been temporarily pop-riveted over the hinging areas, both top and bottom. Don't forget to number the gussets before drilling them loose and have a corresponding number on the aileron or flap. This way you'll remember which one goes where.

You have three basic areas of adjustment: 1) putting spacers under the feet of the hinge mounts themselves where they hit the rear spar (btw: remember to tighten all of those bolts and check them for correct length, ditto all the bolts in the wings). 2) sliding the bearing in and out of the hinge tube and 3) moving the aileron/flap side of the hinge itself left and right, up and down, on the aileron or flap spar before drilling the mounting holes.

The supplied plywood template is the key to establishing the vertical placement of both the ailerons and the flaps.

Have the wings laying on a flat surface that extends far enough behind the wing that you can use the flat surface to line the aileron/flap up with the bottom of the wing. The plans builders have their wing rib forming blocks that assist in doing this.

Kit builders have been provided a "rigging board" that can really help in the alignment process. The goal is to have something hard that establishes the wing surface at the front of the

aileron/flap cutouts so you have the control surfaces installed in the right position vertically.

Bolt the hinge pieces to the bearings (left and right L-shaped piece on each bearing) and slide the shanks of all of them into the hinge mount tubes sticking off the back of the wings. It should be a fairly tight fit and you may have to sand out some paint inside the tubes to get them in. If you are using the surplus rod ends that already have holes in them, Bob Barrows feels it is important to try and use the existing holes in the rod ends. If you mis-drill slightly, you can go to a -6 rivet to make the hole round.

With the rod end bearings inserted in the hinge tubes, lightly clamp the ailerons and flaps to the hinges. Don't get them too tight because you're going to want to move them around. Also, DON'T FORGET TO PROTECT THE ALUMINUM BY TAPING THE FEET OF THE CLAMPS WITH MASKING TAPE SO YOU DON'T LEAVE MARKS. You'll probably use little 2" C-clamps.

At this point you'll have the control surfaces lightly attached to the wing. Move them in and out to establish the right chord wise distance to get the right gap at the front. Using a sharp pencil, mark the shank of the bearings as reference. Because of the angle of the hinge tubes, the surfaces will move up and down, when sliding them in out.

Keep and eye on how well the top surface of the aileron/flap lines up with the top surface of the wing. If it's not right, loosen the C-clamps and move the aileron/flaps up and down on the hinges. Ideally, the hinges will wind up nearly centered vertically on the control surface's spars. The left and right positions of the hinges on the control surface "cut outs" should be close to the dimensions shown on plans 8, 9, & 10.

The control surface hinge bearings slide into tubes and are fixed in position by rivets or bolts. Prior to installation they can be adjusted in or out. After installation, their position can, to a lesser extent, be adjusted via washers under the hinge attach bolts shown

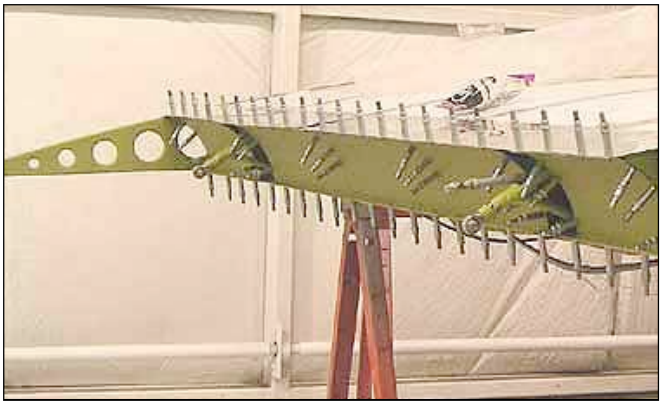
There's the possibility you may find a hinge mount (the wing part) that is angled slightly wrong and may need spacers under its feet, but that's not likely. If you do, use wide area AN 970 washers as a shim to make the hinge angle up or down as needed. This is also a method you can use for rigging-out a "heavy" wing once it's flying.

You'll want to monitor the inboard end of the flap and how it spaces on the little stub section of wing that comes back and the way the outboard tip of the aileron spaces on the tip rib. You want the spaces in those three places to be the same. Also, make sure your tip rib is straight or it'll give you a false reading.

This next is very important: While you're making all of your in and out (chordwise) adjustments keep an eye on the back of the control surfaces. You want to look down the trailing edge and see that it's a straight line from the stub wing section at the root, up the flap, past the aileron and to the tip rib. You definitely don't want the flap/aileron edges to mis-match. The trailing edge aluminum (when you received your ailerons & flaps) is only temporarily pop riveted in place so you can make adjustments to get all the trailing edges lined up properly. Also, the fiberglass wing tip is not to be trusted or used for fore and aft alignment of the aileron unless you have a later kit, where the tip rib isn't drilled and can be adjusted to fit the tip.

All of the control surfaces have tooling holes in the ribs that can be used for alignment: note the threaded rod holding this flap in alignment with the root ribs.

While you're going through this alignment procedure, the way the adjustments can be mixed



The aileron cove cover can be installed at the same time the skins are fastened down. The rivets in the pocket area are stainless steel pop rivets.

and matched will become obvious to you.

When you've got everything just right, rotate the control surface a little to make sure you don't have something binding (you won't).

Then, with everything clamped in position, using a very sharp pencil (a fine lead mechanical drafting pencil works well), mark around each hinge piece on the aileron/flap spar so, when you remove them, you can just line them back up and use the hinge itself as a drill guide.

LocTite the rod end bearings into the hinge tube mounts and recheck all alignments before it has time to set up. Then, after it has set up, remove the hinge tube mounts and drill them for the rivets. Drill all the way through the aileron hinge tube and bearing shank and out the other side. Do your best to keep the holes centered on the hinge tube as you go in. On the other side, it'll more or less center itself automatically as the bit looks for the low place on the inside of the tube.

You can now put the rivets in the bearing/hinges. You can also clamp each hinge in its position on the aileron spar, as indicated by the pencil marks, and match-drill the holes. Then put the nut plates on the back side.

You have a little more rivet work to permanently attach the gussets. Again, refer to the plans to check that everything is finished as shown.

When all the above is done, you can remove the flaps and ailerons, if you desire, and put them some place for safe keeping until they are needed to compete the control system actuation system.

Finishing the Ailerons

At this point there are a number of aileron/flap details that have yet to be completed, but will be in due time. They are:

- Pouring lead in the aileron balance tubes
- Final riveting the trailing edges

Balancing the Ailerons

This can be done at any time after the ailerons are hinged to the wings.

To balance the ailerons we're going to pop rivet or sheet metal screw a 3/4" O.D., thin wall aluminum tube that we've filled with lead inside the leading edge of the aileron. The hole is clearly visible in the ailerons, but you'll have to go down to the hardware store and buy a piece of aluminum tubing. You'll want to put 5 pounds, 4 ounces of

Inside forward view of an aileron nose: note the balance tube at the very forward part of the aileron. This area is closed up on kit ailerons so you can't see the tube.

lead in that tube. It'll hold a little over 6.0 pounds if it is poured solidly full of lead (drill out some to balance it) and just over 5.0 pounds, if other methods are used.

Although you can go through an entire balancing process in which you suspend the aileron by thread and estimate the fabric and paint weight and then determine how much lead you'll need (see Russ Erb's CD), the range will always be between five pounds and five pounds, four ounces. Since overbalancing is better than under balancing, use five pounds four ounces as the target.

Pouring Lead

Go to the fuselage section where you balanced the elevators and all the same caveats and procedures apply: use a face shield and respirator, do it out doors, wear welding gloves and make sure no moisture is present as it will turn to steam and blow molten lead all around.

Stand the tube up and either make a wood

plug for the end or stick it slightly into the ground to seal it. Make sure the can or ladle you're using

Lead can be melted a number of ways, but do it outdoors and avoid the fumes.

has a narrow spout or make a funnel from aluminum flashing.

Because the tube is so long and you want the lead to keep flowing, rather than cool on the way down, carefully warm up the tube with your torch. Remember, it's aluminum and easy to melt,

The tube can be clamped against something or stuck in the ground. Warm it before pouring the lead in.

so don't get it too hot.

Because there is no airspace in poured lead, there will be too much in the tube, so be prepared to drill some out.

When the tube is full, slide it in place and either pop rivet it (using stainless rivets) or run two stainless flathead sheet metal screws into it through each of the rib flanges.

Using Lead Birdshot

If you don't want to mess with hot lead you can fill the tube with bird shot. Go down to your local gun store that sells reloading supplies and get the finest lead shot they have. You want nothing bigger than 8 1/2 (the bigger the number the smaller the shot) and finer is better as there will be less air space in it. If you can find number 12 shot,

The smaller the bird shot, the fewer air pockets there will be. This is 8 1/2 shot and 12 would be much denser.

great! MAKE SURE IT IS LEAD BECAUSE SOME PLACES SELL STEEL SHOT, WHICH ISN'T HEAVY ENOUGH.

Although some builders have made up a paste of lead and epoxy, that is difficult to get down the tube and the epoxy takes up space. The shot itself pours in like sand. First, however, rough up the inside of both ends of the tube with super coarse paper, 60 grit or so, to give an epoxy plug something to hang on to later. Tape one end closed. Fill the tube with the lead shot up to about 3/4" from the end . Make sure to lightly pound the tube against the ground, so the shot settles into place. Then, make up a slurry of epoxy (JB Weld is good) and shot that is mostly lead shot (for weight) and fill the remaining space with it as a plug.

Before plugging up the other end, weigh the

A plug formed of epoxy and shot keeps the loose shot in place.

tube. It should be at least 5.0 pounds and a little heavier is better.

Turn the tube over and remove a little shot to give enough room to form another epoxy/shot plug in place and you're finished with this process

Now, slide it in place.

Lead Wool

Yet another way of getting weight in there is stuffing the tube full of lead wool. This looks like steel wool, but it is lead and is available from McMaster-Carr.

The method of installation involves nothing more than forming plugs that look like cocktail wienies out of the wool, dropping them in and compacting them with a steel rod. Then an epoxy plug is poured in the end the same as with the lead shot.

Lead wool "wienies" are formed really easily and tamped down are nearly solid.