Companion Guide: “Building Fly Baby”
Article 8: Controls

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Version 1.0

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and the Fly Baby Community

This Companion Guide is written to accompany the eighth of Pete Bowers' Fly Baby construction articles in EAA SPORT AVIATION magazine. The article covered the construction of the flight controls systems…the joystick, the rudder pedals and control horn, and the elevator and tailwheel controls. Earlier articles addressed the construction of the control surfaces, this article addresses the pilot-operated mechanisms and how they connect to the surfaces.

You will need to download these articles from the EAA Archives. This Companion Guide merely supplies additional background information and some helpful hints on the actual construction. A full Table of Contents is included on the next page.

There are two kinds of figure references in this Companion Guide. If the reference is "Figure 1-1" (with a hyphen), it's a figure in the original EAA articles. Figures without a hyphen are contained in this document and should closely follow the text which refers to them.

For specific assistance in building the components described, see the Workmanship and Hardware articles on the PB100 Web Page.

Many thanks to Matt Wise, Jim Katz, Jim Hann, William Beauvais, Olan Hanley, Harry Fenton, Bill Hills, Drew Fidoe, Hans Teijgeler, Charlie Gay, and the others of the Fly Baby community for providing some great pictures to illustrate the points in this Guide.

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1 OVERVIEW

The primary emphasis in Article 8 is the construction of the control stick, and the various mechanisms that connect it to the control surfaces. This includes the joystick itself (Figure 1) as well as the pushrods and additional control horns.

Figure 1: Fly Baby Joystick and Torque Tube

Figure 6-1 on Page 10 of Article 8 is a great overall view on how the control system works. Let's take a closer look at the individual controls

1.1 Elevator

Figure 2 illustrates how the elevator control goes together. A short section of tubing (the "Torque Tube," see Figure 6-3) is installed between the lower section of the Station 3 bulkhead and the upper portion of the (short) Station 4 bulkhead. The torque tube is held loosely, so it can rotate left and right to accommodate the aileron controls.

The actual joystick has a set of steel plates at the bottom that "saddle" the torque tube. A bolt goes through these plates and the torque tube so the stick and pivot fore and aft for elevator control. A pushrod attaches from the bottom of the steel plates to a "walking beam" mounted aft of the Station 5 bulkhead (behind the pilot). Cables attach to the walking beam to connect to the elevator horns way in the back of the fuselage.

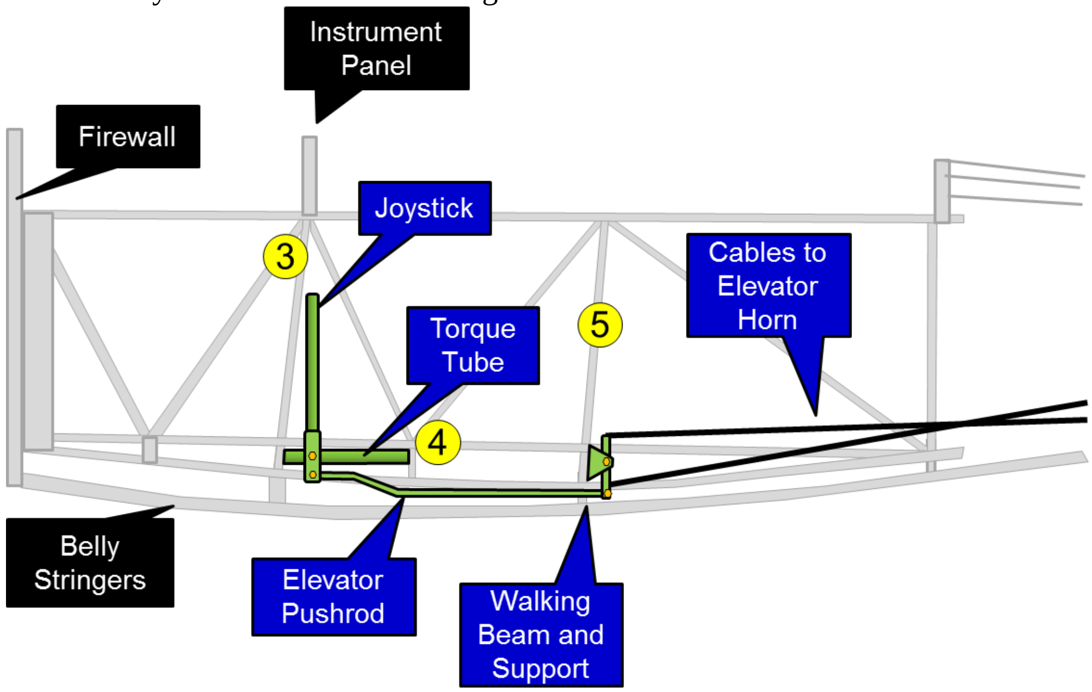


Figure 2: Elevator Controls

The bend in the pushrod allows it to go under the Station 4 bulkhead. This is actually under the nominal fuselage structure, but, if you remember from Companion Guide #4, there are actually a pair of stringers that will attach to the bottom of the fuselage to smooth the belly. These stringers also allow the elevator pushrod to pass between the bottom of the Station 4 bulkhead and the lower covering of the fuselage.

The ends of the pushrod have rod end bearings attached. These eliminate friction with the cross-bolts that hold the structure together, as well as give some adjustability.

1.2 Ailerons

1.2.1 Cockpit Connections

The ailerons are worked, of course, by side-to-side motion of joystick. The stick assembly pivots on the torque tube, and a pair of steel yokes are welded to it, as shown in Figure 3.

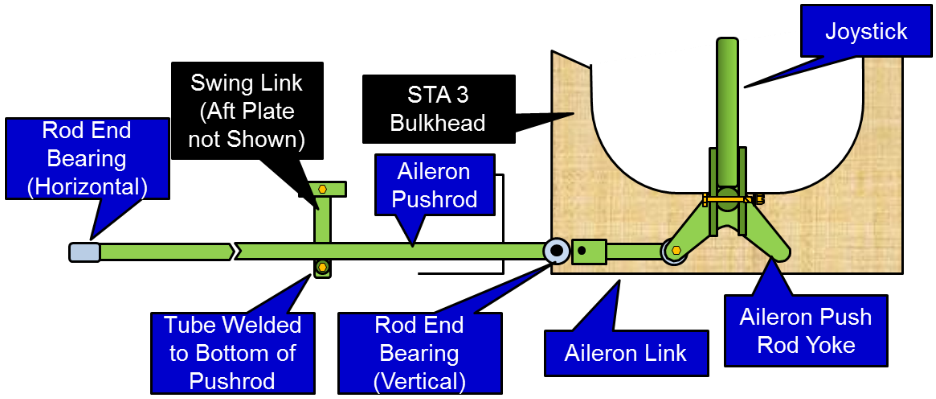


Figure 3: Aileron Control – Rear View

Each wing has long pushrod installed inside it. Both ends of the aileron pushrod have a rod end bearing at the end.

The aileron pushrod doesn't stick far out from the root of the wing. It connects to a short section of tube (the Aileron Link) which then connects to the aileron yoke.

Why not make the aileron push rod long enough and eliminate the Link? A couple of reasons. Primarily, it gives you some adjustability. Without the link, the aileron push rod would have to fit *exactly* from the middle of the wing to the center of the fuselage. The Link, being hinged at both ends, gives you some leeway. If you accidentally make the wing pushrod slightly too long or too short, just re-size the link to match.

1.2.2 In the Wing

Figure 4 shows the wing hardware associated with aileron control. A mounting bracket was installed during the wing construction. The double-deck aileron bellcrank bolts into this bracket. The long aileron pushrod runs from the forward tab of the bellcrank to the joystick, and the short aileron pushrod goes to the aileron horn.

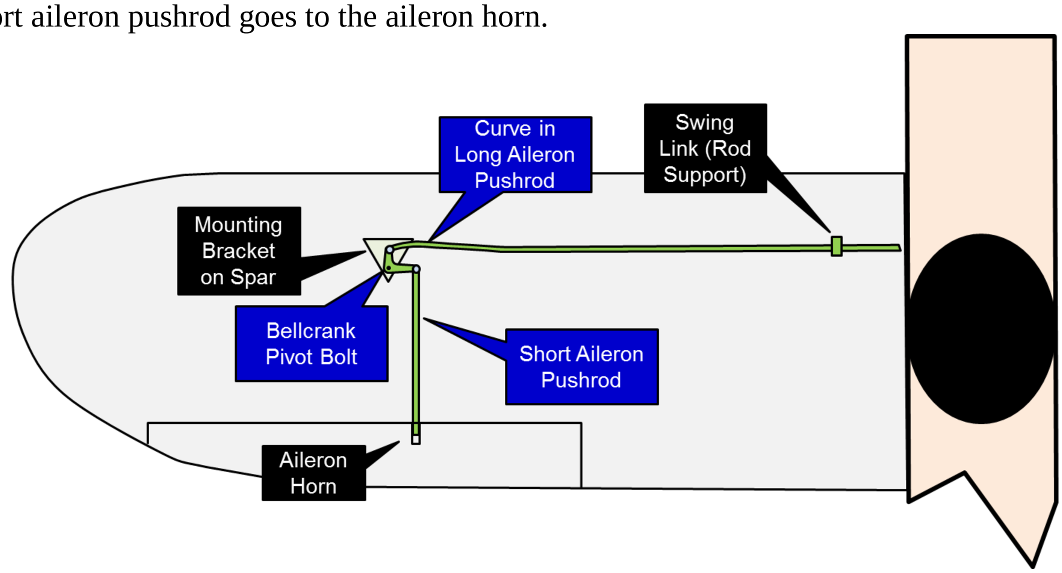


Figure 4: Overhead View of Aileron Control Structure

The long aileron pushrod includes a bit of a curve at the end. As Figure 5 shows, this gives the bellcrank a little more clearance when the inner-pointing arm rotates toward the pushrod

If you recall the wing construction details, the ribs have holes in them to pass the pushrod tubes. Obviously, if a hole interferes with the movement of the long pushrod, the hole should be enlarged so the tube moves cleaning. The swing link is mounted in the first rib bay; it provides support for that long tube. Without it, the rod may tend to bend when it's pushed. Note that it may be necessary adjust/add shims to the swing link to get it to work right.

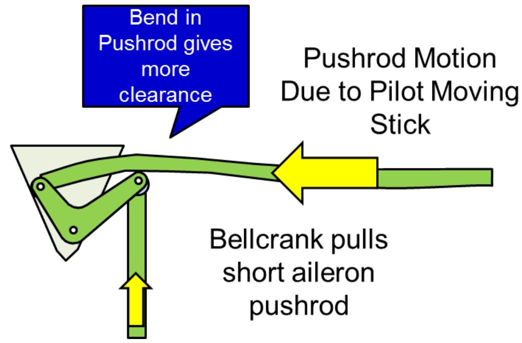


Figure 5: Bend in Long Pushrod

It's still a long way from the swing link to the bellcrank. Some builders have added a bushing inside the hole in one of the ribs to help support the tube. Obviously, if you do this, make sure it's not interfering with aileron action.

1.2.3 Aileron Travel

I occasionally get worried emails from folks concerned about their Fly Baby's aileron travel. "They go up nicely, but they barely go down!"

Fear not, that's the way it's supposed to work. Pete designed the aileron system so that each aileron goes up much further than it goes down. You can see the measurement on my own airplane in Figure 6. Measured at the root of the aileron (the closest end to the fuselage), each aileron will go up nine inches or more, but down only two inches or so.

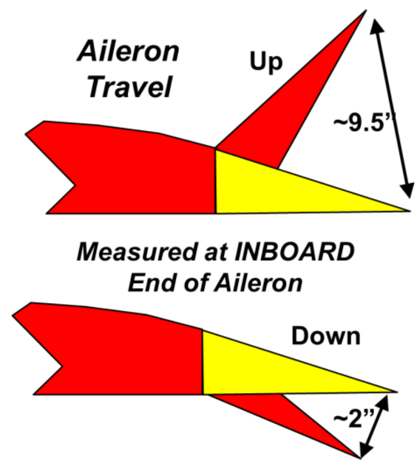


Figure 6: Aileron Travel

Weird? Not really. Most airplanes do this, especially the more modern ones[1]. The problem is adverse yaw. A downgoing aileron produces more drag than when it goes up, which means that the airplane tends to want to turn in the direction of the downgoing aileron (that wing now having more drag).

But….the airplane TURNS in the direction of the upgoing aileron! So adverse yaw will want to send the plane's nose to the left while you're trying to turn to the right. If you learned on modern aircraft, you might be shocked if you ever take controls of an antique. Adverse yaw is often significant; move the stick to the left, and the plane starts to turn right. You learn to lead each turn with the rudder…obviously different from a modern Cessna or Piper.

You're probably familiar with the horror stories associated with the Sopwith Camel from World War I. It had a fatality rate in training four times higher than its contemporary, the SE-5A. The Camel had its ailerons hinged at the bottom (vs. the top, like the Fly Baby). This meant that when the aileron went down, a big gap opened up…and adverse yaw was massive. The Camel, in fact, was the LAST Sopwith built with the ailerons hinged in this fashion. All subsequent designs hinged them at the top.

So Pete built-in aileron differential to minimize adverse yaw. It's handled by the inverted-Vee aileron yoke on the control stick. It has better leverage pulling the aileron pushrods (which raises the aileron) than when it pushes.

[1] "More Modern" isn't a term normally associated with Fly Babies, but it applies in this case.

Note that the travel shown in Figure 6 happens to be the travel that my own airplane has…it's certainly not a "standard". Other owners have reported slightly less or slightly more travel. Use of full travel of the ailerons in flight is almost unheard of.

1.3 Rudder Control

Compared to the aileron and elevator system, the rudder system is fairly simple.

Figure 7 shows its components. The main ingredients are a pair of rudder pedals, a pair of turnbuckles, the rudder cables themselves, and a couple of horns bolted to the rudder.

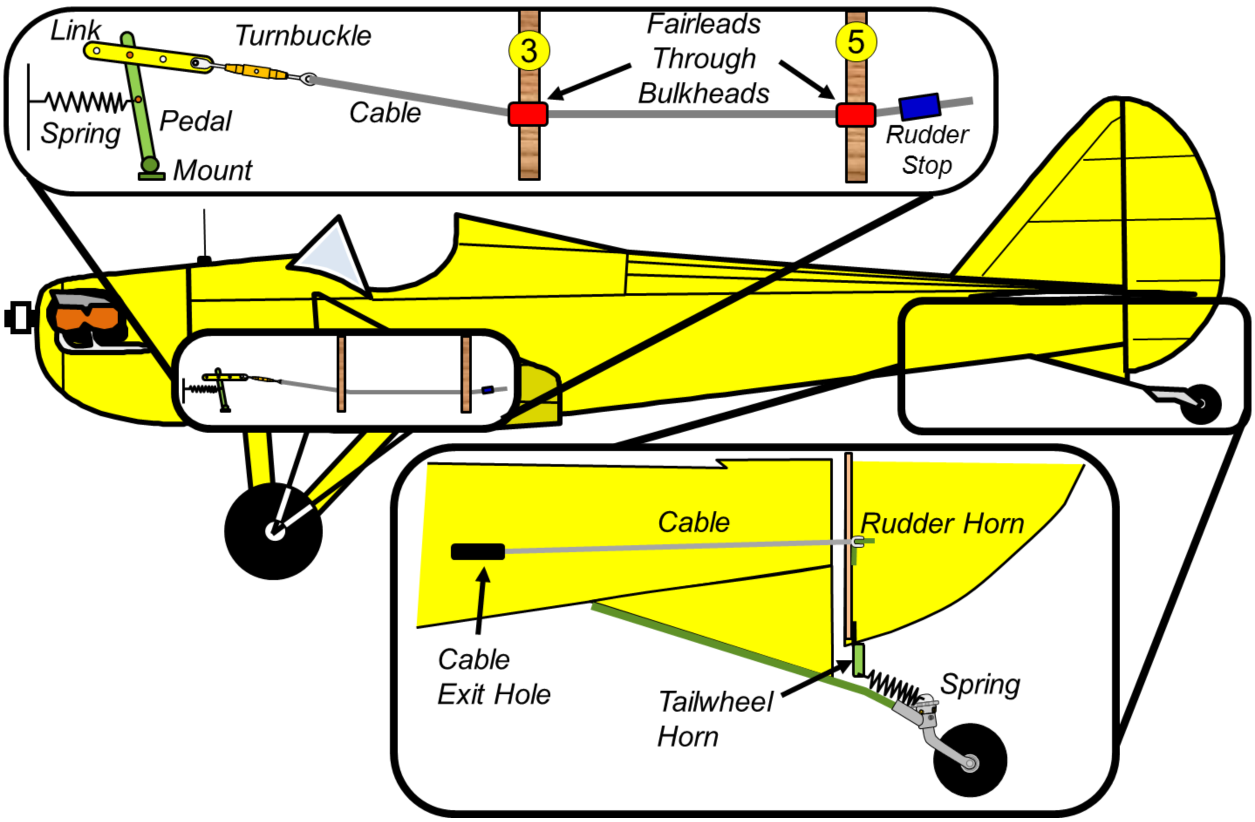


Figure 7: Rudder Control

The rudder pedals attach to the front cockpit floor…which doesn't exist, yet! It's described in the next EAA article. We'll add the necessary bit to this Guide when the rudder system comes up.

There's an unusual feature regarding the Fly Baby's rudder system—one which can lead to some comments.

The rudder pedals on Fly Babies are connected to cables, and are independent of each other. In one way, they work like any other aircraft…. If you press the left rudder pedal forward, the right cable pulls the right rudder pedal back.

But what happens to the right rudder pedal if you hook your foot on the left pedal and pull it back? Nothing, because the cable can only pull, not push.

Fly Babies have springs on the rudder pedals to pull them forward, but that's for convenience only (to keep the pedal from flopping aft onto the floor). They're not needed when you fly, since you'll have your feet on the pedals.

But when the airplane is sitting on the ground with no one in it, the spring is the only thing keeping tension on the rudder pedals. Which means the rudder cables attached to the rudder horn might sag a bit! This can lead to people assuming there's something wrong with the system…when, in fact, there isn't. Figure 8 is a photo of my airplane; notice how there's a little "wiggle" in the rudder cable.

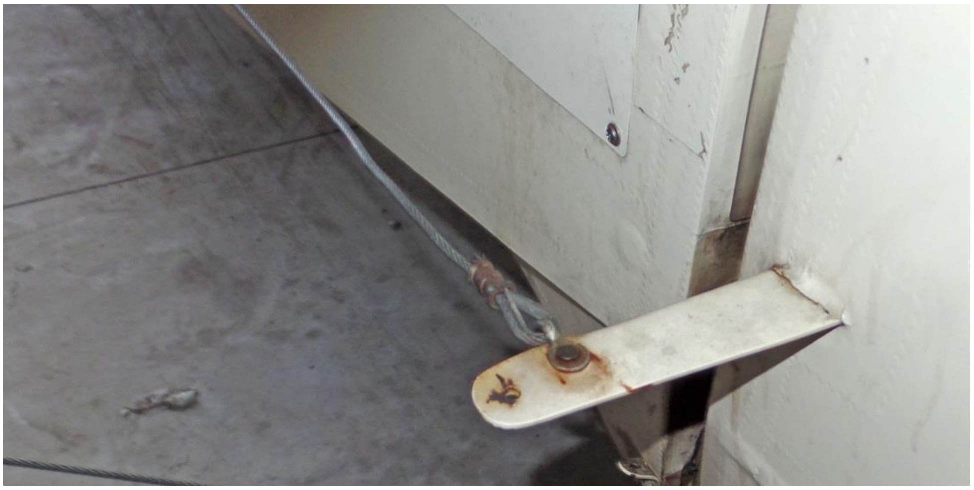


Figure 8: Slack in Rudder Cable

Stronger springs would reduce this issue, but then, you'd be fighting the spring pressure on a pedal every time you pressed the other one down.

So, don't worry if the rudder cables look a bit slack.

1.4 Note about Illustrations

To make things clearer, I have drawn up a lot of sketches to illustrate some of the aspects of the assembly. Peripheral details on these sketches are just there to complete the drawing—they may not, exactly, match the original Pete Bowers figures. My sketches always are in color; Pete's are black and white.

Where there is a difference between my sketches and those from the Pete Bowers articles, assume the original article sketches are correct.

If two pieces in my sketches are supposed to be the same size but look different, just assume that was an error.

1.5 Workmanship

Let's review the Basic Workmanship rules for building Fly Babies. Key notes:

- Do not varnish any areas which will subsequently be glued
- Varnish any closed areas (double-plywooded forward section, etc.) before they are closed up.
- Drill holes in wood directly to size, using a brad-point drill bit
- Varnish all bolt holes
- Varnish all areas where metal parts will be in contact with the wood
- All metal components should be painted or otherwise protected.

2 ERRATA

2.1 Figure 4-27

Well…at least it was corrected prior to printing the articles in the magazine.

When they drew the view of the aileron bellcrank, they had the bellcrank turned the wrong way. Rather than re-draw the whole diagram, Pete just added a prominent note about the error. Figure 9 shows the drawing corrected.

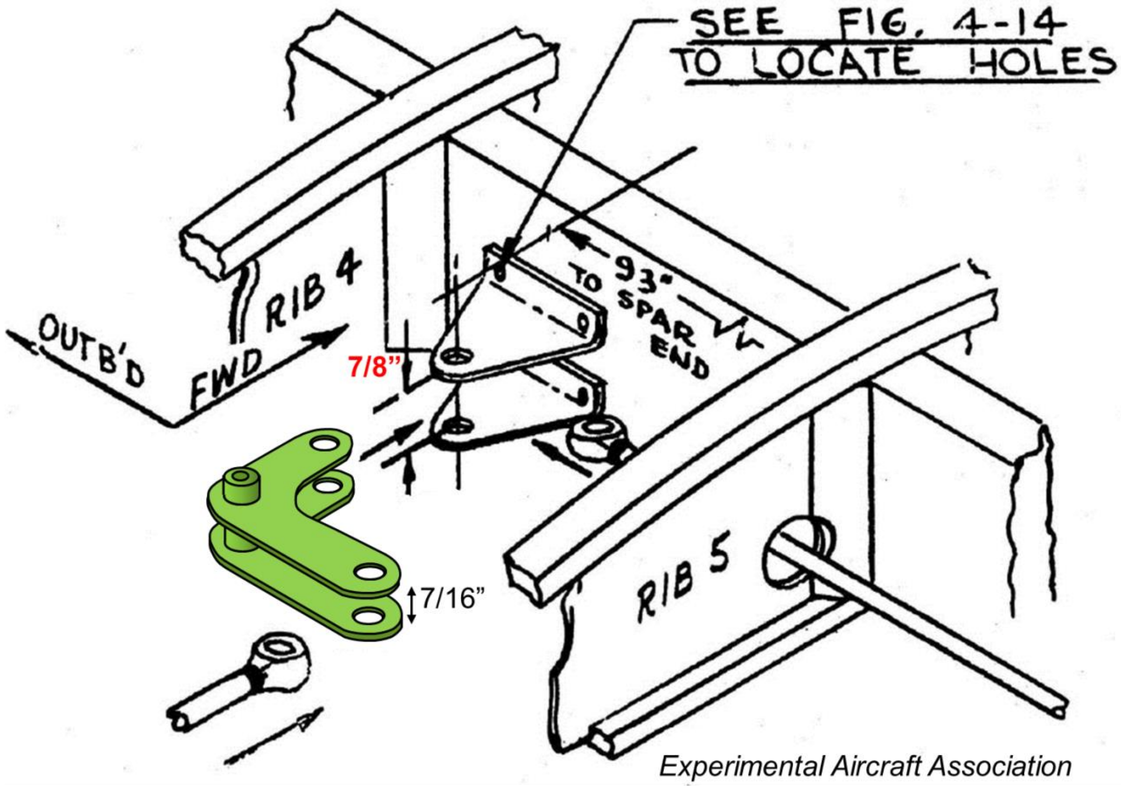


Figure 9: Figure 4-27 Corrected

Note, also, the dimension in red labeled 7/8" in the figure. Pete shows 7/16" here, which is the separation of the plates in the bellcrank, NOT the gap in the mounting plates bolted to the spar.

This shouldn't be an issue at this point, as Pete specified the bolt pattern for the brackets back in Figure 4-14 in Article 2.

2.2 Figure 4-28

This was addressed in the second Companion Guide, but the tubes that support the aileron push rods are supposed to be welded to the BOTTOM of the push rods, not the top as Pete shows in Figure 4-28 in the plans.

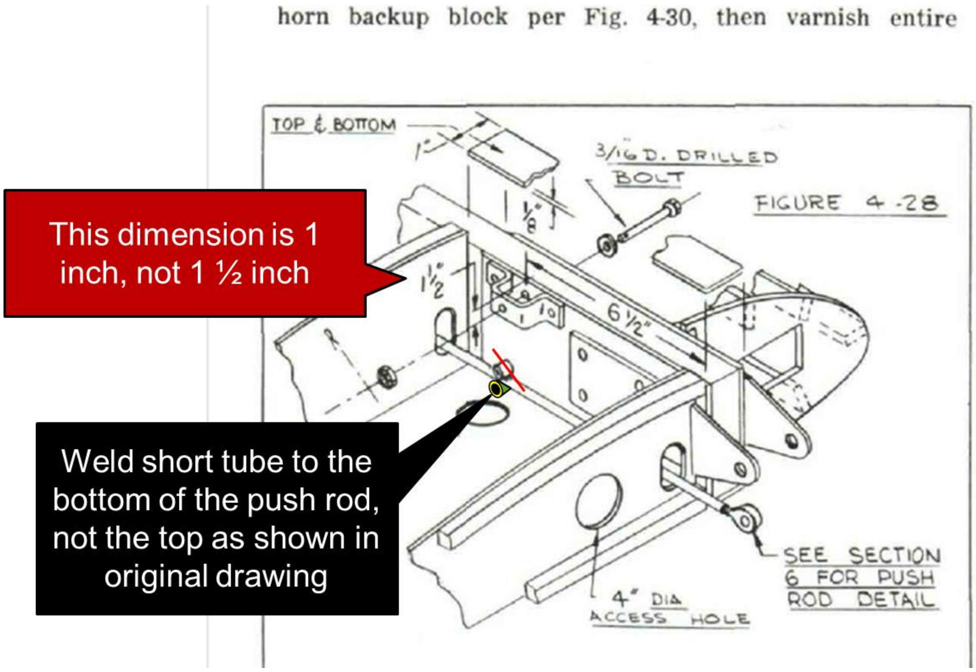


Figure 10: Aileron Linkage Changes in Figure 4-28

Figure 11 provides a side view of the aileron linkages, which hopefully will be a bit clearer.

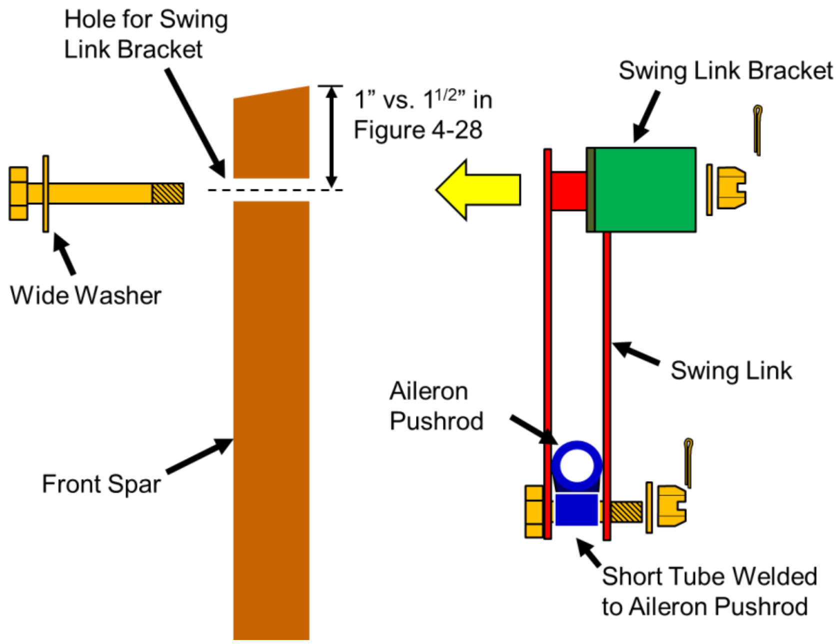


Figure 11: Cross-Sectional View of Aileron Pushrod and Swing Link

2.3 Elevator Cable Interference

Several builders have reported some minor interference with the fuselage Station 8 diagonal and the elevator cables. This is addressed in Section 4.3.2.

3 SAFETY ISSUES

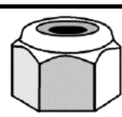
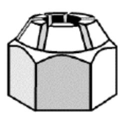
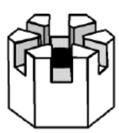
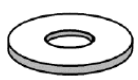
Your primary issue? This is the control system, for goshsakes. This is all critical to your safety. Here's a warning Pete added to the plans:

> If you have any. doubts at all about your. skill as a welder, have a professional do this job. There are relatively few welds in FLY BABY, but your life will be dependent on the quality of the work in these.

In other words, the control system is not the place to be trying out uncertain skills in welding. This is a place where it might be a good idea to "farm out" the work to a professional.

3.1 Lock Nuts

The AN365 self-locking nut is commonly used on aircraft. However, it should never be used in situations where the bolt is used as a pivot…like in the control system. Use drilled bolts and AN310 castle nuts and cotter pins, instead.

	To Fit AN3 (3/16") Bolt	To Fit AN4 (1/4") Bolt	To Fit AN6 (3/8") Bolt
Elastic Stop Nut 	AN365-1032A AN364-1032A*	AN365-428A AN364-428A*	AN365-624A AN364-624A*
Metal Stop Nut 	AN363-1032	AN363-428	AN363-624
Castle Nut 	AN310-3 AN320-3*	AN310-4 AN320-4*	AN310-6 AN320-6*
Washer 	AN960-10 AN960-10L* AN970-3**	AN960-416 AN960-416L* AN970-4**	AN960-616 AN960-616L* AN970-6**
Cotter Pin 	AN380-2-2	AN380-2-2	AN380-3-3

* Thin unit... use only when called for
** Extra-wide washer

Figure 12: Lock Nuts and Related Hardware

The drilled bolts have the same nomenclature, but don't have an "A" at the end… and AN3-16 bolt vs. an AN3-16A.

3.2 Rod Ends

Rod Ends allow two components to be bolted together with a bit of "give". A bearing is enclosed that can tilt a little; a bolt through the bearing can rotate a bit in all directions without making a loose connection between the two joined parts. They are defined as "Male" (they end in a threaded rod like a bolt) or "Female" (internally threaded to screw onto a bolt).

Fly Babies use about a dozen of these, all female as shown in Figure 13. They're installed on 1/2" steel tubes to be used as pushrods. They're threaded to 1/4-28 thread to match an AN4 bolt.

Figure 13: Rod End Bearing

However, I'm not too fired up about how Pete attaches these to the pushrod tube. As shown on the top of Figure 6-4 in Article 8, he has you weld an AN4 bolt into the end of a tube, then extend the threading on bolt.

Generally, one doesn't extend the threading on AN4 bolts. The bolts are manufactured with rolled threads, and hand-threading the remainder has the potential to lead to cracking.

One solution is to use a Grade 5 bolt (e.g., non-aviation). Grade 5 bolts run the threading all the way almost to the head of the bolt, so you don't have to add threads. Figure 14 shows an example rod end made in this fashion. In this case, Matt Wise also put the bolt in a lathe and turned the hex head to make it circular.

Figure 14: Threaded Rod End Made From Grade 5 Bolt.

An easier solution would be to use AN490HT8P threaded rod ends (Figure 15). These slide into the end of a 1/2" outside diameter, 0.035" wall tube.

Figure 15: Threaded Rod End

Why didn't Pete mention the AN490? My guess: He was being cheap. Today, the AN490 rod end sells for about $15, and was probably proportionately pricey back then.

The rod end can be welded in place, or installed with a set of cross-rivets, as shown in Figure 16. Use solid rivets, not pop rivets. One builder did have problems with rivets…since the fittings are hollow, the rivets would bend instead of setting properly. He eventually welded, instead, with a single cross-bolt for backup.

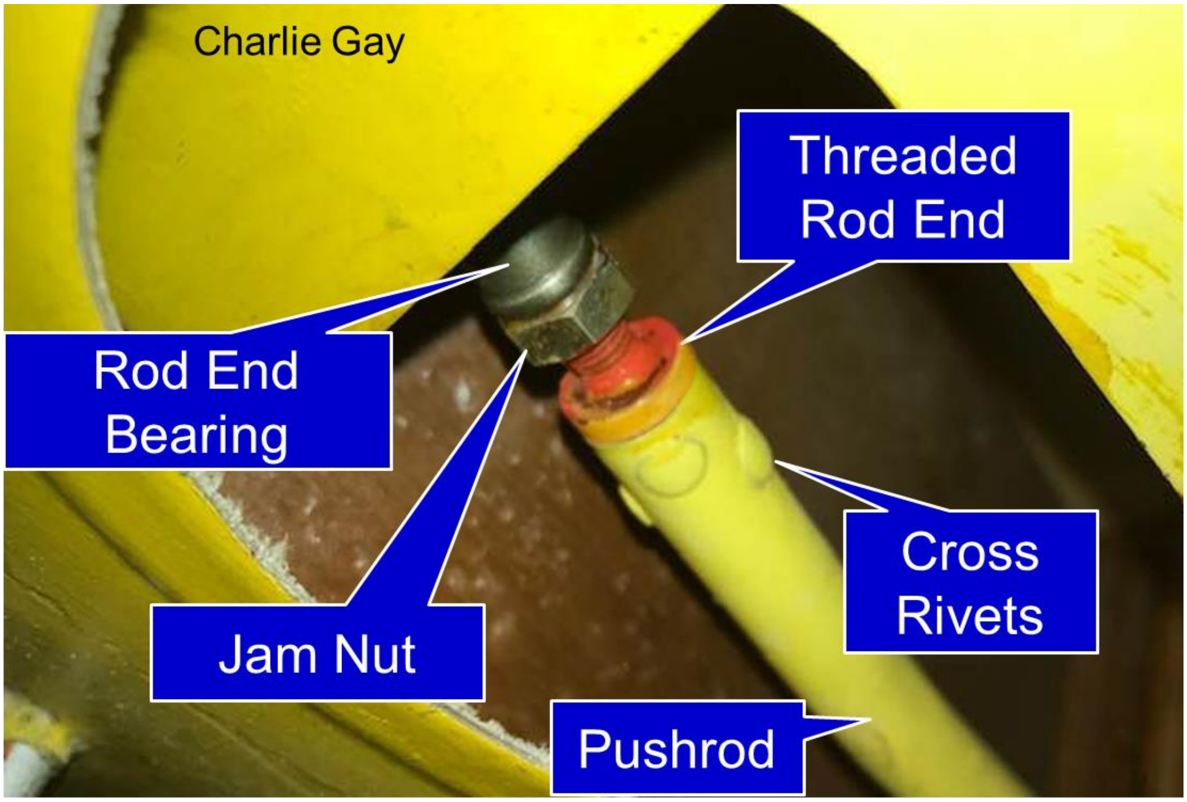


Figure 16: AN490 Rod End Attached with Rivets

Whenever installing a rod end bearing, include a separate jam nut on the threaded shaft, as the figure above shows. Once the pushrod is in place and properly adjusted, tighten the nut against the bottom of the bearing to hold it in that setting. The way Fly Baby pushrods are designed, they really can't rotate (far), so it's not a big thing. But it is a good practice your DAR will want to see.

3.3 Tailwheel Steering Horn Modification

The tailwheel is steered by a bellcrank bent out of flat 0.090" steel, as shown in Figure 6-6 on Page 12 of Article 8.

At about 1700 hours total time on the original Fly Baby, it was discovered that one of the legs of the horn was tearing off right at the bend line. The tear was almost 3/4ths of the way through when discovered.

While the design is similar to the rudder horn, the rudder horn is flat and incorporates a bend at the leading edge to strengthen it. The legs of the Tailwheel Horn bend down at a 45 degree angle and thus can't incorporate a bend.

Our fix on N500F was to weld up the crack and add stiffeners to the legs by welding on small triangular pieces of steel at the leading edge (Figure 17).

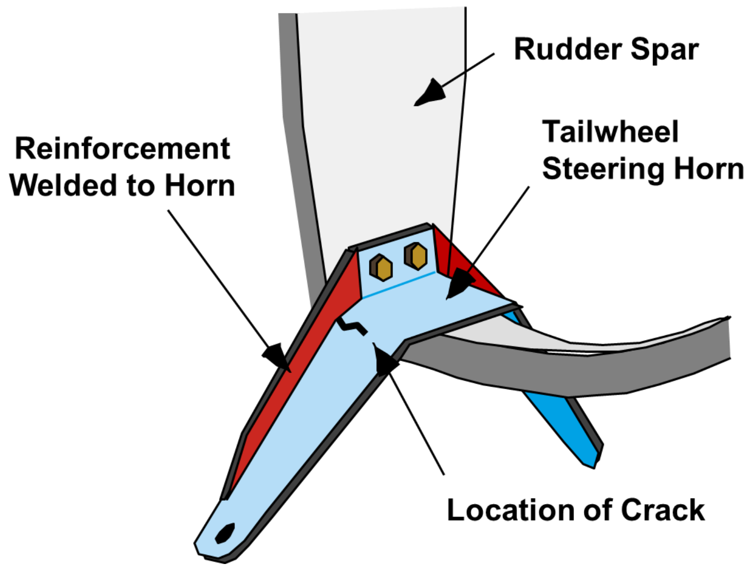


Figure 17: Tailwheel Horn Reinforcement

Add this reinforcement to your tailwheel horn.

4 CONSTRUCTION ISSUES

4.1 Control Stick

The control stick consists of two major elements: The joystick and the torque tube (Figure 18). Both are made from 1" diameter tubing, although the joystick is a minimum 0.032" wall and the torque tube minimum 0.064."

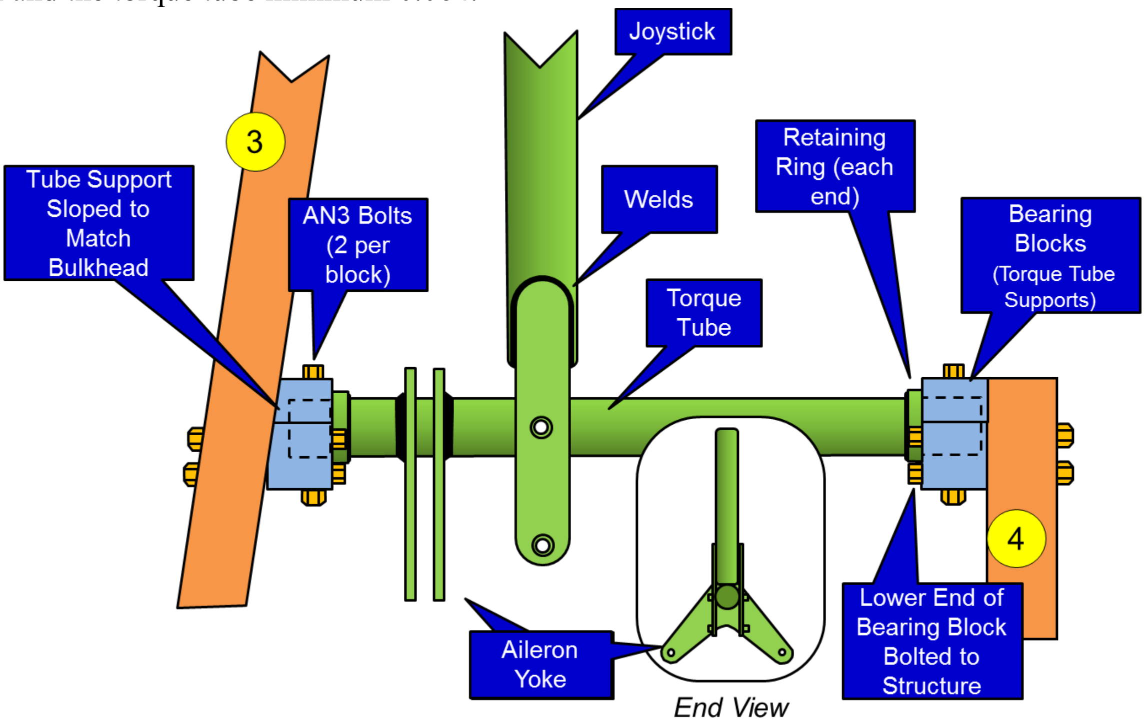


Figure 18: Fly Baby Flight Controls

4.1.1 Torque Tube

The torque tube is basically the mount, and the inverted-Vee yoke for aileron control is welded to it. It rotates left and right to facilitate aileron operation.

Now, if this was one of those hoity-toity modern homebuilts, you'd be looking at installing some fancy bearings to allow that tube to rotate with no friction. But since you're building a brawny, old-fashioned, hairy-knuckled Fly Baby, you're just going to stick the tube inside a couple and small blocks and just make sure it's not held too tightly.

Pete gives the dimensions in Figure 6-3 in the article, but Figure 19 is included below as a dimensioned sketch.

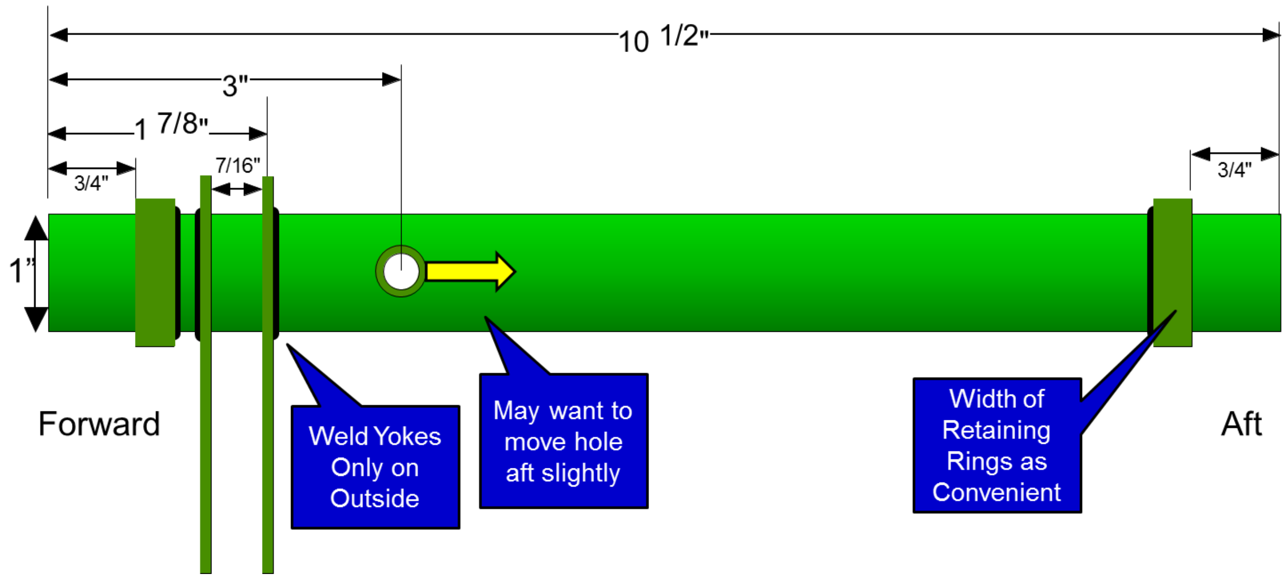


Figure 19: Torque Tube Features

There's a hole in the middle of the torque tube, where a long 5/16" bolt connects the joystick. The bolt is thus used as a hinge pin for elevator action. Pete shows this as three inches back from the front of the tube. At least one builder feels that it's too close to the aileron yoke, and recommends moving it back slightly. Shouldn't make much difference, although the elevator pushrod will need to be shortened to match.

There's a lot of force on the skinny little 0.064" wall of the torque tube where the joystick bolt goes through, so Pete has you weld in a cross-tube for reinforcement (Figure 20).

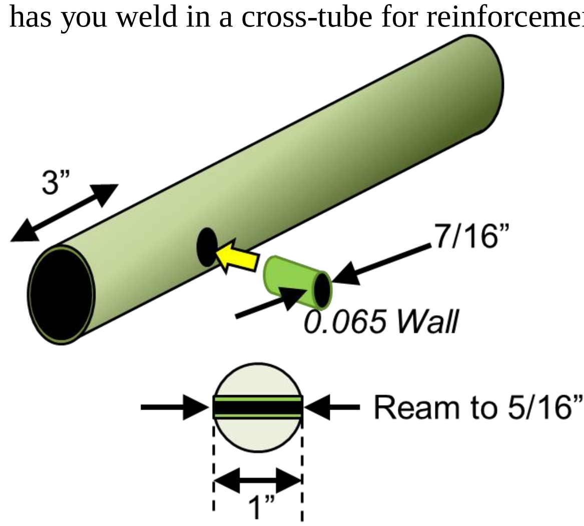


Figure 20: Torque Tube Reinforcement

Pete's instruction say the tube should be 5/16" inside diameter (0.3125), but he doesn't specify the thickness of the tube wall. One builder recommends using a 7/16" outside diameter tube with 0.065" wall thickness. This tube is slightly undersized inside (0.308"). But you can ream it out to 5/16" after the joystick is in place. The AN5 bolt that slips inside will be the pivot bolt for elevator action. Use a drilled bolt and castle nut.

Remember, the reinforcement tube must be ninety degrees to the centerline of the aileron yoke, as depicted in Figure 21.

4.1.1.1 Aileron Yokes

The dimension and shape of the aileron yokes are provided in Figure 6-3 in the article. The first one is welded about 1 7/8 inches back from the front of the tube, the second one is installed a bit further forward so that there's a 7/16" gap between them to fit the rod ends on the aileron pushrods. Both should be welded only on the outside….with the thin (~0.093") steel, there's a danger of undermining the first weld, if you try to weld the other side.

Weld the first yoke in place, then slide the second yoke on and clamp it to the first one with the appropriate 7/16" spacers.

As Figure 21 shows, the centerline of the yokes should be perpendicular to the axis of the through-bolt.

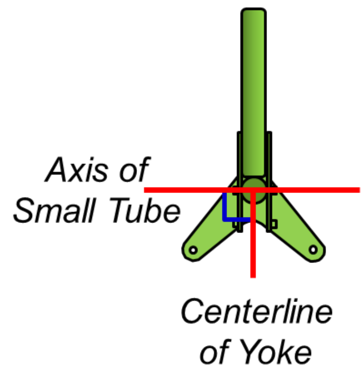


Figure 21: Axis of Reinforcement Tube

4.1.1.2 Retaining Rings

The retaining rings are just there to minimize fore-and-aft movement of the torque tube. Install the front ring first, since it's closer to the aileron yokes and more difficult to access on the airplane.

4.1.1.3 Bearing Blocks

Figure 6-3 on Page 11 of the EAA article shows the support blocks, or "bearing blocks" for the torque tube. Pete says, "The bearing blocks can be micarta or any acceptable material, even aluminum or hardwood."

I asked the folks on the Fly Baby Facebook page, and got a wide variety of responses. Aluminum ("add small hole to shoot some WD40 or LPS into either end), Nylon, Delrin, Oak, etc. Figure 22 shows a set of bearing blocks made from nylon.

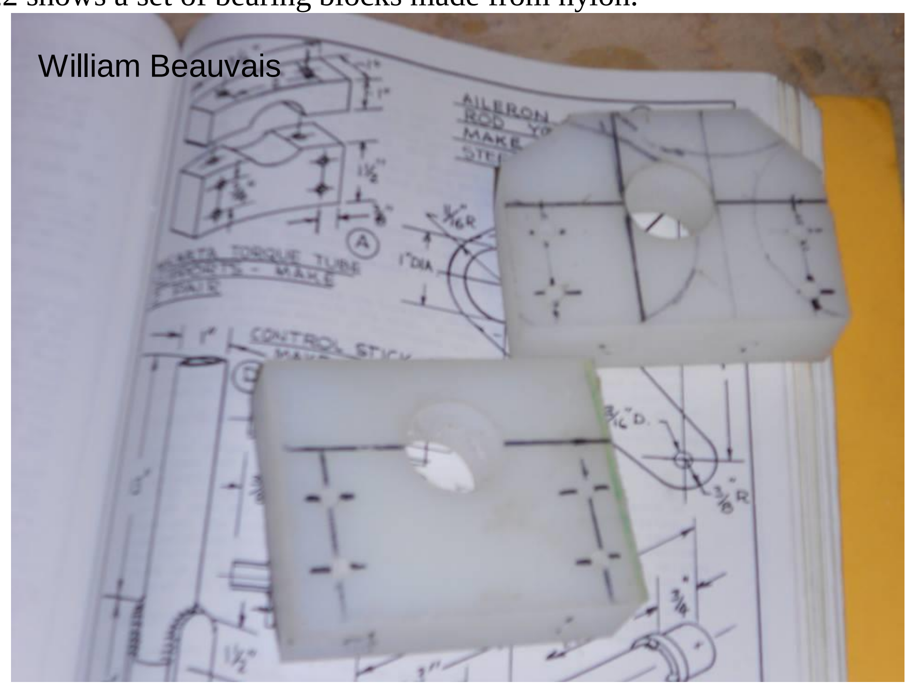


Figure 22: Bearing Blocks for Control Stick Torque Tube

Whatever material you use, the block is cut across the center of the hole for the torque tube. The big half is bolted to either the Station 3 or Station 4 bulkhead, and vertical bolts clamp the other half down over the tube. Of course, not a lot of clamping force is desired, nor is it needed. The retaining rings actually prevent the torque tube from coming out the blocks, so you just want it tight enough to keep it from moving much. It should rotate (roll) smoothly. Plan on squirting some lubricant in there during each Condition Inspection.

If you look back at Figure 18, you'll see that the Station 3 Bulkhead is sloped…so the bearing block in front has to be tapered to match. Some folks have just built a wood wedge to fit between the block and the bulkhead, others have just slanted the back of the bearing block.

4.1.2 Joystick

Two plates are welded to the base of the joystick to straddle the torque tube. View "E" of Figure 6-3 shows the details.

The plates have two sets of holes…one matching the location of the reinforcement tube on the torque tube, and the other lower down for attaching the elevator pushrod. Bushings are welded to the plates to contact a broader surface of the cross-bolts. The same 7/16" 0.065 wall tubes can be used for the central set of holes. In this case, the tubing is flush with the surface of the plates.

The one on the end have a 3/16" inside diameter rather than the 5/16" of the upper holes, and they actually stick inside the plates by 3/16". A 3/8" OD tube with 0.095" wall would be about right. Or even a 5/16" with 0.065" wall. You can see one set of these in Figure 24.

Years ago, the welds on one of the small tubes broke on N500F. It's important to get these welds right, like all the control system welds.

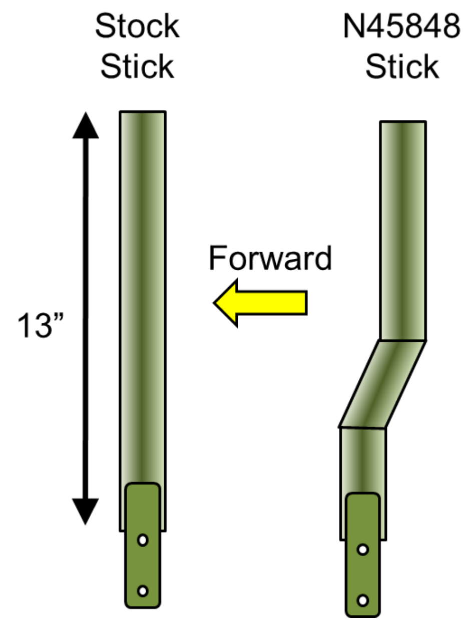


Figure 23: Joystick Styles

As Figure 23 shows, he stock joystick is straight and about 13" long (the bottom plates have a 1 1/2" overlap). The limiting factor for the stick length is the height of the opening in the bulkhead at Station 3. Obviously, the stick shouldn't be so tall your knuckles hit the bottom of the wood at Station 3.

The builder put a "kink" in my joystick. The airplane originally had a box located on the floor under the panel, containing the electrical system controls, radio, and transponder (Figure 24). I think the box was set so far back that the stick had to be kinked to keep from bashing the front of the box with full-down stick.

It probably doesn't make a lot of difference, but of course there's the potential for a bad weld causing the stick to snap. Hasn't happened yet, of course.

Figure 24: Avionics Box Required Kinked Stick

Figure 24 also shows another common feature: A grip installed at the end of the stick. The stick is one inch in diameter, an extremely common stick size. A lot of commercial grips can be found to fit, including those with buttons and wiring for using them as a push-to-talk switch for your radio (or any other reason the highly-inventive Fly Baby community can come up with). Some folks are even using 3D printers to print their own custom grips.

Two small cautions: First, make sure that adding the grip to the end of the stick doesn't make it too long! Note that the top of the stick in Figure 24 still has a couple of clearance with the bottom of the hole in the bulkhead.

Second…well, don't make control of your aircraft dependent on the durability of the stick grip. If you use a fancy grip that the steel tube only goes in an inch or so, you're relying on that stick grip not unexpectedly breaking. You'd lose control momentarily if that happened, and if it happens at the wrong time….

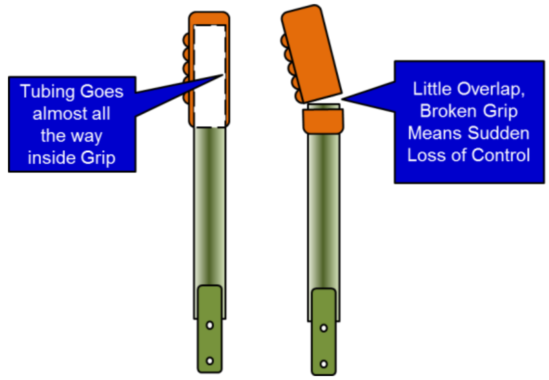


Figure 25: Stick Tube Overlap Inside Grip

4.2 Pushrod Ends

Both the ailerons and the elevator use pushrods that are constructed similarly, so let's look at the generalities first.

The pushrods consist of a length of 1/2" steel tubing and the rod ends. The term "Rod End" applies to the goodies that attach to the end of the pushrods. Of the seven pushrods on the Fly Baby, five of them put rod ends on both ends of the tubing. So you'll need 12 of them…five for each aileron, and two for the elevator. Figure 26 shows what a typical rod end assembly looks like. There's the rod end bearing (which has the hole for attaching the pushrod to the controlled device, the threaded rod end (for attaching the rod end bearing to the tube, and a "jam nut" to lock the rotatable rod end bearing.

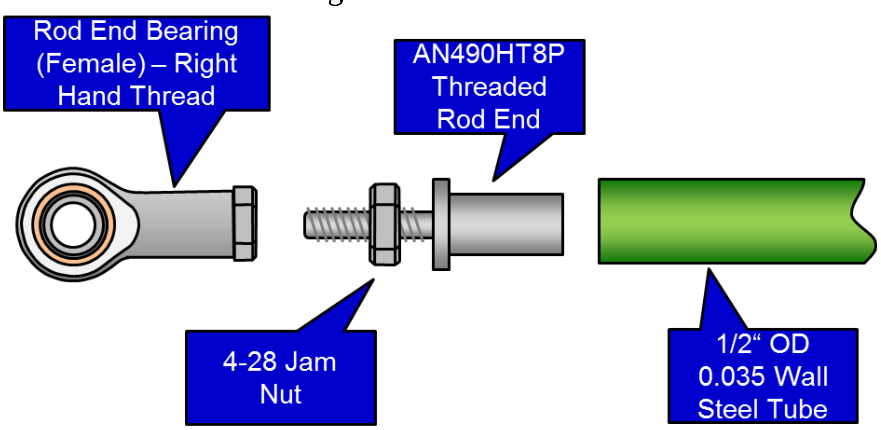


Figure 26: Rod Ends on Pushrod Tube

4.2.1.1 Rod End Sizing

The Fly Baby uses the same size rod ends everywhere. Rod bearings come in a variety of sizes, and you have to be sure to get the right size. Figure 27 shows the required dimensions. An AN3 cross-bolt is used at all mechanisms, so the hole through the bearing end should be about 3/16" (0.01875 inches) in diameter (the spec is usually slightly larger, such as 0.19"). The parallel plates that the bearing bolts to are all 7/16" (0.4375 inch) apart, so the end with the bearing should be about that thickness. Finally the threaded end of the pushrod tube is 1/4-28 RIGHT HAND THREAD, so the threaded opening in the rod end should be the same.

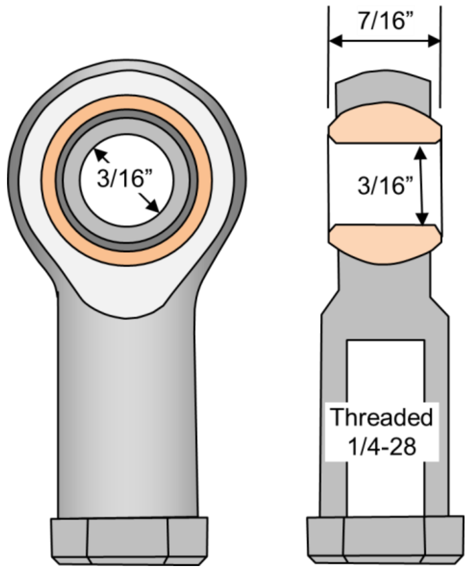


Figure 27: Dimensions for Fly Baby Rod Ends

I'm showing the rod end bearing screwed onto a threaded rod end attached to the tube. Pete says to weld 1/4" bolts (with their threading extended) directly to the end of the pushrod tubes. But, as I discuss in the "Safety" chapter (Section 3.2), this is not really the best way to do it. Best way is to bite the bullet and buy twelve AN490 threaded rod ends. Yeah, it's another two hundred bucks, but it's worth it.

4.2.1.2 Rod End Attachment

There are three typical ways to attach the threaded rod ends: Weld, rivet, or bolt (Figure 28).

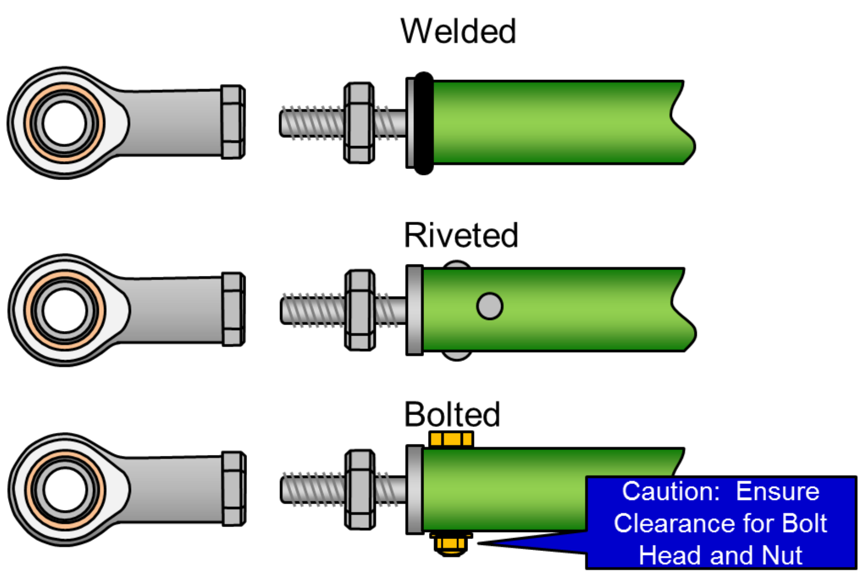


Figure 28: Threaded Rod End Attachment Methods

Welding is the classic method, and there's nothing wrong with it. Rivets are often used as well, although some have had problems with the rivets bending inside the open end of the threaded rod end, and not seat properly.

Finally, you could just drill a hole through and bolt it together. A single AN3 bolt should be plenty strong enough, but be aware of where the rod end is going to be installed. The bolt head and nut are going to stick out more than the rivets (and especially more than the weld) so make sure it's not going to clunk into something as the pushrod goes over its complete travel.

OK, now how do you drill a hole exactly through the end of the pushrod tubing?

Figure 29 shows how. Clamp the tube solidly to the tabletop, and slide a carpenter's square along the tube on opposite sides. It'll leave a mark on the centerlines of the tube, exactly opposite of each other. I usually smear the tube with a Sharpie and mark in the ink. After that, measure the same distance in from the end of the tube, along the marked centerline, and drill a 1/8" pilot hole in both sides. Insert the threaded rod end, drill through one pilot hole, then insert a cleco to drill the other side.

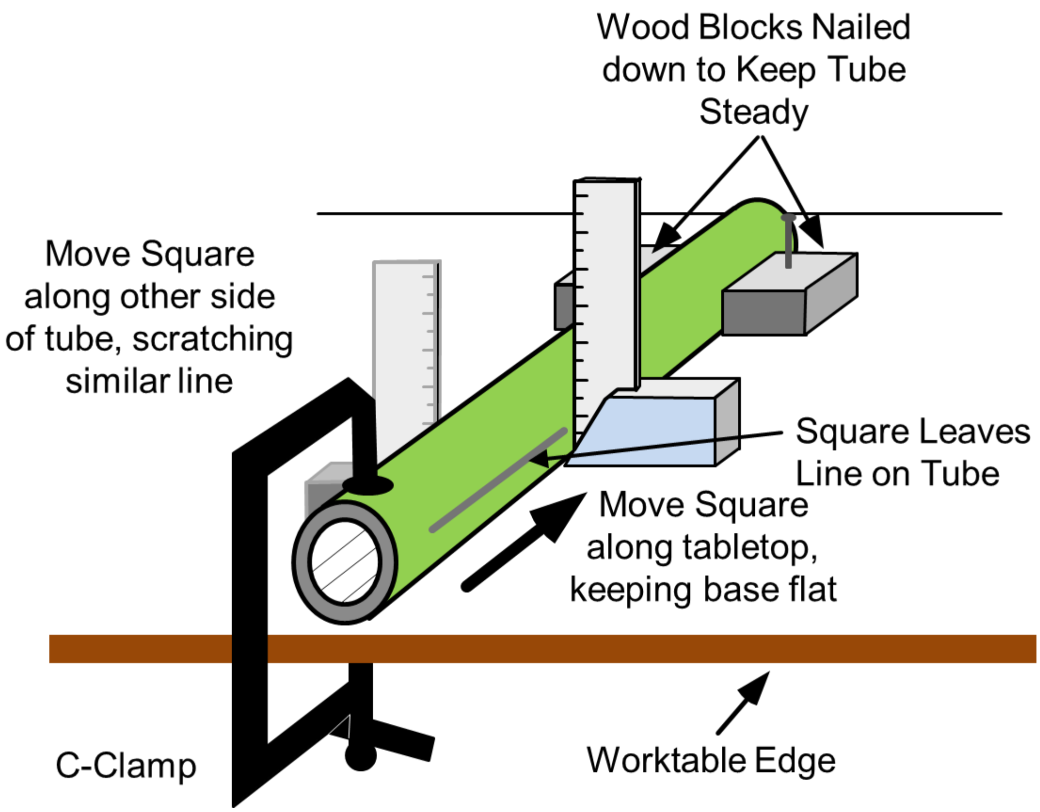


Figure 29: Drilling Holes Straight Across Tubing

Enlarge the holes to your final size, and ensure you drill across as the last step.

Now, consider using this process to drill a bit of tubing that will slide over the 1/2" pushrod tube. You can then use this as a template to mark each tube…quicker than running this whole process over each end of the tube.

Don't forget to debur the holes, and, if welding, add some primer to the inside of the tube and the threaded rod end. If you're going to rivet or bolt, consider covering the joining surfaces with epoxy prior to joining. It can't hurt.

4.2.1.3 Rod End Minimum Engagement

The threaded portion of the AN490 rod end is almost an inch long. This gives you some capability to adjust the tubing length once it's in place.

But it obviously MUST have a certain length inside the rod bearing to ensure the strength of the unit. That distance is 1.5 times the diameter of the threaded portion… in other words, 1.5x0.25, or 0.375 (3/8"). See Figure 30.

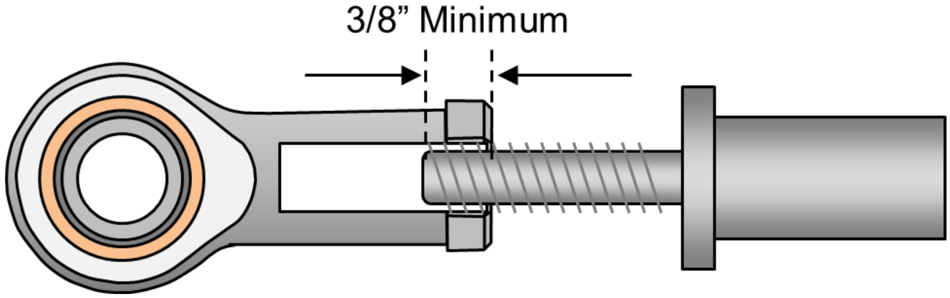


Figure 30: Rod End Minimum Engagement

What this means is that you're better off if the pushrod is too long, rather than it being too short. If you build a pushrod where both ends are engaged only the minimum, it can't be adjusted any shorter. If the pushrod is assembled with both at midrange (1/2" engagement, the pushrod can be shortened an inch, if necessary, but can only be lengthened 1/4" (1/8" on each end to reach 3/8"

So keep this in mind while you're building a pushrod. It's always easier to shave off a bit from the end of the tubing (assuming you're doing a test fit with the rod end not permanently attached) than it is to add tubing length.

Now, some brands of rod end bearings have an inspection hole at the right distance. If you can see the threaded area through the hole, or a piece of wire won't poke in, then the minimum engagement criteria is met. Not all brands of rod ends have the inspection hole, though.

4.3 Elevator Walking Beam

The elevator walking beam converts the fore-and-aft movement of a pushrod into the rotation of a bellcrank. As Figure 31 shows, that bellcrank, in turn, is connected to the main elevator bellcrank in the tail.

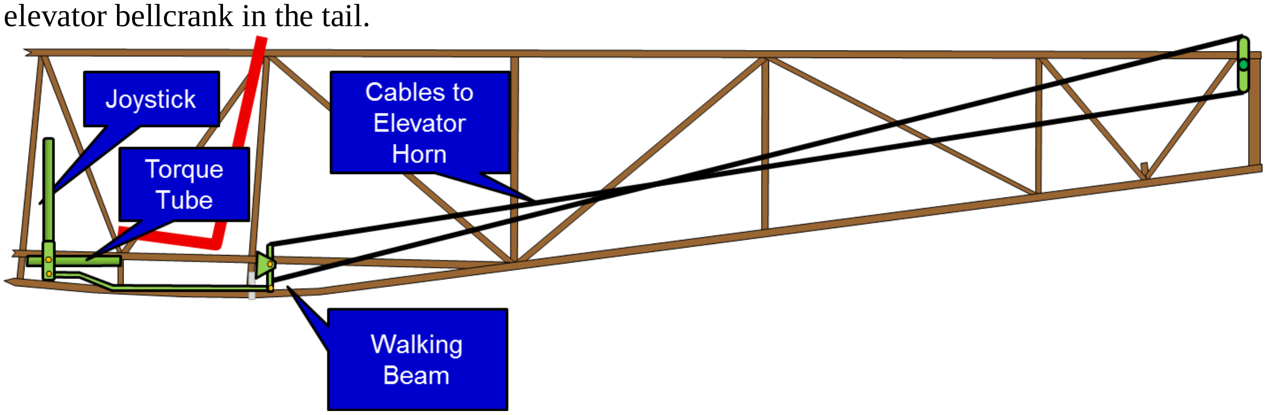


Figure 31: Elevator Control

One key factor: Note that the cables to the elevator horn actually cross…the top cable at the walking beam connects to the bottom of the elevator bellcrank. If you trace the action in the above drawing, you should see why.

Figure 6-5 on Page 11 of Article 8 shows the construction of the walking beam. Figure 32 is a photo of an actual example. There's a little distortion due to the camera angle; the sides of the walking beam are actually parallel.

The walking beam is actually a bit asymmetrical; there's more below the hinge bolt than at the top. The reason for this is pretty obvious, the top and bottom turnbuckles are the same distance from the hinge bolt, and the longer bit at the bottom is just to give a spot for the elevator pushrod to connect to.

Also, Pete later noted that the crossed rudder cables tended to rub against each other. He recommended, "The cables can be kept from rubbing on each other at the crossing point if the walking beam is tipped slightly to one side of the vertical and the elevator horn is bent just a bit the opposite way."

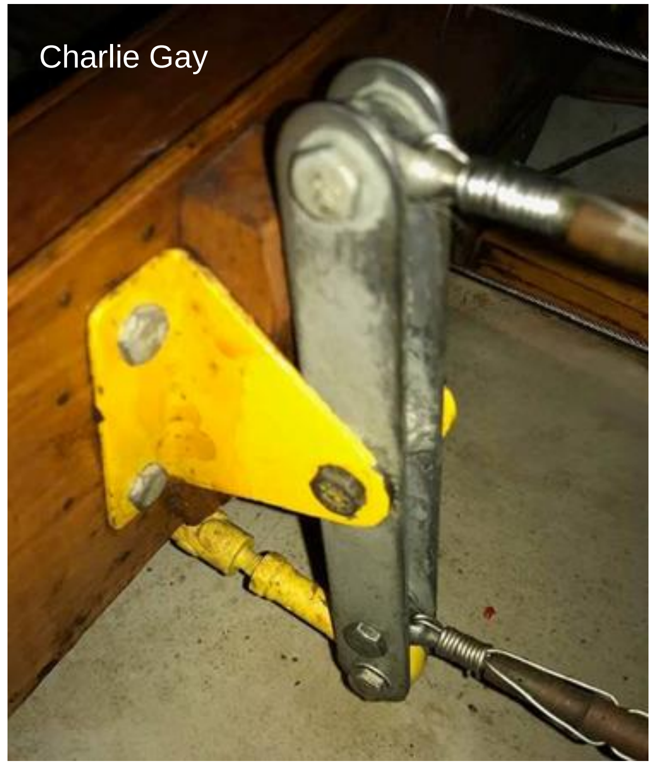


Figure 32: Elevator Walking Beam

4.3.1 Elevator Stops

The elevator travel should be restricted to a maximum of 25º up and 20º down. This is accomplished by adding blocks that restrict the motion of the walking beam. The function of the blocks can be seen in Figure 33 below. Note the implementation of the blocks in Figure 32 above, as well.

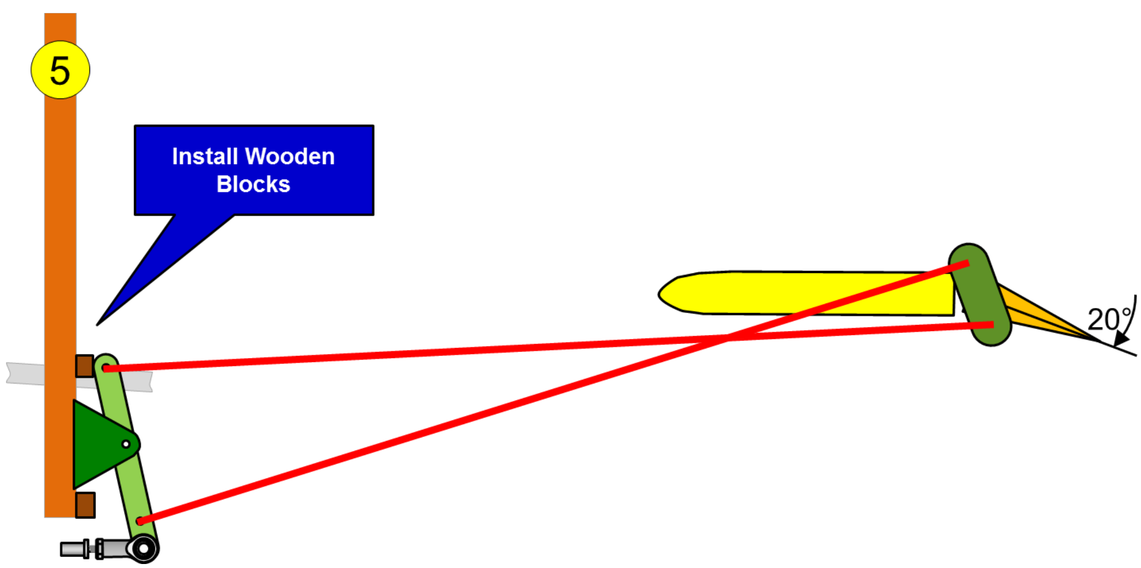


Figure 33: Elevator Stops

4.3.2 Elevator Cable Interference

The elevator cables travel back to the tail of the airplane to attach to the elevator horn. It's travelling through a maze of diagonal bracing, and several builders have reported that the cables tend to rub against the fuselage diagonal at Station 8 (which is located just forward of the front attachment point for the horizontal stabilizer).

Figure 34 depicts the issue. You can see the varnish on the diagonal is a bit scraped by the cables going past.

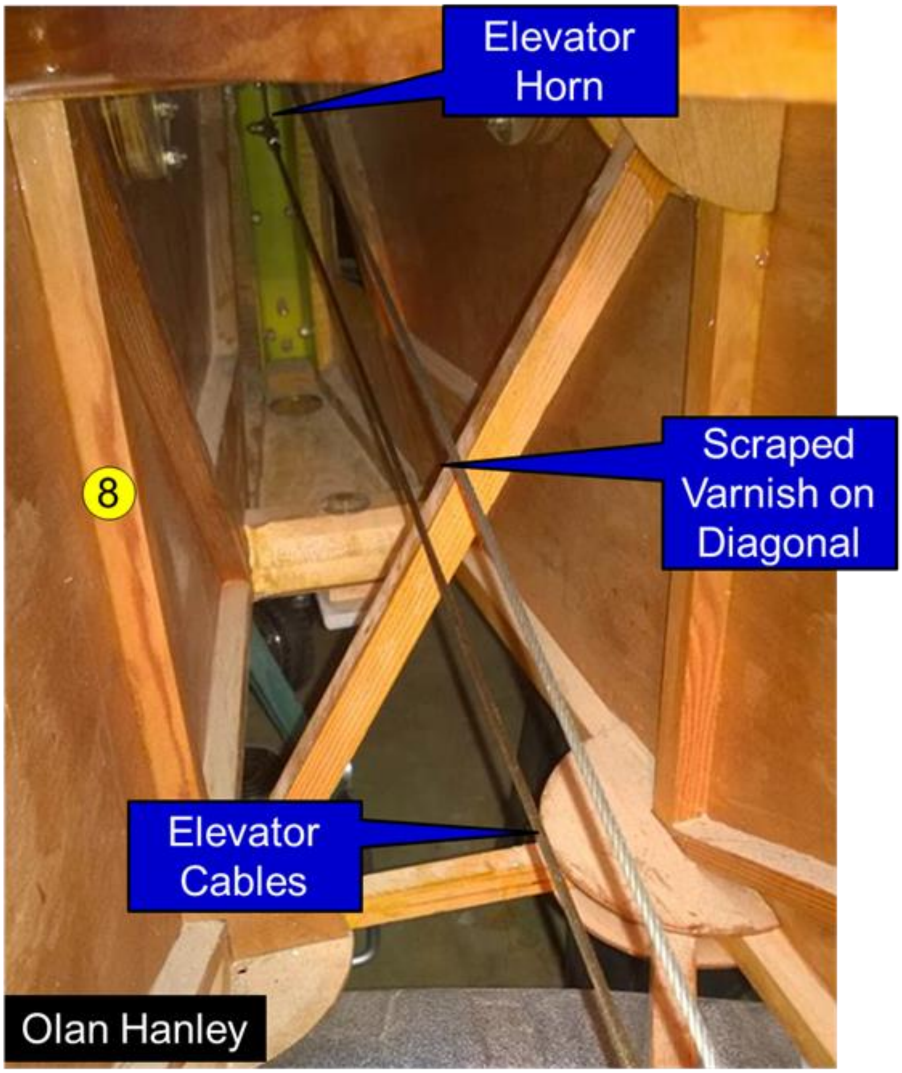
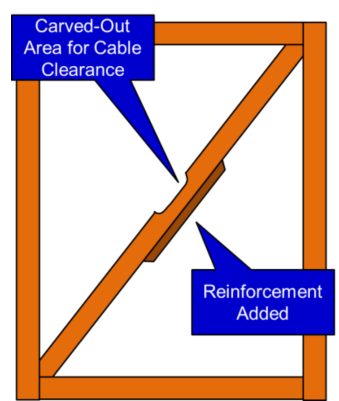


Figure 34: Elevator Cables Scraping on Diagonal

The solution Pete suggested for the rubbing rudder cables solved this issue as well, for at least one builder. When you experiment with the walking beam position, check the diagonal interference as well.

Builders have suggested a couple other solutions for this issue:



1. Add a protective cover of delrin or nylon in the affected area.
2. Use a sander to carve out the diagonal, and add reinforcement to the diagonal opposite to the relieved area. If the diagonal

has been varnished, sand away the varnish in the areas where the reinforcement will be added.

Back in the guide for the fuselage construction article, I recommended waiting to varnish this diagonal just in case changes were needed. Once this issue is resolved, don't forget to varnish the Station 8 diagonal.

4.4 Pushrods

Figure 35: Relieving the Diagonal for Clearance

This section provides details on the individual pushrods

4.4.1 Elevator

The elevator pushrod is depicted on Figure 6-5 on Page 11 of the article. While the aileron pushrods have slight bends, and the aileron link is perfectly straight, the elevator pushrod has some significant bends.

Figure 36 shows why: The pushrod has to make a major deviation to miss the Station 4 bulkhead located just ~5 inches aft of the rod end bearing. The angles required are too acute to try to bend the tube; Pete has you build the pushrod out of three sections of 1/2" steel tubing.

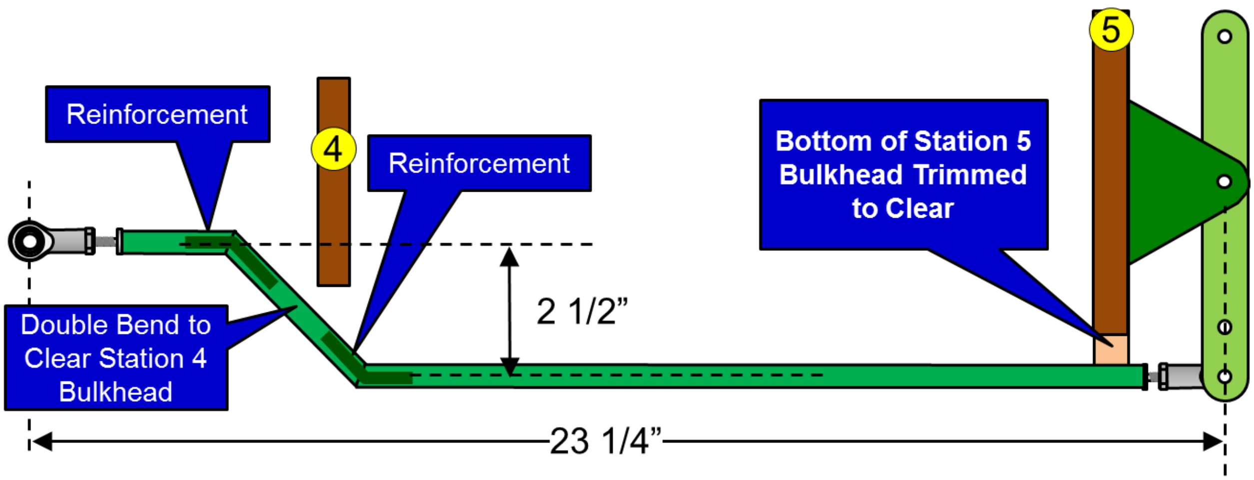


Figure 36: Elevator Pushrod

This has a number of ramifications. First, sharp angles at the weld will be weak; pressure will tend to make them want to bend rather than pass the full deflection of the stick back. So Pete has you weld plates to either side of the angles to reinforce them.

Second…well, this angle makes sizing this pushrod a bit sportier. Not only does it have to match the total length, but it has to have the angles right to miss the bottom of the Station 4 bulkhead.

Obviously, this would be a good place to build a sample pushrod out of cheaper/easy to work with materials to verify that your dimensions are good. One good move would be to just tape the threaded rod ends in place until you're confident of the layout.

Figure 37 shows the recommended starting point. Clamp both the joystick and the walking beam to a vertical position, then screw the rod end bearings onto the threaded rod ends about 5/8" (measure 5/8" from the end, and mark that thread with a Sharpie). Assemble your pushrod, undo the clamps on the joystick and walking beam, and move the stick back and forth to ensure things work and don't interfere.

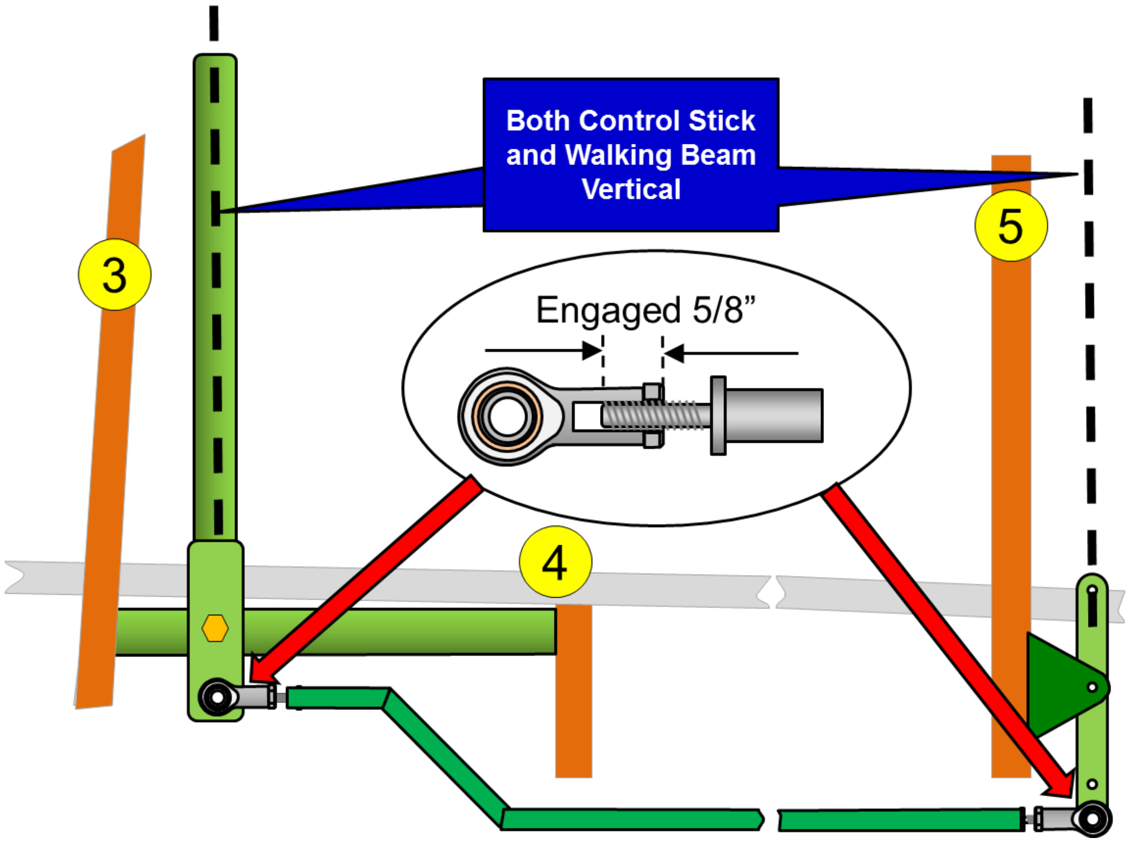


Figure 37: Notional Positioning for Constructing Elevator Pushrod

Note that it is NOT unknown for folks to carve a bit out of the bottom of the Station 4 bulkhead to clear the pushrod tube. I wouldn't do it more than a half-inch or so…that bulkhead is where the landing gear bolts to the plane. Note that the bottom of the Station 5 bulkhead does require a bit of carving out…you can see it in Figure 6-5 of the article.

Happy with the pushrod? Weld/Bolt/Rivet that sucker up. Don't forget to prime and paint the steel.

Now, there's one thing interesting about the elevator pushrod: It's the only one where the rod end bearings get a true workout.

The aileron rod bearings basically handle the minor changes an eight-foot-long pushrod might experience as it shifts back and forth ~2-3 inches, but the elevator bearing accommodate a much broader shift as the stick goes left and right. Figure 38 shows this; note how the rod end bearing has to twist a bit as the pilot works the stick for aileron control.

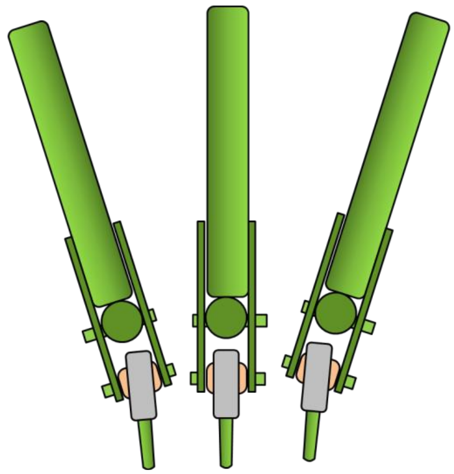


Figure 38: Rod End Bearings Accommodate Aileron Travel

Remember, too, how I mentioned that minor carving out of the bottom of the bulkheads at Station 4 and 5 was acceptable? Check out Figure 39. The elevator pushrod will actually go left and right as the stick is moved for aileron control. So the areas that need to be modified are actually a bit wider than you might first think.

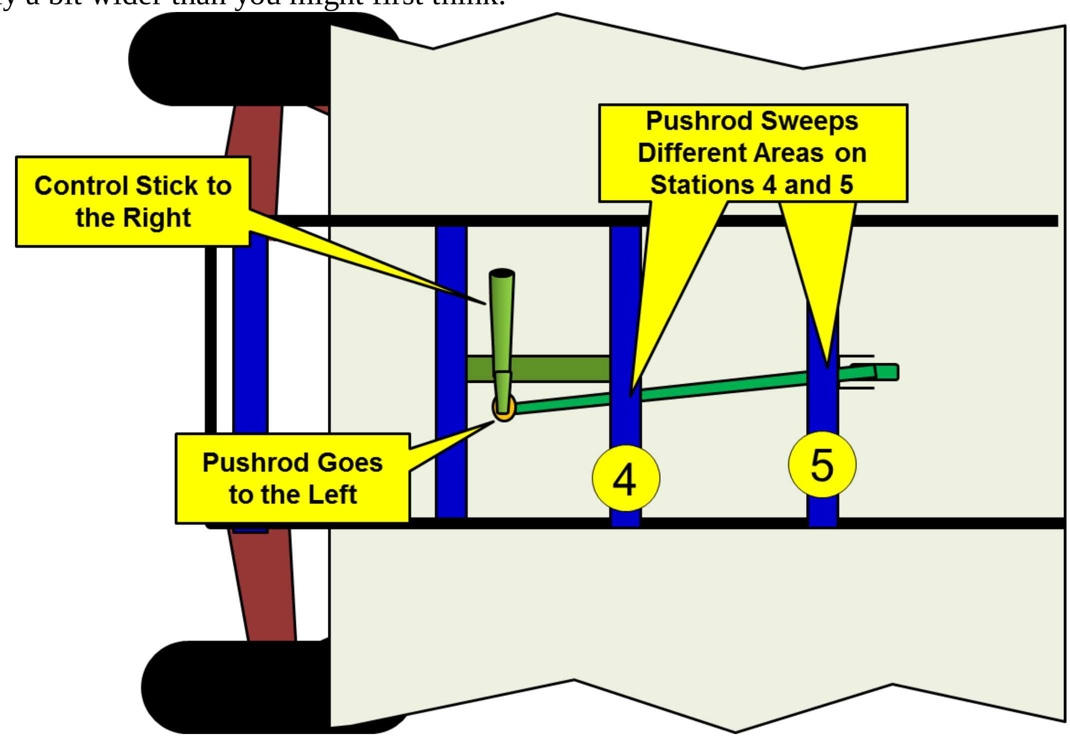


Figure 39: Joystick Roll Action Causes Side-to-Side Motion of the Elevator Pushrod

Don't forget to re-varnish any modified areas on the bulkheads.

Figure 40 shows a completed and installed elevator pushrod.

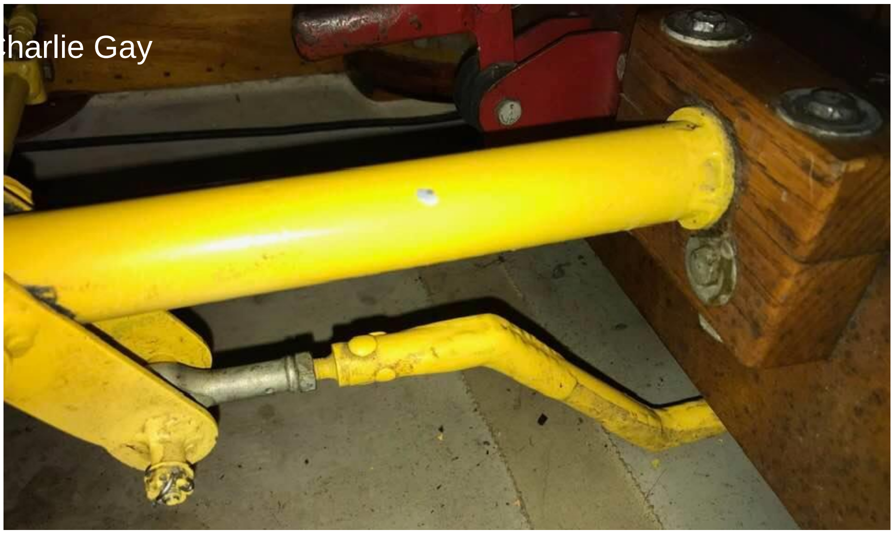


Figure 40: Installed Pushrod

4.4.2 Aileron Pushrods

There are two pushrods for each Aileron. The "Long" pushrod travels span-wise in the wing, transmitting control-stick motion (in league with the Aileron Link) to the aileron bellcrank. The "Short" pushrod goes chordwise, from the bellcrank to the aileron. The system is illustrated in Figure 41.

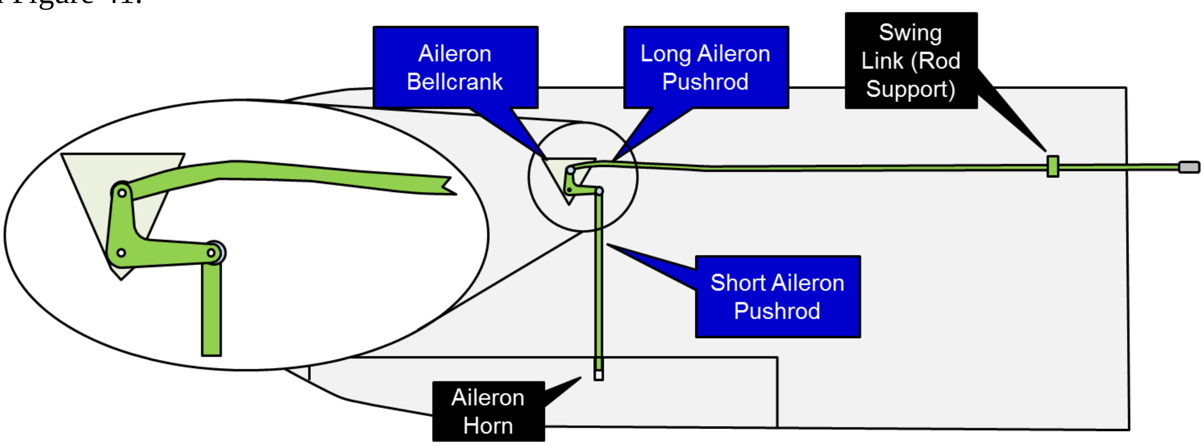


Figure 41: Aileron Pushrods

4.4.2.1 Long Aileron Pushrods

The dimensions for the long aileron pushrods are shown in Detail "B" in Figure 6-4 on page 11 of the Sport Aviation article. Note that the long pushrod is truly long… 95 3/4 inches, just a quarter-inch shy of eight fee. The length has to be built to a tolerance of 1/64".

Nahhh…I'm just messing with you. Because the long pushrod connects to the joystick via the aileron link, length errors of the long pushrod can be corrected with the much shorter aileron

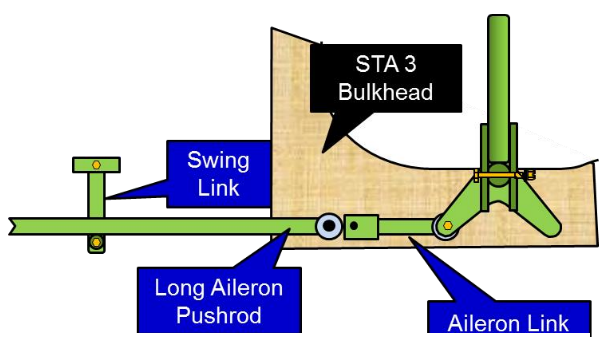


Figure 42: Aileron Connections in the Cockpit

link. It needs to stick out of the wing and into the fuselage for several inches once the wing is attached (Look ahead to Figure 45).

Just inside the wing root, the long pushrod is supported by the swing link. However, it's still about six feet to the aileron bellcrank. That's a long run of unsupported tubing (Figure 43). Some builders add bushings at one or two the ribs, where the tube passes through. Obviously, one has to be careful not to bind the tube and restrict the aileron motion.

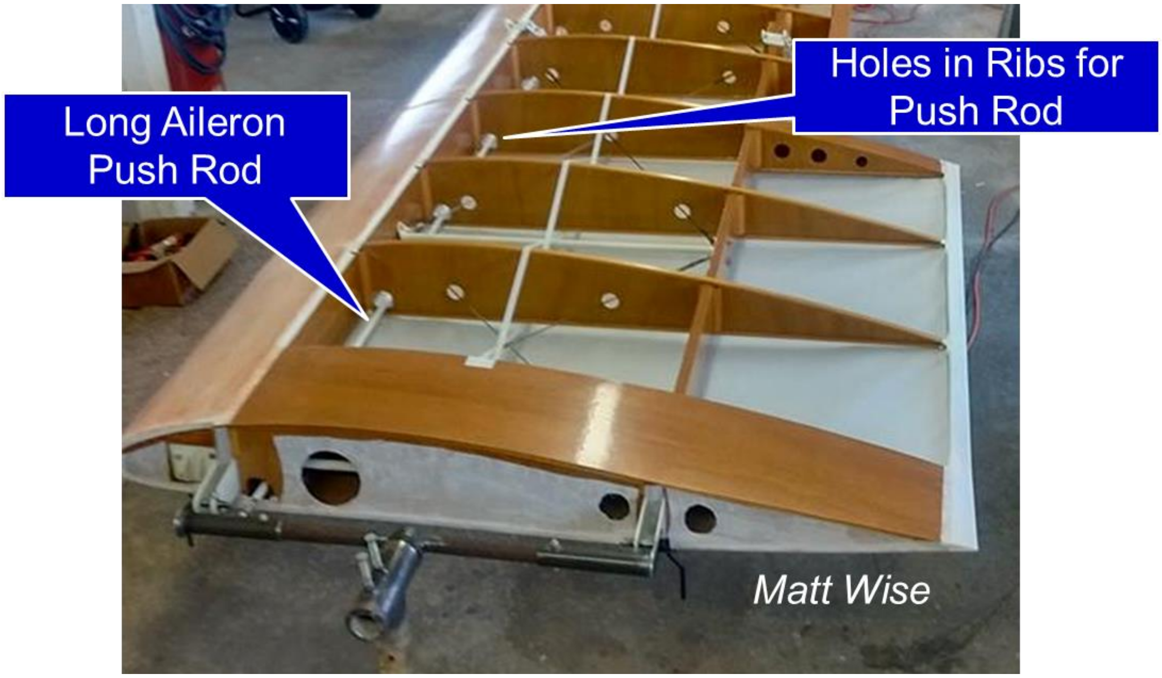


Figure 43: Long Aileron Pushrod in Wing

Install the rod ends in the same fashion as the elevator pushrod.

Figure 6-4 in the article shows the very slight bend in the end of the long aileron pushrod. This is only a half-inch off the centerline, and gives the short aileron pushrod a bit more clearance when the aileron goes down to lift the wing.

4.4.2.2 Short Aileron Pushrod

The short aileron pushrod is illustrated in Detail "C" of Figure 6-4. *Why* it has its wavy shape should be obvious from Figure 44.

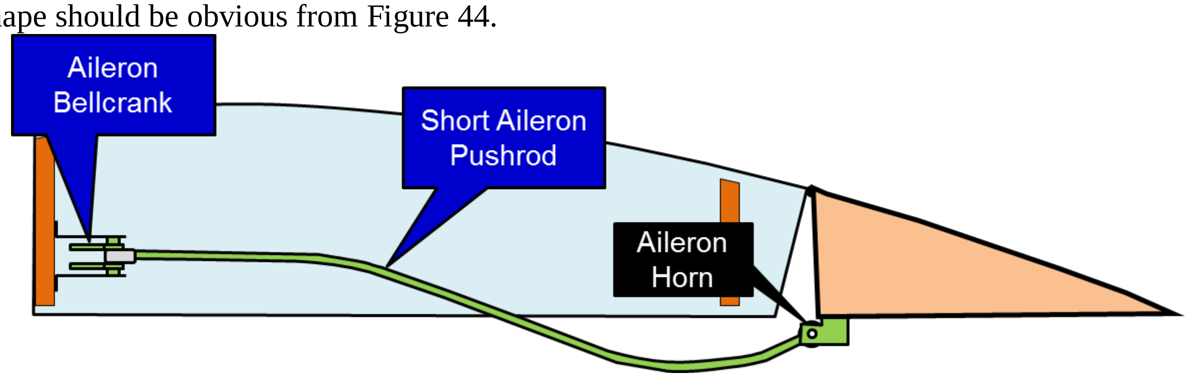


Figure 44: Short Aileron Pushrod

Figure 6-4 shows both rod ends flat to the page, but of course, the end that attaches to the bellcrank is turned horizontally.

When sizing the short aileron pushrod, block the bellcrank in the middle position (long arm parallel to wing spar) and size the short aileron pushrod so that the aileron is in the neutral (e.g., level) position. Like the elevator pushrods, screw the threaded shaft of the rod end about 5/8" into the rod end bearing when sizing the pushrod. That'll give you plenty of ability to lengthen or shorten the pushrod should it later become necessary.

4.4.2.3 AILERON LINK

The purpose of the aileron link (Figure 45) is to connect the long aileron pushrod to the control stick. Sure, the long aileron pushrod could have been made ~eight inches longer and eliminated the separate link. But it would have been difficult to bend the long tube just right to hit the aileron yoke on the control stick. Using a separate link means the "bend" is handled just by the clevis pin through the forked end of the link.

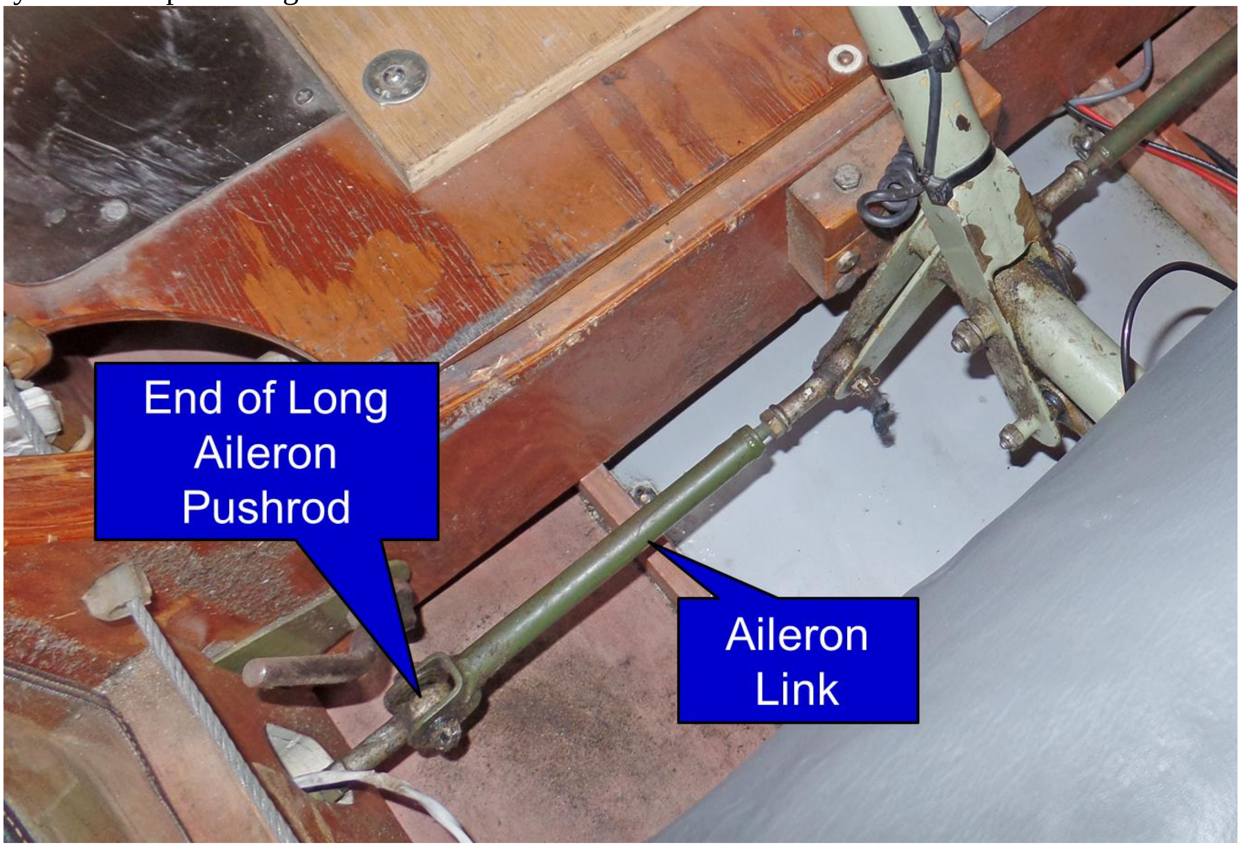


Figure 45: Aileron Link

The clevis pin is there for quick disconnection of the ailerons when folding the wing. If you don't intend to fold the wings, feel free to use an AN3 bolt and locking nut.

At this point, one might expect to connect up all the pushrods and get them properly adjusted. However, the actual relationship between the fuselage and the wings isn't set until the "Assembly" article, number 12. So let's hold off for now.

However, there's one thing that should be verified at this point: The hole in the fuselage side where the long aileron pushrod enters the fuselage to connect to the control stick.

The shape, size, and location of the hole were defined in Figure 1-7, included in Article 3. Figure 46 highlights the aileron hole. You'd like to test-fit each wing to ensure that the hole lines up where the aileron is coming through. Install each wing, inserting the spar pins, with a saw horse holding the wing at its approximate 3º dihedral angle. Connect the long pushrod and the aileron link to the control stick, and push the stick left and right. If the long pushrod contacts the edge of the aileron, modify the hole as needed. Don't forget to re-varnish.

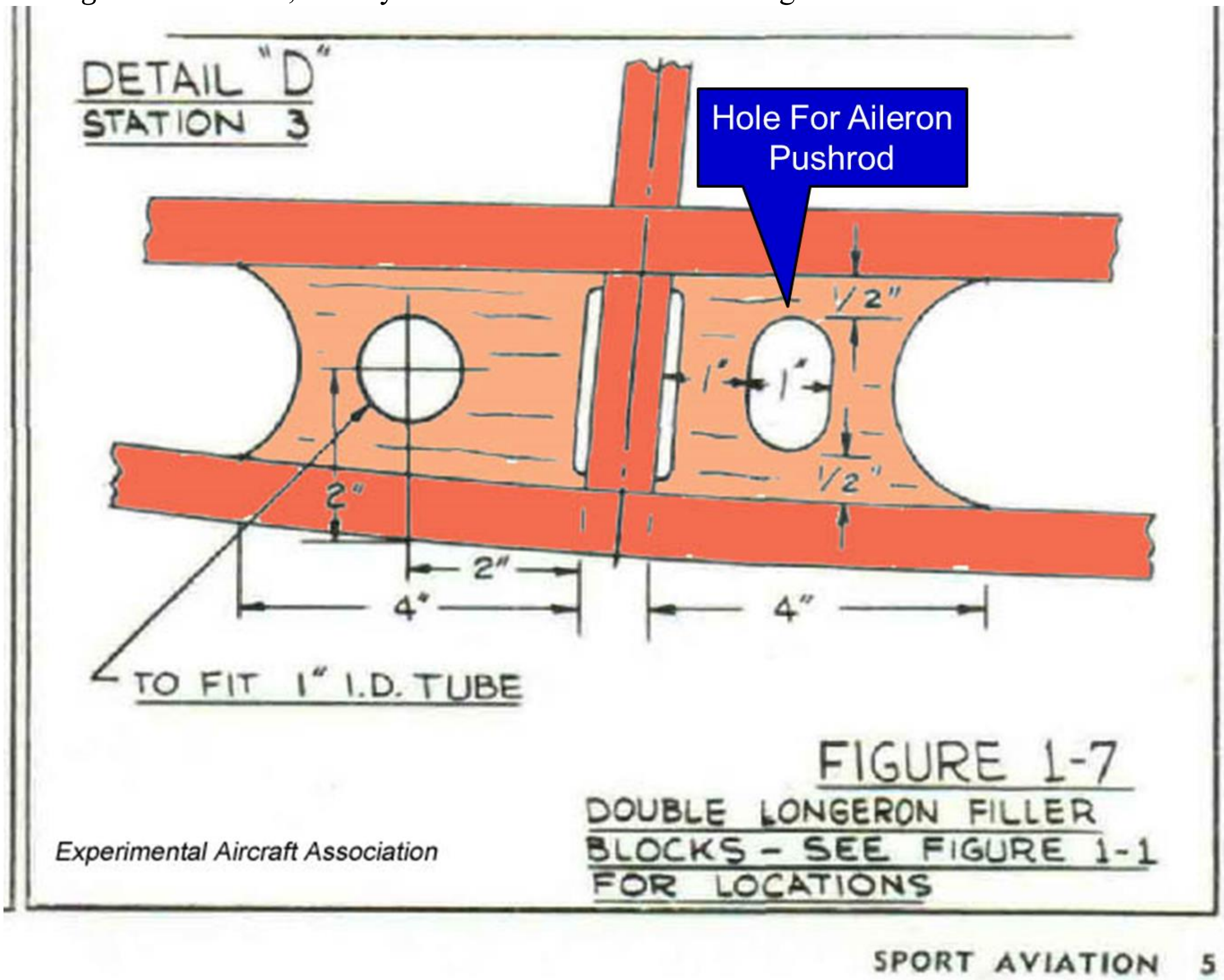


Figure 46: Hole for Aileron Pushrod in Fuselage

4.5 Rudder Control

Most of the hardware associated with rudder control is located in the cockpit area. The hardware in the cockpit is illustrated in Figure 47.

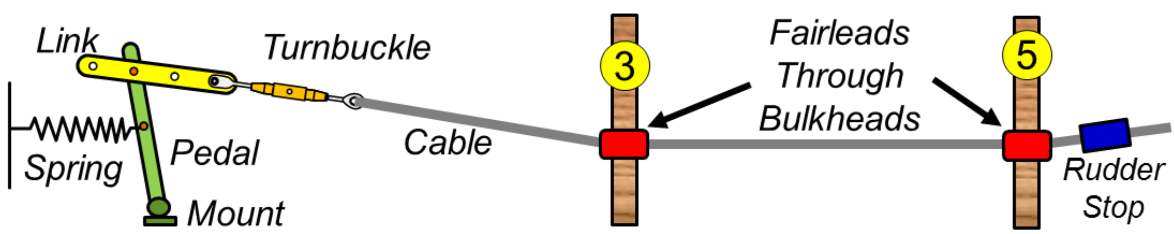


Figure 47: Rudder Controls – Cockpit Area

The link allows adjustment of the pedals for pilots with different leg lengths. Obviously, you probably won't need it during your ownership of the airplane, but if you ever sell it, the new owner will thank you for it. Plus, right now, you may not really know where you want to be. It's simple enough to include the adjustment link.

The spring exists only to keep the rudder pedals from flopping back onto the floor when your feet aren't on them. It's not likely to happen in flight, but the spring beats having to try to hook your feet underneath the pedals to flip them upright when you get into the airplane.

With the spring and the adjustment link, the turnbuckle on the rudder cable doesn't have really all that much use. Turnbuckles are used to make cables tight…and, because of the spring, the rudder cables are NEVER tight. Some builders have eliminated the turnbuckles on their rudder pedals and saved $70.

The cable itself is standard 1/8" aircraft control cable. To keep the cable clear of the cockpit area, holes are drilled in the Station 3 and Station 4 bulkheads. Just behind the Station 5 bulkhead, a set of wooden blocks are installed on the cable for control stops.

The cable connects to a steel horn on the rudder, through an elongated exit hole in the fuselage. At the very bottom of the rudder, a second horn provides tailwheel control (Figure 48).

The following sections provide more information on the construction of these elements.

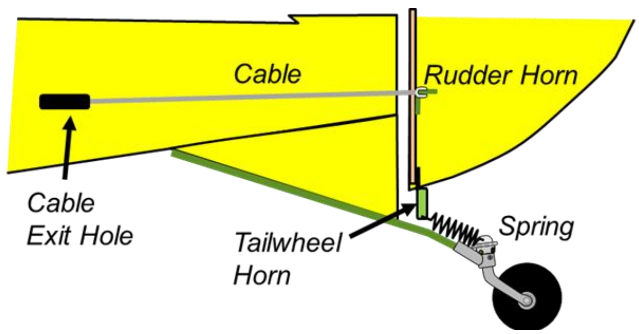


Figure 48: Rudder Connectivity

4.5.1 Rudder Pedal Assembly

Pete provides a diagram showing the construction of rudder pedals in Figure 6-2 in Article 8. They're pretty simple…just an inverted "U" of steel tube, with short crossbars at the top to allow them to be attached to mounts that secure them to the cockpit floor.

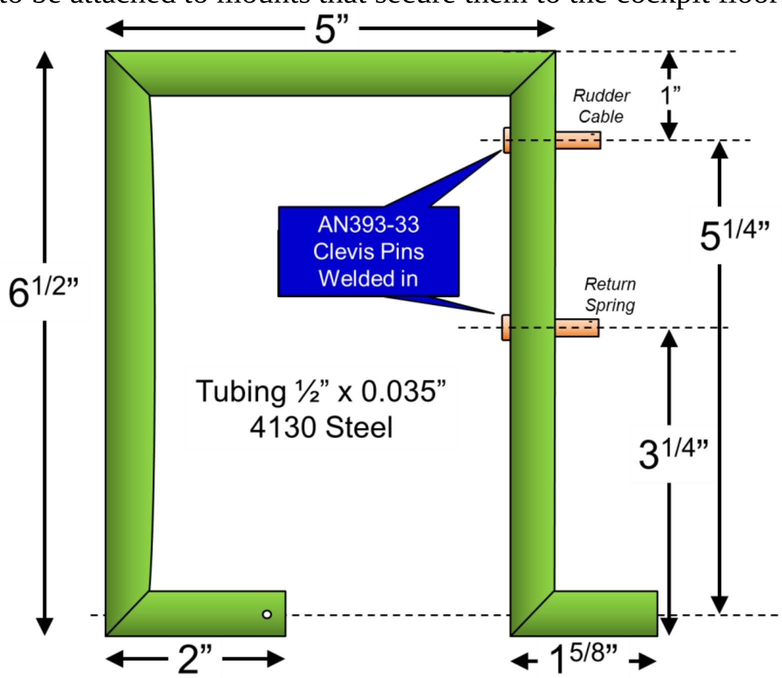


Figure 49: Stock Fly Baby Rudder Pedals

The pedals attach to the cockpit floor using small brackets made from sheet steel and a short piece of tubing with an inside diameter of 1/2". The "crossbars" of the inverted-U of the rudder pedals slip into these, and the brackets are bolted to the floor. These brackets are about 1

5/8" wide. One of the crossbars is a bit longer; a separate short bit of tubing is used to hold the rudder pedal in the bracket, with a cotter pin to secure it.

The rudder pedals includes two posts pointing outboard. The upper one is for the adjustment link that attaches to the rudder cable, and the lower one is for the rudder return spring. Figure 50 shows the rudder pedals attached to the forward cockpit floor, with the adjustment links lying in front of them. The springs are attached to the back of the firewall bulkhead by eyebolts.

Figure 50: Standard Rudder Pedals

Speaking of the spring, there's nothing "aircrafty" about it. Any sprint that'll hook over the post and attach to the eyebolt is fine. Although Aircraft Spruce does sell a rudder return spring for $6.

Now…one little thing you might have noticed about the above picture: "WHAT cockpit floor?!!!" The cockpit floor is actually defined and constructed in the NEXT Sport Aviation article. So skim ahead and make a floor per the diagram there. Don't permanently attach it, yet.

Pete's rudder pedals are pretty simple, but they aren't the only way to go. You can buy commercial pedals, you can make a different design if you wish. Figure 51 shows another stab at a Fly Baby rudder pedal The wear is because this particular Fly Baby has over 1,500 flying hours…obviously, the pedal design is OK. The little bends on the top keep one's foot from slipping off.

Figure 51: Alternate Rudder Pedal Design

The pedals don't even have to be steel tube…could just take a couple pieces of wood and hinge them to the floor. Make sure they have full travel, though.

If you want toe brakes on your plane (instead of heel brakes) your rudder-pedal work is going to be more complex. Figure 52 shows the rudder pedals with toe brakes installed on my own airplane. I'm not sure where the original builder got these, but I'm told they came from a Cessna 140.


Figure 52: Rudder Pedals with Toe Brakes

These pedals were designed to be installed on a cross-tube, so the original builder of my airplane had to install such a cross-tube under the floor. Obviously, more complex than a separate rudder-and-heel brake setup.

The key point for these alternate pedals is the distance from the hinge point to the rudder cable connection. As Figure 49 illustrates, the rudder cable (or adjustment link) should attach 5.25" inches above the CENTERLINE of the hinge. If this distance is larger, the pedals move the rudder proportionately more (but due to the increased leverage, the rudder "feel" is stiffer). If the distance is less, the rudder pedals have to move further to work the rudder…in other words, you'll have less effectiveness.

4.5.2 Rudder and Tailwheel Horns

The Rudder and Tailwheel horns both are made from 0.090" steel (minimum size) and are bolted to the spar of the rudder (Figure 53).

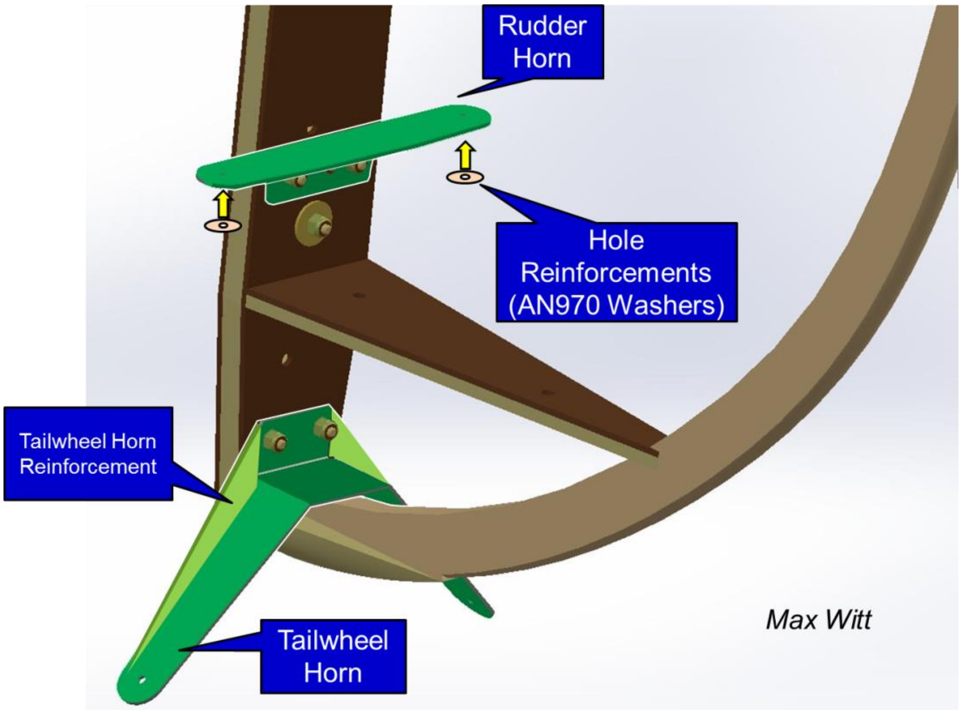


Figure 53: Rudder and Tailwheel Horns

The rudder horn is illustrated in Figure 6-2 on page 11 of Article 8. It's pretty straightforward, but there's one subtle detail to catch: Weld two oversize washers at the rudder-cable attachment holes for reinforcement. These are standard AN970-3 washers.

The tailwheel steering horn is of similar design, but the ends "droop" to give a better angle to the tailwheel control horn (Figure 54).

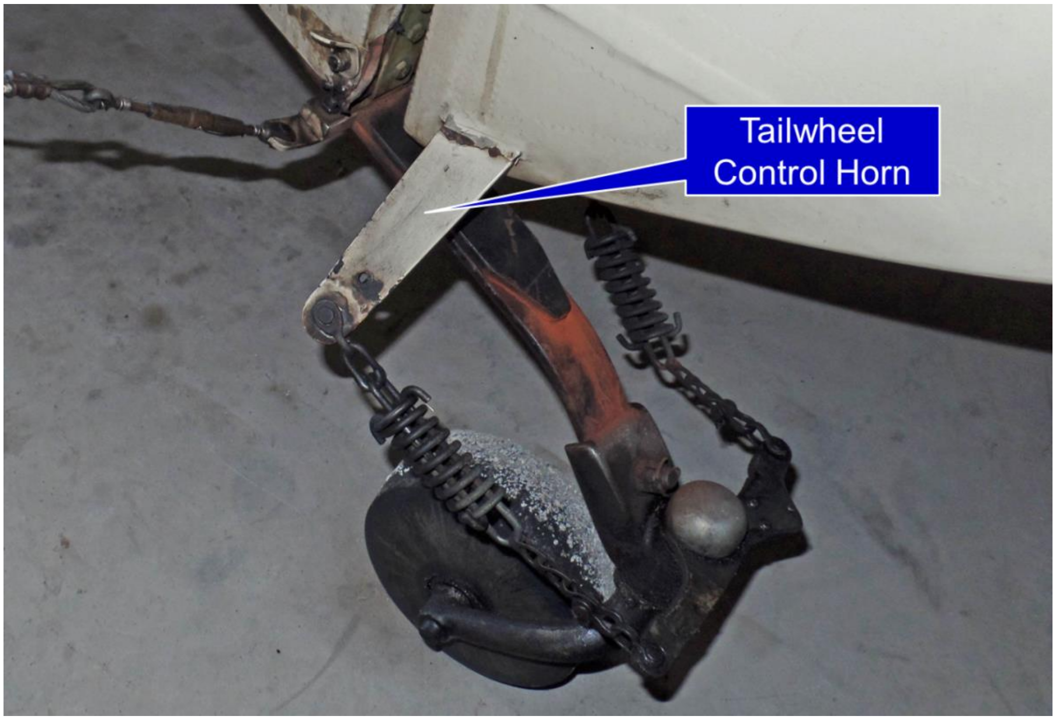


Figure 54: Bend in Tailwheel Control Horn

As described in Section 3.3, the tailwheel horn in the original Fly Baby developed some tears at ~1500 total hours. It's recommended that some reinforcements be added to it during construction. This is shown in Figure 53, but the horn in Figure 54 doesn't have it.

4.5.3 Station 3/Station 5 Rudder Cable Holes

Obviously, there has to be a 1/8" cable running from the rudder pedals up front to the rudder horn out back. Figure 55 shows how the cables are routed. Of course, they can't go through the pilot, so they're routed outboard and towards the bottom of the cockpit. Holes in Stations 3 and 5 manage in the in-cockpit routing.

One thing to notice is the angle the cable takes as it passes through the Station 3 bulkhead (the one in front of the pilot). This is an obvious spot for wear. Standard aviation practice requires a pulley if the angle is more than 15 degrees. But the Fly Baby angle is about 10 to 12 degrees, so a pulley isn't needed.

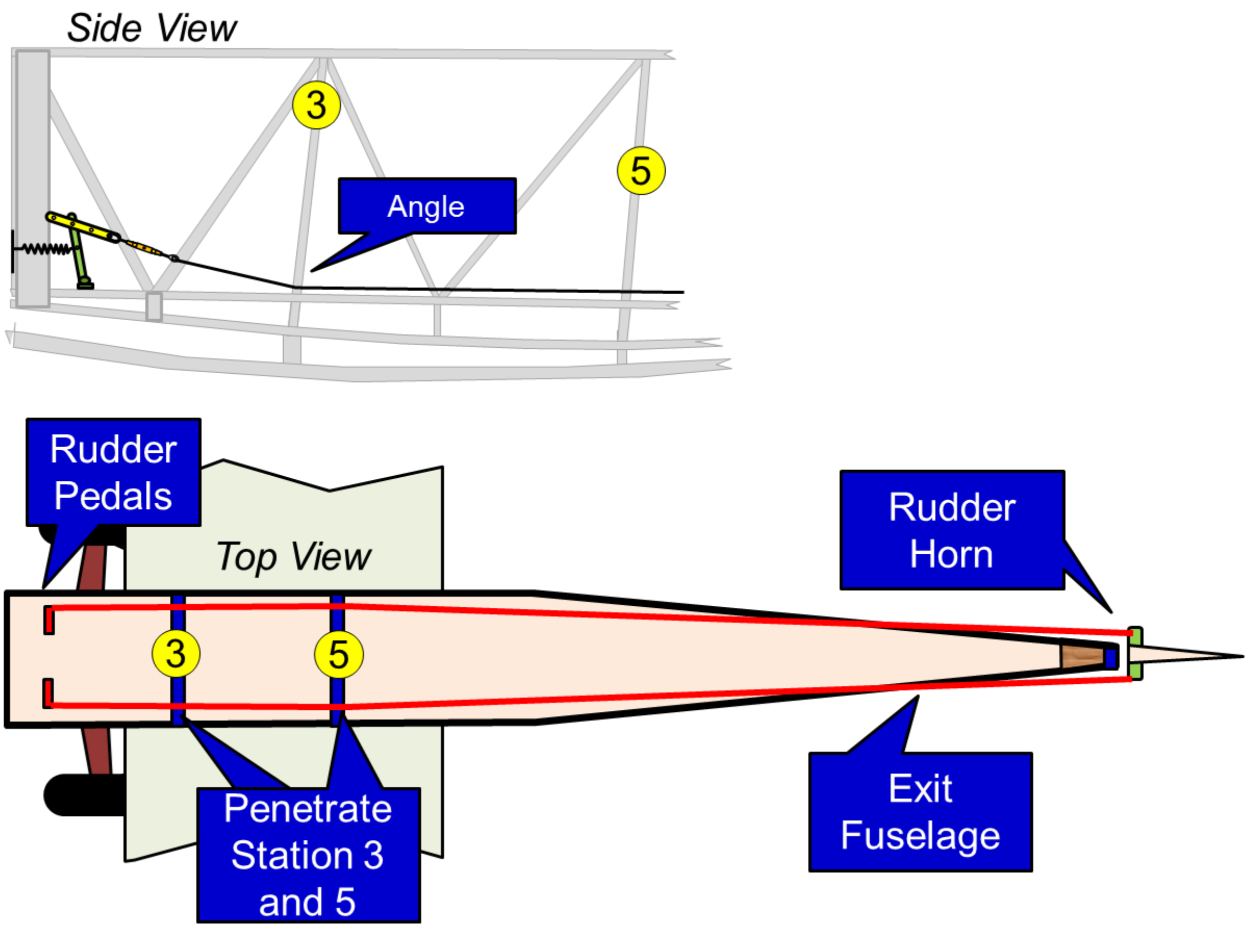


Figure 55: Rudder Cable Routing

Pete just shows the holes through the bulkhead, with no additional protection for the cable. Usual practice, though, is to include a "fairlead" in cases like this where the cables have less than a 15 degree change in direction. These fairleads are usually very smooth, very solid materials that either can the rubbing from the cable and allow replacement as needed.
Figure 56 shows the fairlead mounted in my own Fly Baby. Fairleads like this can be found at Aircraft Spruce for a couple of bucks. They're split, so they're easier to install.

Figure 56: Rudder Cable Fairlead in Bulkhead

4.5.4 Running the Rudder Cables

With the horn on the rudder, the pedals on the floor, and the holes in the bulkheads, it's time to run the cable all the way. Hang the rudder on its hinges. Nicopress a turnbuckle to the end of the cable, and attach it to the adjustment strap at the pedal. Leave the other end free for now. Lead the cable through the holes in the Station 3 and 5 bulkheads (with fairleads in place, of course).

Just after running the cable through the Station 5 fairlead, slip a nicopress sleeve over the cable. This will be used, later, for the rudder stop. At this point, you'll be looking to take the cable outside the fuselage.

4.5.4.1 CUTTING THE SLOTS

A pair of slot are needed in the fuselage sides (Figure 57) to let the rudder cables pass from the inside to the outside (where the rudder horn is). Some precision is needed here, for cosmetic reasons if nothing else. The slots are 3/16" wide and four inches long, and are placed just forward of the Station 7/8 diagonal on the fuselage side.

Figure 57: Exit Slot for Rudder Cable

How high up on the fuselage? Well, here's where it gets fun. Figure 58 shows a summary of the process

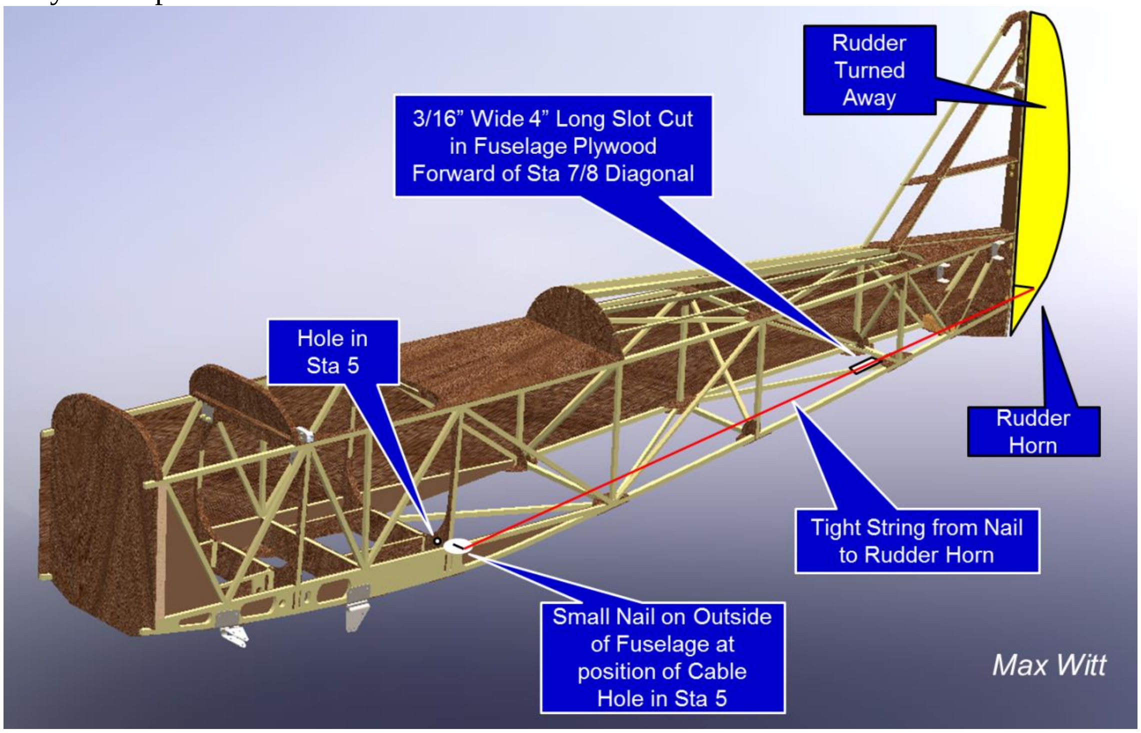


Figure 58: Overview: Marking the Cable Exit

Note the position of the rudder-cable hole through the Station 5 bulkhead, and add a small nail to the outside of the fuselage lined up with the aft side of the hole in the bulkhead. The nail should be at the same height as the middle of the hole, and be aligned with the aft face of the Station 5 bulkhead.

Clamp the rudder all the way to the opposite side, and run a tight string from the nail to the point where the cable attaches to the rudder horn. Using the string as a guide, draw a light line from the Station 7 to Station 8. The string may not actually be touching the fuselage at this point, but use a square to draw its "shadow" on the fuselage. This is illustrated in Figure 59.

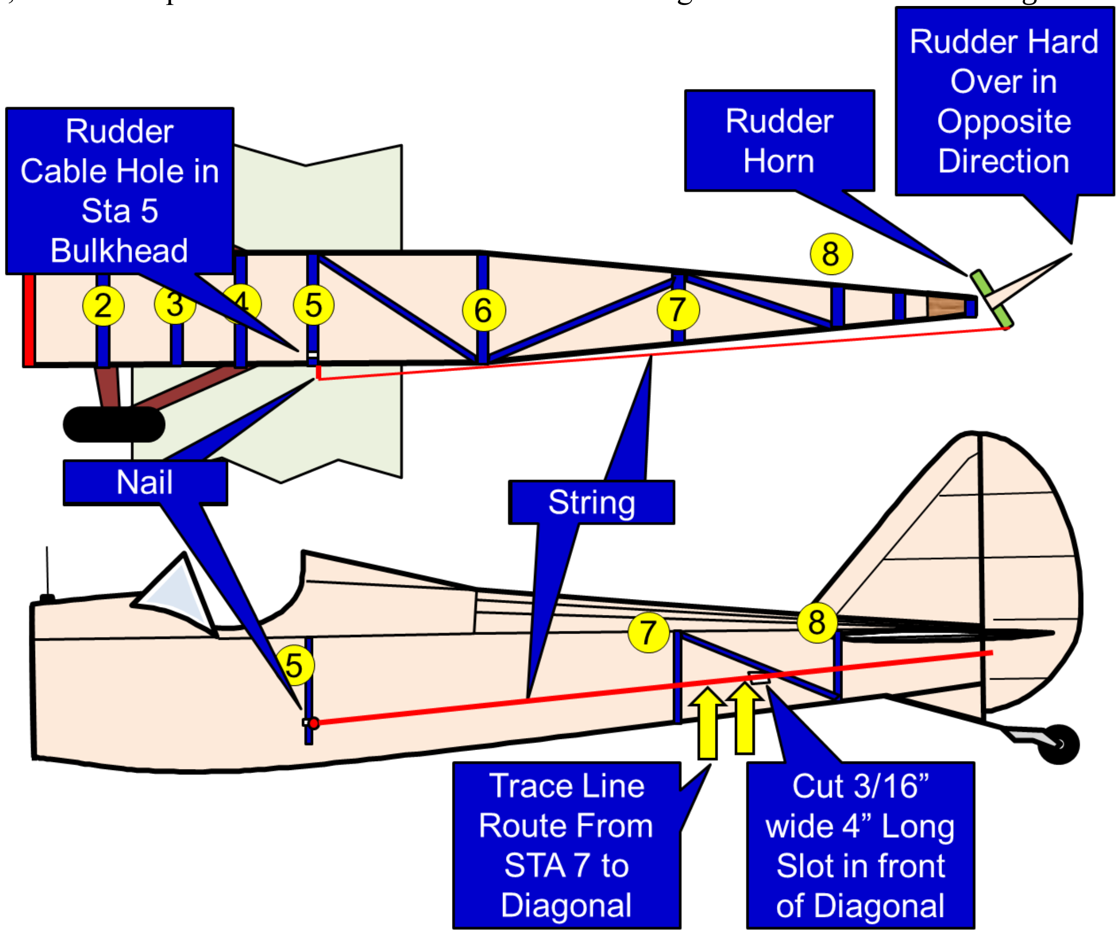


Figure 59: Using a String to Mark the Rudder Cable Exit Point

Now, look on the inside of the fuselage and note the diagonal that runs on the fuselage side between Stations 7 and 8. The slot, nominally, starts just forward of this diagonal and runs four inches along the trace line.

Now, being a wise, cautious individual, you might consider NOT just willy-nilly made that long cut right yet. And I wouldn't blame you.

Consider what's illustrated in Figure 60. Drill a 3/16" hole about two inches (e.g., half the slot length) forward of the diagonal. Then feed the rudder cable through, connect it (temporarily) to the rudder horn, and add some tension to the setup to see where the cable actually wants to be. It should be in roughly the right spot, and you can move the hole up or down slightly as necessary. And, of course, expand it into a full slot when you're confident of the position.

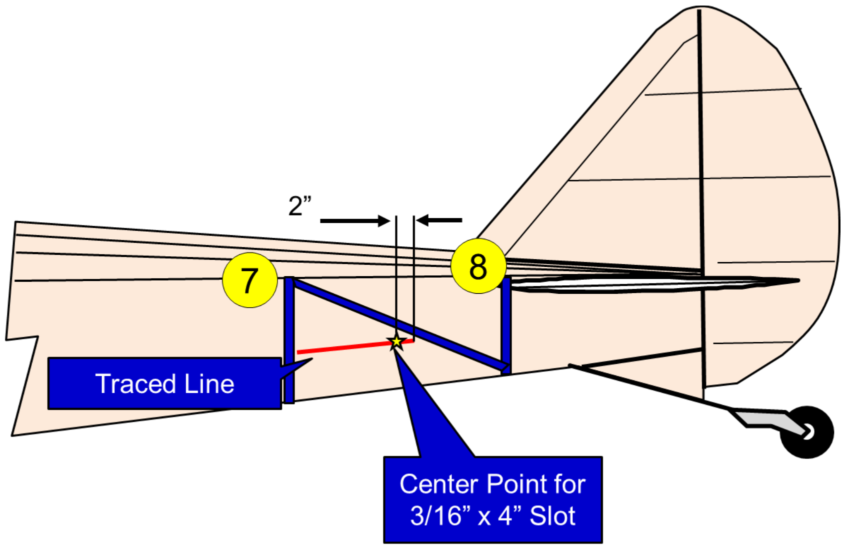


Figure 60: Rudder Cable Slot Center Position

As long as you don’t compromise the longerons, verticals, or diagonals on the fuselage slide, there isn’t any concern about structural solidity. Many builders rout out the plywood in these areas, as seen in Figure 61. So if you have to end up moving the slot slightly…no big deal. You’ll probably want to do some cosmetic fixing if that happens.

Figure 61: Routed Fuselage

Ok, you might think those slots on the side of the fuselage look a bit crude. You can buy fiberglass control cable fairings for about $12 a pair; they make this look spiffy. You can see mine in Figure 62. These will have to be attached after the fuselage is covered with fabric.

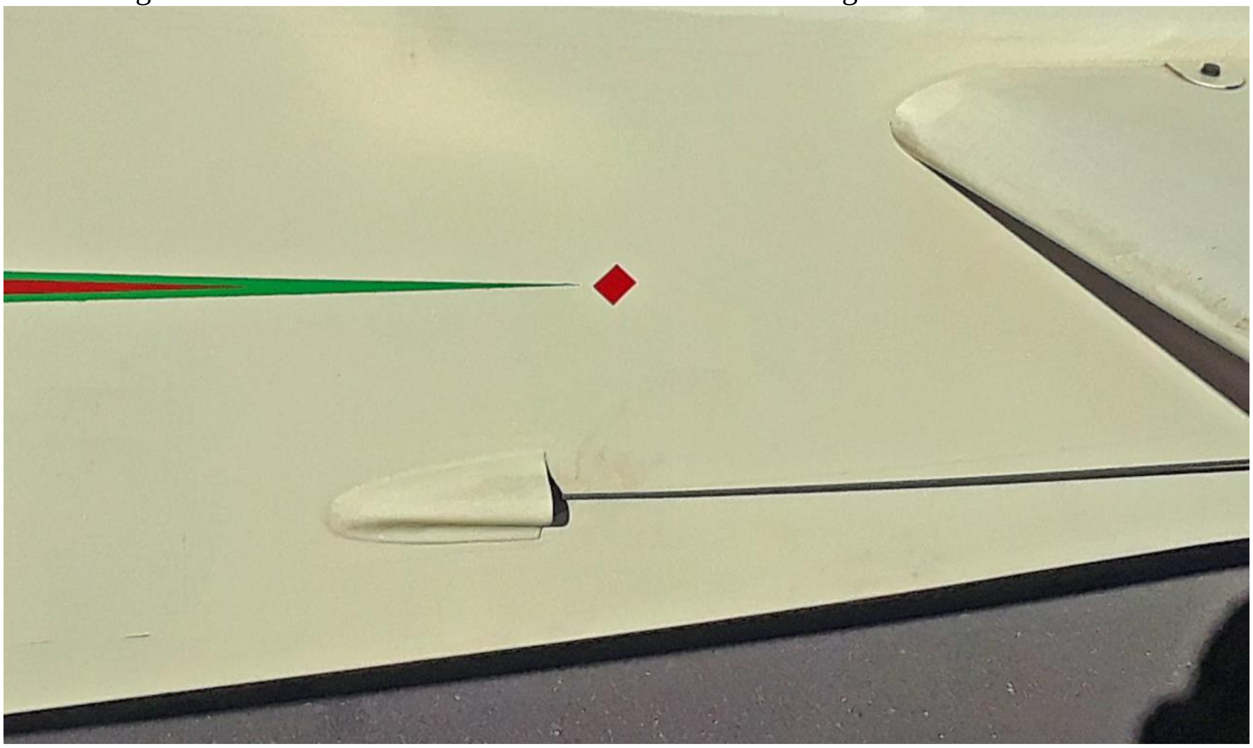


Figure 62: Cable Slot Fairing

4.5.4.2 Rudder Stops

The last step is to install the rudder cable stops. These prevent the rudder and elevators from jamming into each other. The ones Pete specifies look all the world like the cork from a wine bottle. A typical stop is shown in Figure 63.

Figure 63: Stop Installed on Rudder Cable

If you remember, we slid a nicopress sleeve onto the rudder cable just behind the Station 5 bulkhead. This sleeve is what will hold the rudder stop. All the other nicopress operations on the rudder cables should be done at this point, since we're going to establish a hard point on the cable.

Start by putting the two blocks of a rudder stop in the approximate place. Install the horizontal stabilizers and elevators in addition to the rudder. Block the elevators level. Move the rudder until it is one inch from the elevator, and clamp it in place.

From the pedal side, take all the slackness out of the rudder cable…you need it as tight. Attach it to the pedal and have it clamped forward, or just disconnect the cable from the pedal and clamp it tight somehow.

Slide the rudder stop blocks until they touch the back of the Station 5 bulkhead, then slide the nicropress sleeve up to it. Mark its position on the cable, then release the cable and swage the sleeve (assuming you can easily swage is in place. Move the rudder over to the other side, and repeat on the other cable.

The basic goal is to ensure that the cable stop prevents the rudder from coming closer than one inch to the elevators. In the plans, Pete said to set things up so that the rudder pedal is 2.5" forward when the rudder stop makes contact. With the adjustment link and the turnbuckle, I don't think the actual 2.5" measurement is important, but it's a good target. Figure 64 shows the basic process.

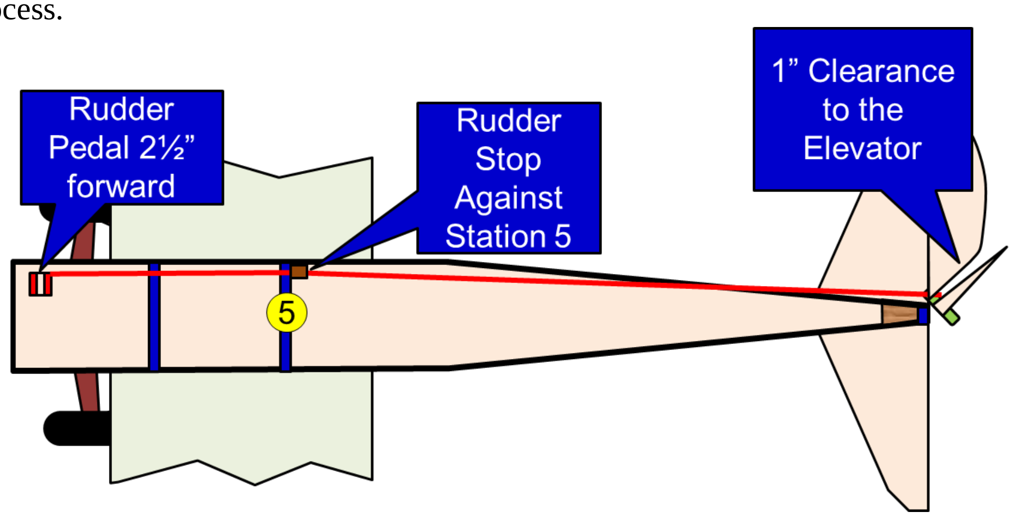


Figure 64: Rudder Stop Installation

5 ALTERNATE APPROACHES

5.1 Ball-Bearing Control Stick

The control stick for the Fly Baby is a rather crude device; an ordinary bolt is used as a pivot for the elevator control.

Most builders find this adequate, but Fly Baby owner Hans Teijgeler wasn't satisfied. He modified his stick to include ball bearings.

Here's his story:

I've always had some sideways play on my control stick. Not terrible, but enough to annoy me and to distract from the tight handling of my Baby (Somewhere around 1/2 inch at the top of the stick).

Earlier, I've tried a slightly thicker bolt. This worked in that it removed all play, but all but locked up the elevator control. Not good.

And so I've made this little modification: an 8 mm pin that is tight in the torque tube as well as tight in some 8 mm bearings. These are the same type of hearings as used in skateboard wheels etc and cost me $2.50 for the pair. Welded on two rings onto the control stick, 21.9 mm ID, to encapsulate the 22.0 bearings very snugly.

Result of two hours of work: play is gone... Mission accomplished.

I've since flown half a dozen hours with the mod and it's brilliant! Not only has the play disappeared completely, it has also made the pitch feel so much more refined. And that while pitch breakout forces were minimal to start with. This aspect has really surprised me.

If I were to build a new Baby, I'd definitely put these bearings in!

I've includes a couple of Hans' pictures, as well

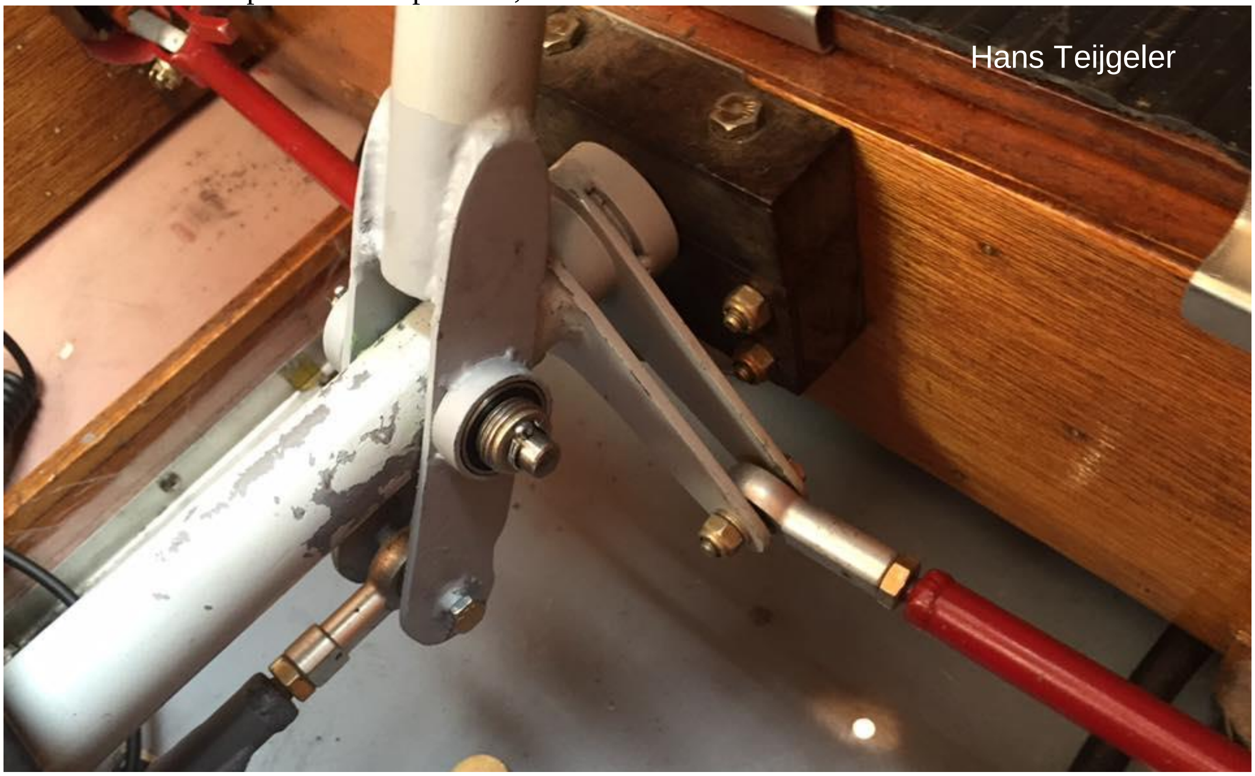


Figure 65: Ball-Bearing Control Stick

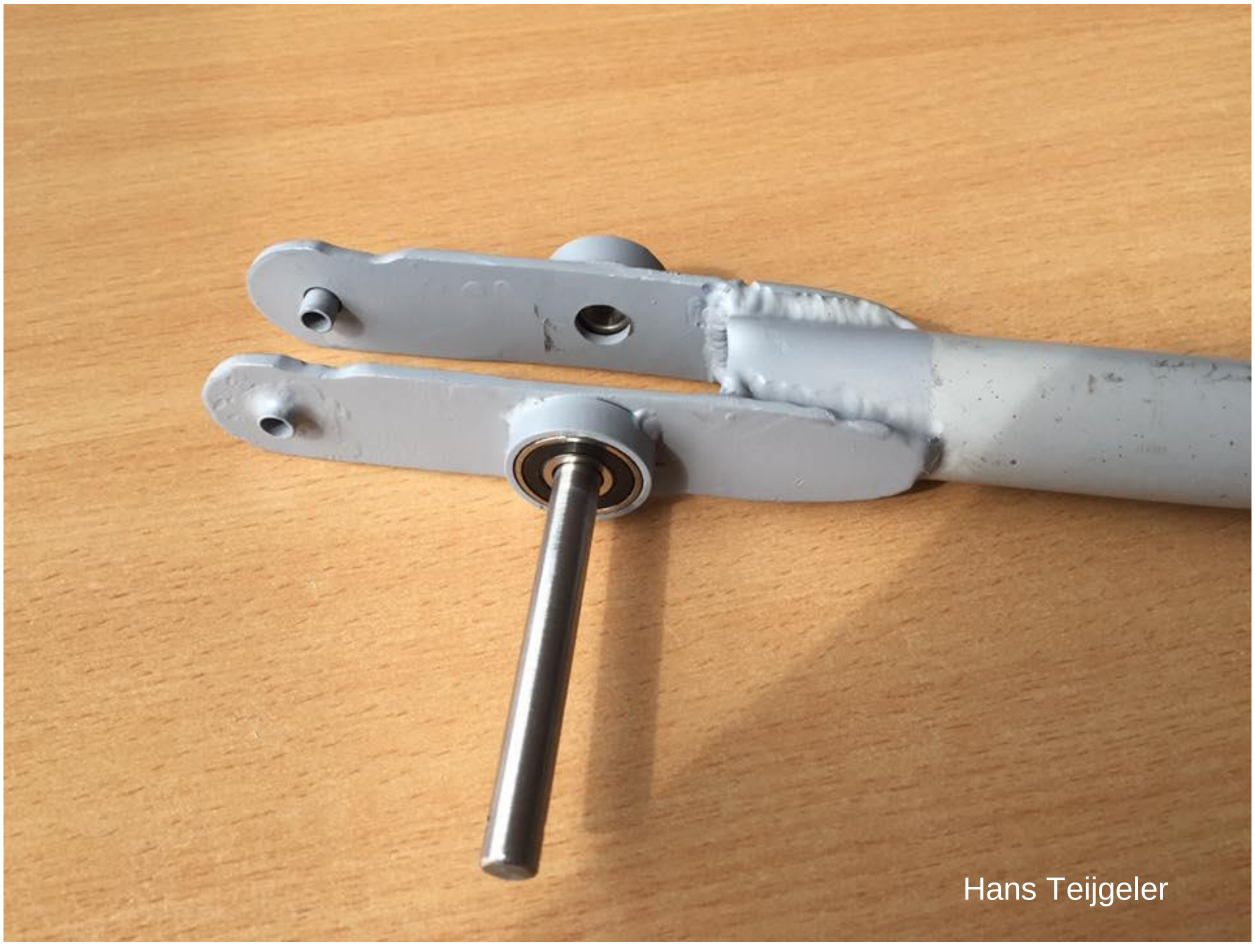


Figure 66: The Bearings are the Kind Used in Roller Skates

5.2 Cockpit Floorboards

The stock Fly Baby includes a pair of floorboards forward of the Station 3 bulkhead (the instrument panel bulkhead. These are described in the next Article, number 9.

The area around the control stick is left wide open. This gives good preflight visual access to the control stick, key linkages, and the wing spar pins (Figure 67). Most Fly Babies are built this way.

However, there are a few owners that don't like the "crude" look, and have added a floor in the control area as well. There are aspects of this I like…it gives a much nicer look to the cockpit, and if you run guests into and out of the cockpit, they won't be trying to stand on your aileron linkages.

There are a couple of drawbacks. If you intend to fold your wings relatively often, you're going to have to pull the floorboards out to access the wing pins. The floorboards will also hide the control stick linkages, which means finding any issues during preflight will be more difficult.

The biggest caution is the "hole" in the floor. If something… glove, cell phone, chart, eyeglass case, etc…. it could block the stick. Depending on the circumstances, you might not be able to recover the item before some bad things happen.

Figure 67: Open Floor

If you do add a floor over the central area, include a "boot" on the base of the stick to prevent stuff from going down. You can see an example in Figure 68.

Figure 68: Cockpit Floorboard with "Boot"