Companion Guide: "Building Fly Baby"
Article 5: The Landing Gear

EAA SPORT AVIATION May 1963, Pages 4-8

Version 1.2

By Ron Wanttaja
and the Fly Baby Community

This Companion Guide is written to accompany the fifth of Pete Bowers' Fly Baby construction articles in EAA SPORT AVIATION magazine. The previous two articles constructed the fuselage; the fifth article builds the landing gear the fuselage stands upon.

You will need to download these articles from the EAA Archives to actually build the wings. 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, and the others of the Fly Baby community for providing some great pictures to illustrate the points in this Guide. Special thanks to Drew Fidoe for his information on tailwheel setup, and Andrew Armstrong for his suggestions on building the gear Vees.

TABLE OF CONTENTS

List of Figures

1 OVERVIEW

Just the landing gear?

For some airplanes, perhaps. For the Fly Baby, though, the main landing gear is a fundamental component of the load-bearing structure. In plane English, a properly-built landing gear is necessary to hold the wings on.

Got your attention?

1.1 Fly Baby Wing Bracing

To start with, let's take care of a little basic terminology. There are two primary types of bracing wires on the Fly Baby: Landing and Flying wires. Landing wires attach to the top of the wings, Flying wires attach at the bottom (Figure 1). You'll see it's the landing gear legs (the "Vees") holding the whole assembly in place. The wing support structure includes the landing gear Vees, the axle, and BOTH the landing and flying wires.

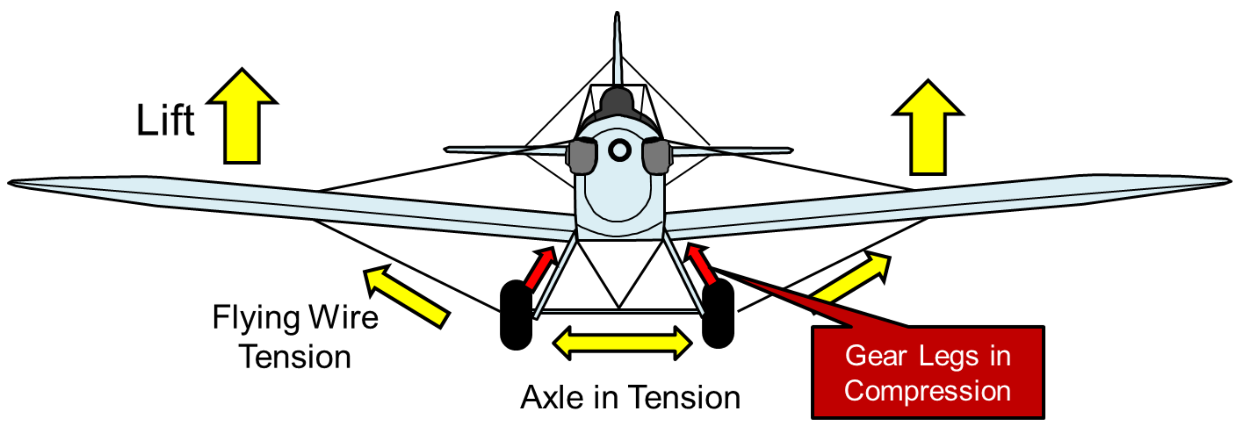

Figure 1: Fly Baby Wing Bracing

If you follow one set of flying wires out from one wheel hub, you'll see the loads go into the bottom of the wing, then out the top via the Landing wire. The load crosses the cockpit via the Master Turnbuckle, down the Landing wires and the Flying wires on the opposite wing, then across the axle to the wheel hub where we started the process. I call it a "closed-loop" bracing system.

Think of when you were a kid, and wanted to build a tire swing. You could climb a tree, tie one end of a rope on a limb, then climb back down and tie the other end of the rope to the tire. Or...you could tie one end of a long rope to the tire, throw the other end of the rope over the limb, and tie it to the tire as well. It's a lot easier to do, and just as strong as the first method.

The Fly Baby bracing concept is similar. However, just like the tree is essentially immovable, the Fly Baby needs a rigid section to anchor its bracing. That's where the landing gear comes in. The gear is composed of the most effective structural element: Triangles. The gear legs, the axle, and the bracing wires all combine to produce a rigid base for the rest of the rigging.

That means the gear system has to be built properly…or the wings won't be adequately supported.

1.2 Landing Gear Philosophy

In Article 5, Pete spends half the first page justifying the…well, let's say it… crude landing gear design for the Fly Baby.

A Neanderthal's stone axe was crude, too, but it got the job done.

There are two main drawbacks to the Fly Baby's landing gear. First, there is no shock absorbing capability. There are no bungees, no spring steel, no oleo.

So landing a Fly Baby requires a slightly better touch. Drop it in, and it'll slam.

As can be seen in the recommendations for flying a Fly Baby, one should perform wheel landings for the first ten flying hours. This gives the pilot a chance to fly the airplane down to ground contact.

But what happens if you blow it?

Nothing. Believe me. See Figure 2, it's a post landing photo of one of my worse days. I stalled it in too high, and the plane hit the runway hard, in three-point attitude. The G-Meter is pegged at its maximum setting: Four Gees.

Figure 2: G-Meter After Hard Landing

Damage to the plane? Zip.

The second drawback to the gear design is the axle that runs all the way across the front. Some folks claim the axle will get caught in tall grass.

Perhaps. But how tall does that grass have to be? The axle itself is about eight inches off the ground. You're not likely to find any airport with grass that long, and it would have to be significantly longer to cause a problem.

What are the advantages of the Fly Baby's landing gear? Primarily, it's simple to build, and there's zero issues with setup. On most homebuilts, builders have to carefully adjust the camber and caster of the landing gear. Get it wrong, and the plane acts squirrelly on the ground.

In contrast, the Fly Baby landing gear is a long pipe with wheels bolted to it. Make the gear legs the same size, and pay attention to getting the axle straight when the gear is installed, and you're good.

1.3 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 article, assume the original article sketches are correct.

This is especially true when looking at the sketches of the fuselage trusses. There are subtleties that Pete includes that may not be reflected in this document.

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

1.4 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 Axle Length

There's only one major error in Article 5, but it's a doozy.

On Page 7 of Article 5, look just above the drawing of the shackle and clevis pin at the lower left of Figure 2-5. It shows a dimension for the length of the axle.

It says 6' 1"…six feet one inch. It should ACTUALLY say, 61 inches.

I once saw a Fly Baby built with the 73-inch axle. It wasn't a pretty sight.

So remember: The axle is 61 inches long.

2.2 Axle Diameter

In the plans, Pete says to use a 1.25" outside diameter 0.093 wall thickness steel tube for the main axle.

The 1.25" outside diameter was selected to be able to use J-3 Cub wheels and brakes. Back then, they were stacked up cheap at the aircraft junkyards. Today, they're antiques, and are priced as such.

Use 1.5" outside diameter tubing, instead. 0.095" is available, and would be a good pick.

Note that the tubing at the center of the axle support assembly will have to be resized to match (Figure 3). A tube with a 1.5" inside diameter is necessary.

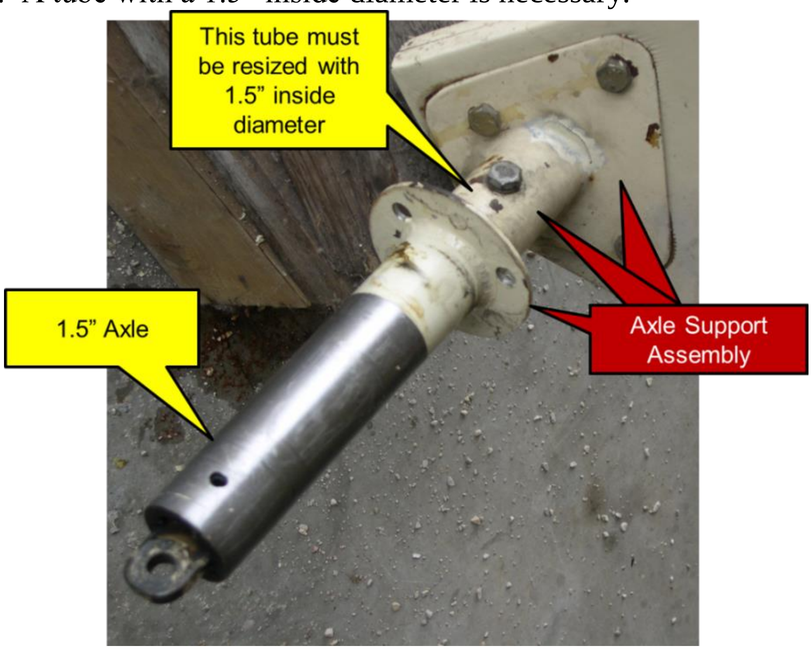

Figure 3: Axle Support Assembly

However, there are still some wheels sold that match a 1.25" axle. You need to know what wheels you'll be using before building the landing gear.

2.3 Main Gear Outer Support Fittings

The main gear outer support fittings (Figure 4) are shown in Figure 2-2 on Page 5 of Article 5. Pete calls for these fittings to be made out of 0.093” steel; that size isn’t easily available anymore, so go to 0.100”.

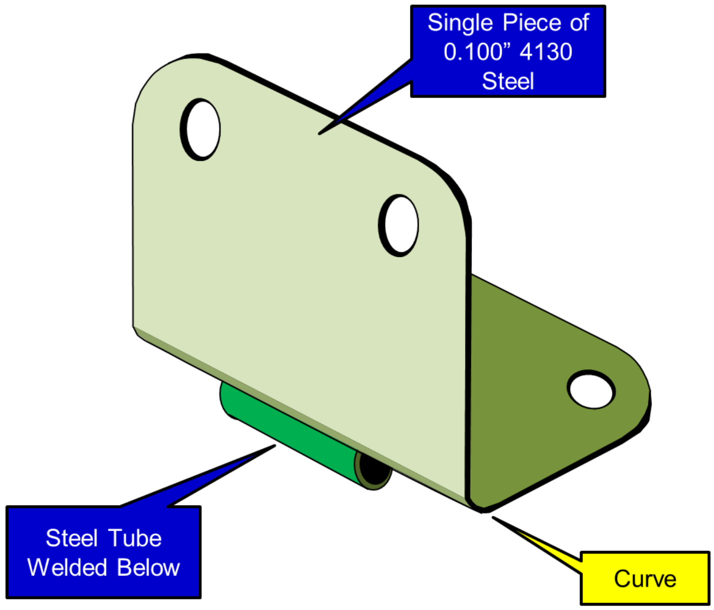

Figure 4: Main Gear Outer Support Fitting

The fitting is made from a single piece of steel, bent on a brake, or even by sticking it in a vice and pounding it over with a rubber or plastic hammer (what Pete calls “cold forming”).

However, there is a little issue here. The bend has to have a slight curve, so you can’t just clamp it in a vice and hammer it over the edge of the jaws. If you do your research online, you’ll see the modern standard for the radius of the bend is at least three times the thickness of the metal being bent.

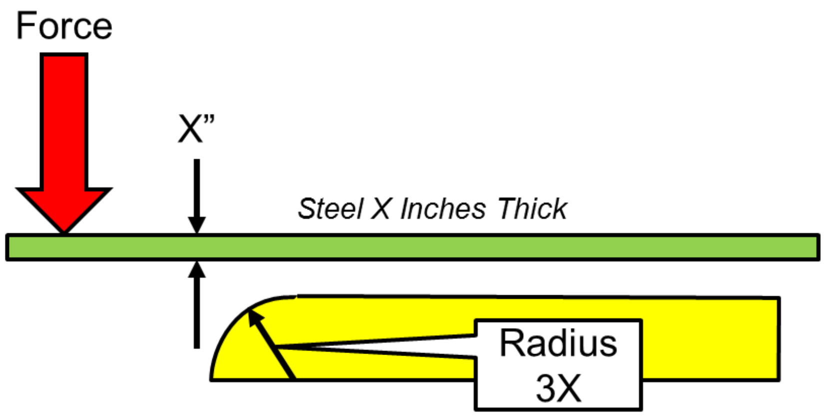

Figure 5: Bend Radius Standard

That’s the modern standard. The reason for this is to prevent the metal from cracking—if the bend radius is too sharp, the metal at the bend will crack trying to accommodate such tight bend.

However, if you look at the cross-sectional view of this bend in Figure 2-2 Detail 2, Pete shows a lot sharper bend than the 3X of the modern standard (Figure 6).

It appears that standard back when the Fly Baby was designed was a minimum bend radius of a single thickness of the metal…not the 3X of today. EAA technical guru Tony Bingelis mentions the 1X radius in both an article in the January 1973 issue of Sport Aviation, as well as in his book "Sportplane Construction Techniques" (Page 44).

Why does it make a difference? Because this fitting is bolted to the lower corner of the forward fuselage. To get a tight fit, the lower part of the fuselage should be shaped to match the inside edge of the fitting.

What to do? If you're building new fittings, I recommend the 0.300" bend radius. If you're working from existing fittings, examine them closely looking for cracks, but I think you'll be fine. I haven't heard of any cracks on these plates on completed aircraft, and I believe most builders have bent their fittings in accordance with Figure 2-2.

Figure 6: Detail 2 of Figure 2-2 (EAA Sport Aviation Magazine)

In addition, a piece of steel tube is welded onto the fitting at the bend. It's quite possible this weld is supporting the fitting and minimizing the potential for cracking.

3 SAFETY ISSUES

There are no major safety issue with landing gear construction—except a repeated reminder of how important the gear legs are.

The legs themselves are four laminations of 1/4" spruce, and it produces one heck of a strong landing gear.

Back in the Companion Guide for Article 2, I mentioned how the laminated wingtip bows are incredibly strong. So are the landing gear legs. Like the bows, one often sees the landing gear still intact in crashed Fly Babies. The gear and its support structure often rips out of the fuselage, still attached (Figure 7). And as mentioned earlier, I once performed a 4-G "arrival" with zero damage.

Figure 7: Intact Landing Gear Post-Crash

On the PLUS side, building the landing gear legs is dead-simple, and there's little opportunity to make subtle mistakes during construction. There's no enclosed structure, there's just alternating planks to be glued together. You don't even have to align the edges carefully, since the Vees are built large and cut down to size. It's a very simple structure, and easy to glue up. If you make a mistake, just throw it in the scrap pile and make another. It's not like you're scrapping a spar.

A final warning: Just because it LOOKS like plywood, doesn't mean you can substitute plywood. I once inspected a Fly Baby (still under construction, fortunately) where a previous builder had substituted plywood for the laminated spruce. You could literally grasp the center of the Vee and flex the wood back and forth.

So don't do that.

According to Article 5, the landing gear Vees can be made from spruce, fir, or pine. Whatever wood is used, it should meet the airworthiness requirements described in FAA Advisory Circular AC43.13-1B, Chapter 1.

4 CONSTRUCTION DETAILS

This chapter is divided into two main parts: The main gear, and the tailwheel.

4.1 Main Gear Construction

Basic construction of the Fly Baby main landing gear can be seen in Figure 8. A 61" long axle runs between the two gear legs. A metal assembly is bolted to the legs to support the axle and the mounting of the brakes. A steel strap slides inside the axle to provide an anchor for the flying wires, and a short section of tube helps holds the wheel in place. At the other end of the gear legs, metal brackets hold the landing gear to the fuselage.

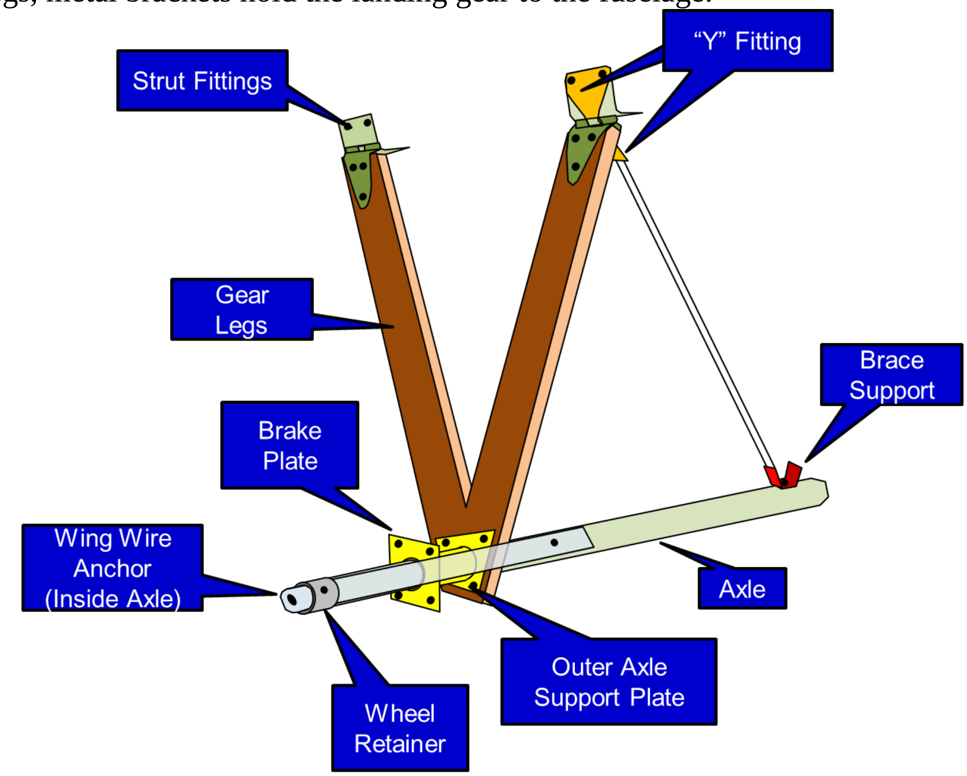

Figure 8: Main Gear Construction

4.1.1 Building the Vees

Let's start with the only wooden components of the landing gear: The struts, usually referred to as the "Vees." These are identical in construction, so build two[1].

Dimensions for the Vees are provided in Figure 2-1 on Page 5 of Article 5. You might wonder why no dimensions are provided in the lower part of the figure, the perspective view of the Vee construction. That's because the diagram shows what the gear legs look like after they've been cut per the top part of the figure. Getting there is remarkably easy.

The Vees are laminated from 1/4" solid wood (no plywood!). I prefer spruce, but Pete does let you opt for pine or fir. Pine is easy to cut but has a propensity for splintering, so I'd recommend the fir or spruce. Whichever is selected, it must meet the specifications for aircraft-quality wood in AC-43-13b.

[1] The two will eventually be cut differently for left and right sides, but the assembly of the Vees themselves is the same.

The legs of the Vees are $3^{3/8}$" wide, but there's some shaping required after the glue sets. Pete recommends cutting the wood 1/2" wider on either side. Let's round that up to an even 4.5 inches.

Cut out four pieces of each size in Figure 9. The lengths shown are approximate; I've left plenty of extra on the ends of the boards. I swear, the people of Pete's generation provided formal funeral services for any left-over scrap of wood longer than an inch. My philosophy is to leave plenty of room for error.

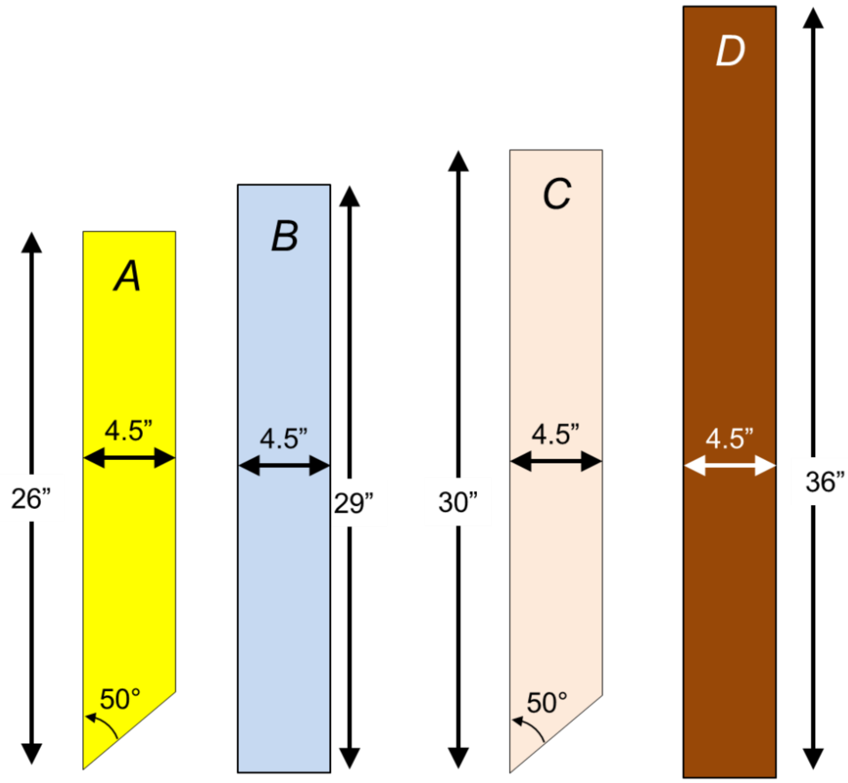

Figure 9: Working Dimensions of Landing Gear Vee Components

4.1.1.1 CUTTING THE ANGLE

The key part is the 50° angle on boards A and B. Pete doesn't actually give a value; I measured this from Figure 2-1.

A miter or radial arm saw would be a good way to cut this angle. Another possibility uses the miter gauge on the table saw.

However, there's a "gotcha" here that you have to be careful about. Figure 10 shows a typical gauge for a miter saw. To cut a 50-degree angle, just set the saw to the 50° setting…right?

Well, no.

The miter gauge for miter saw or the miter gauge on your table saw measures the angle *relative to the end of the board*. Not to the length of the board, which is what we want.

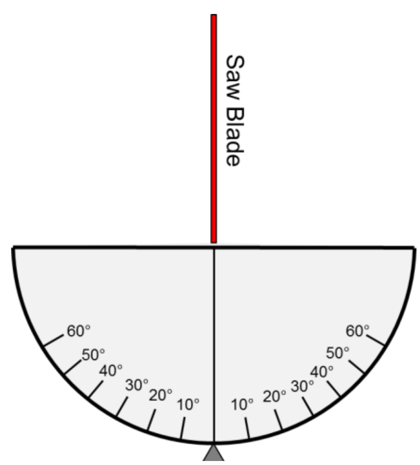

Figure 10: Miter Saw Gauge

Figure 11 illustrates this. If you set the miter to ten degrees, the actual cut on the board is 80 degrees, relative to the long dimension of the board. This demonstrates what geometry refers to as the *complement* of the angle; basically, the two angles will always add up to 90 degrees.

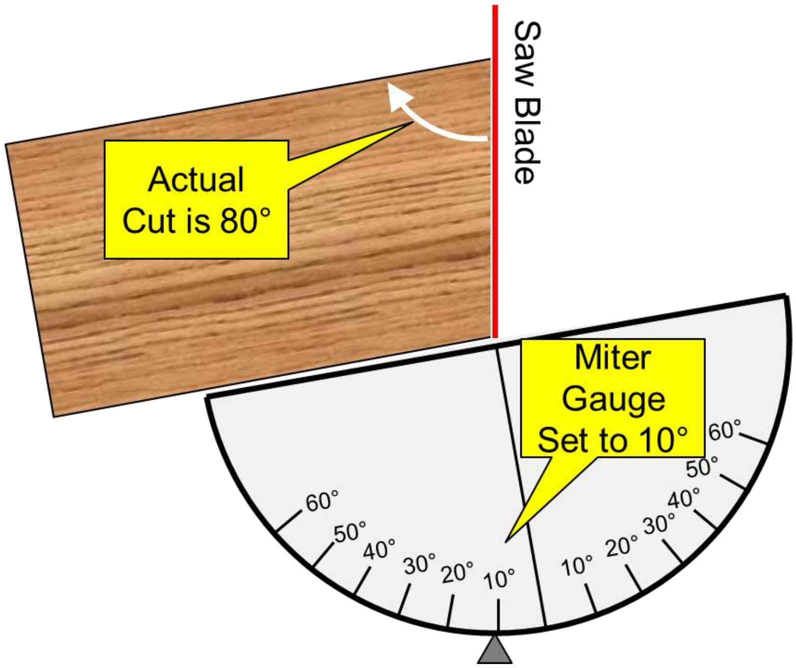

Figure 11: Miter Cuts the Complement of the Desired Angle

The first lesson here: When cutting the gear legs, set the miter to the complement of 50 degrees, which is 40 degrees (90 minus 50).

Second lesson: After cutting the first leg, slap a protractor on the board and verify that yes, you are indeed cutting the leg at 50 degrees. Who knows…Pythagoras might have been wrong.

Figure 12 shows a set of cut-out laminations.

Figure 12: Landing Gear Lamination Panels

4.1.1.2 FIRST LAYER

Lay up the gear legs without glue first, to check the fit.

Step 1 on leg construction takes one of the “B” boards and aligns it with one of the “C” boards, as shown on the left side Figure 13. Note that the lower, square edge of “B” is about

3/4" lower than the diagonal board. This ensures there's enough room around the bottom to do the final shaping.

Put blocks into the worktable to hold these tight against each other. These blocks have to be at least 1" high to be able to hold all the laminations. You could put a block on the ends of the boards, but the boards being laid down on top might be a bit longer and a high block would interfere with them.

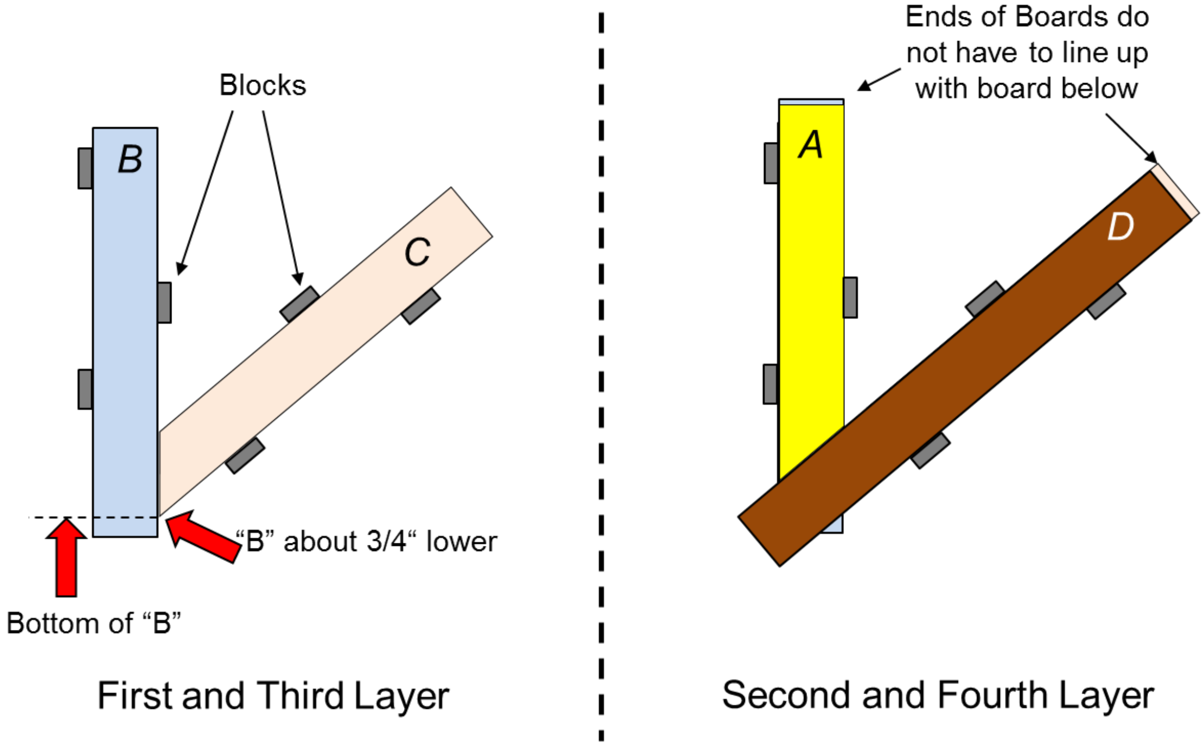

Figure 13: Vee Lamination Sequence

4.1.1.3 Second Layer

For the second layer, place a board "D" over board "B" and "C", and board "A" butted up to board "D" and over board "B". The intersection should look as shown on the right side of Figure 13. Note that the free ends of "A" and "D" do NOT have to line up with "B" and "C" below them. These ends will be cut back when the final shaping is performed.

4.1.1.4 Third Layer

The third layer is identical to the first.

4.1.1.5 Fourth Layer

The fourth layer is identical to the second.

4.1.1.6 Gluing

If you're satisfied with the fit of the laminations in the gear leg, go ahead and disassemble it, and reassemble it with glue. Use a lot of glue, and place a bunch of weights atop the assembly to hold the parts together while the glue cures.

Jim Katz recommends using a foam roller cut down to 3 inches for applying glue to the gear laminations.

Figure 14: Using a Foam Roller to Apply Glue to Gear Laminations

Note that the outer ~1/2” of the legs is going to be cut away, so you can put some nails through it to help hold the leg together why the glue cures. However, keep the nails away from any area that you’re going to have to hit with a saw.

As ever, don’t forget to put wax paper on the work table!

When the glue is cured, lift the legs off the table.

4.1.1.7 MARKING BOTTOM OF VEE

Once the glue is cured, the next step is to draw centerlines down the middle of the two legs of the landing gear. Mark the center points top and bottom, and connect the points with a pencil line.

Make sure the vertical part of the leg includes the centerline all the way to the bottom of the diagonal, as shown on the left side of Figure 15.

Once the centerlines are in place, use a carpenter’s square to find the location on the front gear leg where the diagonal centerline is one inch forward of the front-leg centerline. Mark this line; it’ll be the bottom of the gear leg. This process is illustrated on the right side of Figure 15.

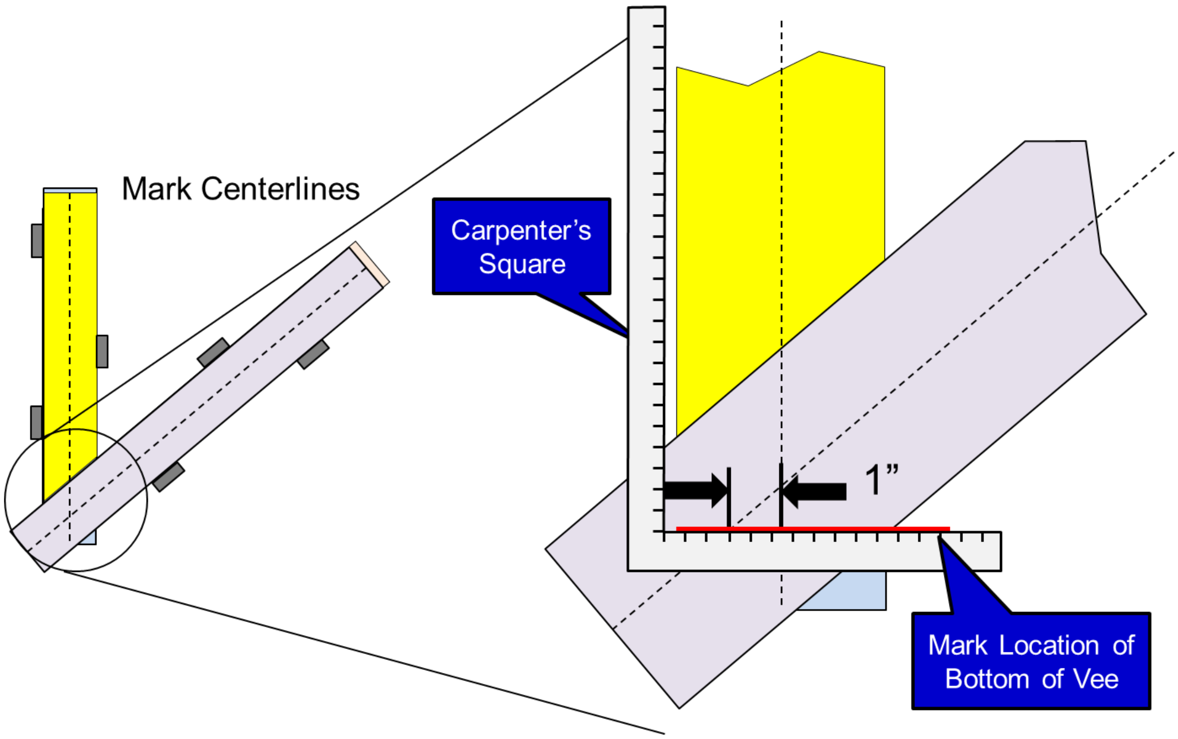

Figure 15: Defining the Bottom of the Gear Leg

4.1.1.8 MARK THE TOP OF FRONT LEG

Next, mark the place where the front leg will be cut. Measure 25 inches along the centerline of front leg, from the bottom-line established in the previous step.

However, the leg is not cut straight across. As Figure 16 shows, and as illustrated on Figure 2-1 on Page 5 of Article 5, the line goes across the top of the leg at about a 12° angle. Pete marks this as 102°; this is the angle to the centerline.

Note that the 25 inches from the lower edge is not affected; the angle is on either side of the center point.

Cut out a cardboard template with the correct angle on it, and use that to mark the gear leg.

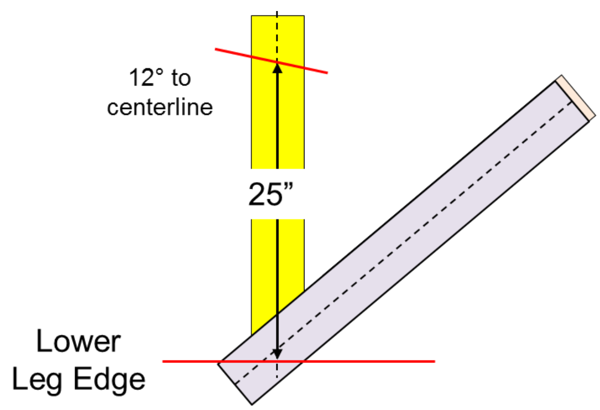

Figure 16: Marking Top of Front Leg

4.1.1.9 MARKING THE AFT GEAR LEG

The aft gear leg (the diagonal leg) is marked similarly to the front one. In this case, the center of the aft gear leg cut is 32 inches from the intersection of the centerline of the diagonal leg with the lower leg edge that was just determined.

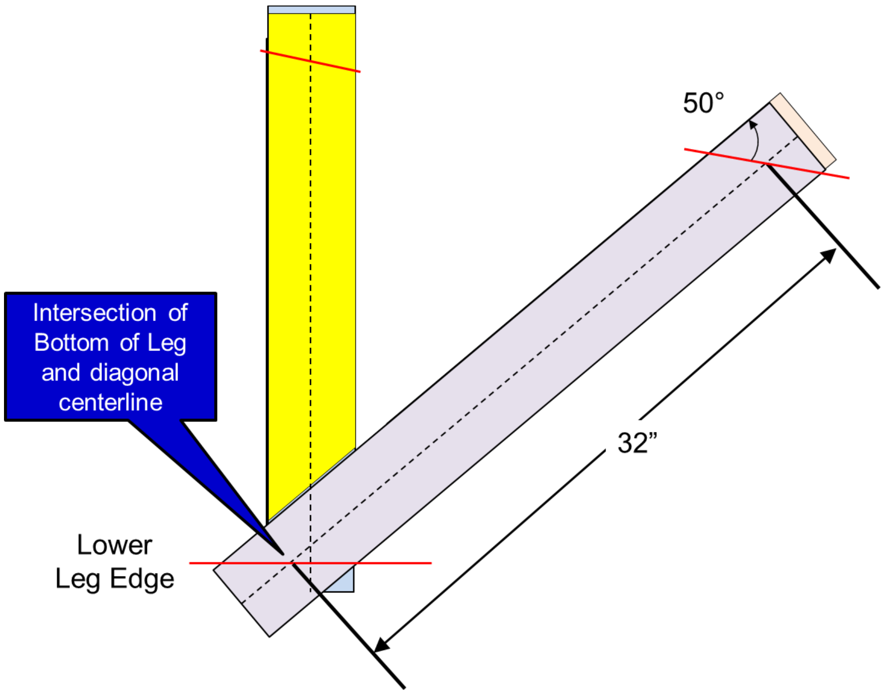

Figure 17: Aft Gear Leg Angle

4.1.1.10 GEAR LEG SPACING

The deciding factor on a gear leg is whether the mounting interface for the two legs match the fuselage brackets. The centerpoints for those two brackets are 24 inches apart. Basically, this should be the distance between the centerlines of the two gear legs at the point where the ends are going to be cut. Figure 18 shows the dimension.

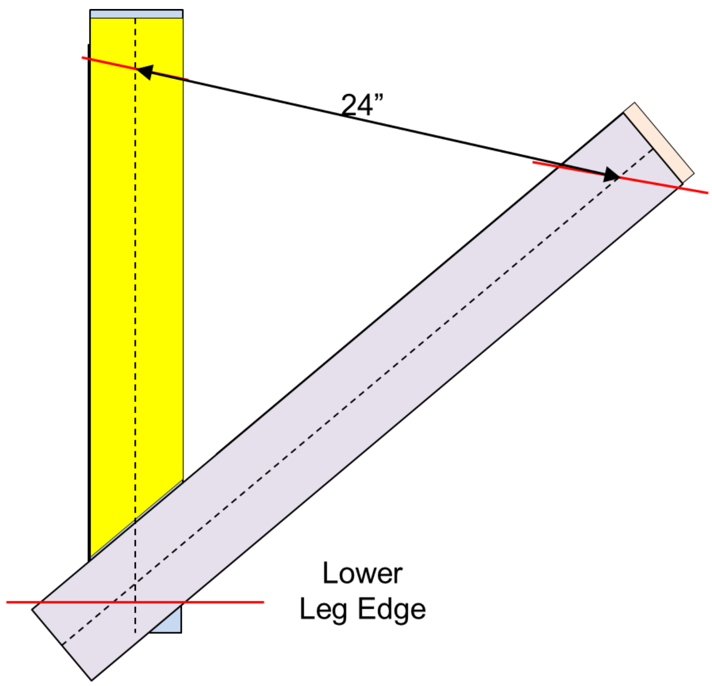

Figure 18: Double-Checking Gear Legs

4.1.1.11 FINAL SHAPING

With the glue all cured and the dimensions checked, it's time for the final shaping of the gear legs. As Figure 19 shows, first cut the ends of the legs and the bottom line. Then draw lines down each leg at $1^{11/16}$ inches from the centerlines (half the full 3.375 inch width) and trim down the two legs to the final dimensions.

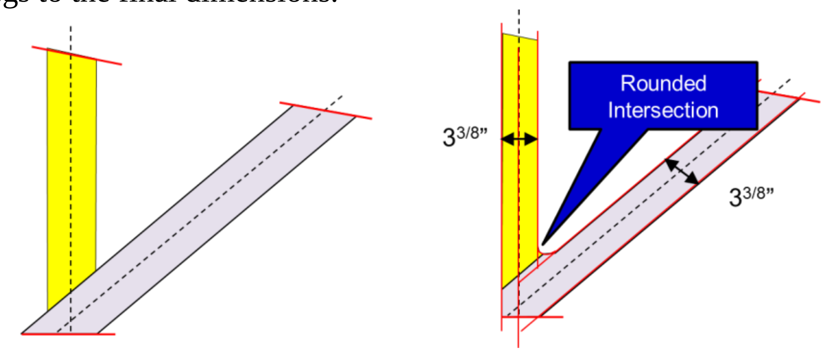

Figure 19: Gear Legs Final Shaping

However, note where the two legs intersect. That area needs to be cut in a bit of a curve, for both cosmetic and structural purposes. After you draw the $1^{11/16}$ cut lines, just sketch in a curve between the two sides.

In addition to carving the gear legs to the right size, you can "soften" their cross-sections as well. Pete kind of depicts this on the top part of Figure 2-1; he shows a rounded-rectangular cross section for the legs. You can do this with a sander, or using a router (Figure 20).

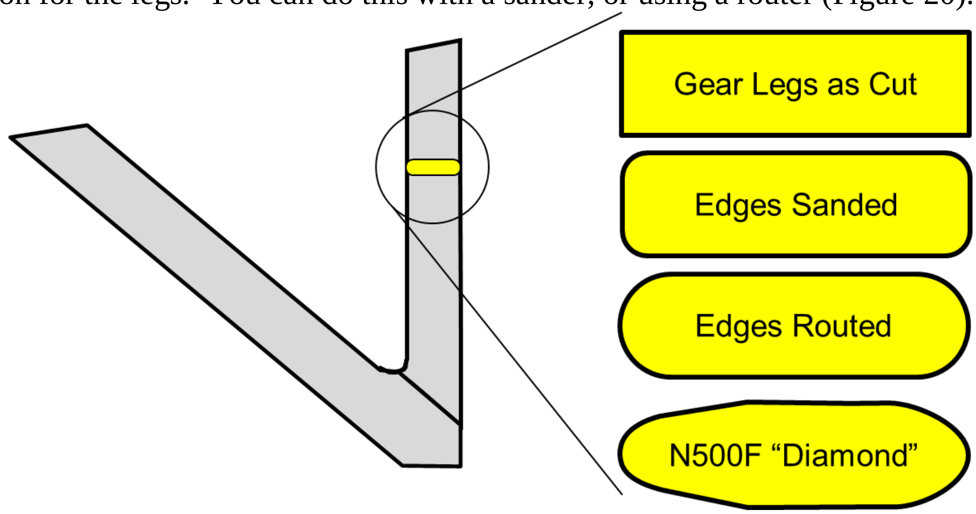

Figure 20: Gear Leg Cross-Section Options

On N500F, Pete did a kind of "Diamond" shape…almost an airfoil. Not sure how he did it.

Note that this is almost totally cosmetic, so it's up to you. Keep in mind that if there's an especially aggressive trim, it should be eased off a bit at the ends of the gear legs, where the axle fitting is attached and where it bolts to the fuselage.

4.1.1.12 ANDREW ARMSTRONG'S SUGGESTIONS

Soon after the first version of this Guide appeared on the PB100 web page, Andrew Armstrong used it with the EAA articles to build a practice set of landing gear. Andrew posted about his experience on the Fly Baby Facebook page. With his permission, I've included his comments below:

This last weekend I glued up a practice gear leg "V" following the plans from EAA site and Ron's companion guide.

I created the planks using some douglas fir I had in my shop, re-sawed and planed to the right dimensions. It doesn't meet 'spec' due to the grain direction, ring count, and knots, for goodness sake. But it was perfect to practice with. What follows are my observations and suggestions for consideration.

Glue Considerations:

You will need a lot of glue. The face of each Vee layer is about 544 square inches. According to the box of T-88, the glue is placed on both faces, which gives you 6 layers of glue. I calculate that to be about 22 square feet of surface area.

Again, referencing the box, that's about a quart of glue. For my practice joint I cheated and only put the glue on one face. I can tell there are a few places on the edges where the joint is starved and I won't be surprised to find more when I trim the Vee to size.

Prepping the wood:

Make sure all boards are the same width (all 16 for both Vees) or they won't fit in the blocks properly. The 50° angles should be stacked cut together if possible, or touched up on disk sander with a miter gauge. Clean up any 'whiskers' on the angle cut so it will snug up tightly - more for cosmetic reasons. It's possible that the wood may not all be of the exact same thickness; small differences won't matter, but larger ones could put enough of a gap to cause a cosmetic issue where the boards overlay. If needed, pair the thicknesses up by layer and put the two most mis-matched boards on top where the difference can be smoothed out after glue-up. Mark the 3/4" spot on the "B" boards where the point of the "C" board will rest (Figure 13).

The process I followed:

I used a 2'x4' piece of MDF on top of my work bench and laid out a couple rows of wax paper. I assembled the Vee with the "C" board parallel to the long edge of my work table; about a 40° rotation as shown in figure 11. I secured two wood blocks along the long edge, on top of the wax paper, spaced out using TLAR (that looks about right). I secured a third block on the opposite side of the "C" board - inside the Vee. I then aligned the "B" board as per figure 11 and secured the other 3 blocks (two outer and one inner). That held the first layer of the Vee in pretty good alignment. I stacked the boards up as if I was gluing them, got the clamps, and some weights and dry fit everything; then took it apart and laid everything in some semblance of order to make glue-up easy. I used paste-wax on the face and edges of the blocks so that the 'squeeze out' won't glue the blocks to the work piece. [Ron's note: This is an alternate approach to using wax paper.]

From there, it's just like the guide says: layer - glue - layer - etc. Clamp, weights, and let cure. With T-88, you have plenty of time to glue up all four layers. I let cure overnight and then removed the clamps and inspected the results.

What I'm going to do differently next time:
These are the things I'm going to try when I make the real "V"s:

1) The inner blocks would work better if it was more of a 'cam' style: a disk of wood secured off center so you can rotate it into alignment.

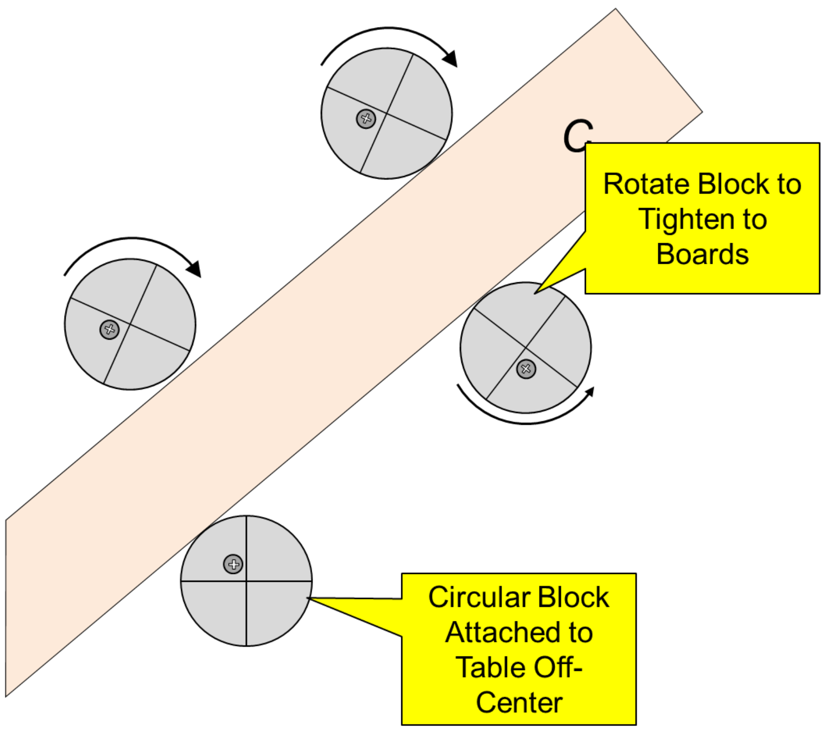

Figure 21: "Cam Style" Blocks

2) Use small nails or pins to hold the boards in place, even the first layer - they really want to slide around. Glue tends to be kind of slippery till it cures.

3) Follow the instructions on the box for the T-88; apply glue to both surfaces, let it sit and touch up the dull places where the glue is absorbed.

Conclusion:
I recommend you try a practice Vee with cheap wood (say some 1/4" MDF milled to size) as you will learn something - unless you do this type of lamination often. You will be surprised at how sturdy this finished piece feels in your hands.

- Andrew Armstrong

Notice how Andrew recommends practicing building Vees. This actually ties into a recommendation I make later in this Guide (Section 4.2.4)—building a set of practice Vees to use while getting the shaping and welding right. Build a set for practice, now, and they'll be available later.

4.1.2 Gear Attachment Fitting Construction

Figure 2-2 on Page 5 and Figure 2-3 on Page 6 of Article 5 shows the three types of steel fittings needed to attach the Fly Baby's gear legs to the fuselage. There are the Inner Support Fittings (top of Figure 2-2), the Outer Support Fittings (bottom of Figure 2-2), and the strut fittings, shown in Figure 2-3. A slightly different strut fitting is used for the front and rear landing gear legs.

4.1.2.1 OUTER SUPPORT FITTINGS

Figure 2-2 on Page 5 of Article 5 shows the design of both the inner and outer landing gear attachment fittings. Pete calls for these to be made from 0.093" steel, which doesn't seem to be readily available. So use 0.100".

The Figure might be rather confusing. There's a kind of Y-Shaped pattern atop a rectangular one. What's going on, here?

Simple: Pete was showing two fittings atop one another, to save space. Figure 22 shows the math in play, here.

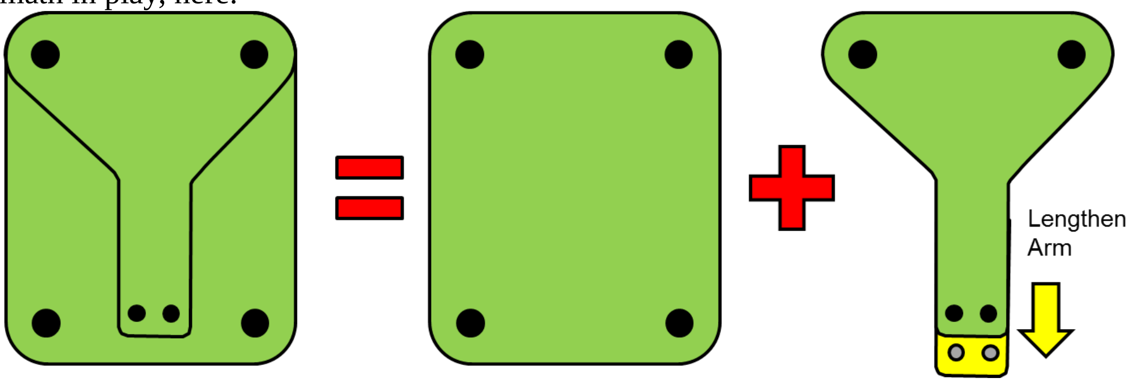

Figure 22: Main Gear Outer Support Fittings

Figure 23 illustrates how the two fittings stack when bolted to the airframe, and their relationship to the landing gear legs.

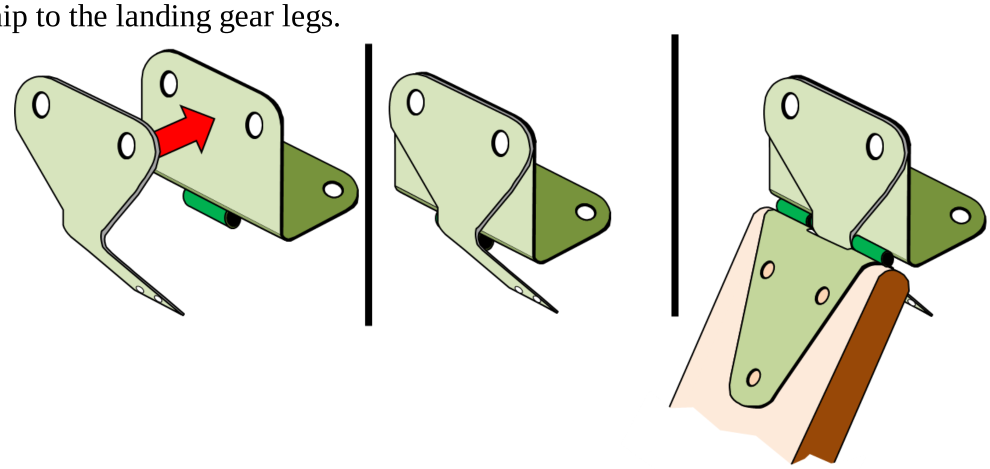

Figure 23: Stacking of Front Outer Support Fittings

The arm on the Y-Shaped fitting actually goes through a gap at the top of the front gear leg, and the cross-brace wires between the gear legs and axle attach to it. Some builders have found that the stock plate puts the two holes a bit near the fuselage and gear leg; it's hard to install the turnbuckle and clevis pin. It'd be a good idea to lengthen the arm a bit, as the Figure shows. Another inch would be good. If you hold off drilling the holes, you can shorten the arm if it's too long.

You'll need four of the simple plates (center image in the above figure) and two of the "Y"-fittings.

One thing I might recommend is to NOT drill the holes in these fittings to the final size until they're being test-fit on the fuselage. Drill a ~1/8" pilot hole at the indicated location, instead.

As shown in the various figures, the outer plates are bent to 90° and a short piece of steel tubing is welded to it (see Detail 2 of Figure 2-2). Two similar tubes are welded to the gear legs, and a bolt goes through holding the fittings together.

When you weld on that piece of steel tubing, remember the "Y" fitting that gets bolted on over the fuselage fitting, and has a tab that crosses the gear leg. Don't weld the tube on the actual "corner" of the fitting, inset it a bit as shown in Figure 24.

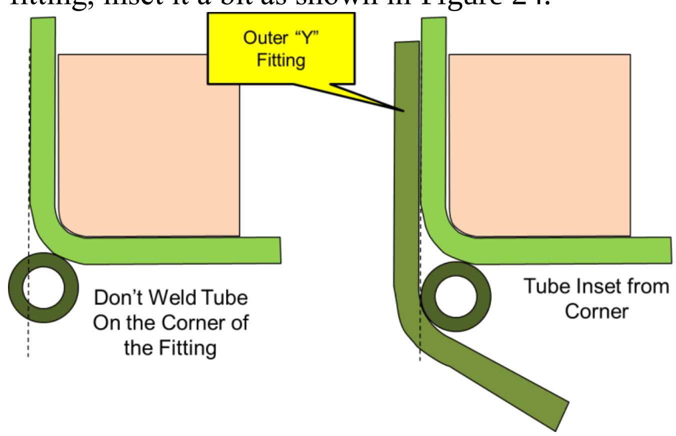

Figure 24: Steel Tube Positioning on Fuselage Fitting

Bowers shows a bend radius of just the thickness of the metal (0.100"), rather than the more modern three times the thickness (0.300"). This is discussed in Section 2.3.

Whichever you use, the lower fuselage corners must then be shaped to match the inside curve of the fitting (Figure 25). A sharp edge on the fuselage slide prevents the fitting from snugly fitting the fuselage.

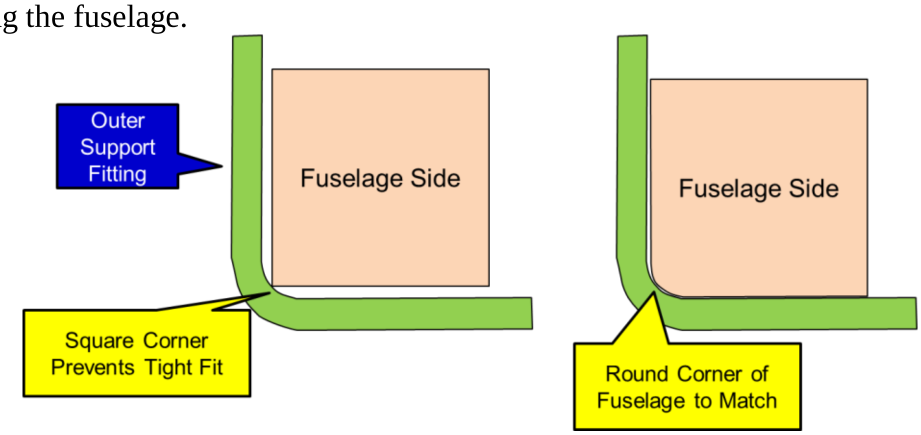

Figure 25: Matching Fuselage Corner to Fitting Inside Contour

Mark where the fittings will go, and file/sand/route the corner to match the fittings. You can make this alteration somewhat tight so it's just behind the fitting, but there'd actually be nothing wrong in doing this shaping all the way along the lower front fuselage, just to eliminate an obvious transition.

4.1.2.2 Inner Support Fittings

Figure 2-2 says that the Inner Support Fittings are made from steel, from 0.064" to 0.090". Note that Figure 2-2 is a bit confusing…the "A" in a circle looks like it's marking the location of a hole, but it isn't. It's just labelling the two "flaps" of the fitting, "A" and "B".

Why is there only a hole in one side? By the time you're done, there'll be holes in all three panels of the fitting (the two "Flaps" and the center portion), but the other two will be drilled in place to match the outer fitting. Again, I recommend just drilling a pilot hole for this fitting and drilling the final in place on the airplane.

You might wonder what Pete means by "left hand" and "right hand" fittings. It just means which "flap" of the fitting has the hole drilled through it for bolting to the fuselage bulkhead. Figure 26 illustrates this.

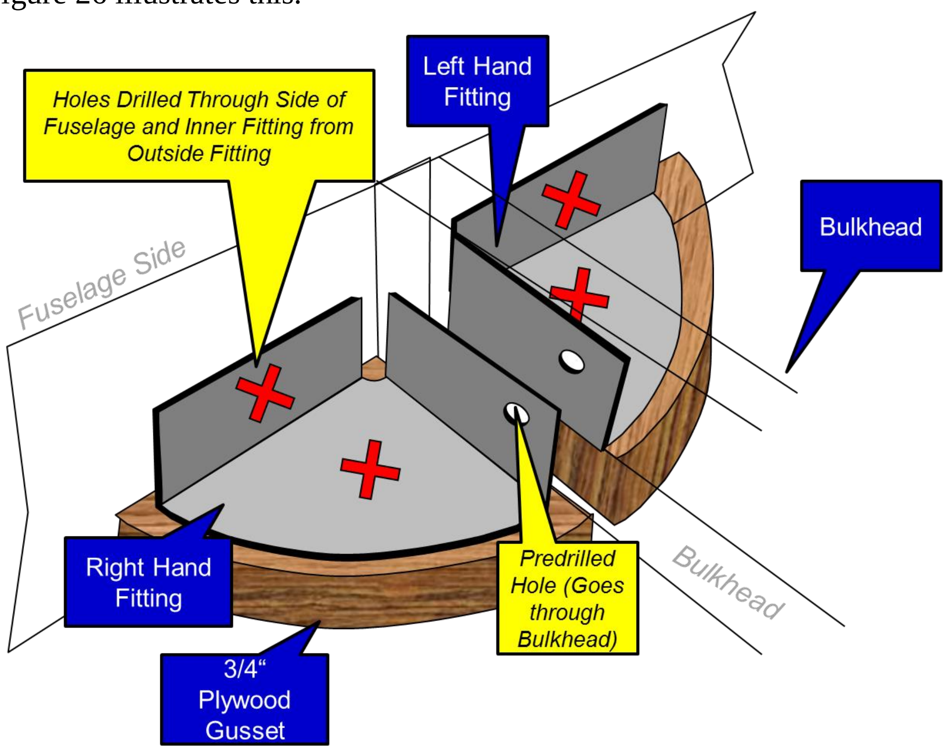

Figure 26: "Left" and "Right"-Hand Inner Fittings

Since Pete only provides one diagram, how to you make the "Left" and "Right" versions? Simple: Cut out the outline from steel sheet, pre-drill the bolt hole. On half the blanks, bend the flaps UP, and on the other four, bend the flaps DOWN. That'll produce the left and right side versions.

Figure 27 shows one of the inner fittings positioned on the gusset.

Figure 27: Inner Gear Fitting in Place

Figure 28 shows how it all goes together. There are already 3/4" plywood gussets installed on the bottom of the fuselage at Station 4 and Station 2. The inner support fittings are placed on top of these gussets, snugged up against the inside of the fuselage side and the bulkhead. An AN5 bolt goes through the single pre-drilled holes in the two fittings, pinning them to the bulkhead.

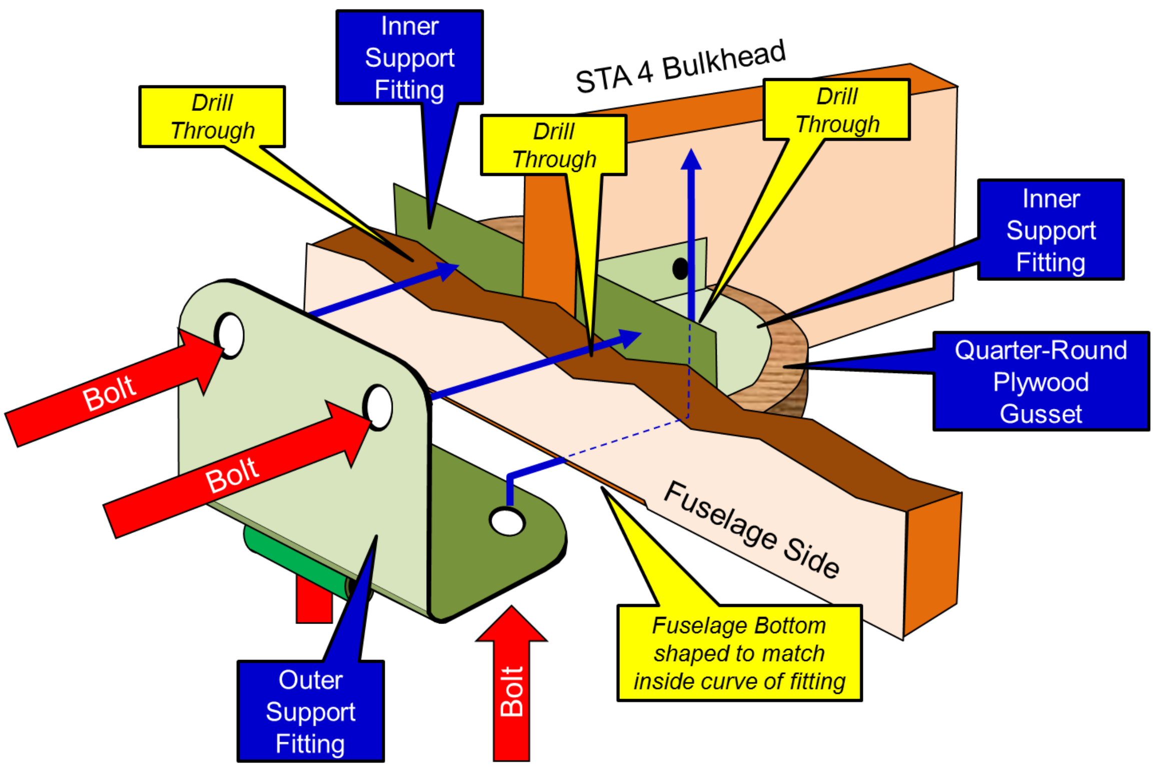

Figure 28: Landing Gear Fitting Attachment

When the outer fittings are placed on the outside of the fuselage. The upper holes in the outer fitting are used to guide drilling through the fuselage side into the blank tabs on the inner fittings. The holes in the bottom of the outer fitting are used to guide drilling up from the bottom through the 3/4" plywood gussets and the flat center section of the inner support fittings.

4.1.3 Landing Gear Strut Fittings

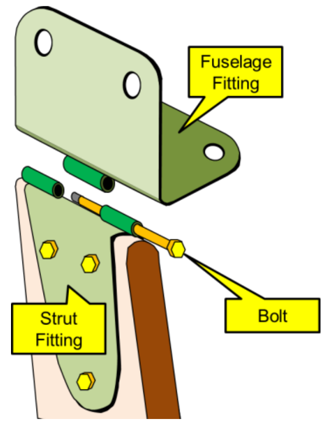

Figure 29: Sample Fuselage and Strut Fitting

Combined with the fuselage fittings, the strut fittings are essentially hinges. Complimentary tubing is welded to both sides, and an AN4 (1/4") bolt acts as a hinge pin (Figure 29).

There's no real significance to the "Hinge Pin"; when installed, the gear is solid and there's no motion. But the slight amount of motion makes it easier to get the whole landing gear straight, and the fact that the gear is removed by just four bolts makes it easier to work on in the shop.

The sequence for both strut fittings:

1. Cut out the fitting from 4130 steel
2. On the front fitting, cut out the "Notch"
3. Bend the fitting over a 1" diameter steel tube (as a mandrel).
4. Carve the end of the struts to match the inside curvature of the fitting
5. Weld the sections of steel tube to the centerline of the fitting

The following section describe the operations.

The strut fittings are held in place by three bolts that go through the gear leg into the other side

One caution when making these fittings: Drill holes into only <u>one</u> side. When installed, you'll drill through the gear leg into the other side of the fitting.

4.1.3.1 CUTTING OUT THE FITTING

Pete specifies 0.093" 4130 steel, which is hard to find. As mentioned in previous articles, most folks are using 0.100." The patterns in Figure 2-3 are pretty clear.

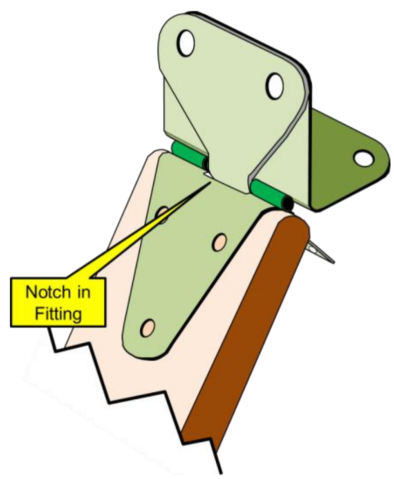

Figure 30: Front Strut Fitting

4.1.3.2 FRONT FITTING "NOTCH"

Remember that there's a "Y" fitting that goes over the front fuselage attachment, and bends inside the gear leg to attach cross-bracing (Figure 30). This means that a squarish sort of hole needs to be added to the middle of the front strut fitting.

Pete provides next-to-no information on this notch, merely an inset diagram on Figure 2-3. I've done a bit of work with an old gear leg to try and establish the nature of the notch. My insights are shown in Figure 31. The notch is about 1 1/8" square.

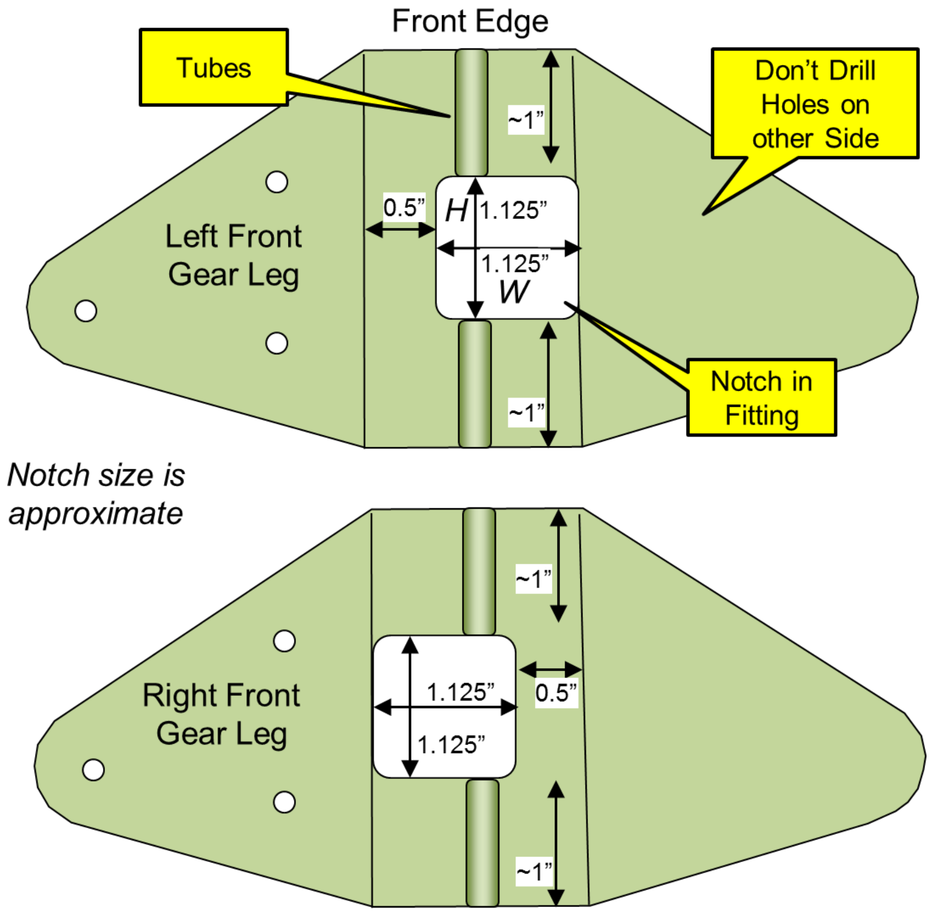

Figure 31: "Notch" in Front Strut Fitting

The notches for the left and right gear legs are on opposite sides of the centerlines, as shown in the Figure. The same pattern can be used for each—you just have to flip it, when cutting the fitting for the opposite side.

How to cut the notch? Figure 32 shows two common approaches. One is to drill many holes around the periphery, use a chisel to remove the center, and clean up with a file. The second is to drill one big 1 1/8" hole in the center of the area, then file away the remaining corners.

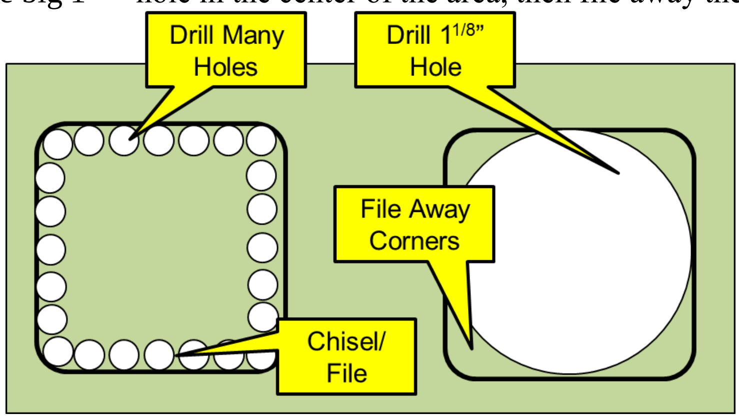

Figure 32: Making the Notch

Or, of course, if you're having parts cut by laser/plasma/water jet, ensure your drawing includes the cutout.

Remember, the edges of the notches shouldn't be square—there needs to be a slight radius to prevent concentrating stresses.

Now: About the Dimensions

In Figure 31, I show the notch being about 1.125" ($1^{1/8}$") square (with rounded corners, as mentioned). We know it has to be at least 1" high (noted as "H" on the figure) to fit the 1" strap from the T-Fitting. I've allocated an extra one-eighth of an inch…only a sixteenth-inch leeway on either side. Fiddling with a spare gear leg, I've determined that a 1.125" hole will allow the T-fitting strap through.

However, these are just estimates. I've tried to be conservative (e.g. keep the hole from getting too big), but it's possible that one or two dimensions may be too tight. You might have to use a file to enlarge some dimensions.

[If so, let me know what dimensions you end up with….]

4.1.3.3 Bending the Fitting

The fitting has to be bent on a smooth curve to fit a 1" wide gear leg. Pete provides two approaches, both using a 1" diameter steel tube as a mandrel. Both require heating the fitting to some extent to make it easier to bend.

It's be easier to perform a cold bend, but the diameter is pretty important. So heat it up.

4.1.3.4 Carving the Strut Ends

At this point, the ends of the gear struts should be shaped to fit snugly within the fittings.

Figure 33 shows why. If the end of the struts are left straight across, nothing is backing-up the fitting. When it comes under load, it will distort. So you need to shape the strut, as shown in the right side of the figure.

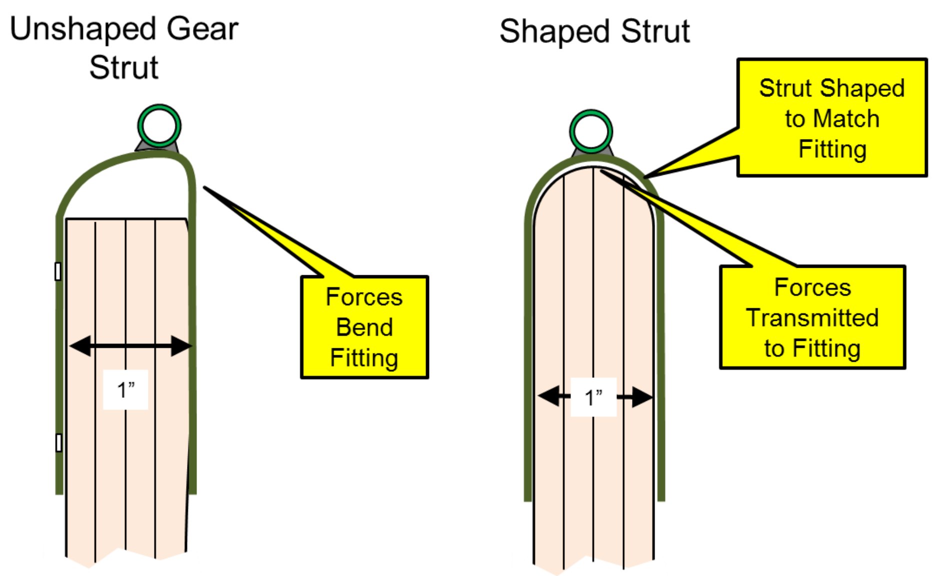

Figure 33: Shaping the Strut Ends

This is basically going to take a lot of work with a rasp and a sander. Draw a line down the center of the end of the strut (to try keep from shortening it), and carve down the sides until they match the fittings.

You <u>might</u> try a router with a rounding bit. But folks have cautioned me that this might tend to dig out too much of the wood. Experiment with scraps, first. An example of this is shown in Figure 34.

Figure 34: Gear Legs Carved to Fit Brackets

Oh, one last bit of carving. Test-fit the fitting on the aft strut, then cut away the wood behind the fitting that is left hanging. Turns out that if you leave it in place, it makes it impossible to put the nut on the end of the “hinge” bolt. Ask me how I know (Figure 35).

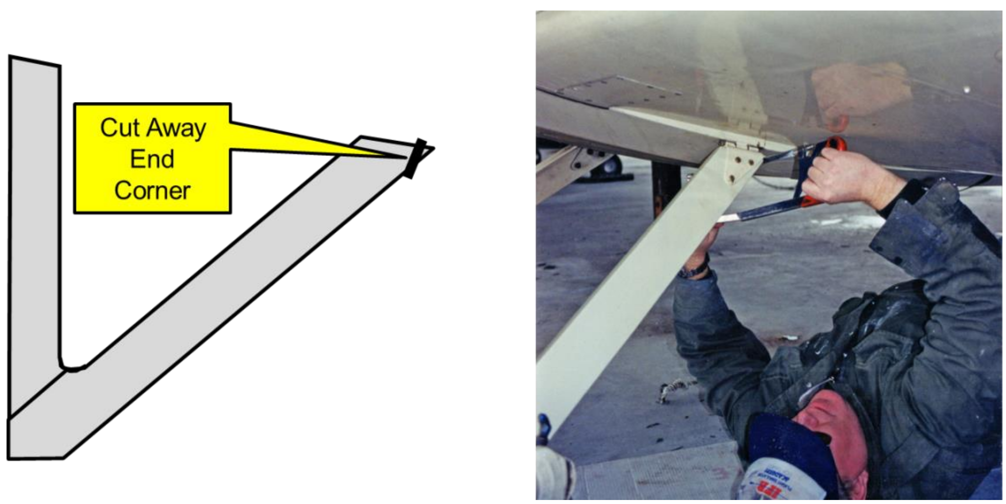

Figure 35: Carving Corner of Aft Strut

4.1.3.5 WELDING THE TUBES

While there's a single piece of tube in on the fuselage fitting, two matching tubes are on either side of it, on the strut fitting. How do these get lined up?

It's pretty slick: You weld on a single, long piece of tube, then cut out the center section. To make this easier, Pete has you cut the tube partially away before welding. See the detail on the tube on the lower right of Figure 2-3.

Draw the centerline of the strut/fitting on the top of the fitting, then lock the tube in place and weld. When it's cool, cut away the center section.

4.1.3.6 FINISHING UP

When the fittings are snugged up to the ends of the struts, it's time to drill the holes.

Insert the struts to the fittings all the way and clamp them solidly. Then attach the gear legs to the fuselage, with a stick at the bottom holding the gear legs about 20 degrees out from the fuselage.

Check the relative position of the gear legs, vs. the aircraft axes (Figure 36). You might find one leg a little further forward than the other. Loosen the clamps, and adjust its position. You might even have to shave a bit off the end of one get leg or the other. When everything looks aligned, clamp down the fittings (hard) and prepare to drill the bolt holes.

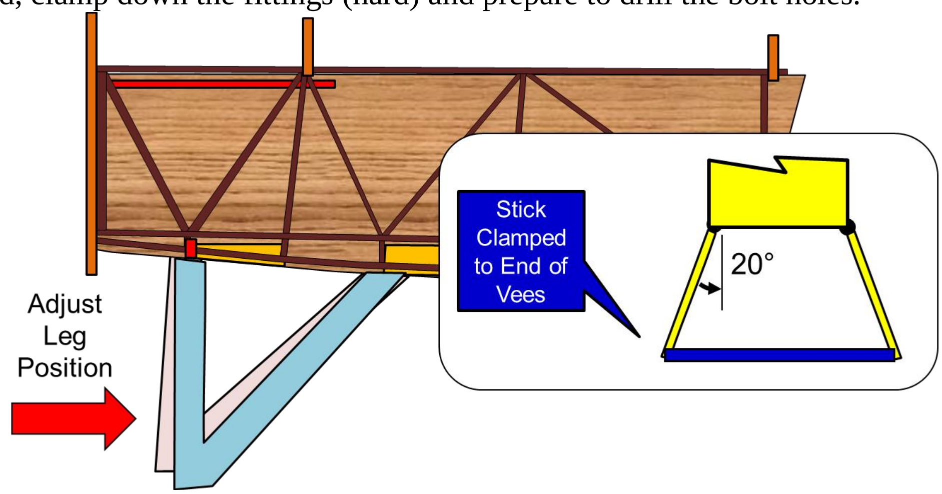

Figure 36: Checking Gear-Leg Position

You should have made the fittings with holes on only one side. Drill through the leg into the fitting on the other side. Insert a bolt temporarily to while you drill the next. When they're all drilled, remove the fittings and debur the drilled holes.

Remember when I said, "one last bit of carving"? I was just kidding.
The front gear strut will need to be notched to match the notch in the strut fitting. This is illustrated Figure 37. Bolt the fitting in place, mark the strut, then remove the fitting and carve away the wood. A 1" strip of wood or metal should be able to pass through from one side of the notch to the other without touching the wood.

(Though as noted, this may have to be adjusted later.)

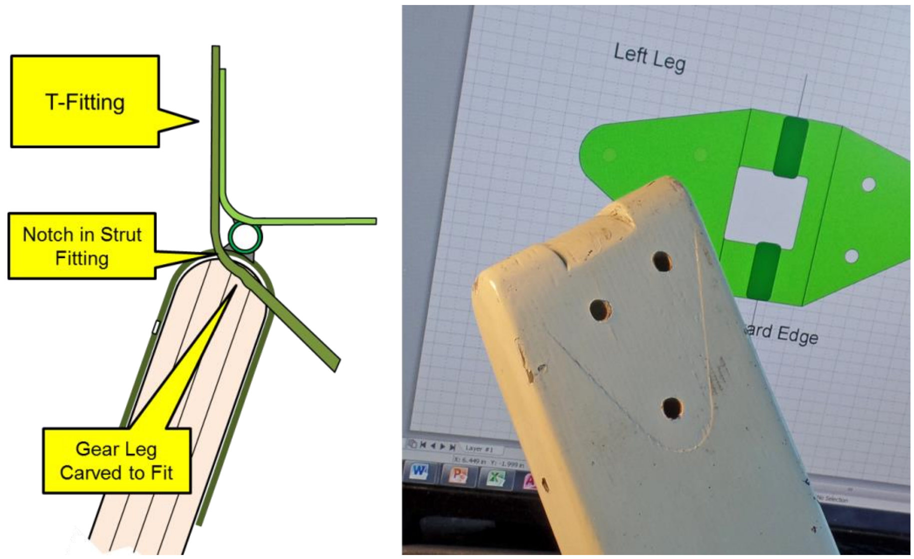

Figure 37: Notching the Front Gear Strut

Finally, remove the metal fittings from the fuselage and the strut fittings from the struts. Paint the metal fittings, and apply varnish where they bolt into the fuselage.

4.2 Axle and Lower Gear Legs

We can now turn our attention to the lower part of the gear legs, and the installation of the axle and supporting hardware. Figure 38 shows an exploded view of a typical gear leg. A hole needs to be cut in the end of the Vee, which will have two steel support plates bolted to the gear leg on either side. The inner support plate will be welded to the axle, while the outer one becomes part of a small assembly that supports the brake plate. Finally, a thick strip of steel slides into the axle to support the attachment of the flying wires.

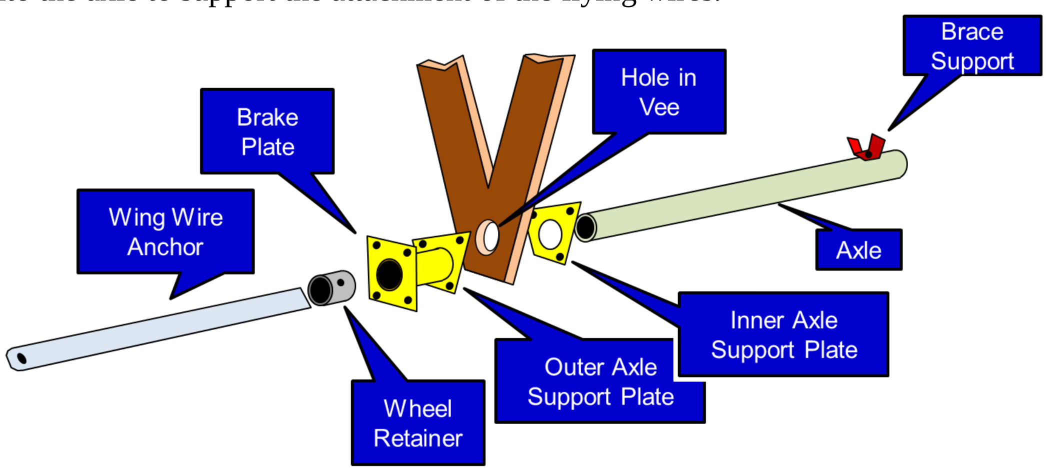

Figure 38: Exploded View of Axle Assembly

It's easier to install the gear with the fuselage on its back (Figure 39), but remember that the instrument panel and turtledeck area complicates this. A set of sawhorses, vs. the work table, might be the best solution.

Figure 39: Positioning for Landing Gear Installation

Let's look at the fabrication of the major components, first, then we'll look at how to tie them together.

4.2.1 Axle[2]

As mentioned earlier, the building instructions specify a 1.25" outside diameter 0.093 wall thickness steel tube for the main axle. That size was selected to be able to use J-3 Cub wheels and brakes. There are some wheels that still use the 1.25" axle, but most use 1.5". I recommend a 0.095" steel tube with 1.5" outside diameter tubing, instead. And, as mentioned in the "Errata" section, the axle is 61 inches long…not six feet one inch.

Drill a 1/8" hole dead through the tube at its exact center of its length. This will eventually be enlarged to fit an AN5 bolt (5/16"), but for now, a smaller hole will work better as a reference when you true up the gear.

How do you drill a hole evenly through the center of a tube? Clamp the tube down to the table top. Add some paint, printer's ink, or even scribble with a Sharpie around the area where you'd like the hole.

Then take a reference angle or combination square, hold one side flat on the table, and scrape the blade end along the ink. This scribes a line on the exact center of the tube.

Then, without disturbing the tube clamping, flip the square over to the other side and repeat the process. You've now got two reference lines exactly opposite to each other. Figure 40 shows this process.

[2] "Axel" is a common Scandinavian name. An "Axle" is what wheels get attached to. Just thought I'd mention that.

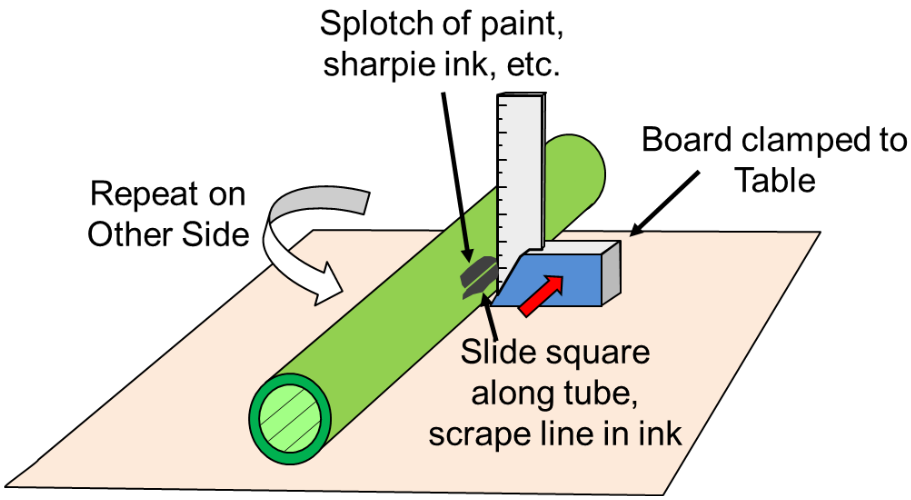

Figure 40: Marking Tube for Drilling

Measure 30.5 inches from the end of the tube (one-half of 61 inches) and use a center-punch to mark the drill point on one of the lines. You could make the same measurement on the other side. What I've done is to take a thin strip of paper and wrap it around the tube at the marked point. Get the overlap perfect, and the paper will cross over the other line at the right distance.

There are those who just chuck up the tube in their drill press and drill both side at one pass. I'm not one of them…I drill each side individually.

By drilling just a 1/8" hole to start with, you not only end up with a good reference point, you can actually make minor corrections when you drill the hole out to the final 5/16" size.

This hole will be vertical when the axle is assembled: It will be parallel with the forward gear leg.

4.2.2 Support Plates

Next step is to make the support plates, from 0.100" 4130 steel. There are two support plates: The inner and the outer. The inner plates are welded to the axle, while the outer plates are part of the brake-mounting assembly.

Figure 2-4 on Page 5 of Article 5 shows the template used for both support plates. Their outlines are identical, as is their bolt pattern. The only difference is the position of the oval opening in the middle to admit the axle.

Figure 41 shows how it works. The two support plates bolt to each other through the gear leg, basically clamping the leg between them. However, since the axle is at an angle relative to the leg, the hole in the outer support plate has to be slightly lower than the hole in the inner one.

How different? Simple geometry says that the hole in the inside support plate has to be about 0.27 inches higher; a tad over a quarter-inch. As Figure 2-2 shows, the hole should be no closer than three-quarters of an inch to the bottom of the outside plate.

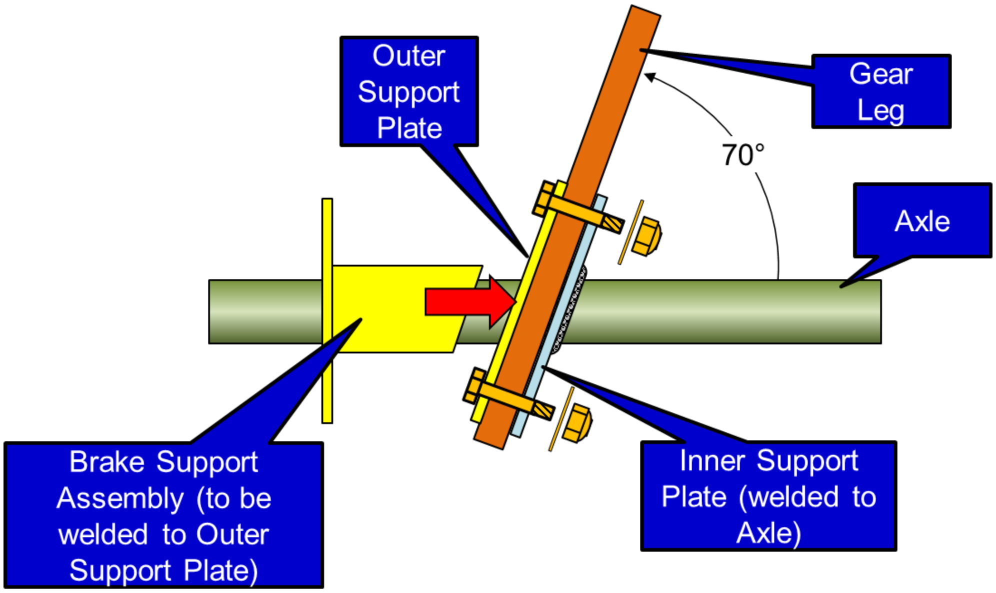

Figure 41: Inner and Outer Support Plates

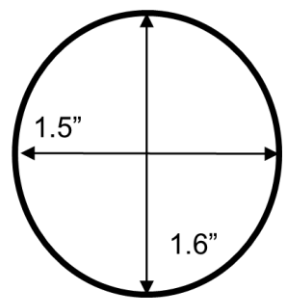

Figure 42: Oval Dimensions

What are the dimensions of the oval holes? It depends on the axle diameter. Pete specifies a 1.25" axle for the Fly Baby, but as discussed in Section 2.2, this is based on the use of now-antique J-3 Cub wheels and brakes. Almost every wheel system you'll find now needs a 1.5" axle, so count on that size.

With that, simple geometry tells us that the minor axis (which is horizontal to the plate) is the same 1.5" of the axle diameter, and the vertical dimension is only slightly larger, 1.6 inches.

Cut out two each of the inner and outer plates. Clearly label each one, whether it's an inner or outer. Make sure the bolt patterns exactly match.

4.2.3 Cutting the Holes in the Ends of the Vees

A hole needs to be cut in the bottom of the "Vees" to allow the axle to pass through. With the outer and inner plates available, this is relatively simple.

First, place some sort of marking on the outside of the two gear legs. I'd suggest putting a strip of blue painter's tape on the wood, with "Outside" marked on it. Note that the outside of the gear legs has the smallest part of the notch on the front leg. If you're going to paint the gear legs, go ahead and write "outside" on the leg itself.

It's important to get this right. You've got some important carving coming up, and if you're mixed up as to the inside or outside of the leg you'll have to scrap that piece.

The position of this hole is shown on the top part of Figure 2-1 on page 5 of Article 5. But the easiest thing to do is to mark/cut it per the outer and the inner support plates.

Look at the top illustration on Figure 2-2, and place the OUTER support plate on the OUTSIDE of the first leg in accordance to the dimensions shown. Clamp it in place, and mark the outline of the oval. Then put the inner plate on the inside of the leg, and mark the oval on that side.

The hole is basically a 1.5" hole drilled at a 20-degree angle from the vertical. The outer edge of the hole is about 7/8" from the bottom of the leg—this is based on the ¾" minimum from the bottom of the outer support plate to the hole, plus the fact that the plate is mounted at least 1/8" from the bottom of the leg.

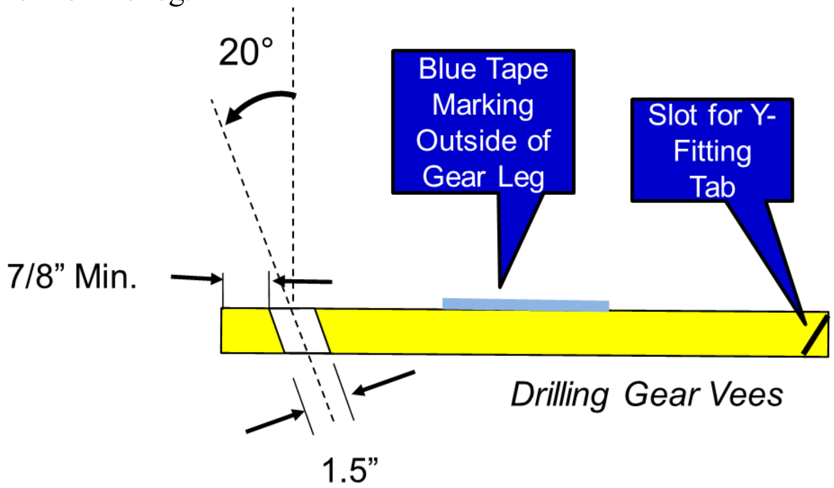

Figure 43: Drilling Gear Vees

How to cut it? It's left up to you. I'd start with a ¼" pilot hole, drilled using a drill press with the table set up at 20°. Then use a 1.5" hole saw to complete it. With the pilot hole to guide the drill, this wouldn't have to be done on the press.

Ideally, you'd cut halfway through from one side, flip the leg, and cut the rest of the way from the other. But if you've chucked up the hole saw in a bench press, it may not be possible to replicate the angle.

Now you know why I recommend some practice gear legs….

On the PLUS side, the accuracy of this hole isn't critical. The gear loads are carried by the inner and outer support plates, clamped the legs by the three bolts. Don't worry if the hole in the leg doesn't fit the axle tightly.

Before moving on, radius the edges of the angled holes. "Radius" in this instance means to use a file and sandpaper to round the edges a bit. The support plates may end up with a bit of a weld on the inside, and this may interfere with the flat fitting of the support plates to the gear legs.

4.2.4 Welding the Inner Support Plates

The next step is to weld the inner support plates to the axle. This is critical: The axle must go smoothly between the gear legs, and the support plates must rest solidly on the side of the landing gear.

Pete has a simple declarative sentence about the this process: "Weld inner axle support plates to axle and outer plates to brake support tube per dimensions and angles of Figs. 2-4 and 2-5."

Sounds simple—until you discover there ARE no angles provided in Figures 2-4 and 2-5.

This is weird, when you consider the landing gear is all angles….the Vees are, well, "V" –shaped, the gear legs spread outward to some unspecified angle, and the axle and support plates all have to be welded together to support this angle.

Best theory currently is that Pete intended for builders to assemble the gear components based on their dimensions, and let the angles fall where they may. However, an angled hole has to be cut in the bottoms of the Vees, and a matching hole needs to be cut in the support plates.

I took the close-up view of the axle and gear leg in Figure 2-5 and imported it into a drawing package. The angle between the gear legs and the axle, as depicted, was exactly 70° (Figure 44). That's 20 degrees from vertical.

Now: here's where it gets fun.

That 70 degree angle is not critical. Whatever the angle is, the primary goal is to ensure the angle is the same on both sides. If it isn't, your plane will sit a little tilted on the ground. Depending on how bad the difference is, you probably won't even notice.

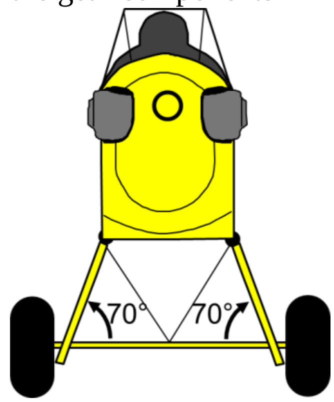

Figure 44: Gear Stance

The neat thing is, the final angle is ACTUALLY set by the "V" shaped bracing wires in the middle of the gear. A pair of cables (and their turnbuckles) go from the tang at the exact centerpoint of the gear to the tab at the end of the "T-fittings" described earlier. After the gear is in place, you can adjust the gear so it's even.

But only if you build the gear *symmetrically*. With both sides the same. Even if both sides are wrong , it's not likely to make much difference as long as the same error was made on both sides. The nose may sit a little higher, or a little lower, but the plane will track straight on the ground and that's the most important thing. And that symmetry is based on the welding of the inner support plates to the axle.

To build it symmetrically, you have to know what the dimensions should be. We'd like to know what the ANGLES should be too, but as I mentioned, Pete didn't list those.

Figure 45 illustrates known, measured, and computed dimensions of the landing gear.

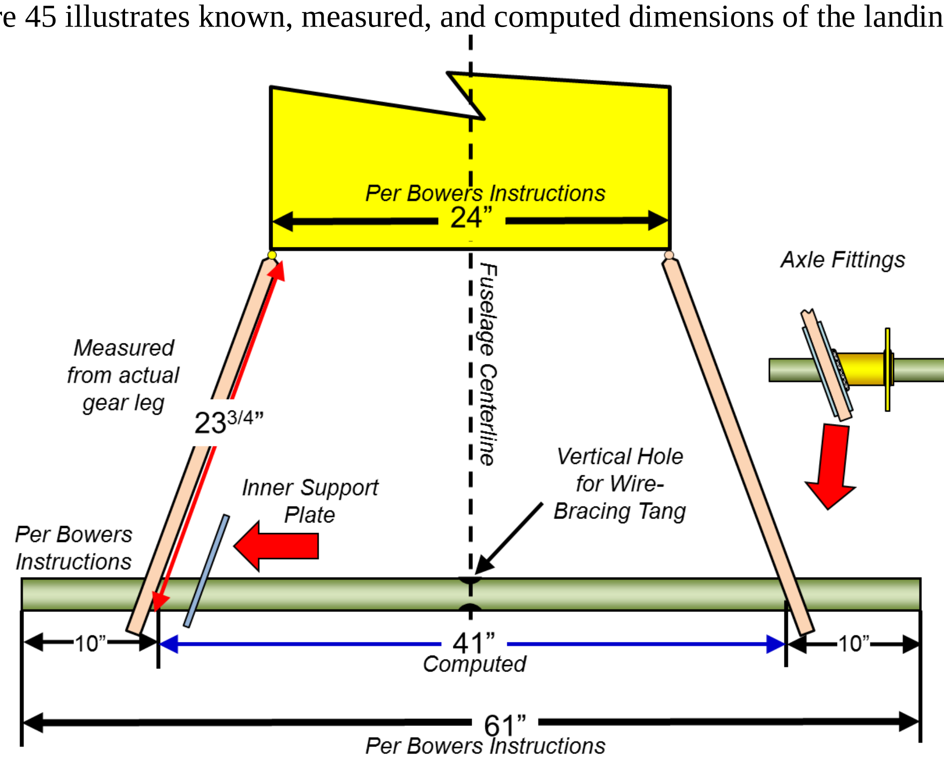

Figure 45: Landing Gear Geometry

At the top, we know the fuselage is 24 inches wide.

At the bottom, we know the axle is 61 inches long, with the inner support plates (on the axle, on the inside of the legs) ten inches in from the ends of the axle. Sixty-one inches, minus two times 10 inches, means there's 41 inches between the gear legs at the axle.

Pete never provides the distance from the end of the landing gear strut to the hole where the axle passes through. I have a used gear leg, and measured about 23.75" .

Dead center on the axle is a vertical hole to mount the brace-wire tang. That hole should be even with the fuselage centerline.

If you took some angle iron and a bunch of clamps, you could lock the gear into the positions shown in Figure 45, weld the inner support plates onto the axle, and end up with a perfect landing gear.

One wee problem with that: All that heat on your nice, pristine wooden Vees is not likely to be good for them.

If you're a welder yourself or have a buddy who'll come over and do it for you, consider tack-welding the components in place. Tack-welding is temporary, and doesn't put as much heat into the underlying structure. Put some thin protection between the metal and the wood.

If you're having the axle professionally welded, have your welder assemble things as shown in Figure 46. Check the fit, then pull the axle off and have them do the full weld.

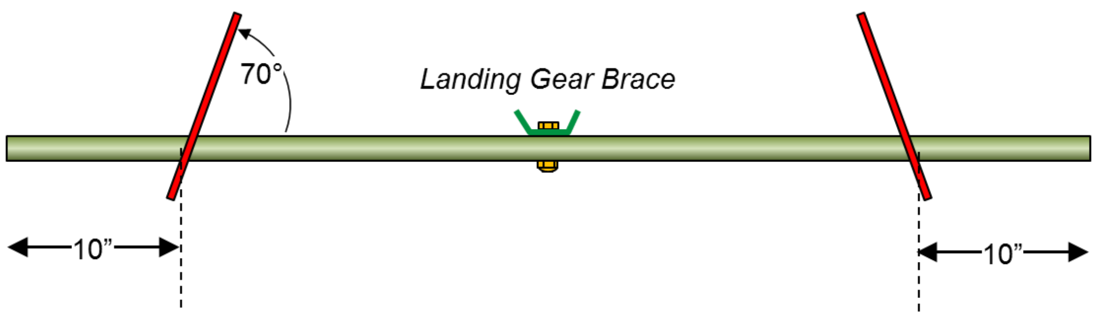

Figure 46: Welding Inner Support Plates

One builder had an intriguing suggestion: Built a pair of landing gear legs from scrap wood and practice on them. Not only does it minimize the chance of damaging your "good" legs, it gives you a structure to hold the axle parts while they're being welded.

Back in Section 4.1.1.12, Andrew Armstrong recommended building a set of Vees from scrap wood for practice. If you did that, you're ready to go.

Otherwise, take a 4x4 foot sheet of 3/4" plywood, and lay a 4x4 sheet of 1/4" plywood atop it (this gives the 1" thickness of the gear legs). Using the actual legs, trace out as many gear leg shapes as you can fit, as shown in Figure 47. Insert some #8 wood screws, 3/4" long, along the areas of the gear legs to hold the two thicknesses of plywood together. Then cut out the gear legs. Rough cut the ends of the legs as shown in Figure 47; you don't have to get an exact fit of the end of the practice legs into the metal fittings.

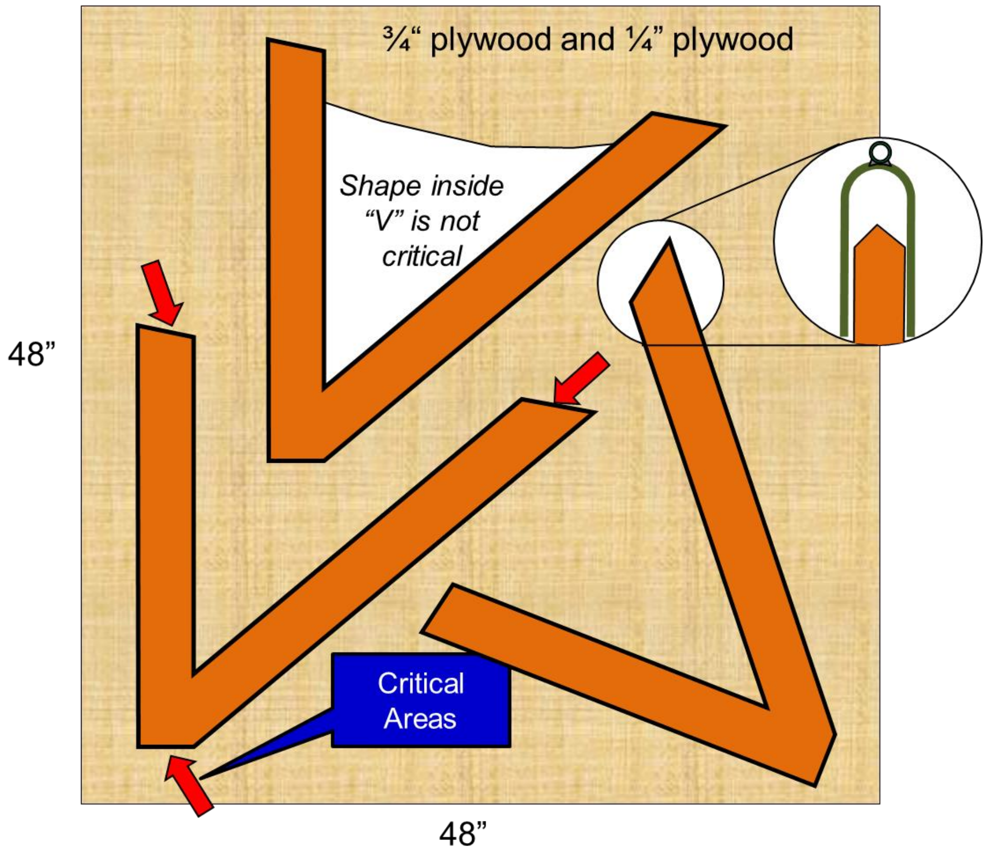

Figure 47: Making Practice Gear Legs

Note that you have to be accurate to the original gear shape only on the ends of the Vees, where the metal parts attach. The "web" portion inside the vees, and the actual width of the legs, isn't important.

When the legs are cut out, separate the two sections of plywood, apply glue in the middle (just ordinary wood glue is fine) and reassemble them with the screws. Let the glue dry, and you've got some practice pieces.

4.2.5 Welding the Inner Support Plates

With the brace in place, slide the axle between the gear legs. Add some temporary brace wires (could just be string) to position the gear evenly. Check the fit of the inner support plates, and adjust and re-weld as necessary.

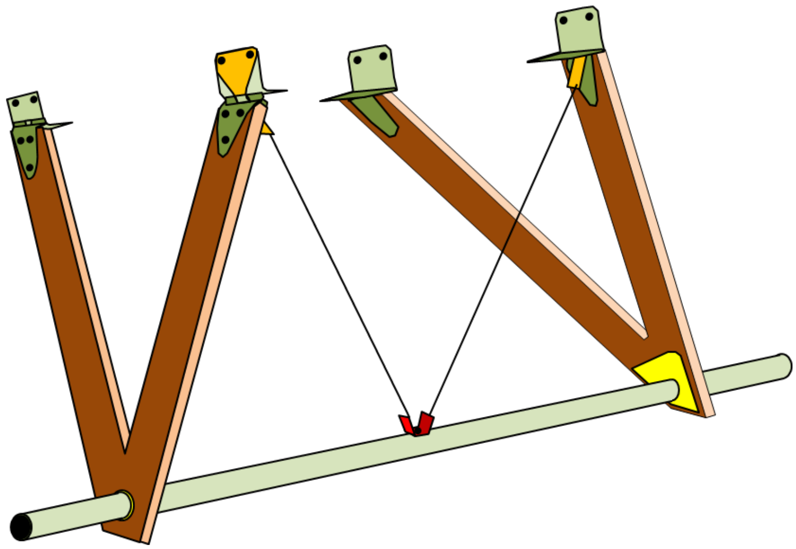

Figure 48: Axle Fitting Check

4.2.6 Brake Support Assembly

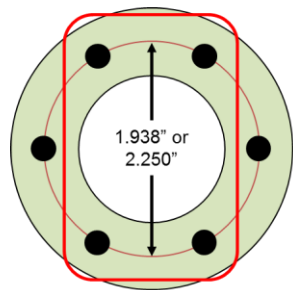

Figure 49: Brake Plate

The brake support assembly includes the outer support plate, the brake plate, and the tube that connects the two. It's shown on the top part of Figure 2-24.

The brake plate is merely a flat plate that the wheel's brake assembly will bolt to. The brakes usually attach with four bolts, but I recommend a circular plate with six holes. Your brakes will be designed to bolt to either a 1.938" or 2.250" diameter pattern, as shown in Figure 49. The red outline shows how a typical four-bolt brake will attach to the plate. The hole in the middle should be slightly greater than the tubing used for the brake support assembly so the plate will slide over the end of the tube.

So…why six holes when all you need is four? Flexibility. Since the holes are evenly spaced, it allows the brake unit to bolt on at several different angles. This may make a difference, as will be discussed later.

The outer support and brake plates are joined by a piece of tubing designed to slide over the axle. Pete specifies a minimum 0.093" wall thickness, but you'll need to balance that with the requirement to fit over the 1.5" axle tube. 1.75" tube with a 0.095" wall is available, and would probably be a good pick.

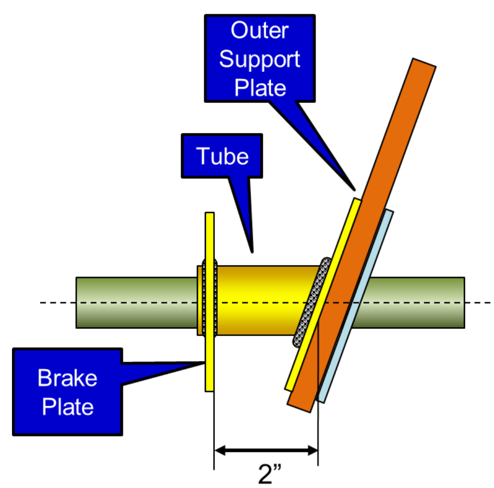

Figure 50: Brake Support Assembly

The assembly is shown at the top of Figure 2-4 on page 6 and Figure 2-5 on page 7 of Article 5, and in Figure 50 here. Note that the "center length" of the tube is two inches, but of course it must be cut at a slant to match the outer support plate. Cut a longish piece of tube, and work on it so it matches the outer support plate. Cut it down evenly at the end to get the length to ~2.5 inches, then weld the brake plate over the free end. Slide the brake plate and tube into the axle, and tack-weld the tube to the outer support plate. Remove the assembly, and finish up the welding.

4.2.7 Wing Wire Anchor Straps

The Wing Wire Anchor Straps are strips of 1/4" thick 4130 steel inserted into the ends of the axles. They're sized to fit within the axle tube, and are shown in Figure 2-5 on page 7 of Article 5. Ideally, the edges of the strap should be curved a bit to fit snugger into the axle, but I don't know how many people actually do that.

Length? Pete doesn't outright specify, but adding up some of the other dimensions, we're probably looking at about 15 inches. Might as well make it a bit longer, and cut it down once the final hole is installed.

The orientation of these straps is critical, and some builders have gotten it wrong. As Figure 51 shows, the strap is aligned with the rear gear leg. This is important, as its long axis is aligned with the direction the two sets of flying wires is pulling it.

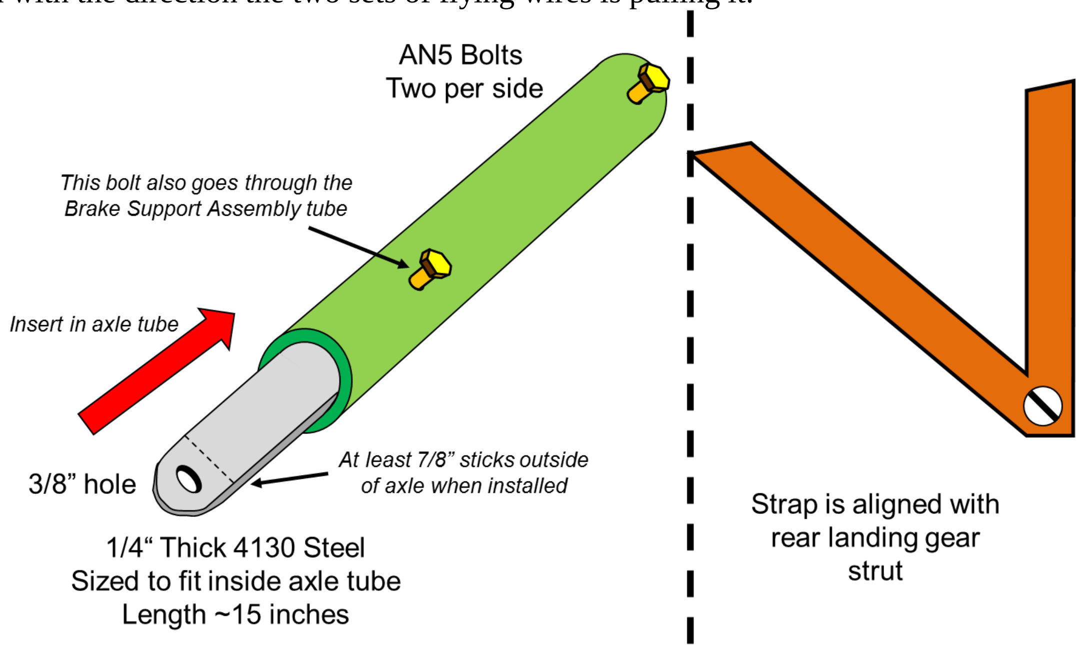

Figure 51: Wing Wire Support Strap

The straps are held in place by two AN5 (5/16") bolts, each. One of these bolts is inboard of the inner support plate, and the other actually goes through the tube that's part of the brake support assembly. Detail "B" of Figure 2-5 shows these bolt holes, as does Figure 52. They can be drilled using piece of board clamped to the axle and the same process described in Figure 40. Because the strap is at an angle, this means that the bolts are at an angle as well.

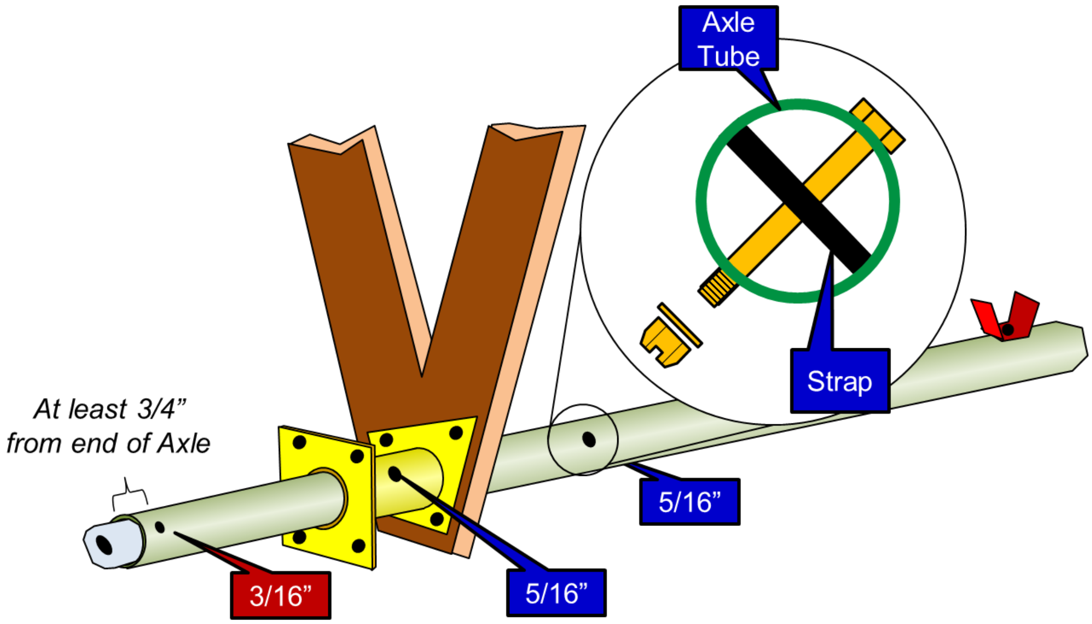

Figure 52: Bolts Holding the Axle Straps

There’s a third hole that needs to be drilled through the axle and strap, but it’s not really part of the strap support design. It’s drilled near the end of the axle, roughly an inch in from the end of the axle, at the same angle as the other straps, but it’s only 3/16” in diameter. It’s a cross-bolt for the wheel retainer, discussed in Section 4.3.

Figure 53 shows the wire support strap on my own airplane. Note the bolt hole through the Brake Support assembly, one of the two bolts holding the strap in place. The smaller hole for the wheel retainer is visible as well.

Figure 53: Brake Support Assembly and Axle

4.2.8 Bracing Wires

As of this point, you're ready to add the center bracing wires. Set up the gear as true as you can, then install a single cable on the left and right sides, with the turnbuckles with four threads showing, as Pete describes in the article.

The turnbuckles should be at the top, as seen in Figure 54. As mentioned in Section 4.1.2.1, making the tab on the "Y" fitting a bit longer makes it easier to get the turnbuckles installed.

Once the pair of cables is ready, gradually tighten both sides, checking that the centerpoint of the axle (the bolt for the attachment tang) remains aligned with the centerline of the fuselage.

Figure 54: Gear Brace Wires

Prepare another set of cables to fit the second brace on each side. Don't worry about tightening it down; a single set of cables will hold during wheel installation, and you're just going to have to disassemble it when it comes time to varnish the gear.

4.3 Wheel and Brake Installation

Pete doesn't provide any information on actual installation of the wheels and brakes. This is because it will vary, depending upon the type of wheels and brakes used.

However, the Fly Baby attaches its wheels using a system that's a bit unusual. We'll get to that in a bit, but let's take a look at some background information.

4.3.1 Nomenclature

If you take a look, there seems to be a bewildering combination of terms… five inch wheels, six inch wheels, 8.00x 4 tires, etc. Let's get this straightened out, first.

Aircraft wheel sizes are defined by the size of the "hole" in the middle of the tire. Typical sizes are four inch (used on the J-3 Cub), five inch (used on light planes like the Cessna 150), and six inch (used on most GA four-seaters), eight inch, ten-and-a-half inches, etc..

The first number ("8.00") is what's called the nominal section width. This is basically the cross-sectional width of the tire at its fattest point.

So an "8.00 x 6" tire is designed to fit on a six-inch wheel, and will have a maximum width of eight inches.

The strange thing to me is that there isn't a designator for the overall diameter of the tire for General Aviation tires! For all we know, one manufacturer could build a tall, skinny tire, and another make a stubby small tire, and both some in under the "8.00 inch nominal section width" designator.

This is an offshot of the use of "Type Three" tires on light aircraft. Type Three tires are designed as low-pressure tires for cushioning and floatation. Hence, the specification for width to show how wide the footprint is (the wider the

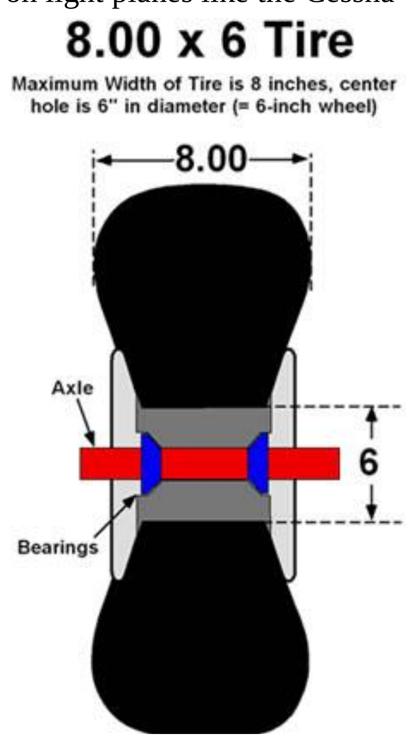

Figure 55: Tire/Wheel Nomenclature

footprint, the more rubber in contact with the ground, and the lower ground pressure).

The aircraft world is about the last bastion of tubes, too....you don't often see tubeless tires on light aircraft. Probably the main explanation is that small aircraft use two-part wheels...they split, left and right halves, to allow you to mount tires with ordinary hand tools. Go to the automobile tire shop and you'll see a pretty hefty piece of machinery necessary to install and remove the tubeless tires on a car rim. The split-rim design makes our lives much easier, but the two halves would have to include an airtight seal if tubeless tires are to be used. Hence, tubes are standard.

4.3.2 Selecting Feet for the Fly Baby

As I've mentioned several times, Pete assumes the use of J-3 Cub tires and wheels for the Fly Baby.

There are a couple of reasons for this. First, when Pete designed the Fly Baby, the Cub units were very common. Cheap used versions could be bought at the airplane junkyards.

The second reason turns on a bit of history. The tires for early aircraft were tall and thin, basically bicycle wheels and tires. In the '20's, Goodyear introduced the "Airwheel." This was a departure from the past, introducing fat, low-pressure tires for aircraft to help absorb the landing shocks.

Figure 56: Goodyear Promotes the Airwheel

One of the beneficiaries of the new wheels was the J-3 Cub. Combined with bungee cords, its big fat tires helped the trainer handle both the ineptitude of students as well as the cow pastures planes were operating from. The Cub used a 4-inch wheel. Compare that to the eighteen-inch wheels used by some of the contemporary biplanes.

Skip forward thirty years. Pete Bowers designed a homebuilt airplane very similar to the Cub, but WITHOUT the bungee cords. To help absorb the landing shocks, Bowers used the fat, low-pressure Cub wheels and brakes.

So, there IS an argument for using J-3 wheels and brakes even today.

The argument against it is cost. A brand-new tire of the common 7.00x6 size costs about $160. The Cub tires are twice as expensive.

Of course, one doesn't replace aircraft tires that often. But the Cub wheels and brakes are rare, and thus any repair parts are pricy.

So. What size should you use on your Fly Baby?

The most common General Aviation wheel is six-inch, and that's what you should select. They just don't make a variety of tire sizes for five inch wheels, and you'd be stuck with some dinky tires that won't give you much shock absorbing capability. And eight-inch wheels are probably overkill.

What size tire for that six-inch wheel? I like 8.00x6, as they give a big fat profile much like the Cub tires used on the original Fly Baby…and offer a lot of "squish" for those hard arrivals.

However, others don't like the "big tire" look, and go with 7.00x6 tires (they fit on the same rim).

I installed Grove 6-inch wheels on my airplane about ten years ago, and have been very happy with them.

Mind you, there's nothing wrong with picking up a used set of aircraft wheels. The six-inch size were used on most modern GA aircraft, and are readily available.

4.3.3 Brake Installation

Most aircraft now use disk brakes. A typical aircraft disk brake is shown as Figure 57. When I replaced my Goodyear brakes with Groves, they bolted directly in place with only slight changes.

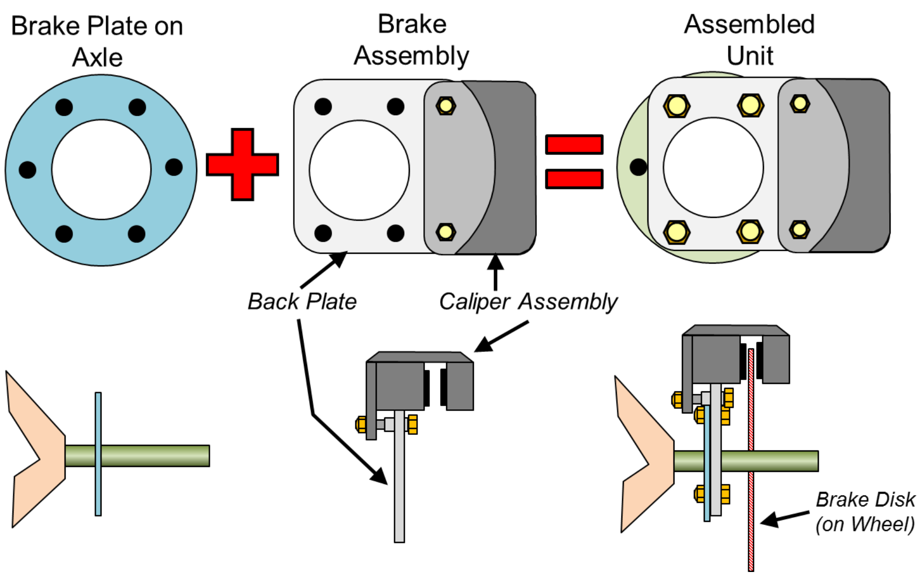

Figure 57: Brake Installation

The brake plate has six holes in a circle. These can be matched to the brake assembly in several ways, to position the assembly in the most advantageous angle.

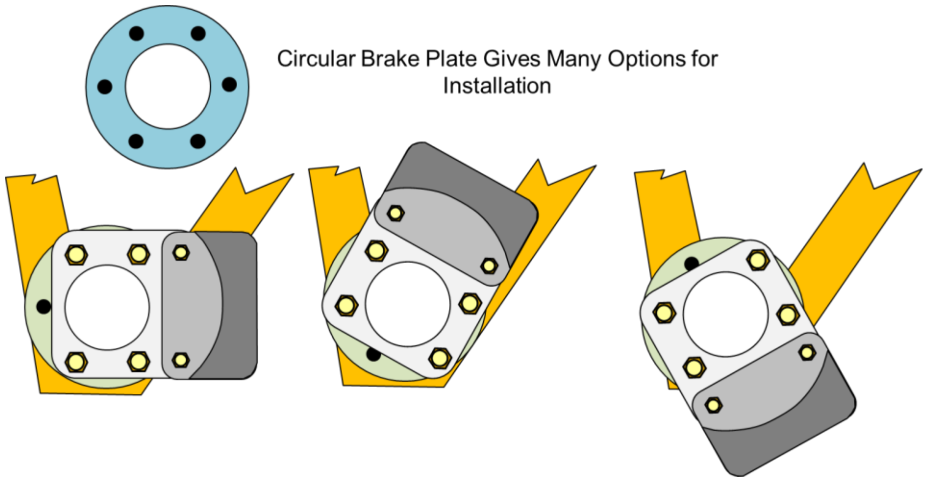

Figure 58: Brake Positioning Options

However, you'd like to avoid the orientation shown on the far right of the above diagram. Figure 59 shows why. With the caliper low, there's the danger that a flat tire will cause it to contact the ground…with half the airplane's weight on it.

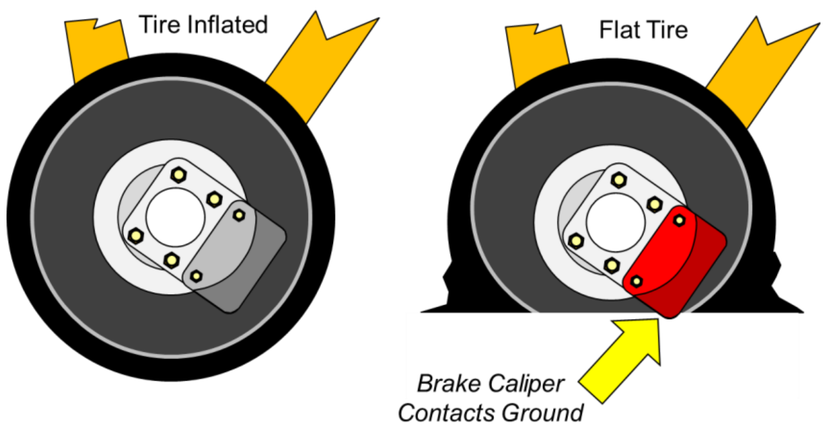

Figure 59: Badly-Positioned Caliper

4.3.4 Wheel Attachment

How the Fly Baby's wheel is held on tends to throw a lot of traditionalists.

In most aircraft, the end of the axle is threaded to accept a very large nut. The wheel is placed in position, and the nut tightened down—not all the way, just enough to ensure it's secure with a tiny amount of drag.

Not so the Fly Baby. The wheel is held in place by a tube slipped over the end of the axle with a bolt through the axle.

The keys to wheel installation are the inner spacer and the wheel retainer (Figure 60). These are made of steel tubing sized to slide over the axle. In fact, the same tubing as went into the brake support assembly would be fine.

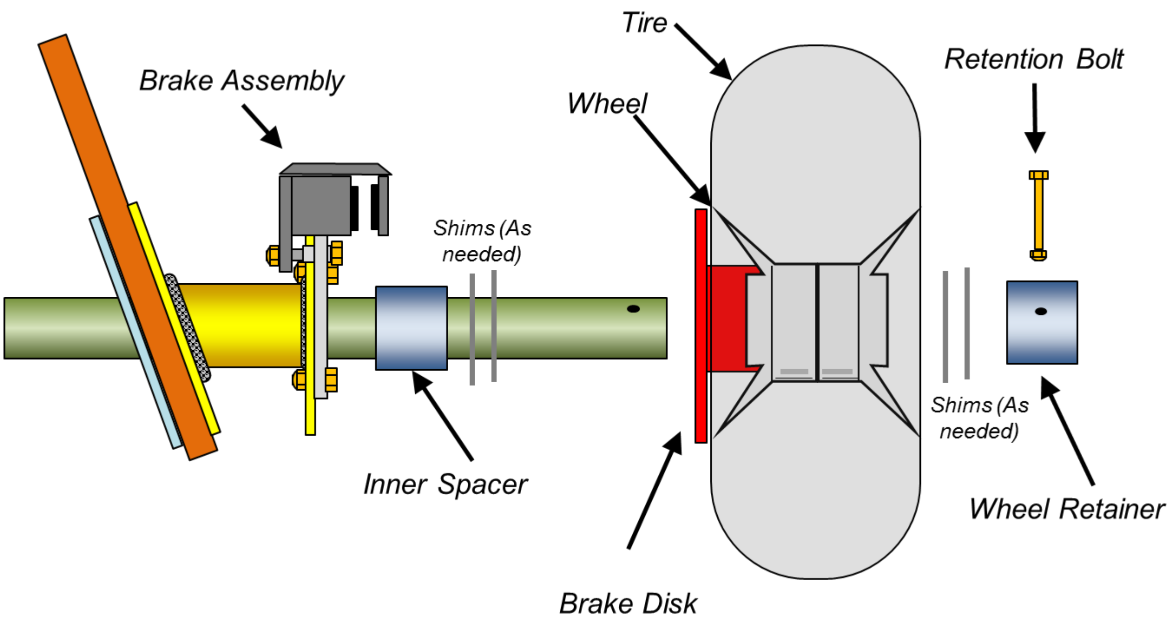

Figure 60: Fly Baby Wheel Attachment

The inner spacer has just one task: To position the wheel so that the brake disk is at the desired orientation to the brake assembly (e.g., the brake disk is inside the calipers). Cut-and-try would be sufficient here, although you do want both ends of the spacer cut very evenly.

The wheel retainer goes on the opposite side of the wheel, and includes a crosswise hole that matches the hole drilled through the end of the axle in Section 4.2.7. Its total length is about 1.5 inches. Slide the inner spacer into place, add the wheel, and slide the wheel retainer to hold it all together.

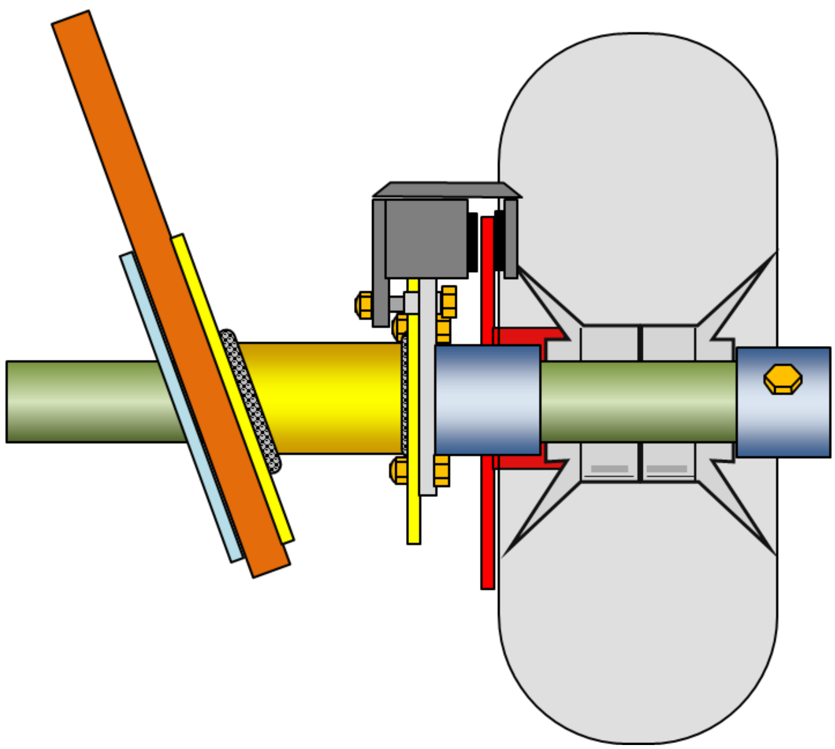

Figure 61: Assembled Wheel

Getting things precisely sized is sometimes an issue, so having a selection of thin shims (basically, big washers with a 1.5” hole) may be necessary. You do want this as tight as you can make it—it should require a little bit of encouragement to force that AN3 bolt through the end.

Ok, what about the calibrated compression of a great big nut at the end of the axle? What about tightening it so there’s just a little (but not too much) drag on the bearings as the wheel rotates? Won’t the bearings wear funny?

Consider: The wheels you’ll be installing are designed/sized for MUCH larger, much faster aircraft. The Goodyears that I pulled off my plane in 2009 were from a Cessna 172 (with a gross weight almost twice that of my Fly Baby. The same units were used on Bonanzas, with 20-30 MPH faster touchdown speeds.

It’s not the ideal method, but I’ve never heard of anyone having a problem. I’ve flown Fly Babies for 30 years, and have never had to replace a wheel bearing (albeit mine new wheels in 2009 came with new bearings).

If you want, and have the capability, feel free to thread the ends of the axles to accept a standard axle nut. If so, please use a cotter pin or safety wire to keep the nut from backing off.

4.3.5 Wrapping it Up

As of this point, all the construction on the landing gear should be done. Take off all the metal fittings and varnish the gear legs. Ensure that all the metal fittings are painted.

Let everything dry, then reassemble the gear. Build in all four cables for the bracing, this time.

Re-install the wheels, but leave off the brake calipers for now. They’ll just get in the way, and collect dust.

4.4 Tailwheel Support

The front of the tailwheel spring attaches at the hardwood cross-member at Station 9, which has a 5/16” hole drilled vertically in the middle of it. The middle of the tailwheel spring is clamped to the fuselage’s tail post by a special bracket, and the far end holds the tailwheel assembly.

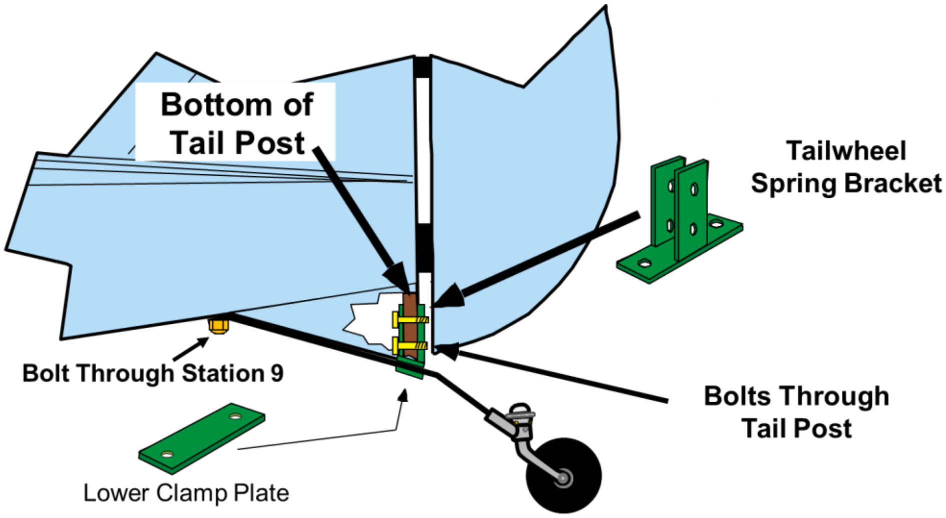

Figure 62: Tailwheel Installation

4.4.1 Tailwheel Spring

Pete shows a very nice diagram of the tailwheel spring at the top of Figure 2-6 on page 7 of Article 5. He's pretty precise about it. The spring is a single piece of steel, a quarter-inch thick and 1.5 inches across. The last nine inches bend at a 30° angle to the main part of the spring.

In reality…well, heck, you see a wide variation in tailwheel springs. Some have more of a bend, some less. Some put the bend further out from the fuselage, some bend right at the bracket. Some planes even use more than one leaf, like mine (Figure 63).

Figure 63: Ron's Tailwheel Installation

The lesson? Just about any small-aircraft tailwheel and spring will work on a Fly Baby, as long as particular geometric requirements are met.

Pete specifies 1.5" wide. The other common dimension is 1.25", and that would probably work.

The bolt at Station 9 is 5/16" diameter; many commercial springs have a 3/8" hole, here. Make a bushing out of 3/8" tubing with 0.028" wall.

The opposite end must be shaped to match the tailwheel assembly to be used.

The spring will need to be bent near one end, to match the hole in the Station 9 cross-member. And at the other end to position the tailwheel at the proper angle.

The tailwheel spring, when attached to the fuselage and with the tailwheel assembly installed, should have its pivot axis slanting back from the vertical. According to Drew Fidoe's "Maule Tailwheel Inspection, Repair, and Set-Up" manual,

> *I like to have my tail-wheel set with the vertical fork shaft set for about 15 to 20 degrees in the forward to aft plane. This allows the weight of the aeroplane tail to naturally straiten the tailwheel giving a bit of stability when on the roll.*
>
> *This angle may make ground handling a bit stiff however I feel the added stability is worth it. This vertical angle can be adjusting the angle of the tail spring-leaf, drawbacks*

are increased wear to the oilite bushing and reduced sensitivity. Be sure that your tail-spring will not easily contact your rudder when compressed in a bounced landing. http://www.bowersflybaby.com/tech/Maule_Tailwheel.pdf

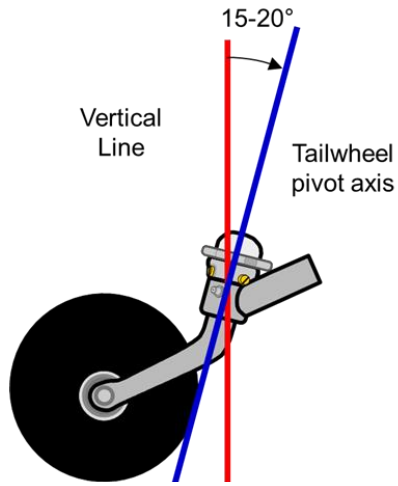

Figure 64: Tailwheel Installation Angle

This would hold true for non-Maule tailwheel assemblies, as well. It is illustrated in **Error! Reference source not found.**. Note that this is the angle when the plane is loaded. The tailwheel spring will tend to flatten out when fuel and the pilot are put aboard, so I'd tend towards the lower side of this range.

It's likely that you won't find a perfect spring, and thus may have to cut/bend your own.

Got bad news and good news. The bad news is that these bends MUST be done very carefully. If any amount of twist is introduced, it will affect the way the Fly Baby taxis.

The good news? These springs are hardened steel, and there's little a guy like you or me CAN do with them in the shop. The work will need to be professionally performed. The bends will need to be made in a hydraulic press. There are specialty shops that perform this work for cars. Do a Google search for "Suspension Repair." Often "hot rod" and tractor shops do this work. They can possibly drill them, but they should be able to recommend a machine shop if needed. Remember, you need the 5/16" hole at the front end, and the rear end cut to match your tailwheel assembly.

One recommendation: When you go out to do this work, *do not mention* the spring is for an aircraft. Some outfits are pretty nervous about that. If they ask—and they may not—do what I do in these sorts of situations: Tell them it's for an "Off-Road Vehicle." You won't even be lying.

If you're still curious about how to size the spring, Figure 65 shows the approximate dimensions of my own tailwheel spring. Mine has a short second leaf, but otherwise is pretty close to stock. The 160° measurement as shown is roughly equivalent of a 20° the way Pete defines it. So my angle is about ten degrees less.

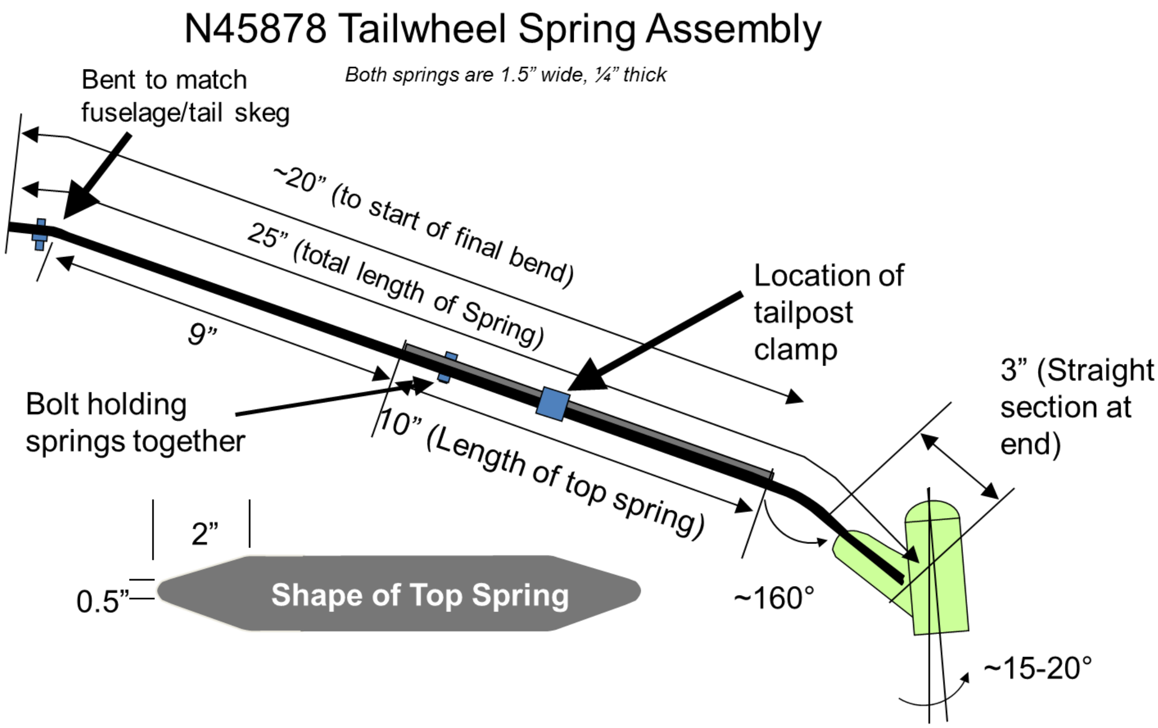

Figure 65: N45848 Tail Spring Dimensions

4.4.2 Tailwheel Assemblies

By "Tailwheel Assembly," I'm referring to the complete component that bolts onto the end of the spring. That includes the wheel itself, the fork that holds it, and the bracket assembly that holds it to the aircraft. Figure 66 shows a disassembled Maule unit.

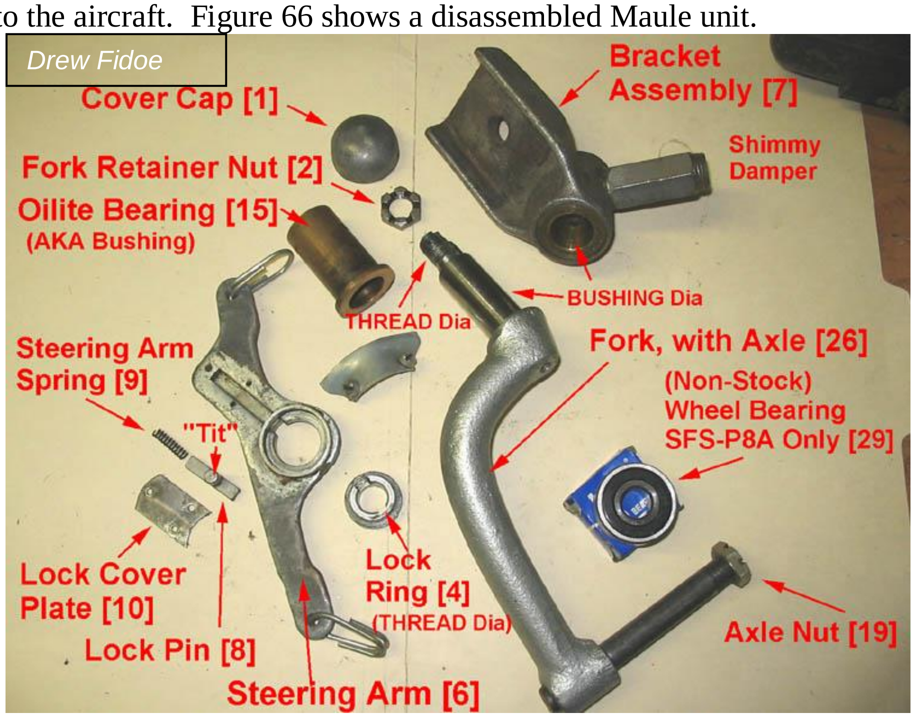

Figure 66: A Disassembled Tailwheel Assembly

Typically, though, people just use the term "Tailwheel" to refer to the entire assembly.

There are two kinds of tailwheels you'll find on Fly Babies: Steerable, and full swivel.

"Steerable" is kind of a misnomer…other than some antiques, all tailwheel assemblies are able to be steered.

What "Steerable" means, basically, is NOT full-swivel.

Confusing? Let's look at the full-swivel tailwheels, first.

A full-swivel tailwheel steers normally, until a certain amount of side-load is reached. At that point, the steering mechanism disconnects, and the tailwheel freely turns just like the wheel on a shopping cart. The steering mechanism re-locks when you're taxiing in a straight line again.

This is very useful in a number of ways. It allows very tight maneuvering. By applying the brake to one wheel, the tailwheel will kick into swivel mode, and you can turn a lot tighter. This is how you see taildraggers spin around in tight quarters.

It's also nice when you're putting the plane to bed after a day's flying. You start pushing the plane backwards and the tailwheel swivels to let you move the plane in any direction necessary.

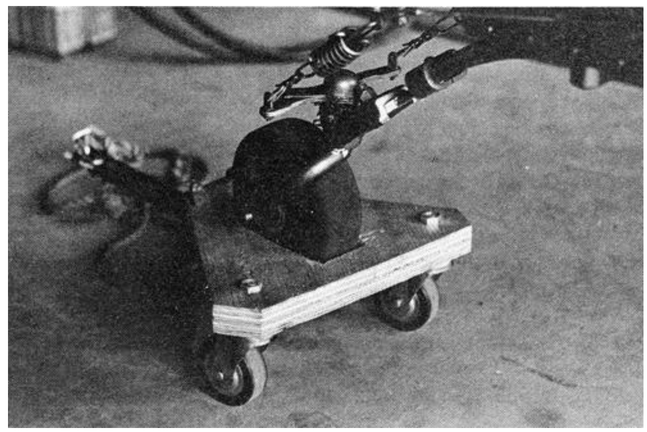

Figure 67: Tailwheel Handling Cart

A non-swivel tailwheel? Well, it's not as easy. The plane won't turn as tight on the ground. And when you push it backwards into the hangar, it doesn't want to roll straight.

Owners often cobble up a little cart, as shown in Figure 67. It's basically a wooden triangle with full-swiveling casters at the apexes and a slot for the tailwheel tire in the middle.

Of course, the full-swivel tailwheels can malfunction, occasionally. If the mechanism gets weak it can disconnect the steering at a time when you'd just as soon NOT lose steering—such as a landing in a stiff crosswind.

So if you get a good deal on a non-swiveling tailwheel assembly don't pass it up. Otherwise, Drew Fidoe has written a great guide to refurbishing and adjusting Maule tailwheels:

http://www.bowersflybaby.com/tech/Maule_Tailwheel.pdf

The tailwheel doesn't just swing along meekly behind the aircraft. It's connected to the rudder and you'll use that to steer on the ground.

If you set up the tailwheel spring properly, that is. Figure 68 shows how tailwheel steering works. There's a set of horns at the bottom of the rudder, and they connect to the steering arm of the tailwheel via chains or springs (we'll talk about that in a later Guide).

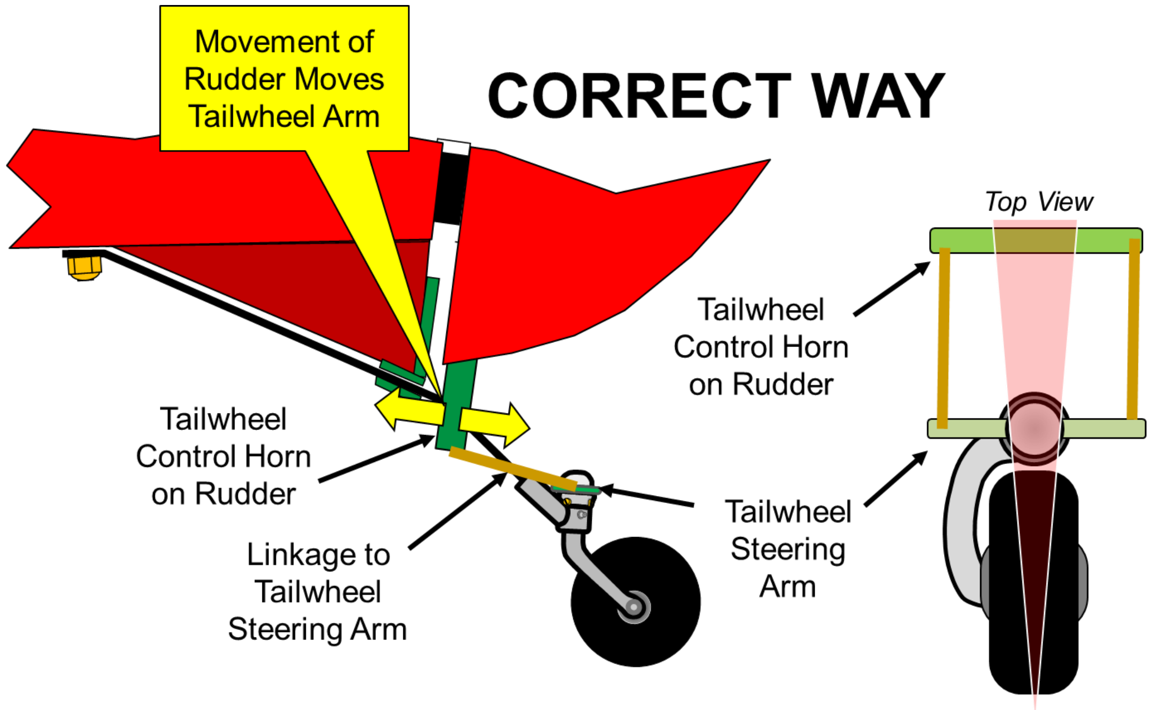

Figure 68: Tailwheel Steering

Note how the end of the control horn is pretty-well aligned with the steering arm.

However, some guys get the bright idea to make the bend in the tailwheel spring a lot sharper. It has the effect of raising the tail, giving the pilot better visibility forward while taxiing. Admittedly, the Fly Baby is a bit blind forward and S-turns are usually needed.

However, raising the tail isn't the solution. For one thing, it complicates full-stall landings, as the tail will hit the ground before the main gear.

And for another, it significantly reduces the ability to steer the airplane on the ground. Figure 69 illustrates this. It's an exaggerated bend, but not that the tailwheel steering arm is now BELOW the rudder control horns. When those horns move forward and back, they're not going to have much effect on the steering arm.

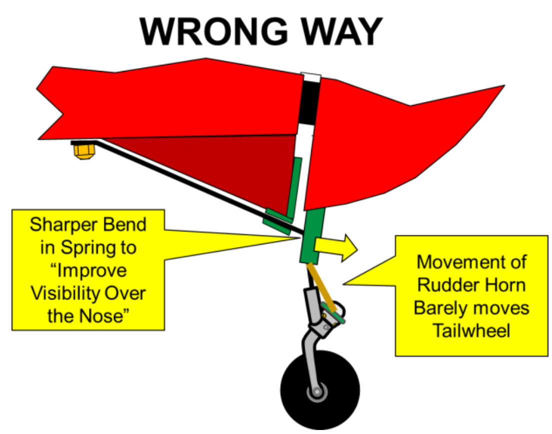

Figure 69: Effect of a Higher Bend in the Tailwheel Spring

4.4.3 Tailwheel Bracket

A dimensioned bracket for the bracket that holds the spring to the tail post is shown in Figure 2-6 on page 7 of Article 5. It's basically just a C-clamp that goes around the end of the tail post and is bolted through the post. At the bottom, a flat plate is welded across, and a second plate is bolted to it to secure the spring to the bottom of the tail post. Spacers between the two plates keep the spring centered on the bracket.

The tail post has a solid piece of wood between the two plywood sheets in the area where the bracket bolts (Figure 70). The bracket attaches to this area using two bolts through the tail post.

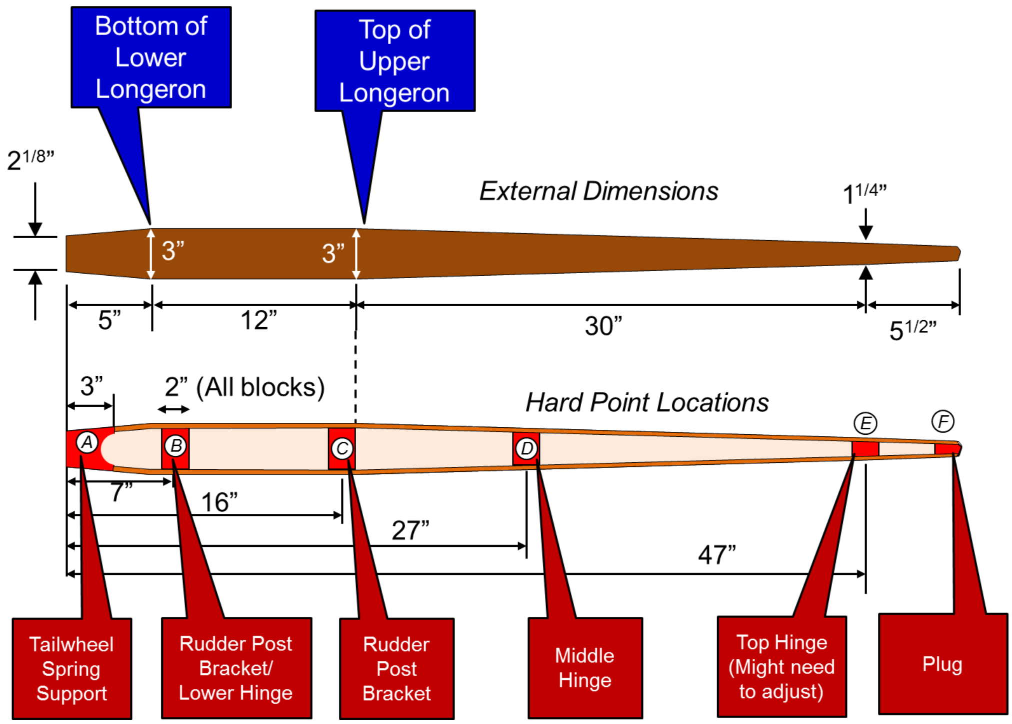

Figure 70: Hard Points inside Tail Post

However, in my opinion, the tailwheel spring can be subjected to side forces that can justify a taller bracket, allowing three bolts instead of two. As mentioned in the Guide for Article 3, I recommend a longer block inside the tail post, and a taller bracket that can accept three bolts instead of two. Assuming you installed the taller block, Figure 71 shows the modified bracket.

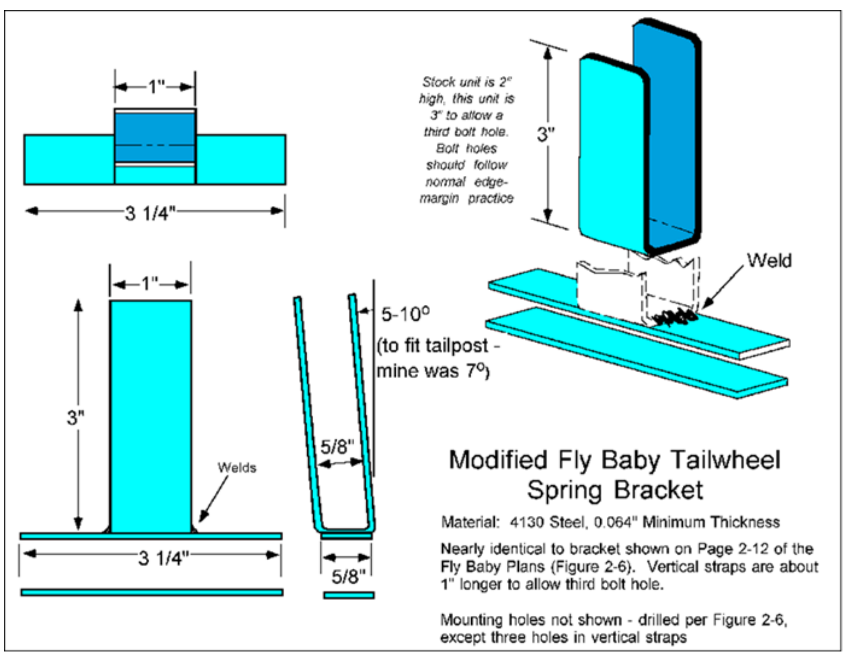

Figure 71: Modified Tailwheel Spring Bracket

5 ALTERNATE APPROACHES

The following topics have been discussed within the Fly Baby community. They may provide advantages to the builder, but have not been verified as viable.

5.1 Horizontal Tail Bracing Using the Spring Bracket

A set of diagonal bracing wires will eventually be installed to support the horizontal stabilizer. The Articles describe drilling a hole through the tail post above the spring support bracket, and adding a couple of steel tangs.

However, many builders merely extend the lower plate on the spring support clamp, and bent both edges upward to allow attachment of the bracing wires. Figure 72 shows what this looks like.

Figure 72: Bracing Wires Attached to Tailwheel Spring Clamp

I really like this modification. It eliminates some extra hardware in the tail, and the braces have a slightly better angle for support. N500F had this change performed when it was restored in 1982, and I did the same thing on my airplane when I repaired the tail post.

5.2 Myths and Legends of the Wing Wire Anchors[3]

A heard a weird thing a number of years ago. Pete's instructions show two strips of ¼" steel inserted into the ends of the axle and bolted in place, for attaching the flying wires. However, this man told me it was SUPPOSED to be a single long strap (Figure 73).

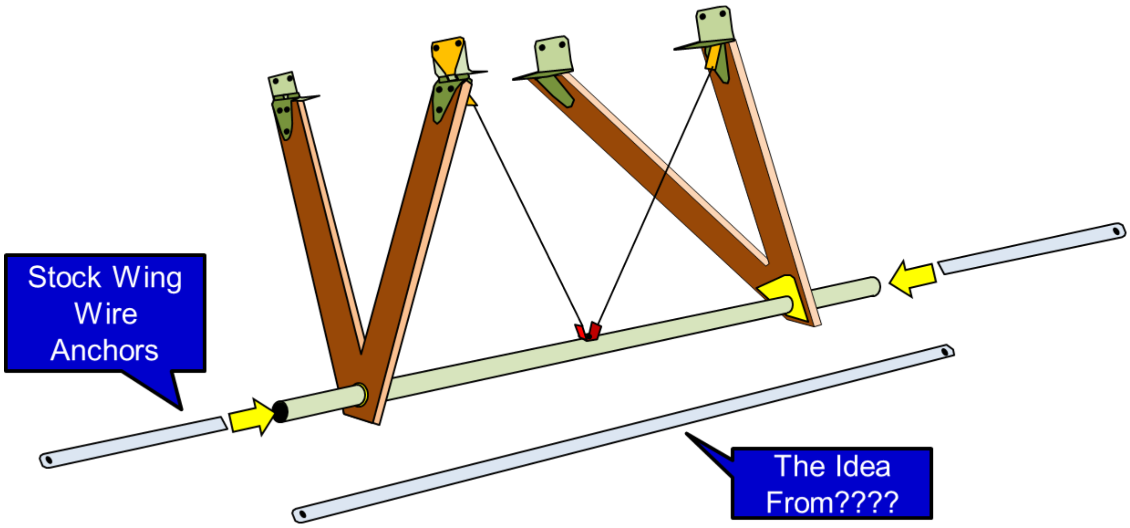

Figure 73: Single-Piece Anchor

Got no idea where this came from. There's no reason to spend the effort and have the extra weight of a once-piece strap. As far as I know, there has never been a failure of the two-strap system.

Along the same lines, I was once told that the wing wire anchors needed to be welded in place, not just bolted.

I'm not even sure how you'd do that. The only place the interface is accessible is right at the very end of the axle, which wouldn't make for a very large weld. You'd have to cut open the axle tube, weld the strap in place, and then re-close and weld up the axle tube.

So don't worry about welding the strap.

5.3 Wheel Pants

I am not a real big fan of wheel pants. I prefer the ability to easily inspect the wheels, tires, and brakes during the preflight inspection, and the fact that it's a lot easier to add air to the tires.

However, I don't argue that they do look attractive (Figure 74).

[3] Why, yes, I AM a Rick Wakeman fan.

Figure 74: Installed Wheel Pants

Wheel pants usually require support brackets on both sides of the wheel. This isn't much of a problem on the inboard side (the bracket can be bolted right to the brake support plate), but for a Fly Baby, this can be a bit more of a problem on the outboard side. Most attachment hardware is designed for the big-axle-nut systems, not the tubular keeper the Fly Baby uses.

The main advice I can give is to solve the installation issues *before* buying the pants. But if a good deal comes up on a set of used ones, nothing wrong with snapping them up.

Obviously, the time to add the supporting hardware is when the landing gear is being built. But adding the pants later would not be a big deal…no worse than pulling the wheels off, one at a time. It could be done in conjunction with a yearly condition inspection.

5.4 Split Axle Gear

At the end of Article 5, Pete discusses and shows a drawing for "Divided Axle" landing gear; one that doesn't run the axle all the way from side to side.It wasn't really Pete's idea. In the plans, he says, "The designer is against the divided axle and includes it in these drawings only to show that it CAN be done….To be effective, the inner stub should be almost as long as the axle, largely nullifying the anticipated benefit of the divided axle...."

I don't think Pete thought the gear was less strong; I suspect he was just trying to steer people away from building something that was more complex but didn't have any real advantages.

Fly Babies have flipped on their backs when landing in tall grass, but it is a pretty rare event...and, like Pete says, grass that tall might just flip a split-axle plane as well. But check out Harry Fenton's experience:

> *I can relate one benefit of the split axle gear- tall grass clearance!! A couple of summers back I landed at the airstrip on the family farm. It had not been mowed for some time, and the clover was in bloom, so the overall height of the greenery was about 10-12 inches. Being that it was the family strip, I gave it no thought as I knew it like the back of my hand.*

The landing was a non-event and I taxied back to take off. Acceleration was routine, but a bit slow, something I would anticipate to be correct with the grass length. The climb out was routine except for a noticeable buffet. I headed the Fly Baby back to Cottonwood Airport, about 15 miles to the south. As I chugged along, I was puzzled why my airspeed was pegged at 70 mph, a full 12 to 15 mph slower than normal. I must have got some fuzz or something in the pitot tube, I reckoned and plodded back to the airport to land.

As I was flaring to land, I noticed that the Baby required just a tad more force to flare out. What was really unusual was the small crowd of onlookers elbowing each other in the ribs and pointing to my plane. The clearly puzzled expressions on their faces puzzled me even more.

I taxied up to the hangar, shut down, and hopped out. It took about a second for me to understand the that the speed loss, flare pressure, and puzzled onlookers were all related to a common item- the hay bale of grass and clover wrapped around the straight axle! I pulled two five gallon buckets of cuttings from around the axle that had formed about a 1 foot high bale across the axle.

Maybe a serrated edge on the axle would be a nice safety device!

My personal opinion is that they aren't necessary, but if someone prefers the look (Figure 75), they should at least recognize that it's going to take longer to build.

Figure 75: Split-Axle Landing Gear

END OF COMPANION GUIDE FOR ARTICLE 5