

Copyright 2019 Ronald J. Wanttaja
All Rights Reserved
Non-Commercial Reproduction and
Distribution authorized

Companion Guide: “Building Fly Baby”

Articles 9: Miscellaneous #1

EAA SPORT AVIATION November 1963, Pages 27-29

Version 1.0

**By Ron Wanttaja
and the Fly Baby Community**

This Companion Guide is written to accompany the ninth of Pete Bowers' Fly Baby construction articles in EAA SPORT AVIATION magazine. The article didn't have a subtitle, but it can best be described as "Miscellaneous Topics."

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.

TABLE OF CONTENTS

1 Overview..... 5

 1.1 Note about Illustrations 5

 1.2 Workmanship 5

2 Errata..... 6

 2.1 Floorboard Holes..... 6

3 Safety Issues..... 7

4 Construction Issues 8

 4.1 Floorboards..... 8

 4.2 Seat 9

 4.3 Seat Belt and Shoulder Harness 11

 4.4 Brakes..... 13

 4.4.1 Types of Brakes 14

 4.4.2 Activation..... 15

 4.4.2.1 Toe Brakes..... 16

 4.4.2.2 Heel Brakes..... 17

 4.4.3 Brake Lines 18

 4.4.3.1 Flexible Hoses 18

 4.4.3.2 Metal Tubing 19

 4.4.3.3 Hybrid Systems..... 21

 4.4.3.4 A Note About Threads..... 21

 4.4.4 Filling the Brake Lines..... 22

 4.5 Flight Instruments 23

 4.5.1 What Instruments are Required 24

 4.5.2 Gauges You REALLY Need 24

 4.5.3 Finding Gauges 25

 4.5.4 Gauge Positions 26

 4.5.5 Going Electronic 26

 4.5.6 Making the Panel 27

 4.5.7 Plumbing 30

 4.6 Wing Hinge and Attachment..... 32

List of Figures

Figure 1: Forward Cockpit Floor	8
Figure 2: Aluminum Floorboard Coverings	9
Figure 3: Stock Seat Design.....	10
Figure 4: Stock Seat	11
Figure 5: Shoulder Harness Routing.....	12
Figure 6: Modified Shoulder Harness Routing.....	12
Figure 7: Stock Seat and Shoulder Harness	13
Figure 8: N500F Upside Down.....	14
Figure 9: Drum Brakes.....	15
Figure 10: Disk Brakes	15
Figure 11: Typical Fly Baby Brake System.....	16
Figure 12: Cessna 140 Rudder Pedals/Toe Brakes on a Fly Baby	16
Figure 13: Scott Master Cylinders	17
Figure 14: Switching Scott Master Cylinders from Horizontal to Vertical	18
Figure 15: Aircraft Hose Fittings	18
Figure 16: Assembling Hose Fittings	19
Figure 17: Adding Connections to Aluminum Tube	20
Figure 18: Tubing Flare Tool.....	20
Figure 19: Flexible Hose to Metal Tube Connection.....	21
Figure 20: AN Flare and Pipe Thread.....	21
Figure 21: Oil Can Brake-Fluid Pump.....	22
Figure 22: Filling Brakes	23
Figure 23: Instrument Panel.....	23
Figure 24: N500F Panel	25
Figure 25: Turn and Bank	25
Figure 26: Non-Sensitive Altimeter.....	26
Figure 27: Typical Gauge Positions.....	26
Figure 28: Dynon EFIS.....	27
Figure 29: Panel Drawing for Fly Baby N45848.....	28
Figure 30: Instrument Hole Template.....	29
Figure 31: Copying a Panel using a Router	30
Figure 32: Pitot/Static Plumbing.....	30
Figure 33: Holes in Nose Ribs for Pitot/Static Plumbing	31
Figure 34: Pitot Mast	32
Figure 35: Securing the Wings While Folded.....	33

1 OVERVIEW

Magazine editors don't like excessively long articles. Most of the articles in Pete's construction series are three to five pages long.

At some point, Pete had to talk about, basically "other stuff". Stuff that wasn't structure, or controls, or engines. He needed six or more pages to talk about subjects like the turtledeck, flooring, wheel brakes, windshields, etc. No one subject really justified an individual article, and a long series of short articles probably didn't make much sense, either.

So Pete divided these miscellaneous topics into two separate articles, in November and December, 1963. Curiously, the PREVIOUS Fly Baby article was in September...October was missed.

October is the month that EAA traditionally uses to cover the events of the annual convention the previous summer (Oshkosh nowadays, Rockford back then). So the issue is full of pictures of the planes that had attended the convention that summer, with no room for Fly Baby construction articles. Pete apparently didn't even bring N500F to the convention that year (the year after it won the contest), though he received an award for "Outstanding Contribution to Homebuilt Movement."

I considered combining the two articles into one Companion Guide, but that meant that this guide would cover almost a dozen unrelated topics. Nothing wrong with that, I guess, but it would just mean the release of this article would be delayed quite a bit until all the topics were covered.

Instead, I'll just address the subjects in Article 9.

1.1 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.

1.2 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

Everything in these articles are pretty minor stuff. Not much scope for mistakes in the original articles, though I'll talk about potential problems as they may arise.

2.1 Floorboard Holes

Figure 6-7 on Page 27 of Article 9 shows the shape of the two floorboards in the forward cockpit. There are some dimensioned holes in the forward floor.

These were the required holes for a particular installation of Scott master cylinder units. Your brake installation will probably be different, even if you use Scotts yourself. So don't pre-cut these holes.

3 SAFETY ISSUES

No real safety issues...however, when we talk about the shoulder harness attachment, there are some things to consider.

4 CONSTRUCTION ISSUES

4.1 Floorboards

The floorboards addressed in Article 9 are forward of Station 3 (the instrument panel bulkhead). You would have needed the first one already, to bolt your rudder pedals into place.

Figure 1 provides some orientation for the forward cockpit floor. The two separate floorboards (depicted in Figure 6-7 in Article 9) are shown in place, and shaded. They're made of 3/8" plywood...just from the hardware store would be fine. You can see the two rudder pedals (described in the Companion Guide for Article 8) as well as the brake pedals (Described in Section 4.4)

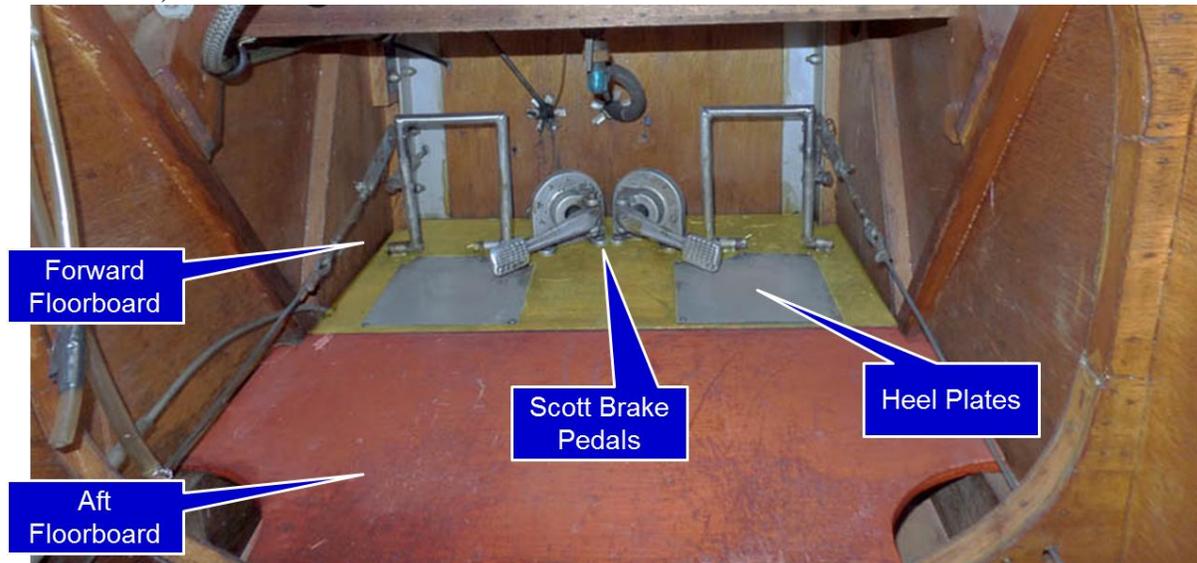


Figure 1: Forward Cockpit Floor

Pete has you just lay the floor panels in place. I flew N500F for a number of years with these panels loose. It was never a problem while flying, and DID make ground maintenance easier. If you decide you want yours attached, just use a couple of screws.

One thing Pete doesn't discuss is the heel plates, as seen in the above figure. This is where your feet will be resting when you fly the airplane. Obviously, the heels of your shoes might tend to scrape and mar the wood floor plates. A couple of thin pieces of aluminum gives you a set of scuff plates that either won't show the wear or can be easily replaced if needed. Just use four wood screws to hold each in place, and bend the outer edges of each plate downward a bit, or they'll bend upwards and catch your shoes.

They don't have to be dinky pieces of aluminum, either. Some folks just cover the entire top of the floor plywood with aluminum (Figure 2).

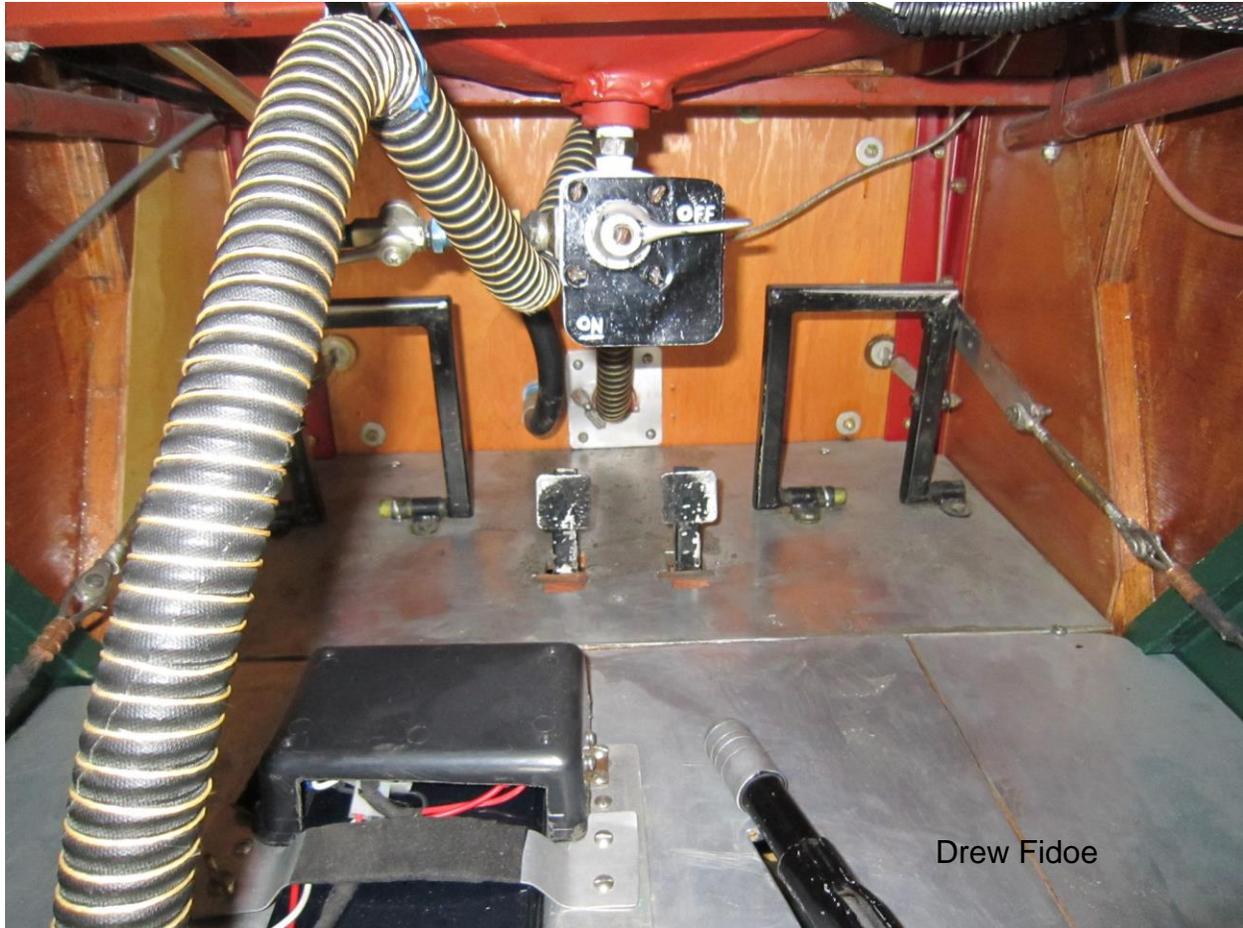


Figure 2: Aluminum Floorboard Coverings

(What's the hose in Figure 2? It's from the heater. Drew actually pokes this into his flight suit when flying in cold weather.)

4.2 Seat

Figure 6-8 in Article 9 gives dimensions of the seat Pete designed for the airplane. It's basically two sheets of plywood, hinged together, with a set of $\sim 3/4$ " "rails" where the seat rests across the seat bearers in the bottom of the fuselage. Pete doesn't give what the thickness of this plywood should be, but I'm guessing it's about $3/8$ ". Figure 3 shows the major portions of the seat, except for the back. The design includes a couple of notched plates that match with a block installed vertically in the seat support area. This allows the seat to be adjusted back and forth.

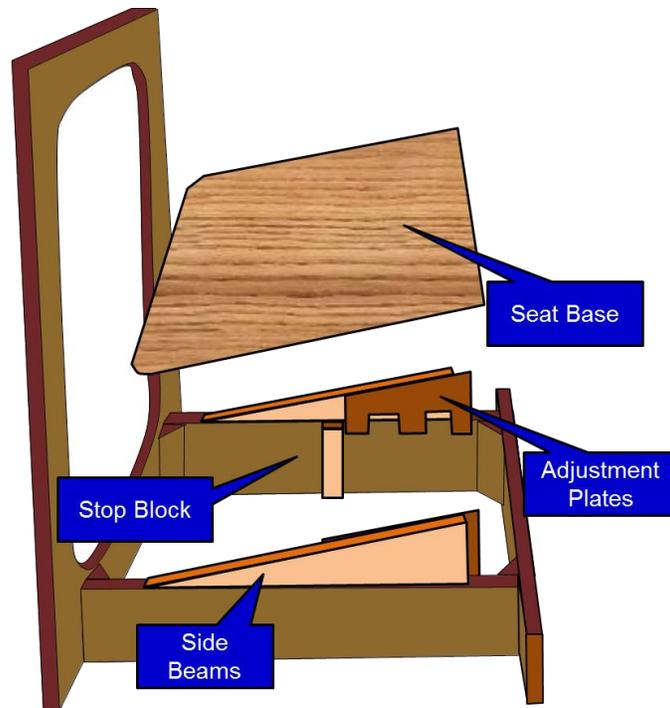


Figure 3: Stock Seat Design

Most Fly Baby pilots seem to agree: Pete was having an "off day" when he designed the seat for the Fly Baby. It has most of the good attributes of a piece of aircraft hardware: It's light, it's sturdy, it's adjustable, it takes little time to build.

It is also as uncomfortable as all getout. It's just two flat pieces of plywood. Sure, you can add some foam, but when you're sitting on it, your points of contact are concentrated into one small area on your rear end and one small area on your back. It's OK for short flights, but it really gets uncomfortable on anything but a short flight. Some owners call it a "45-minute seat."

Figure 4 shows a stock seat in place. Notice that the back is notched a bit to clear the slot where the shoulder harness comes through the Station 5 bulkhead. One can cover this with foam and upholstery, and it'll look pretty good.



Figure 4: Stock Seat

Still won't be all that comfortable, though. It's not hard to come up with another seat. On N500F, I built a wood frame for the bottom and curved the upper side rails to a seat design...then bent a piece of aluminum over the top surface. The back was a U-shaped frame of aluminum tubing, with thin sheet straps across it like a lawn chair. For Moonraker, I bought a fiberglass chair at the local surplus store for \$5. The seat part unbolts cleanly from the legs, and I just built a frame to match.

It's not something that has to be done before the first flight. But I think you'll want to eventually count on another seat. The advantages of Pete's design is that it is 1) Quick to build, 2) Cheap to build, and 3) is able to be adjusted fore and aft, to some extent.

4.3 Seat Belt and Shoulder Harness

Shoulder harnesses are not legally required. But geeze, guy, if you ever need one, you REALLY need one. Please include one in your aircraft.

Figure 6-9 in Article 9 show how to attach the shoulder harness and seat belt. The belts can be bought at places like Aircraft Spruce.

As mentioned back in Companion Guide 3, the design of the shoulder harness is not ideal. The stock harness attaches to the Station 6 area and is routed forward underneath the baggage shelf. It then emerges from the slot on the top of the Station 5 bulkhead and wraps over the pilot's shoulders (Figure 5).

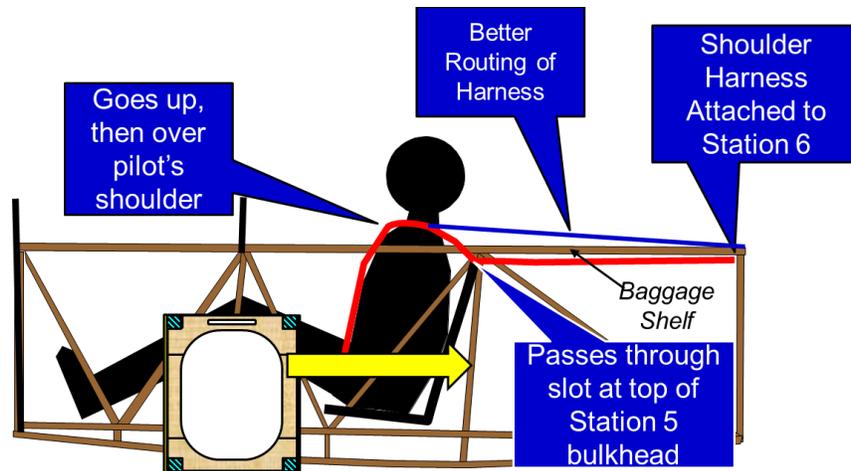


Figure 5: Shoulder Harness Routing

The problem is the upward curve in the shoulder harness applies downward pressure in a crash. This is not the ideal situation.

Ideally, the shoulder harness would run ATOP the baggage shelf, as shown by the blue line in the above illustration. This does tend to make use of the baggage shelf awkward, and the baggage compartment door will need to include provision for feeding the seat belt through.

When EAA Chapter 26 restored N500F in 1982, they performed this modification. Figure 6 shows the aircraft on display in the Seattle Museum of Flight restoration facility. Notches were added to the top of the baggage door, and the harnesses bolted to the back of the baggage area under the turtledeck.

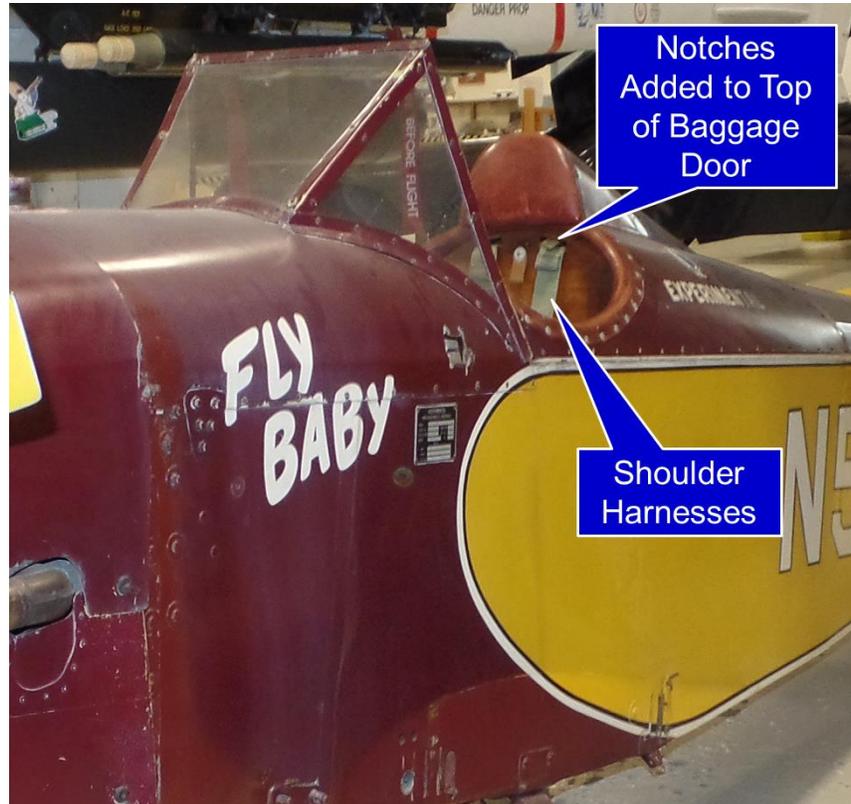


Figure 6: Modified Shoulder Harness Routing

I remember two things about this setup. First, the tension of the harnesses on the top of the door tended to make the door open slightly when sitting in the cockpit. Some builders have added a small steel-tube hoop behind the door opening to support the harness without putting pressure on the door.

Second, the harnesses did not seem to excessively impact the ability pack the turtledeck with baggage. But there was a tendency to flex the harness past the baggage, which meant that it wasn't truly taut.

My current Fly Baby has the "stock" harness routing, and I might change it if I ever do a major rebuild of the airplane. Otherwise, I'm going to leave it as it is.

Figure 7 shows a stock-type seat and the baseline shoulder harness and seat belt arrangement.



Figure 7: Stock Seat and Shoulder Harness

4.4 Brakes

Brakes are composed of systems that push pads against plates or cylinders attached to the wheels.

If you don't have a lot of experience in aircraft, you might be surprised by this: You don't want strong brakes. The Fly Baby is a taildragger, and if the wheels lock up while you're rolling, the plane may well flip onto its back (Figure 8).



The Peter M. Bowers Collection/The Museum of Flight

Figure 8: N500F Upside Down¹

The target for brake effectiveness on a Fly Baby is brakes strong enough to hold the airplane during a magneto check (~1800 RPM). It doesn't matter if your leg muscles are quivering from strain to mash down the brakes and keep the plane from moving—after all, a mag check only lasts for 20 seconds or so. For the condition inspection, you'll need to hold the plane (very temporarily) at full power, but I usually use chocks to help hold the plane, then.

The fun thing about aircraft brakes is that it's all sets of twos. You can opt for drum or disk, hydraulic or mechanical, heel or toe operation.

4.4.1 Types of Brakes

Originally, aircraft wheels were drum type (like the auto brakes back then)... brake pads were mounted inside a cylinder, and when activated, pads pressed against the inside of the cylinder (Figure 9).

¹ I'll admit, this accident didn't happen because the brakes locked. But it is such a cool picture...and does illustrate the aftermath if the brakes WERE to lock.



Figure 9: Drum Brakes

Just like on cars, though drum brakes were eventually superseded by disk brakes. The disk brakes can be an internal setup (Goodyear) or external (Cleveland and Grove). Most folks use the external-type disk brakes (Figure 10), but you might find a good used deal on older drum brakes or on Goodyears. Be advised; parts for these older brakes are getting harder to find and are quite expensive. A set of pads for Goodyear brakes may run \$200 or more.

I replaced my Goodyears with Groves about ten years ago, and have been very happy with them.

4.4.2 Activation

The pads/calipers on aircraft brakes are activated mechanically or hydraulically.

Mechanical brakes were used in a lot of '30s or '40s aircraft, and they do end up being installed on Fly Babies occasionally. They certainly eliminate some hassle, since you don't have install master cylinders in the cockpit or run hydraulic lines. But you have to run a cable from the wheel to wherever you put the pedal. This means setting up and aligning a series of pulleys. This will take quite a bit of work to get running properly.

Most folks install hydraulic brakes. The downside is that you have to install a master cylinder for each side and run the hydraulic lines between the master cylinders and the brake cylinders (Figure 11).

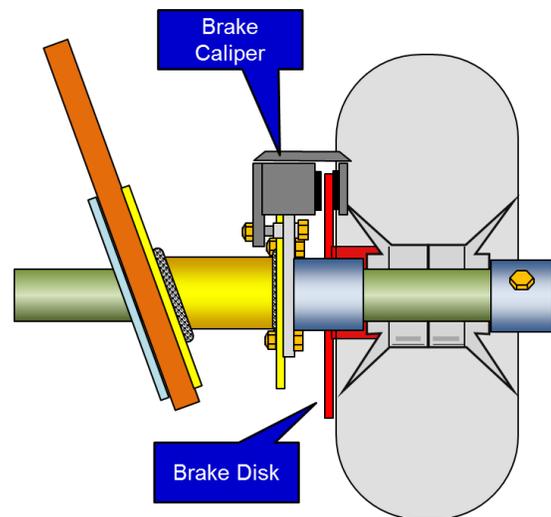


Figure 10: Disk Brakes

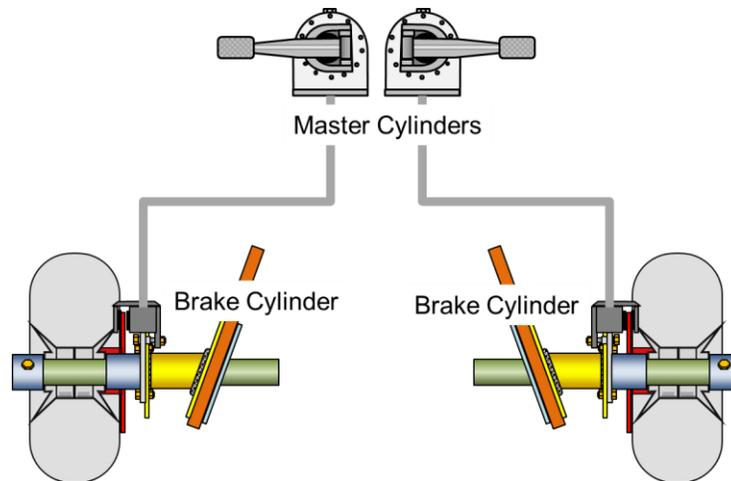


Figure 11: Typical Fly Baby Brake System

4.4.2.1 TOE BRAKES

Odds are, you learned to fly on a plane where the wheel brakes were activated by pressing your toes down on the top of the rudder pedals.

Yet you don't often find Fly Babies...or many of the simple plans-built designs...that use toe brakes. Most of them have a separate actuator for the brakes that the pilot controls with their heels. You leave your toes on the rudder pedals, and slide your heel inward (or outward, depending on the installation) to the brake pedals.

I learned to fly on a Citabria with heel brakes, and flew N500F for seven years with heel brakes. When I bought my own Fly Baby in 1996, it came with toe brakes (rudder pedals adapted from a Cessna 140). The forward cockpit floor had been significantly modified to fit the pedals (Figure 12). The forward floorboard was eliminated, a traverse tube was installed across the forward cockpit below the nominal floor level for mounting the pedals. Two stainless-steel plates were installed to support the pilot's feet.



Figure 12: Cessna 140 Rudder Pedals/Toe Brakes on a Fly Baby

Obviously, these changes are a pretty big deal. I don't have any of the dimensions, and can't access the area very well to take any.

So if you have to have toe brakes...well, you're going to have some problems to solve.

Aircraft Spruce sells a set of rudder pedals with integrated brake pedals for about \$100 (it doesn't include the master cylinders, though). Before adapting these pedals to your airplane, make sure you have enough vertical space! The fuel tank sits over your feet, and if those pedals are too tall, they (or your foot, working them) will hit the tank. I believe this is why the traverse tube in my airplane (which the pedals slide onto) is mounted low in the fuselage.

4.4.2.2 HEEL BRAKES

One big advantage to heel brakes is that it keeps the brakes as an entirely separate system. You can use the stock rudder pedals, and set up the heel brake pedals wherever you like.

One of the most common implementation uses Scott master cylinders, as seen in Figure 13. These are complete, self-contained units that were used on a large number of production aircraft.



Figure 13: Scott Master Cylinders

Note that the units are installed at a bit of an angle. This is one of the advantages of the Scott unit, they have installation flexibility.

They can even be installed vertically vs. horizontally...in fact, that's what Pete's Article 9 recommends! The "Brake Pedal Cutouts" in Figure 6-7 are to accommodate vertical Scott units. At some point in the aircraft's life, it was switched to horizontal configuration.

The Scott will handle either, but they have to be reconfigured. There's a component on the back of the unit that holds the brake fluid. It's basically a cone with a flange, and is called the "Compression Cover." Attached to the cover is a filler port for the brake fluid, with a screw-in plug.

This filler port has to be on top, so if you convert a set of Scotts to vertical orientation, remove the compression cover and reinstall it so that the filler port is at the highest point (Figure 14). If you're using used Scott units, consider installing a new diaphragm pad under the cover. The old ones do weaken over time.

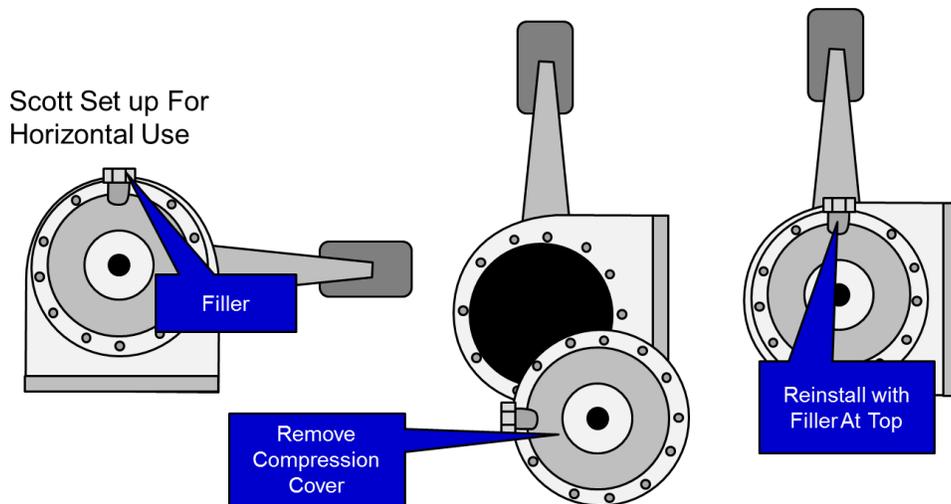


Figure 14: Switching Scott Master Cylinders from Horizontal to Vertical

The vertical orientation gives a much cleaner installation, though you’ll have to add structure under the floor to bolt them to.

Scott master cylinders aren’t the only option... a good thing, as they’re kind of pricy if you can’t find them used. Aircraft Spruce has a couple of other options for somewhat less.

4.4.3 Brake Lines

One thing for sure: you won’t get a straight run from the master cylinders to the brake cylinders. Whatever you use for brake lines has to be able to accommodate a lot of turns.

To do this...well, we’re back to two choices, again: Flexible hoses, or bendable metal lines.

4.4.3.1 FLEXIBLE HOSES

Flexible hoses would seem to be the easiest. The traditional method uses medium-pressure aviation hose; reinforced rubber tubing with high-pressure fittings. Aircraft Spruce sells the “Stratoflex” line of hose, and you’ll also hear of the Aeroquip line.

Fittings are integrated to the hose as shown in Figure 15. The hose itself slides into the nut. The fitting includes both a threaded section that meshes with one just inside the end of the nut as well as a tapered section that goes inside the hose. Tightening the fitting into the nut pins the hose between the tapered section and the inside of the nut.

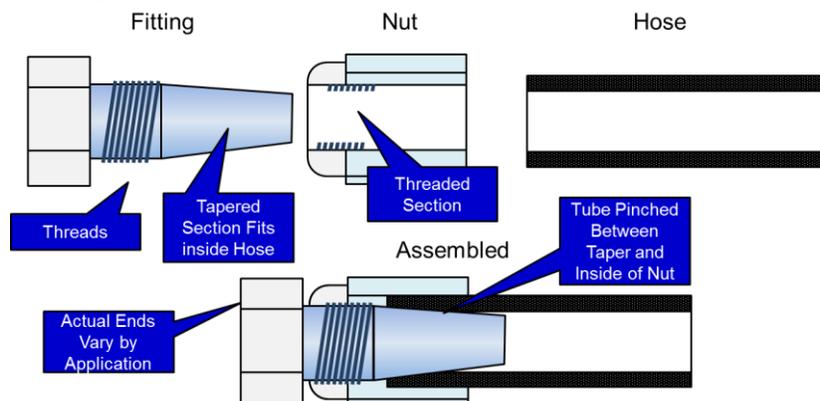


Figure 15: Aircraft Hose Fittings

The actual fittings at the end vary, of course, depending on what the hose is intended to attach to.

The actual assembly will vary based on the type of hose, and the instructions can be easily found online. Generally, you do a test fit of the hose with the nut and wrap a bit of tape on the hose at the end of the nut. Then screw down the fitting (note that the fitting is left-hand thread!). If the apparent position of the tape moved relative to the nut, the hose slipped out as the fitting was being screwed in (Figure 16). Disassemble and re-do.

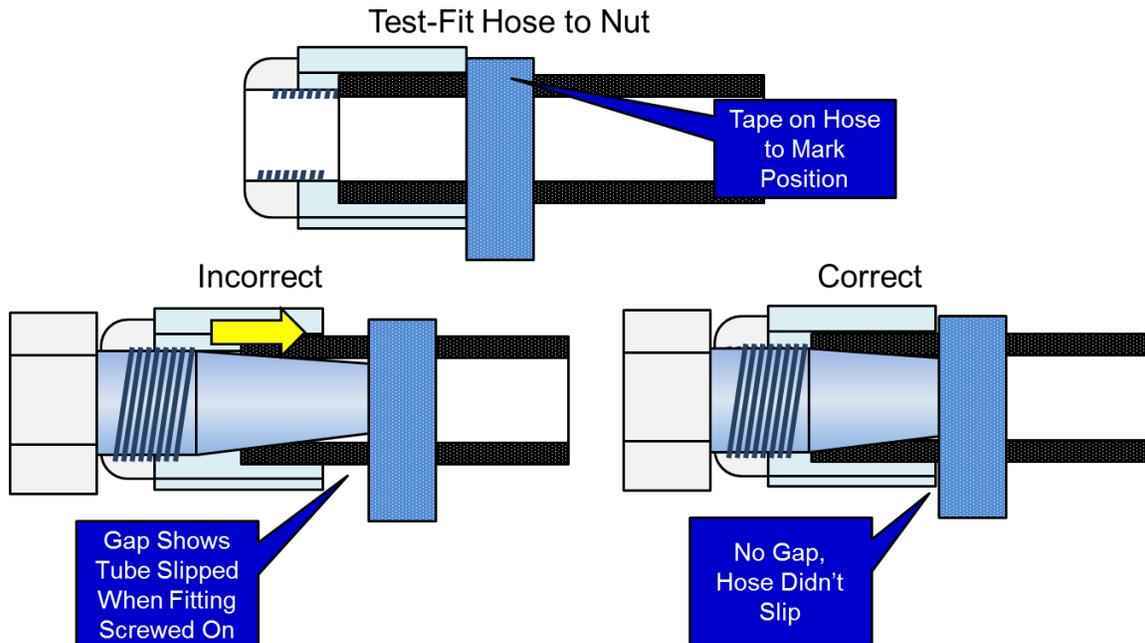


Figure 16: Assembling Hose Fittings

Flush out the hose after assembly to eliminate any hose fibers or metal shavings.

There is another kind of flexible hose, Nylaflo. This is a light plastic hose with matching fittings. Many homebuilts use it. However, a few users have had problems with the fittings popping off. This appears to be heat-related; the problems are occurring in hot climates and if the brakes themselves get too hot during use.

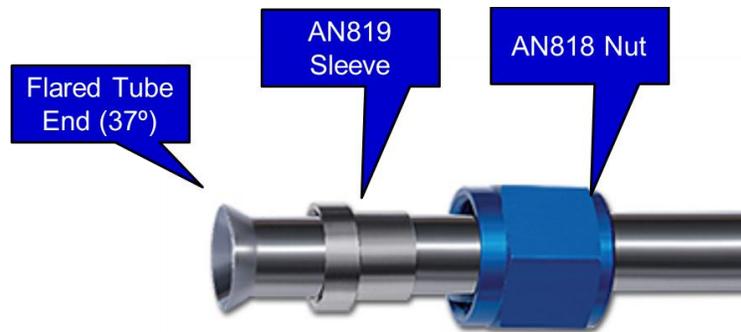
4.4.3.2 METAL TUBING

One problem with this flexible hose is that it's not really all that flexible. If you've got a tight curve to make, it's possible the hose won't bend sharply enough to allow it.

So obviously, the solution is to use metal tubing, right?

Well, actually, it is. If you use relatively soft aluminum tubing, you can bend it very nicely. Typically, a homebuilt will use 5052-0 aluminum tubing, with a 1/4" outside diameter and a 0.035" wall thickness. It's pretty cheap, so it's easy to throw out a piece if you crimp a bend.

The system works by joining hardware and tubing using flared couplers. Figure 17 illustrates how this works. The end of the tubing is flared slightly, and an AN819-4 sleeve is slid up to the flared section, and an AN818-4 nut slides over the sleeve. If you're attaching the brake line to, for instance, a Scott master cylinder, a fitting with a flare end is screwed into the threaded fitting on the cylinder, and the nut on the tubing snugs the flared end of the tube down to the flared end of the fitting.



Brown and Miller Racing Solutions

Figure 17: Adding Connections to Aluminum Tube

The -4 version of the nut and the sleeve is the right size to use with 1/4" tubing. If you're using aluminum tubing, get the -4D version of the parts...they're aluminum as well, and you won't get dissimilar metals corrosion.

Now: Here's a SERIOUS caution about this method:

This flaring system is also used on cars, and you can buy tubing, connectors, and tools at just about any auto-parts store.

However... the aircraft standard flare is 37°, while the automotive standard is 45°.

They are NOT compatible!

So get your tools and parts from the aviation-supply places².

One drawback of this method is that a special tool is needed to flare the tubing. Figure 18 illustrates a typical aviation flaring tool.



Figure 18: Tubing Flare Tool

² Strangely enough, the auto-racing world uses 37° fittings. So you can find the right tool in the racing catalogs. But there's no price advantage, they sell for about the same as the aviation suppliers charge.

The tubing is cut off to the proper length, and the end smoothed and de-burred. Then slide on the nut, follow by the bushing.

Slide the end of the tube into the appropriately-sized hole in the main tool and clamp it down. Position the yoke (the top piece) with the cone-shaped end over the end of the tubing, and rotate the handle to flare the tubing.

The tool will come with specific instructions, and it's important to follow them. The tool itself should be lubricated, and the flaring cone must be as well.

One key point is that you do NOT twist the handle until the tool won't turn any more. That's a mistake I made several times, and my brake lines would subsequently crack. The tool instructions will tell you how far to tighten (typically, just three or four full turns of the handle). It just needs a flare wide enough that the bushing is pinned.

4.4.3.3 HYBRID SYSTEMS

I don't want to give the impression that ALL brake lines must be flexible hoses, or aluminum tubing. In reality, a mix is typical. In my airplane, for instance, there's a flexible hose running down from the master cylinders to a connection under the floor, then metal tubing out the fuselage, down the gear leg, and to the brake cylinder (Figure 19). Note that there is a small "Union" that joins the two types of brake line.

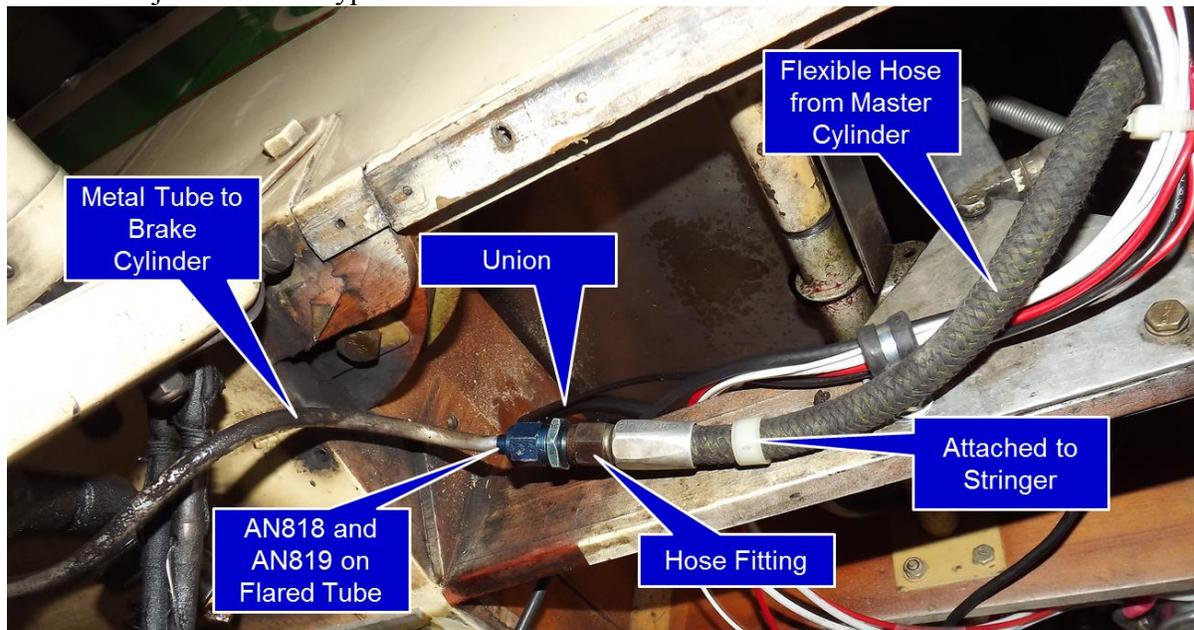


Figure 19: Flexible Hose to Metal Tube Connection

4.4.3.4 A NOTE ABOUT THREADS

You should be aware that there are two basic kinds of threads used for brake hardware.

We've been addressing the AN flared components; for the 1/4" tubing Fly Babies generally use, the thread is 7/16-20.

However, there's another type of thread you'll find in these kinds of connections: "Pipe Thread." This may have about the same diameter, but the threads per inch will be different and they CANNOT be attached to one another.

Generally, this arises when you're trying to attach your



Figure 20: AN Flare and Pipe Thread

hose or tubing to the brake or master cylinders. Generally, these have pipe fittings, not flared fittings.

A problem? No. Just get the appropriate Union. In this case, it would be a pipe-thread to AN-flared-thread adaptor, as seen in Figure 20. For the most part, the hoses or tubing coming from brake or master cylinders are going to need to change direction fairly soon anyway, so a 45° or even 90° adaptor will be a good start.

Take a look back at the picture of my brake lines in Figure 19. There's a union between the two...but I don't know if the fitting on the flexible tubing is flared or pipe! When this was originally assembled, of course, the builder had to know, to pick the right union.

Speaking of leaks, during home plumbing work, a lot of folks wrap the fittings with Teflon tape prior to assembly to reduce seepage. I don't really recommend tape for aircraft brakes (or oil lines, for that matter) because the aircraft lines are fairly small diameter. It's possible for a segment of tape to come free and partially plug the line.

Instead, use the paste-type sealant.

4.4.4 *Filling the Brake Lines*

When you're all done, the master cylinders, brake cylinders, and brake lines need to be filled with aircraft hydraulic fluid³.

Now, the obvious way is to open the filler plug on the master cylinder, and pour in the hydraulic fluid...right?

There's a problem with that. The brake lines are pretty skinny, and the fluid is pretty viscous. You're going to end up with bubbles in the brake lines, and that's bad...when you press the brake pedal, the AIR in the lines will compress instead of the (incompressible) hydraulic fluid. Your brakes will be weak and spongy, if they even work at all.

You can work around this. There's a "drain" at the low point of the brake cylinders. Usually, it's a nipple that has a screw for a plug. You can take out the plug and pump the brake pedal to force fluid AND air down the lines to the brake cylinder. When the air stops spitting out the bleeder, close off the bleeder. This is pretty much the standard automotive practice.

However, there's a very slick system you can use to eliminate this hassle. Go to the car parts store and buy a pump-type oil can and some plastic tube that fits over nozzle of the can. Fill it with hydraulic fluid, then connect the tube to the bleeder (it's usually a sort of nipple for exactly this reason). See Figure 21.

Then, pump hydraulic fluid into the brake system FROM BELOW. This pushes the air out the top. When brake fluid starts coming out the "fill" plug of the master cylinder, the brake system is full and there isn't any air in it.

This process is illustrated in Figure 22.



Figure 21: *Oil Can Brake-Fluid Pump*

³ Why not ordinary auto brake fluid? Because you don't know if it's compatible with the diaphragms and o-rings of your aircraft brake components. They're designed for aircraft hydraulic fluid, so that's what you'd better use.

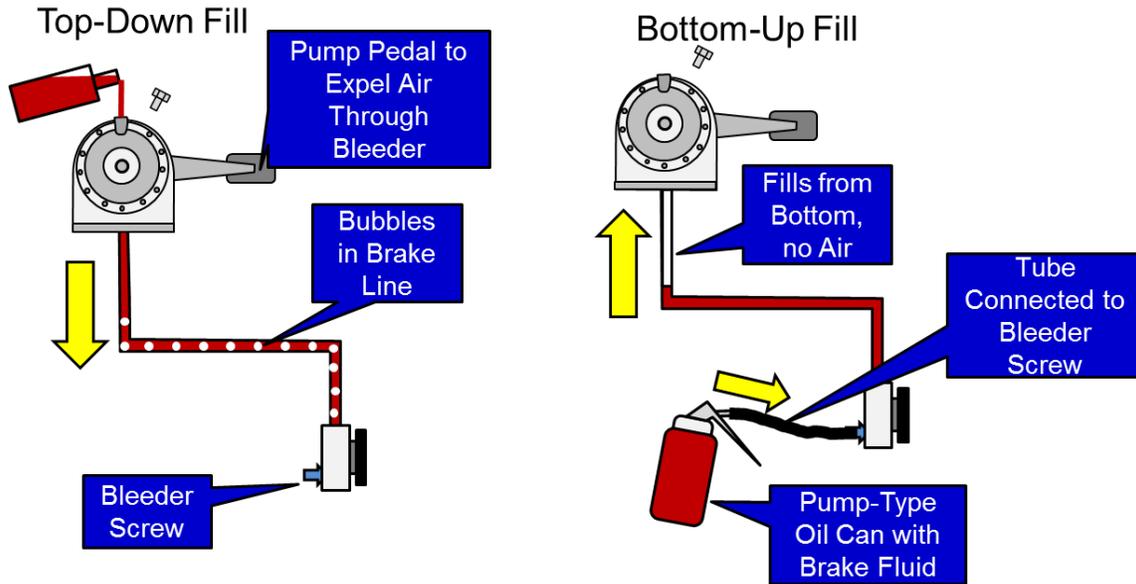


Figure 22: Filling Brakes

4.5 Flight Instruments

Back in the Companion Guide for Article 4, we discussed building the Fly Baby’s instrument panel. Now it’s time to populate it...or, actually, to populate it MORE, since we added engine instruments to it in Article 7.

Figure 23 depicts the stock instrument panel. The two side pieces of plywood are glued to the wood frame of the panel, and the center section is removable.

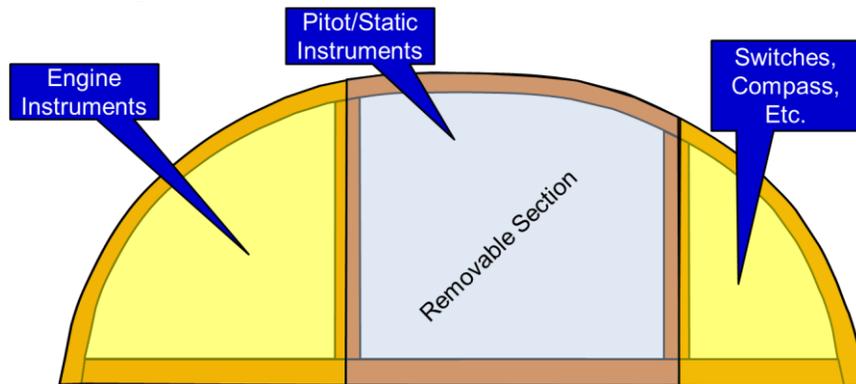


Figure 23: Instrument Panel

What gets put where? Pete intended the removable section to be used for instruments that don’t require rigid connections. As the pitot/static instruments (airspeed, altimeter, rate of climb, etc.) are connected with light rubber or nylon hoses, they work nicely in that center section. You can easily remove the panel, disconnect two hoses, and take it completely off the airplane. As a bonus, with the center section removed, you can easy access behind the permanent sections of the instrument panel.

If you want to see how other Fly Baby builders set up their panels, go to:
<http://www.bowersflybaby.com/pix/panels.html>

4.5.1 *What Instruments are Required*

At some point, you need to decide which instruments to install. For a guide, let's look at what the FAA's regulations say. From 14CFR 91.205, "Powered civil aircraft with standard category U.S. airworthiness certificates: Instrument and equipment requirements":

(b) Visual-flight rules (day). For VFR flight during the day, the following instruments and equipment are required:

- (1) Airspeed indicator.*
- (2) Altimeter.*
- (3) Magnetic direction indicator.*
- (4) Tachometer for each engine.*
- (5) Oil pressure gauge for each engine using pressure system.*
- (6) Temperature gauge for each liquid-cooled engine.*
- (7) Oil temperature gauge for each air-cooled engine.*
- (8) Manifold pressure gauge for each altitude engine.*
- (9) Fuel gauge indicating the quantity of fuel in each tank.*
- (10) Landing gear position indicator, if the aircraft has a retractable landing gear.*

Obviously, the rules for IFR aircraft don't apply. #10 doesn't apply to a Fly Baby, nor does #8. #6 would only apply if you were using a Rotax 912 or a converted auto engine. #9, you're handling with a cork on a wire.

Actually, the whole issue is a trick question. I left off section (a) of the regulation:

(a) General. Except as provided in paragraphs (c)(3) and (e) of this section, no person may operate a powered civil aircraft with a standard category U.S. airworthiness certificate in any operation described in paragraphs (b) through (f) of this section unless that aircraft contains the instruments and equipment specified in those paragraphs (or FAA-approved equivalents) for that type of operation, and those instruments and items of equipment are in operable condition.

Did you catch it? "...no person may operate a powered civil aircraft with a standard category U.S. airworthiness certificate...."

14CFR 91.205 does NOT apply to Experimental aircraft!

So, does this mean you can license your Fly Baby with a blank panel?

No. The Designated Airworthiness Representative (DAR) that inspects the airplane to give you an Airworthiness Certificate is going to expect a panel that contains the instruments required by 91.205. However, you do have some leeway. Instruments installed in an Experimental aircraft do not have to be approved by the FAA. There are companies that sell "Experimentals only" instruments for less than the certified varieties.

4.5.2 *Gauges You REALLY Need*

Take another look at that list of the 91.205 gauges, and you might be a bit surprised. There's a gauge that's been installed in the panel of every plane you've flown, but is NOT required by the regulation.

Pete even installed one in N500F...can you tell which one it is (Figure 24)?



Figure 24: N500F Panel

It's the Rate of Climb gauge. The FAA does not require it, on either VFR or IFR aircraft. But as you can see, it occupies a pretty large portion of the panel of N500F.

Install one if you like, but understand: They aren't required.

Another common gauge that isn't required for VFR aircraft is the slip-skid indicator. Considering that the Fly Baby is a taildragger, having one is a pretty good idea.

Most pilots are used to having one on the bottom of a Turn-And-Bank gauge (Figure 25). These are nice (I'd probably install one before a Rate of Climb) but they require an outside power source, either electricity or vacuum. Small Continentals aren't set up to accept vacuum pumps, so you'd need a venturi, or an electrical system on your airplane.

More hassle than needed. You can buy the slip-skid portion of the gauge separately, for \$60 or so. You can see one of these at the bottom of the picture of N500F's panel.

One of the ironic things, in this day and age, is that the FAA still requires the ol' whiskey compass in aircraft panels. You'll also need to swing (calibrate) the compass once the plane is together, and install a compass correction card.

4.5.3 Finding Gauges

So you'll need to find an Airspeed, an Altimeter, and a Compass to install in your Fly Baby. New, you can expect to pay between \$200 and \$300 each for NON-CERTIFIED gauges. These are produced for the homebuilt market.

Another option is to buy used gauges. They're commonly available.

For the airspeed, you can buy one calibrated in miles per hour or knots, as your preference runs. The Fly Baby has a red-line speed of 135 MPH, so you'll want an airspeed that goes a bit higher than that.



Figure 25: Turn and Bank

There's a weird fillip in 91.205: It requires an altimeter, but not a SENSITIVE altimeter. A sensitive altimeter isn't required unless you're flying IFR.

So...what's a non-sensitive altimeter, you ask? It's one without the ability to adjust it for changing barometric pressure. It might (might, mind you) have a knob so you can set the needle to your field elevation. It also may have only one arm...and may indicate higher altitudes by going around the gauge face AGAIN (Figure 26).

Antique and classic airplanes often had non-sensitive altimeters. If you're operating out the tules somewhere, one would be fine. However, most of us are going to prefer something a little more familiar.

The fact that you don't need to use FAA-approved instruments mean you could use an alternate approach for the compass requirement, such as a digital unit. The DAR is still going to expect you to swing the compass.



Figure 26: Non-Sensitive Altimeter

4.5.4 Gauge Positions

There's room on that center-section for all the flight instruments. Here's a shot of my bird... the airspeed, altimeter, and compass are in the removable section, with an inclinometer and a panel-mounted handheld radio to boot (Figure 27).



Figure 27: Typical Gauge Positions

Where you put the gauges on your panel is up to you. I personally recommend putting the airspeed indicator at the topmost position. When you're flying final approach, a high-mounted airspeed means your eyes have to move less to check the speed.

When I bought my Fly Baby, the altimeter was on the top. That was one of the first things I changed.

4.5.5 Going Electronic

I once came really close to installing a Dynon Electronic Flight Information System (EFIS) in my Fly Baby (Figure 28).



Figure 28: Dynon EFIS

Had I flipped my lid?

Not really. The EFIS is basically an entire panel in a single unit. It has EVERYTHING you need...airspeed, altimeter, compass, etc. It includes a lot of capabilities that aren't required but many pilots like to have, such vertical speed, skid ball, and, of course, attitude.

If you're going to have an electrical system, the "delta cost" of buying their D-10 EFIS over buying all new, TSO'd gauges may not be that significant to you.

Why didn't I buy it? Came down to a panel installation issue; the D-10 was too long. I looked at their flat-panel options, but they were too big to fit in my standard-framed panel.

4.5.6 Making the Panel

The center section is 1/8 plywood. The airspeed and altimeter install in standard 3^{1/8} instrument holes.

There are a number of ways to cut the instrument holes. You can use a drawing program to print the outline of the full-size panel, attach it to the wood, and cut it appropriately. For another \$50, you can turn it over to someone to actually cut the entire panel out per your CAD drawing. The old-fashioned way is to make templates for the gauge installation, and use them to mark where to drill the panel.

One major point to keep in mind: The gauges are going to be a bit BIGGER than the holes you drill, and the plywood panel gets installed OVER a frame. Hence, you have to be careful not to put the gauges or other components too close to the edge.

The template I used for the modified panel in my airplane is shown as Figure 29. The dashed line shows the approximate area of the underlying frame. The compass was actually too close to the edge; I had to shave a little bit from the frame at that location to allow the compass to fit.

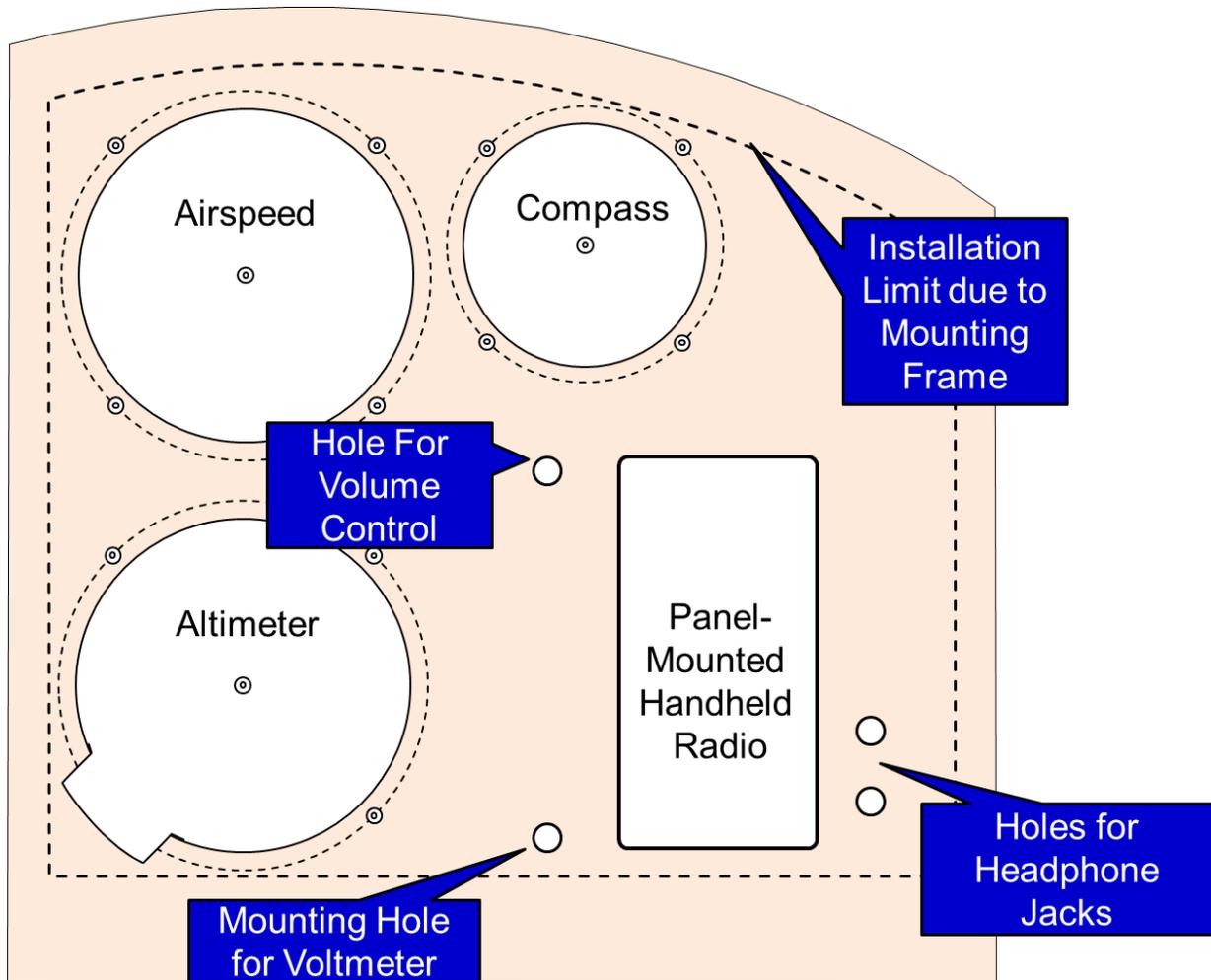


Figure 29: Panel Drawing for Fly Baby N45848

This is good if you've got a drawing package on your computer and know how to use it. But what if you don't?

Well, then you do it the old-fashioned way. Just between you and I, it isn't all that much slower.

You'll need a template to guide drilling and cutting the holes. Take a piece of thin aluminum sheet. Draw a square on it, with sides $3\frac{1}{2}$ " long. Draw diagonal lines between the corners. Where the lines cross will be the centerpoint of the instrument.

Using a compass, draw a circle $3\frac{1}{2}$ " diameter from that centerpoint. Drill four $\frac{1}{8}$ " holes at the points where the circle intersects the diagonal lines (these are for the mounting bolts), and at the centerpoint.

This is your template for marking holes for the airspeed, altimeter, and rate of climb (if any). Take your plywood panel blank, and determine where you want the centerpoint of the first gauge to be installed. Drill a $\frac{1}{8}$ " hole at that point, and cleco the template to the blank. Rotate the template so that the instrument will be level with it, then drill the $\frac{1}{8}$ " holes through the template for the first mounting screw. Add another cleco to that hole, then drill the remaining four.

Use a fly cutter to cut a $3\frac{1}{8}$ " hole, using the center hole as the starting point. Let the fly cutter get about halfway through the plywood, then flip the sheet over and start cutting from the other side. This will prevent splinters.

When the hole is cut, sand the rough edges, then drill out the mounting holes to match a #8 bolt...about 0.17 inches. It should be an $11/64$ " drill bit.

This process is illustrated in Figure 30.

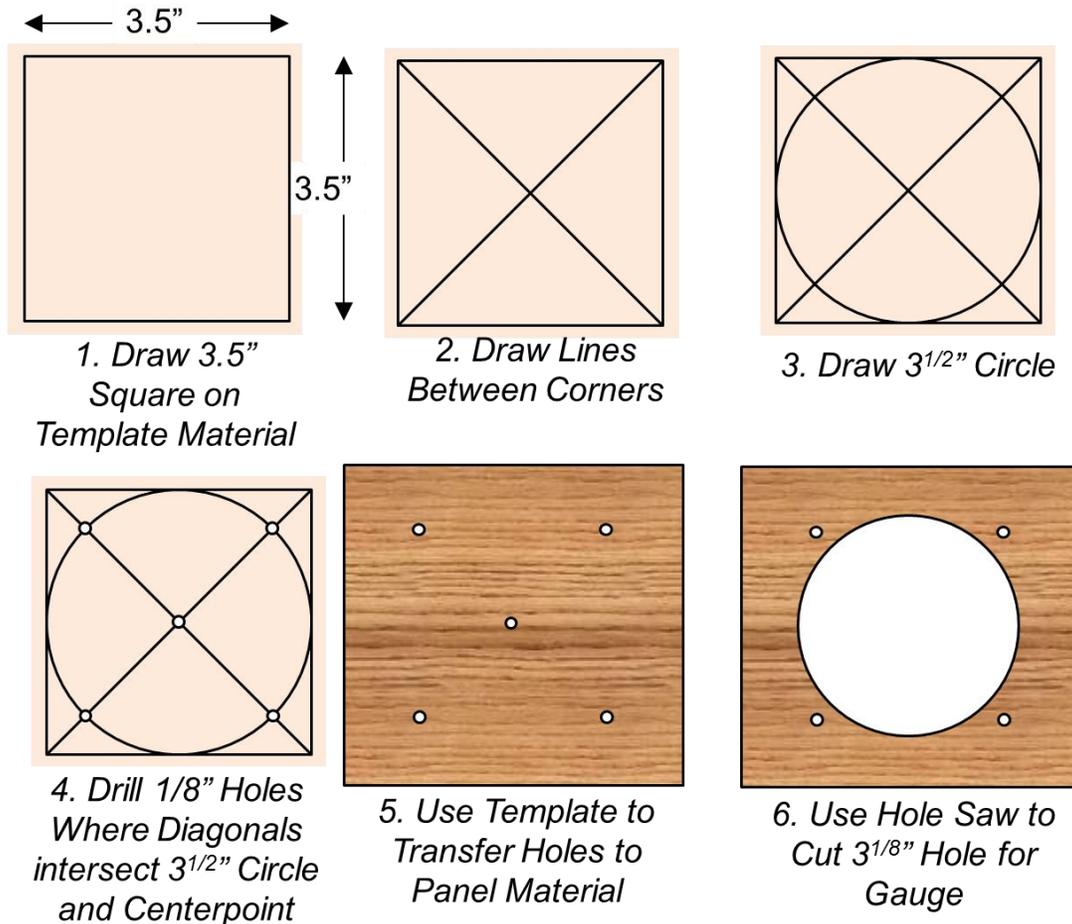


Figure 30: Instrument Hole Template

The altimeter and rate of climb (if any) will need little “notches” on the lower left side to clear the knob.

The compass is smaller. In this case, draw a square $2\frac{5}{8}$ " wide, inscribe a circle of the same diameter inside it, and add the holes in the same way. The hole in the middle is 2.25".

The neat thing is, the center instrument panel is only a single flat piece of $1/8$ " plywood. If you botch it, it doesn't take much to build another one. A patterning bit on a router can make a quick copy of the panel in a few seconds (Figure 31).

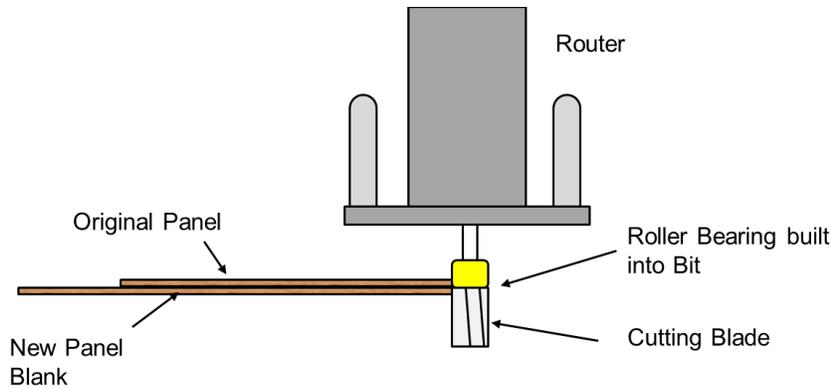


Figure 31: Copying a Panel using a Router

4.5.7 Plumbing

Two types of plumbing associated with flight instruments: The pitot line, and the static line. These can be just simple 1/4" plastic tubing, with cheap fittings to join them together. Figure 6-11 in Article 9 shows how the static and pitot lines are plumbed behind the panel, how they connect to the instruments.

Figure 32 shows the rest of the system. The plastic (or rubber) pitot and static lines connect to aluminum tubes running inside the leading edge of the wing. These, in turn, connect via plastic tubes to the pitot mast on the left wing.

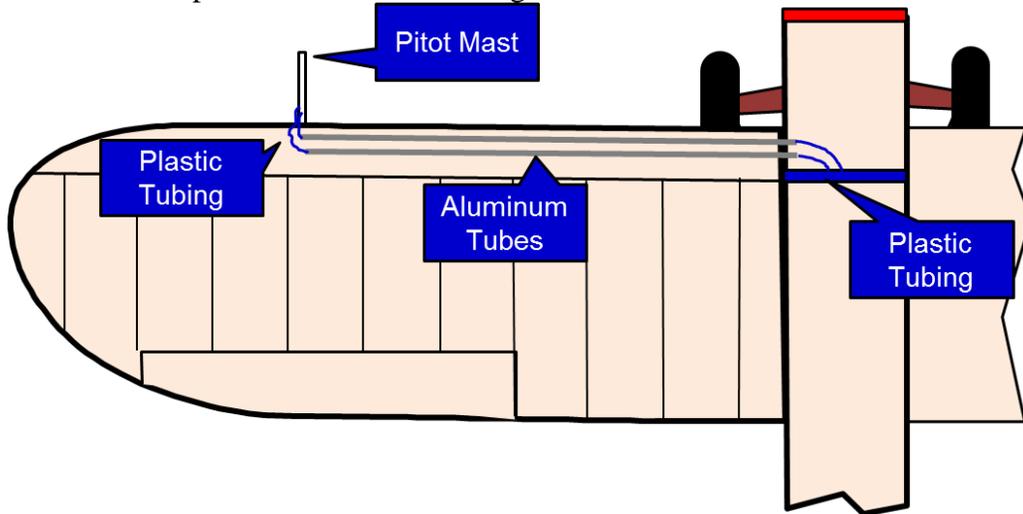


Figure 32: Pitot/Static Plumbing

The aluminum tubes in the leading edge are the same as are used on the brake system. They're 1/4" outside diameter, which means the 1/4" I.D. flexible tubing will slide right over it. Use a twist of safety wire to hold it securely, or a little tie-wrap, if you prefer.

Holes were included in the nose ribs during construction to accept this tubing...see Figure 33. Of course, you don't have to use aluminum; you could just run plastic or rubber tubing here. But it's possible for the flexible tubing to sag a bit and let the end disappear behind the root rib or the outboard rib. In which case, it might be hard to dig out. Use the metal tubing.



Figure 33: Holes in Nose Ribs for Pitot/Static Plumbing

The system terminates at the pitot mast. The mast itself is made from the same aluminum tubing around a central wood “stick.” Pete shows the unit as being taped together, and from the narrow tape shown in Figure 6-11, it looks like electrical tape. I’ve had problems in the past with electrical tape getting weird when it ages, so I’d use something else. Not sure what mine is held with (it doesn’t look like electrical tape), but I’m wondering if wrapping it with a long, glued-on strip of fabric might not be a bad approach.

The mast has the static line on top, with the pitot line on the bottom. They could be swapped, but since the pitot line needs that kink downwards (to keep water from flowing into the system), it would look a bit weird with the kinked tube on top⁴.

The static tube is plugged at the end... doesn’t matter how. You can stuff it full of epoxy and pinch it shut before it cures, epoxy in a screw, solder it, weld it, whatever. The end must completely deny the entry of air. Just behind this plug, drill four to eight small holes in the side of the tube. These vent the static tube to ambient air just like the little ports on the side of a Cessna.

To hold the mast to the airplane, a small wood “tab” is bolted to False Nose Rib #4. This tab is long enough to stick below the wing a bit and has holes on the bottom that match the holes in the end of the center stick for the pitot mast.

The aluminum tubes on the mast go into the wing, and are connected to the two leading-edge lines with plastic or rubber tubing.

⁴ At this point, I’m unable to resist saying, “But you can be kinky on top if you like.” Sorry.

Design of the pitot mast and its attachment are shown in Figure 34. It's not shown, but an inspection panel is installed in the bottom of the leading edge cover to allow access to this area.

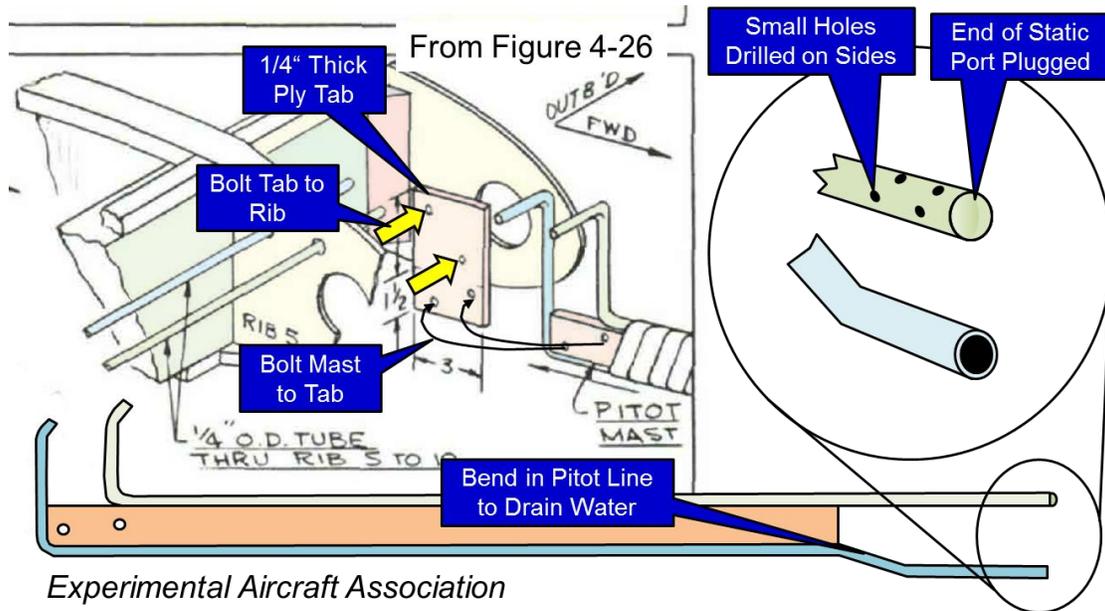


Figure 34: Pitot Mast

Now, Pete's design for the pitot mast isn't the end-all. It sticks forward of the wing leading edge by about 15 inches, and always seems to be at risk for someone stumbling into it and breaking it off. The whole point of the mast is to get away from the aerodynamic effects of the wing, and most planes don't seem to require a full cubit of standoff.

One possibility is to make the tab longer, and put the mast further below the wing. Then, it could be shortened significantly. Other builders make a conventional style pitot tube, sticking out the leading edge.

4.6 Wing Hinge and Attachment

When building the additional wing hardware as part of Article 2, Pete specified bolting some triangular brackets inside the wing roots. These were to take a long aluminum tube that acts as the wing hinge.

Figure 6-12 in Article 9 shows the setup. The tube bolts inside these brackets, and is free to pivot up and down. Holes are cut through the lower-fuselage reinforcement to accept these tubes, and a small stop is bolted to the end.

When the wing is to be folded, the bracing wires are disconnected and the spar pins are pulled out. The wing is then drawn from the fuselage, at which point it's supported at the root by the aluminum tube. The wing can then be pivoted to put the trailing edge up, and then folded alongside the fuselage.

If you don't intend to utilize the wing folding, you can leave this hardware off. It certainly can be added later, if you or a subsequent owner wants it.

It's actually kind of embarrassing from my point of view. Since I didn't build my Fly Baby, I have to have an A&P perform the condition inspection every year. Invariably, as they're lying below the fuselage, they see these tubes and ask what the heck they are for.

What's worse, the builder of my airplane didn't use aluminum tubes...for some reason, he used PVC tubing. It looks weird, and after nearly 40 years, I have doubt there's any sort of strength there.

But I've never folded the wings, so it hasn't been an issue.

The final part of the wing-fold system is the positioning pin. Pete intended the airplane to be towed to and from the airport with the wings folded, and the airplane needed something to hold the wings in place. If you recall during construction of the tail feathers (Article 6), a hard point was added to the second rib of the horizontal stabilizers. The intent was to have a pin in the leading edge of the wing that went into a hole in this hard point. Figure 35 shows how it works.

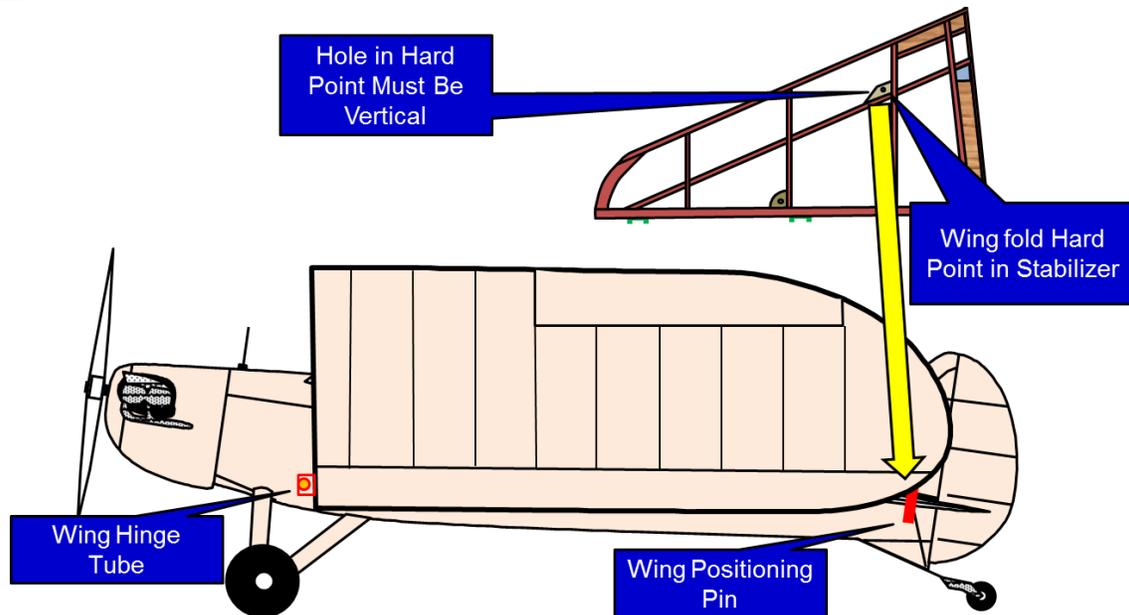


Figure 35: Securing the Wings While Folded

I've seen very few Fly Babies that included this pin. I've got photos of over 100 Fly Babies, old and new, and only spotting the pin in three of them. However, many of the current builders intend to include the system.

N500F didn't have it back when I flew it, but I think it was removed during the 1982 restoration. Coincidentally, the bottom of one wingtip bow is flatted...ground down when the wing came loose while the plane was going towed.

Does make you think.

Personally, though, I'm a bit skittish of putting that additional weight on the horizontal stabilizer. Not an issue in a 1G environment, but imaging driving down a washboard road with the wings' weight resting on the stabilizer.

To install the pin, first drill a small pilot hole vertically through the hard point. Then fold the wing. Drill (carefully) through the hard-point's pilot hole into the leading edge of the wing bow. Enlarge as necessary, and add either the wooden dowel or the stove bolt that Pete shows in Figure 6-13.