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Version 2.1

Building a Fly Baby – Preparations
By Ron Wanttaja

Okay, you're going to do it. You're going to try tackling a Fly Baby. What do you need to do before you start?

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1 WORKSHOP REQUIREMENTS

The following are some general requirements for a Fly Baby construction workshop.

1.1 Space Required

The Fly Baby was designed to be built in a single-car garage. That amount of space, or the equivalent in a basement or hangar, should be the minimum.

Minimum? Sure. Like everything else in life, the more you have, the better off you are. It'd be great if you had enough room for the Fly Baby fuselage to sit on its landing gear with at least one wing attached.

But…most folks have to be satisfied with rolling their planes outside for test-fitting the wings.

One issue to remember is storage space. You're going to be building some pretty big parts…where are you going to stick them when completed?

The EAA Magazine series, in my opinion, has the right building order. It has the builder making the wings first, THEN the fuselage. The plans themselves have the reverse order.

Why is building the wings first, better? Because the wings can be stored almost anywhere. When they're done, you can hang them on the wall, out of the way.

However, there is a slight drawback to this approach: The wings cannot be completed until the fuselage is done. It's not a serious issue, since there's no real drawback to storing a mostly-completed wing. More information is available in the Companion Guide for Article 1.

In any case, building space is a moot point for most of us. We have a basement, a garage, or spare bedroom, and that's what we have to build the airplane in. Most of us can't afford to build a workshop in the backyard. The size equivalent of a single-car garage is sufficient. If you've got a two-car garage, you can chase the wife's Prius (or your husband's pickup) outside for the time period you need the wider space.

Some of the oldest jokes in homebuilding are about guys who have to disassemble the house to get the completed airplane out of the basement. Many of these stories are true. It can easily happen unless you think things through completely. A 24-inch-wide Fly Baby fuselage

won't necessarily fit through a 36-inch door, if there are some immediate turns required. If aircraft egress room is questionable, slap together a mockup of cardboard or plywood and experiment.

1.2 Power

There are two main questions regarding your shop's electric power: Is it adequate and is it convenient?

How many circuits are available for big shop tools? Something like a table saw takes 15 amps. Standard house wiring is 20 amp; so don't count on running more than one tool at a time.

Convenience is usually of greater impact to the homebuilder. You'll be roaming all over the workspace with hand tools. This sounds like a good time to consider buying a good battery-operated tool set! It beats trying to run extension cords to all the places you think you're going to work.

They're hard to escape, though. One or two 25-foot cords should suffice.

Outlet strips are useful accessories. One feature to ignore is those that have power protection or are surge limiting. This feature is intended to protect delicate electronics (like computers) from power fluctuations. Power tools aren't sensitive, they cause surges. Places like Amazon.com sell nice long outlet strips.

Along those lines, if you're using stuff like rechargeable drills, you need a charging station somewhere. That station can be used to keep your portable lights charged, too. If you're using tools that have standard batteries, get to Costco and buy a few "bricks" of AAA, AA, C-cells, or whatever batteries you need. Nothing worse than a light going dark on a Sunday night, and having to go to 7-11 to buy some expensive batteries.

1.3 Lighting

For shop lighting, nothing can beat ceiling-mounted LED tube lights. I switched out my fluorescents a year or so ago, and I won't go back. Get lots…there's nothing worse than trying to do a finicky bit of work in a dark corner.

The one thing that tends to throw off LED buyers is the light "Temperature", or the wavelength frequency the operate at. You see terms like "Bright", "Warm", etc, for the same wattage bulb.

This refers to the "color" the light produces. "Warm" lights are a bit yellow; their intent is to mimic the look of traditional incandescent bulbs. I really prefer them inside.

In the shop? Psssht. Bright White, all the way. This actually mimics sunlight, and, when you come out of the house, everything appears to be brightly lit.

The fixtures can be either screwed to the ceiling or hung from hooks. I hang mine; in fact, I've set up groups of hooks in various areas and move lights as needed. Just tack up extension cords using cable holders.

You'll need portable lighting, too. In the good ol' days, it was the "Trouble Light"… a holder for a single incandescent bulb and a long cord to plug it in. That bulb had to be a "rough service" bulb, or just handling the light might mess up the filaments in the lamp.

Now? LEDs again. You can buy any number of battery-operated LED lights that give pretty good illumination for little weight. The larger ones use rechargeable batteries, but pick up a few little battery-operated ones as well. A lot of times, you might be somewhere and need just a tad more light. Stuff one or two in your pockets. They're small and cheap enough.

Keep your eyes out for Harbor Freight coupons. They often include one for a free LED light with purchase.

1.4 Heat

If you live in the cold country, you'll want some heat for your workshop. You don't want to spend 30 hours a week shivering in the garage and handling cold wood. The only alternative is to stop work during the coldest months, but these are months you'd rather work because you can't fly.

Just because you live in warm climes doesn't excuse the need for occasional workshop heat. If you're using modern epoxy glues on your Fly Baby, you really want to have things a bit closer to 60-70 degrees F. Depending on what covering system you're going to use, too, you might need some warmer temperatures in the shop. And you'd like to rivet skins on aluminum kits while the skins are warm; otherwise they might get a bit wrinkled in warm weather.

Comfort heating might be taken care of by a portable electric heater, but they're going to add the power load in the garage. Other options would be to add some ductwork to the existing furnace (assuming it's in the garage already). You won't get the temperature up too far because the thermostat is still in the house. But any little bit helps.

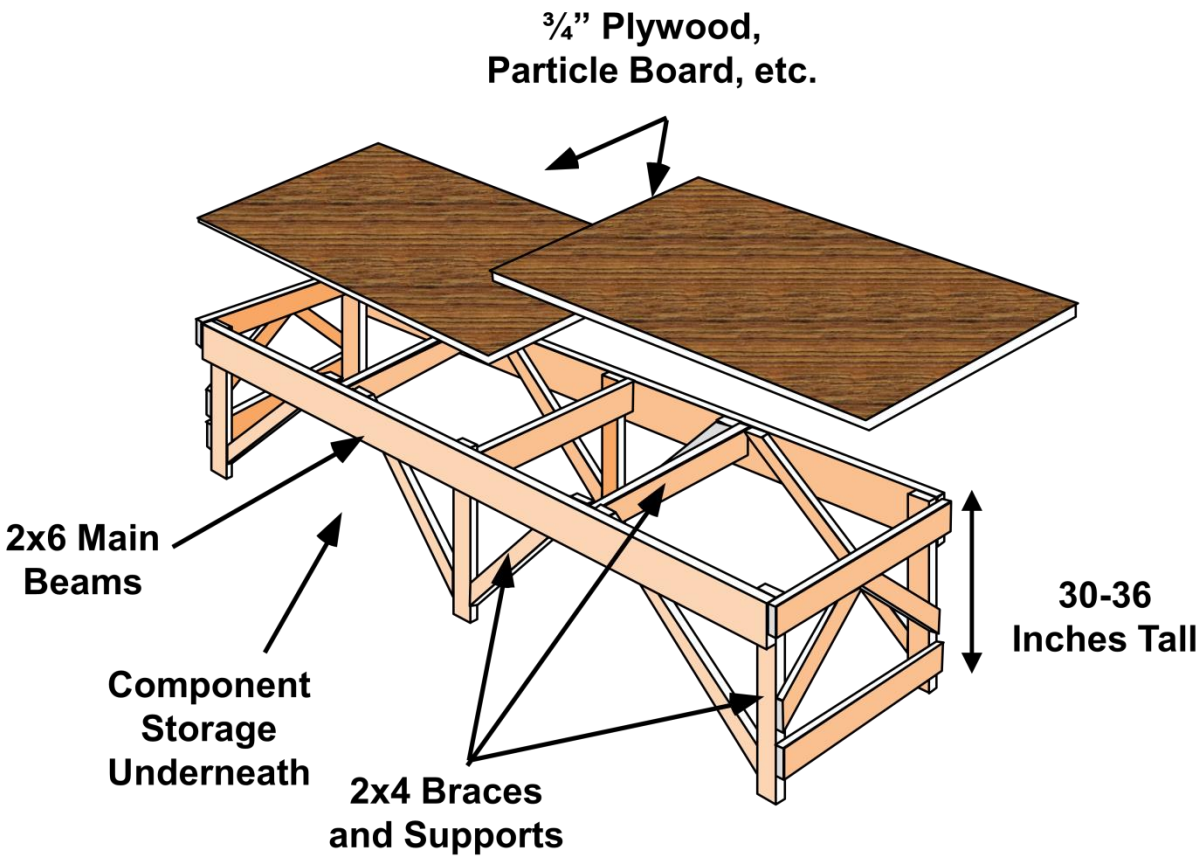
Finally, don't forget insulation. Adding batting between the joists can do wonders. Garage doors are a particular nuisance--they don't seal worth a hoot and are a major source of drafts. Try a curtain of plastic, stapled to either side of the door, with the foot weighted down by boards or sandbags. Also, lay some scrap carpet on the floor of the work area. Cold cement sucks heat from feet and legs, and a little bit of insulation goes a long way. It also keeps dropped parts from rolling too far.

1.5 Worktable

The Fly Baby requires a solid worktable to build the components on; the table needs to be at least 14 feet long and be wide enough to lay the ~54" wide wing atop it. Now, this doesn't mean the table has to be four and a half feet wide…the wing can hang over a bit. But you must include space around the table to get around the outside when a wing is lying on it. If I were starting anew, I'd make a worktable that had two 4x8 foot sheets of plywood, end-to-end. A height of between 30 and 36 inches seems the most comfortable, but you'll want to build it so it's right for you. Compare the height with your kitchen and bathroom counters.

Keep in mind that, if you build in the sequence of the EAA articles, you may not need a worktable right away. Pete says you can build the wing on sawhorses.

A worktable can be built from any material, but if you find one made of anything other than wood, it's probably because the builder found a bargain on a used steel or even aluminum table. The top must be wood, since you'll be nailing temporary jigs to assist building the airplane structure.



When you can, use screws instead of nails...nails tend to loosen over time, and screws are easier to remove if you decide to scrap the table at the end of the project.

In any case, construction must be sturdy. Not only is the airplane going to come together on it, but you'll end up crawling across it to access a hard-to-reach portion. .

The biggest requirement of the worktable is its precision. The table is the basis for accuracy when building the aircraft. You'll build your wing on the table, and if the table is warped, the wing will be warped, too.

The correct top material can cut down on warping. Plywood is most common, but has a lower resistance to warping than particle board. But particle board tends to crumble. Hollow-core doors or drafting-table tops are great at resisting warpage, but can't take the abuse as well. Some builders add a plywood overlay over doors. Whatever you choose, get the thickest you can afford, 5/8" for an absolute minimum, 3/4" or greater preferred.

The table must be precisely horizontal. This allows checking accurate placement of components by using a carpenter's level. This complicates workbench construction, as your shop's floor probably isn't level. The workbench must be able to compensate.

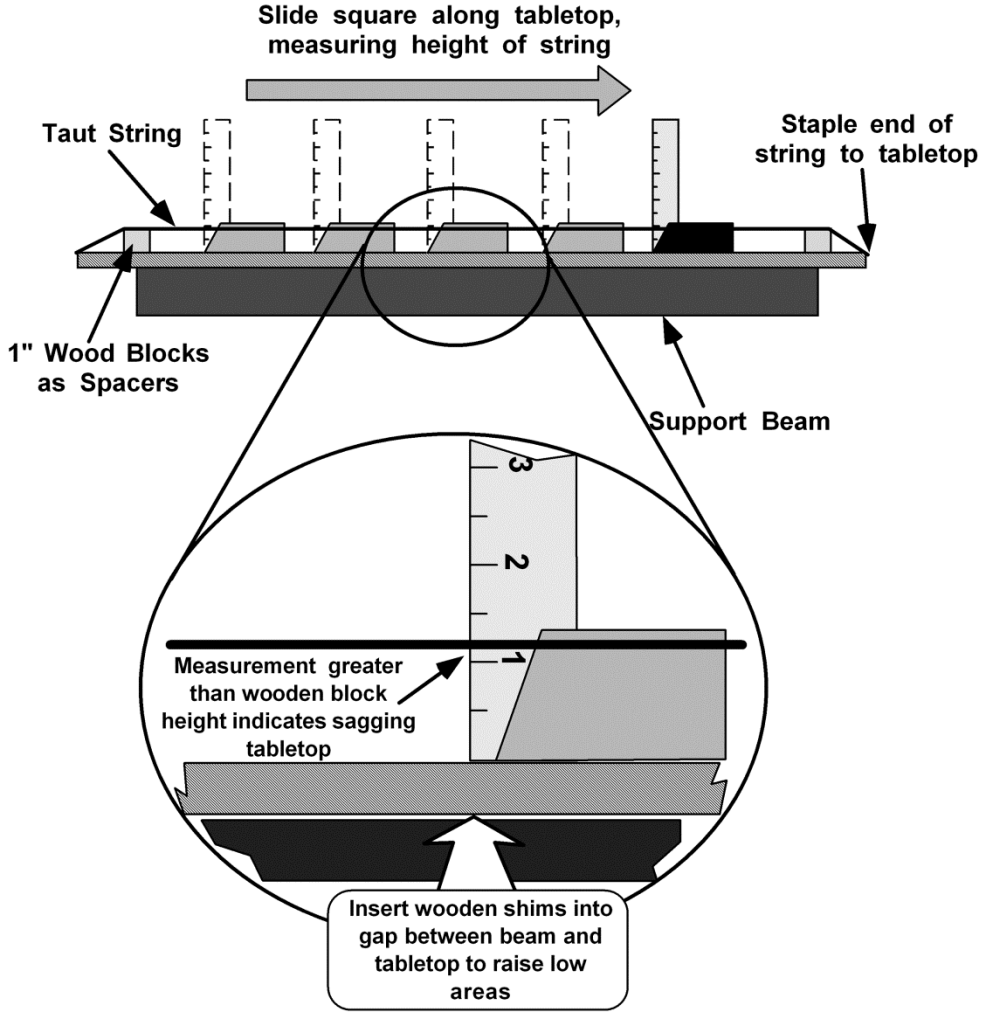
When it comes time to adjust the table, three tools are important: carpenter's level, ruler, and ball of string. Designate one corner of the table as a reference. Attach one end of the string to a block of wood, and stretch it above one long edge of the table. Attach it to a same-sized block of wood in the far corner. Measure the distance between the string and the tabletop at points between ends. Shim up the top where necessary, eliminating any sag.

Then check the level along the edge, and adjust or shim the table's legs to compensate. Use the string and ruler to eliminate sag across the short axis of the table. Make measurements

every two feet or so along the table's length. Then use the level across the short axis. Don't touch the adjustments on the legs you've already set; change the other side's instead. Shim the table edge as necessary.

Repeat the above as many times as necessary to get the errors as small as possible. If I had to make a choice, I'd rather have a table that's a little off level, instead of warped.

Check the table occasionally afterwards, or if the table is moved. Again, the table is vital to airframe trueness; a mere degree of error could cause performance or handling problems.



1.6 Workbench

You can use the worktable for all the activities involved with building the aircraft, but you don't really want to. Parts with sharp edges can cut up the surface, or heavy components can throw the table out of alignment. It's a good idea to have a separate workbench for the rough, heavy work.

There aren't really any specific requirements for the workbench. Make it the same height as the worktable. Don't sweat alignment and warpage too much; however, you might use the bench as practice for the full-size worktable.

Or buy a commercial model. They come with drawers, electrical outlets, and other things that make building easier. I bought a used drafting table for $35; a used metal office desk would work just as well, with a sheet of plywood as a work surface.

If you're very limited in space, don't bother with a workbench. But fit one in, if possible.

1.7 Safe Zones for Welding

If you're going to try tackling the welding for your Fly Baby yourself, you'll not only need space for the tanks/welder, but a safe zone to do the welding in. With a typical welding operation spitting out gobs of red-hot steel, you do NOT want those gobs to be dropping into a pile of sawdust from the table saw.

1.8 Other Items

Building an airplane generates a lot of dust. Shop vacuum at least, with perhaps, a little "dustbuster" type for small clean-ups. Anything else you can do to make the area more comfortable and livable is a good thing. You'll be spending a thousand hours or more, there. Music player of some sort, a small refrigerator for water and tasty beverages (for after you're done using tools for the evening), it's all good.

2 WORKSHOP ARRANGEMENTS

Let's count up the major components of a Fly Baby builder's workshop. Worktables and workbenches. The aircraft's fuselage. Two wings. A heavy engine. Free-standing power tools, like drill presses, bandsaw, and table saw. Racks of waiting parts and components. Cupboards of bolts and fasteners. Not to mention enough room to assemble the entire aircraft, an object 20 feet long with a wingspan approaching 30 feet.

Workshop space is not unlimited, hence the need for efficient layout.

2.1 Hand Tool Storage

Most of us keep our hand tools in a plastic or metal box. That works out OK most of the time. We can scoop up the box and carry it to the car, the broken shelf, or the unassembled bicycle.

But building an airplane means using the same tools continually in the same location. How much time do you want to waste digging through the mess in an old toolbox looking for the 7/16-inch wrench?

Make it easier on yourself and set up a tool board. The easiest way to make one is from white-painted pegboard. A variety of hooks and hangers are available that will hold your tools and keep them handy. The pegboard cannot be attached directly to the wall, as the hooks stick through the board and hold on the back side. Attach your pegboard to a framework of 1" pine furring strip.

Arrange the tools you'll use the most at the most convenient locations, and group like tools. Doesn't make sense to put the 3/8" wrench on the left side of the board and the ½" one on the far right….

Tool boards are a marvelous way to keep track of tools. They work even better if you put each tool back after you use it. Every good homebuilder should develop this habit. Let me know if you figure out how--I certainly haven't picked up the knack.

The tool board can be seen from anywhere in the shop. If the tool is on the board, fetch it. If it's not there, then start searching the worktable and workbench.

If you decide on storing some tools in a toolbox, pick up a rollaway unit with a multi-drawered box. These units consist of a toolbox atop a wheeled cabinet. They normally are fairly expensive, but look for heavy discounts and used ones in garage sales. Cheaply made bargain units can be found for half that, and for the amount of use they're likely to see, they'll do just fine.

While I'm not actively building right now, I have a tool board as above, and spent the money for a professional-quality tool box. I used a cheap labelmaker to label the drawers as to contents. Yes, after ~15 years, I don't need the labels anymore…but they're nice to have.

2.2 Access

In kitchen design, the distance from the sink to the stove to the refrigerator and back to the sink should be no more than 10 feet; the same can be said about aircraft building. Minimize the distance between the worktable, workbench, the tool board, and the free-standing tools.

This rosy view of workshop design is discolored by real-world problems. The first is the worktable itself. The table is 4 feet wide and 16 long. Because you'll probably need to gain access to all sides, at least 2 feet of clearance must be maintained on all four sides (and a little more when working on the wings). This makes the table workspace 8 feet wide and 20 long, or about the size of a typical car.

This not only restricts where the table can be placed, its very size ensures that perfection can't be approached. There'll be plenty of times when the tool you want is on the opposite side of the table. So you'll have to walk all the way around and all the way back.

If possible, place your tools at the ends of the table, rather than the sides. It seems closer when you don't have to turn so many corners.

The layout doesn't have to be fixed. My worktable occupied the center of the garage during fuselage construction. Once the gear was installed, the worktable was shoved off into one corner, ready for later use. (Don't forget to re-level and check the warpage whenever the table is moved.)

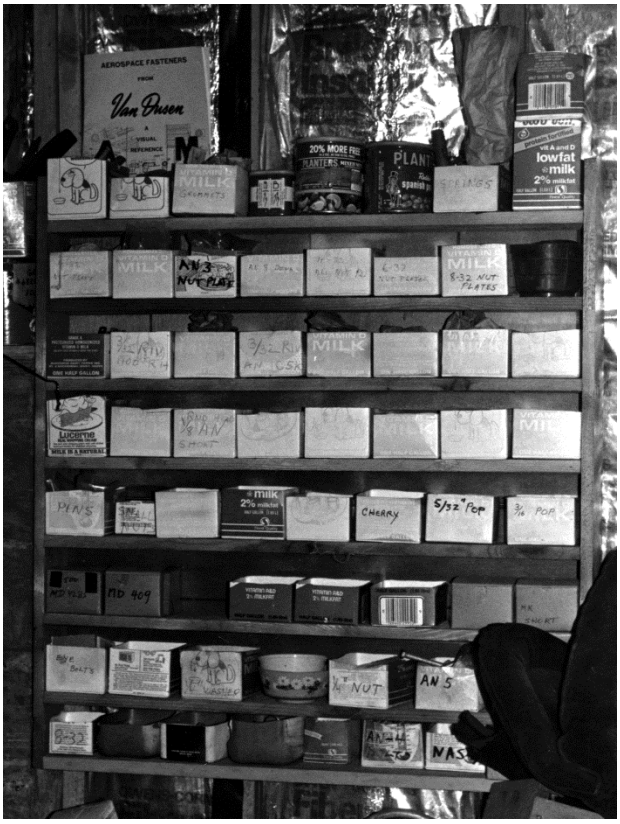
If space is a bit tight…don't sweat it. Make the table 14 feet long instead of 16, and let one size be close enough to the wall to be a tight squeeze. Don't get too worried about it, guys have built Fly Babies in remarkably small spaces.

2.3 Storage of Fly Baby Components

A Fly Baby under construction has hundreds or thousands of pieces that must be carefully stored until ready for use. Problems caused by bad storage can range from ruined material to chronically barked shins. While some general hints are given here, each type of material has specific handling requirements that must be followed.

The hardest pieces to store are large sheets of plywood. They're awkward to handle, for one thing. For another, wood must be protected from rot and warping, so it's best to keep it off the floor by at least a couple of inches. Sandwiching the airplane plywood between two sheets of ordinary plywood is a good way to keep it safe.

Other components are smaller and easier to store. Racks for tubing and board lumber are easy to build, but must support the load evenly. Underneath the worktable is a dandy place for tubing and aluminum extrusions, and for larger kit components like cowlings and canopies.



Smaller parts are even easier; however, access is more important. Nuts and bolts could be stashed anywhere, but you'll be needing them all the time. Plastic multi-drawered storage cabinets are cheap and can be mounted anywhere. A small easel-like mounting lets you bring all the hardware close to the job. Or mount them on the back of your roll-away tool box.

They aren't necessarily the best solution. The cheaper ones have awkwardly small drawers, and those with larger drawers are more expensive. The flat type, with the large top-hinged door, is better for access. A no- or low-cost alternative is to store the hardware in old cans, milk cartons, or what-have-you and build some cheap shelves to keep them on.

A cheap alternative is to mount some shelves and cut the bottoms off milk cartons to

hold the parts. It costs next to nothing, and the cartons are wide enough to make access easy.

Whichever method you choose, it's vital to clearly mark the exterior of each container, be it carton or drawer, with its contents. Some write the part info with a black marker (on masking tape, if the surface won't take the marker). Others tape the actual labels to the outside of the container. Or use your computer and print off a set of self-adhesive labels.

2.4 Storing Finished Components

Safe storage of finished components is slightly different. A ruined sheet of plywood merely drains your pocketbook; a ruined component wastes building time. Similar, but more careful procedures must be used.

As mentioned earlier, build the wings first and hang them up while you're working on the fuselage. . They're easy to store on the walls or ceiling.

Watch for mice. They love the little compartments of Fly Baby wings; they enjoy chewing on wood and insulation. They'll happily build their nests in your turtledeck, and gleefully "piddle" on anything within reach. Ceiling and wall storage is a good first step toward prevention.

3 TOOLS

The following are the basic tools required for building a Fly Baby.

3.1 Power Tools

You'll often meet some wild-eyed older guy at EAA who tells you how he built a Fly Baby back in the '60s using nothing but a hand saw and a set of chisels he made from a suspension spring. No doubt he did…but life is a lot, LOT easier with decent power tools. Save money when you can, but don't go without.

Where to buy them? Well, you can find cheap versions of these tools at the discount tools chains, like Harbor Freight or Grizzly. The problem is, the quality of these tools can vary… they use different suppliers, and the good tool your buddy bought last month might not be the same as they're selling this month. The other issue is spare parts…there usually aren't available.

A better approach would be to buy a name-brand power tool, even if it costs a bit more. I bought my Craftsman table saw over thirty years ago. Not only is it still going strong, Sears still sells parts for it. They're a bit more expensive new, but they flood the garage sales. Keep your eyes open.

3.1.1 Table Saw

Front and center for power tools you'll need: A table saw. Table saws use circular saw blades in a fixed mounting.

You'll be using it a lot, and making some precision cuts, so get a full-size unit with its own legs…in other words, not the kind you set on the workbench. It needs a solid base.

Table saws are big, and can get in the way. I bought a set of wheels for mine…the wheels retract to set the saw solidly down, but allow me to roll the saw out of the way when I don't need it.

Going with the table saw, you'll need sawhorses and, probably, a roller stand. It's basically a sawhorse with a broad roller at the top. The roller stand is under the wing in the next picture, supporting the Fly Baby wing with a piece of foam

The roller stand supports the end of anything you're trying to run through the table saw. Having a helper is actually better (and the best approach when cutting the wing spars) but the roller stand can be pretty handy.

Spare saw blades! It's a PITA to need a blade when the Lowe's isn't open.

The other vital tool is a bandsaw. A bandsaw drives a continuous-loop blade through a small slot in a steel worktable. It's the best all-around tool for any power cutting. While hand tools like hacksaws or saber saws can be used, the bandsaw gives the easiest and most exact cuts. Saber saws drive their blade back and forth; this jiggles the piece being cut and requires a steadying hand. All while trying to steer an awkward saw along a precise path.

3.1.2 Bandsaw

Handheld jig saws are OK, but the material tends to flap as the blade works back and forth. Bandsaws, on the other hand, run the blade in one direction: down through the worktable. The piece stays steady, and both hands can be used to guide the cut. Bandsaws can cut almost any material, if the right blade and speed are selected. Bandsaw speed is stated in blade feet per minute. A speed of 1,000 fpm is needed for wood. Aluminum can be cut at the same speed, or preferably slower, but steel requires no more than 150 feet per minute.

Sadly, you will rarely find a single bandsaw that will cut both steel, aluminum, and wood. One that will go down to 1,000 fpm is sufficient for aluminum and wood, but you're probably need a separate unit for steel.

This may not be important if you're having your steel parts laser-cut by an outside vendor.

One option to consider is the combination horizontal-vertical bandsaw. These can be pivoted downward for precise cutoffs of lumber or tubing. They designed for cutting steel tubing, and have a good slow blade speed. They feature removable worktables for cutting in the vertical position like a conventional bandsaw. The worktables aren't all that solid, though, and their working height is close to the ground.

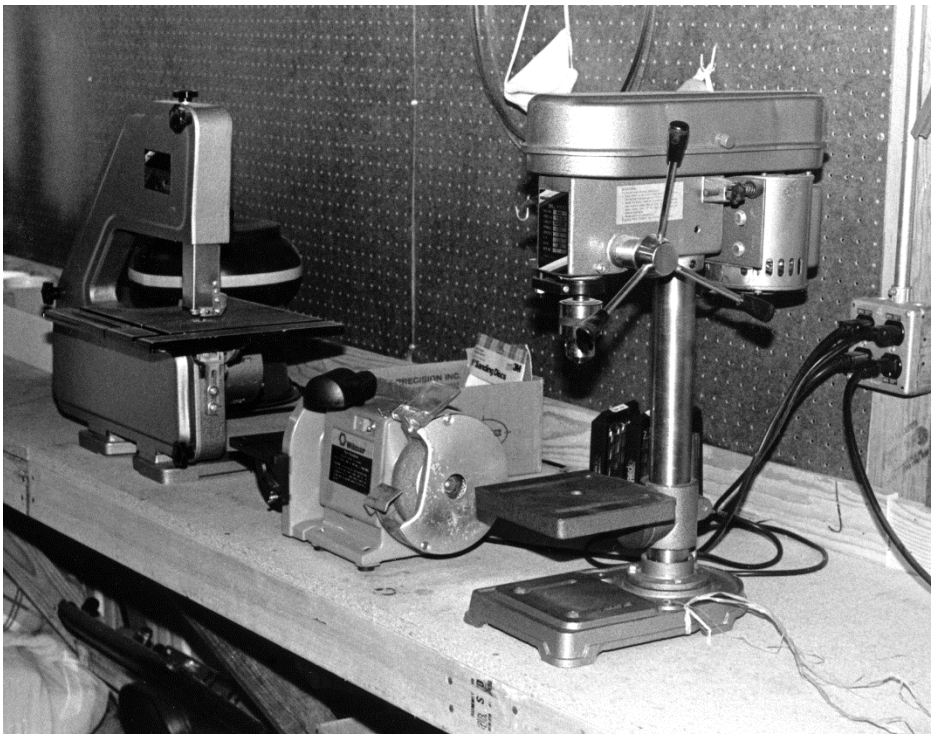
There are usually a variety of types of bandsaw blades available. The key aspect is the teeth per inch. The more teeth, the finer and smoother the blade will cut. But…the SLOWER it'll cut, as well. Ideally, you want there to be at least two teeth inside the material when cutting. Otherwise, it won't cut smooth. So if you plan on cutting 1/8" aluminum, you'll need a ~16 tpi blade. The blade width affects its durability and its ability to make curves. A wide blade doesn't curve as sharply, but it makes a straighter cut.

Like a bandsaw, a drill press is vital. And they're not that much more expensive than hand-held drills, small tabletop units can be found for about $100. Hand drills can't be held steady enough; the drill wavers slightly, and the hole gets oblong. They're well suited for drilling or cutting large diameter holes, and even the cheapest models have at least a 1/2-inch chuck. Drill presses let you position the hole very carefully, too.

3.1.3 Drills

You really need a drill press…it's a lot easier than trying to do a holes with a hand drill.

Tabletop drill presses can't make very deep holes. Not only is the chuck-to-worktable space limited, the very length of the drill bit cuts down on the available room. Floor models are more flexible because they allow the work to be properly positioned no matter its thickness, or the length of the bit.



With THAT said…I have to humbly admit I only have a tabletop drill press. You learn to work around the issues. And they're pretty cheap, even the good-quality ones. Get a tabletop unit and spring for a floor drill press if you really, really, have to.

One advantage of the tabletop drill press is that it's fairly portable. When you get down to drilling the holes through the 13-foot-long spars, it would be far easier to set up the drill press on the worktable.

Even with the drill press, you'll need a hand drill. Plug-in drills are getting rarer; the better quality models are all battery-operated now. Get at least one spare battery. I'm fond of

the Lithium batteries due to their light weight, but the older Nickel Cadmium packs seem a bit more durable.

The usual next step is to buy a nice set of drill bits, typically to 1/4-inch diameter. One lesson from sad experience. Do NOT "cheap-out" on drill bits. The cheap ones get dull and break a lot quicker. Buy a set that includes ~ 1/8" to 1/4", and buy some extras in often-used sizes such as 3/16" and 1/4". Then go to the bargain tool store and get a big pack with the full gamut of drill bits. Use those only if you actually need the weirder sizes.

Sizing drill bits in fractions of an inch is a concession to the home hobbyist. Machinists use a different system, assigning a number or letter to given sizes. If the plans call for using a #30 bit, use that size. There are good reasons not to specify the nearly-identical 1/8-inch bit. These numbered bits can be found at well-equipped hardware stores or at professional outlets.

Size	Decimal Equivalent	Size	Decimal Equivalent	Size	Decimal Equivalent
1/16	.0625	32	.1160	3/16	.1875
52	.0635	31	.1200	12	.1890
51	.0670	1/8	.1250	11	.1910
50	.0700	30	.1285	10	.1935
49	.0730	29	.1360	9	.1960
48	.0760	28	.1405	8	.1990
5/64	.0781	9/64	.1406	7	.2010
47	.0785	27	.1440	13/64	.2031
46	.0810	26	.1470	6	.2040
45	.0820	25	.1495	5	.2055
44	.0860	24	.1520	4	.2090
43	.0890	23	.1540	3	.2130
42	.0935	5/32	.1562	7/32	.2187
3/32	.0937	22	.1570	2	.2210
41	.0960	21	.1590	1	.2280
40	.0980	20	.1610	A	.2340
39	.0995	19	.1660	15/64	.2344
38	.1015	18	.1695	B	.2380
37	.1040	11/64	.1719	C	.2420
36	.4065	17	.1930	D	.2460
7/64	.1094	16	.1770	1/4	.2500
35	.1100	15	.1800	E	.2500
34	.1110	14	.1820		
33	.1130	13	.1850		

3.1.4 Power Sanders

Benchtop belt sanders usually include a belt that can be oriented both horizontally and vertically. Some have a small disk sander attached as well. These are tremendously useful for final smoothing and shaping after cutting aluminum or wood.

A hand-held belt sander and/or a pad sander is useful, too. Feel free to buy these at the discount tool place, but expect to periodically replace them.

3.1.5 Grinder

Another cheap power tool, it's going to be needed if you do a lot of work with steel. Hand filing is slow, especially when working with steel. A power grinder does the job much faster. They make hand-held and bench units.

3.1.6 Router

Routers are slick little tools for precision wood shaping.

That said, routers scare the beejesus out of me. They turn a little cutting blade about 20,000 RPM, shrieking like a Banshee and spewing out a long trail of wood splinters and dust.

There's little on a Fly Baby that needs a router. Except…well, when you read the Companion Guide for Article #1, you'll see a router with a pattern bit is a jim-dandy way to cut out wing ribs.

3.2 Hand Tools

3.2.1 Wrenches

Have at least one set of combination (open end/box end) wrenches, in sizes from 1/4 inch to at least 7/8 inch. The box end should be at a slight angle to the handle of the wrench.

The most common wrench size needed on a Fly Baby is a 3/8", followed by a 1/2". Get several of these sizes. These correspond to what's needed for AN3 and AN4 bolts.

3.2.2 Socket Sets

The minimum is a 3/8-inch drive (the little square hole in the socket is 3/8ths of an inch across) set, with a ratchet wrench and sockets the same size range as the wrenches. The smaller sockets are probably 1/4-inch drive, so an adapter should be part of the set.

An easier way would be to pick up a 1/4-inch drive set as well. Its ratchet wrench will be smaller and easier to swing in tight corners.

Eventually, you might need a 1/2-inch drive. As you might expect, this size is more expensive. Count on picking up the individual components as you need them, rather than buying a full set.

Like with the wrenches, you'll need 3/8" and 1/2" sockets a lot. Get some spares. Consider getting spare handles, and just keep a ratchet handy with a 3/8" socket on it.

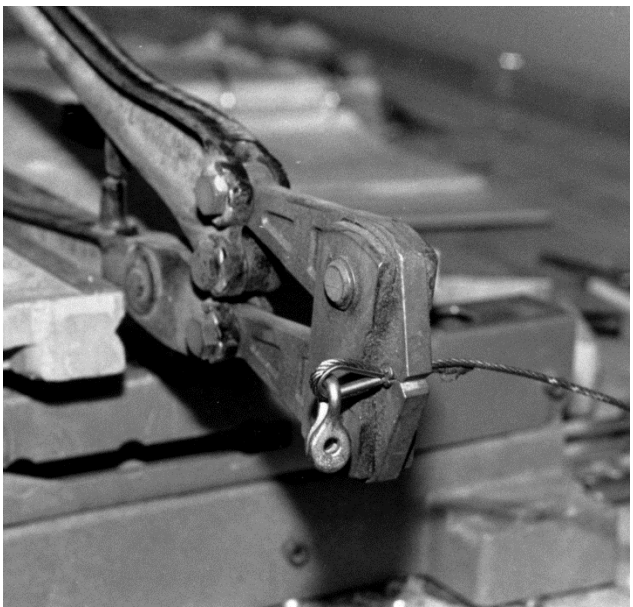
3.2.3 Screwdrivers

A good selection of both regular and Phillips screwdrivers

3.2.4 Nicropress Swage

One tool absolutely vital for building a Fly Baby is a Nicopress swage. You'll need one to form the vital bracing and control cables. Yes, they're expensive…nearly $400. But Fly Baby pilots have died because they tried to swage their Nicopress fittings with pliers.

Yes, they make little hand-held wrench operated units for $30. But these are very, very



slow…and you're going to have to swage hundreds of Nicopress sleeves.

Make sure you get a "Go/No Go" gauge. This is a handy tool that lets you quickly determine if your sleeves were swaged effectively.

Now…on the plus side, this sort of tool is not something that most people need that often. So you might be able to borrow one at your EAA Chapter.

3.2.5 Pliers

Another tool with limited use on aircraft is pliers. Yet, when you need one, there's no substitute. Keep one around and dust it occasionally.

Locking pliers (Vise Grips) are more useful. Pick up two or three, they're pretty cheap. I keep a sharp eye at the local hardware store's bargain bin, and score one occasionally.

The main problem with most pliers is that they are designed to grip; they don't care what damage they do to the material in the jaws. You don't want to use a pliers on an aircraft part--it is going to chew up the part or leave marks. Slipping a sacrificial piece of wood between the jaws and the part is an option.

A variation of the pliers is side cutters, or dykes. Get a medium sized pair for cutting safety wire and electrical cable.

3.2.6 Cutters

You'll need cable cutters for working with the aircraft cables., and a pair of tin snips to cut thin aluminum. The aviation style are comfortable and easy to use, and aren't all that expensive. They come in straight-cut, left, and right varieties. If you're just buying one pair, get the straight. It'll cut curves, but not as tightly as either of the turning varieties. If you're cutting a lot of sheet aluminum with curves, by all means buy a left-cut and/or right-cut model.

Unless the money is really tight, though, buy offset snips. These are shaped more like a set of garden clippers; both handles are on the same side of the jaws. They keep your hand free of cuts and nicks from the freshly-cut metal edge.

3.2.7 Hammer

A standard claw hammer is required, for no other reason than to nail together the worktable and workbench. A useful addition is a rubber- or plastic-tipped hammer. These can be used to tap tight-fitting parts into place without fear of marring the part or the surrounding structure.

3.2.8 Automatic Center Punch

The automatic center punch is used to place a small dimple on metal prior to drilling. It prevents the bit from walking.

The center punch works by a small amount of trickery. Place the point at the center of the desired hole. Push down with the palm of your hand, and the tool resists for a moment, then snaps downward.

The punch can be set to make various dimple sizes, is pretty cheap.

3.2.9 Vise

A bench vise is a necessity. They're sold by the width of the gripping area; a 4-inch model is probably about the smallest you should get. Bench vises are designed to be bolted to a tabletop. Clamp-base models can be moved easily, but they're more expensive, and larger sizes are rare. Forget the vacuum-clamp models. They just won't stick well to a wooden tabletop.

If portability is a requirement, get a standard bench model, place it on the corner of the table, and use C-clamps to hold it. Keep in mind that won't be as solid as a bolted-on unit. They're cheap enough, now, that you could get an extra.

3.2.10 Wood Cutters

Three types of wood cutters you're going to need.

You'll need a wood plane for some of the wood shaping. These are available just about everywhere.

You'll need a "draw knife." This is basically the cutter from a wood plane with two handles on it. You can shave wood off. In fact, for most Fly Baby stuff, the draw knife is probably a better pick than a wood plane.

Finally, get a set of wood chisels.

3.2.11 Clamps

Buy two types: C-clamp and spring. The first is the conventional C-clamp. Get a number of them in assorted sizes. You'll never have enough, anyway. I'm just scrimping by with six, and I'd definitely need more if I were building almost any other type of aircraft.

The other is the spring clamp; the kind that looks like enormous clothespins. You'll need a bunch, for doing the laminated wingtop bows on a Fly Baby These are sized based upon approximate opening width. They'll need to open to about two inches.

Bar clamps are useful in cases where the clamping surfaces are widely separated. These are similar to C-clamps except the top of the "C" is firmly attached to a bar that fits into the base.

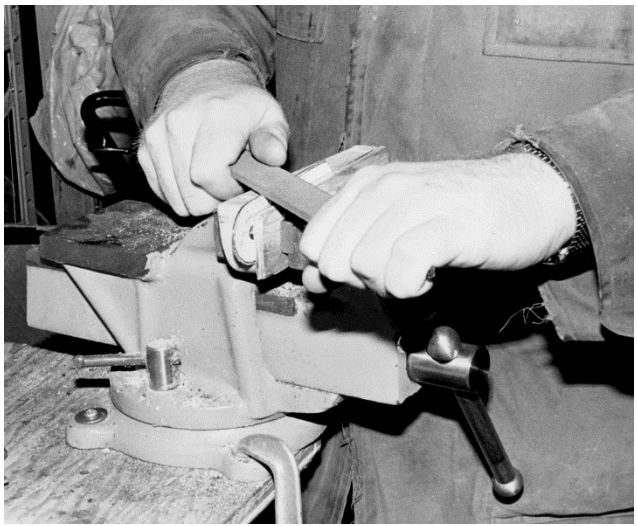
By the way, clamps are a real good opportunity to save money by buying at the discount tool place. Usually, since you'll have a bunch, if one breaks, you can throw it away without concern.

3.2.12 Hand Saws

Numerous handsaws exist, but there's one you'll need for sure: a hacksaw. Most take 10- or 12-inch blades. Twelve-inch blades give the longest wear and fastest cut, but 10-inch blades are easier to use in tight quarters. Pick a hacksaw with long blade-mounting posts because the blade's less likely to pop off under pressure. Remember, when mounting the blades, the teeth point away from the handle, towards the end of the hacksaw. The saw cuts on the forward stroke.

3.2.13 Files

Files are cheap; stock up on an assortment. Files are described by their length, cross-sectional shape, cut, and grade. Length is obvious. The cross-sectional shape can vary from flat, to half-round, to round, and other geometrics. Mill and flat files are almost identical, but the mill file has one smooth edge. The smooth edge protects the opposite side when filing in tight places.



The cut describes whether the file's teeth are long and parallel or small and diamond-shaped: single cut and double cut, respectively; the double cut is more effective at removing metal.

Finally, the grade determines the true roughness of a file. There are four grades: smooth, second cut, bastard cut, and coarse. The coarse file removes a lot of metal quickly, while the smooth cut would be used for finish filing.

However, the grade doesn't tell the whole story. The grade is for comparison between files of the same length. A 12-inch second-cut file will be rougher than a 6-inch model of the same grade.

If you're facing a ragged edge of steel, the best file would be a 12-inch double-cut coarse or bastard file. For taking the last little notches out of a piece of aluminum, select a small single-cut smooth one.

Now you see the importance of picking up a variety of files. The half-rounds are the most useful, followed by the flat files.

You'll also need other aids to smoothing wood and metal, such as sandpaper and emery cloth.

3.2.14 Rulers and References

A variety of rulers will be necessary, including devices that can measure angles and liveliness. A wide variety is easy to get because each is pretty cheap to buy.

A 12-Foot Tape Measure. You'll notice the little metal tip appears loose. Don't try to tighten it. It slides inward to compensate for the width of the tip during inside measurements.

A Metal Ruler, 12 Inches Long, Calibrated to 1/32nds of an Inch. Buy a combination square and you'll get both the ruler and a handy reference tool.

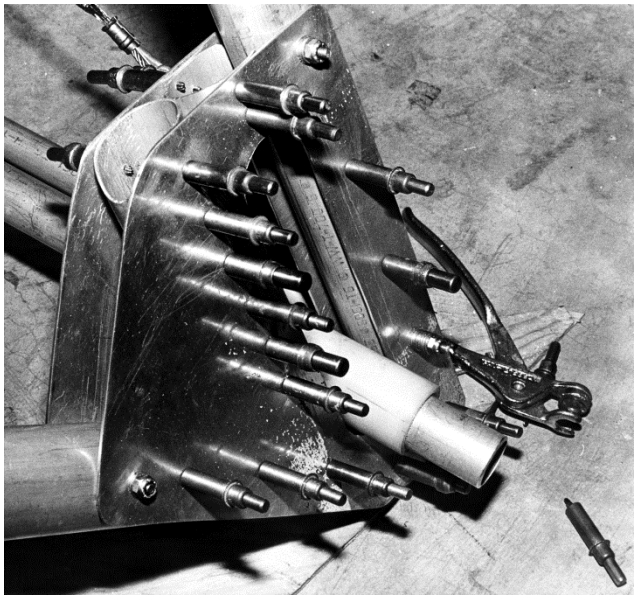
A Micrometer or Vernier Slide Caliper. These take extremely accurate measurements, depending upon the skill of the operator. Study the instructions and learn how to read the tool quickly and correctly. Slide calipers come in either decimal or fraction varieties (reads in .001 inch increments or /1/128 inch). I lean toward the decimal variety. Buy one than can take up to one-inch measurements. Good-quality micrometers and vernier calipers are expensive, so plan on spending at least $20.

A Carpenter's Square. Nothing more than a big L-shaped piece of steel with ruler markings on all edges. They are used to help make good 90-degree angles. You'll need at least one. They are pretty cheap.

3.2.15 Clecos and Cleco Pliers

Clecos are small spring-loaded temporary fasteners with prongs sticking out one end, and a button on top of the other. Insert a cleco in the cleco pliers, squeeze the pliers and the prongs get closer together. Insert the prongs into a hole, release pressure on the pliers, and the prongs spread to hold the cleco fast.

If you're trying to bolt two pieces of metal together, you can drill one hole through both pieces, insert a cleco, then drill a second hole and insert another cleco. From



that point on, each additional hole will maintain proper alignment.

Clecos are color-coded depending upon fractional inch size. The code is:

* 3/32": Silver
* 1/8": Copper
* 5/32": Black
* 3/16": Brass
* 7/32": Silver
* 1/4": Copper
* 9/32": Black
* 5/16": Brass

Note that the color code repeats after 3/16ths inch. You shouldn't have any trouble telling a 1/8-inch copper-colored cleco from a 1/4-inch.

Cleco pliers sell for about $8; clecos for around 50 cents each. I've bought used ones for as little as 18 cents. It pays to find the lowest cleco prices, especially if building a metal airplane because you might need hundreds.

To begin, just buy a few. Two dozen each, for example, of the 1/8-inch and 3/16-inch models.

3.3 Safety Items

No matter what type of airplane you're building, it involves working with fast-turning machinery and/or toxic chemicals.

The first line of defense is safety goggles. Using any sort of power tool puts you at risk to eye damage because they all fling small particles of material. You need two eyes to fly an airplane. Wouldn't you feel real silly spending three years building your dream plane, yet losing your medical for not wearing $3 worth of protection?

Don't count on being safe because you already wear normal eyeglasses. Dust gets blown around and will come in the sides. Get safety goggles, instead. Keep them in a convenient place; get used to donning them.

I did not wear safety glasses. One day I was drilling plastic and a piece about 1/16" inch across flew up and stuck in one eye. A careful bit of tweezer work removed it, with no permanent damage. I wear goggles faithfully now, and so should you.

A set of ear plugs isn't a bad idea, but the earmuff types are a lot better. Hearing loss is insidious, and riveting is deceptively hard on the ears. Buy several sets of hearing protectors, so that assistants and visitors are well-protected.

Finally, your saws will come with safety guards. Leave them on! Use push-sticks while feeding materials into a table saw or band saw.

I learned my lesson last year, when I had to make an emergency room run due to stupidity with a table saw. Use all the safety gear you can, and keep body parts well clear of the cutting stuff.

3.4 Fire Protection

You need several fire extinguishers in convenient locations around your shop, even if you aren't welding. I've had hand tools give up the ghost in glorious clouds of smoke; it's reassuring to have an extinguisher handy.

As a bit of advice, I prefer to do major work in the garage with the big garage door open to the outside. That way, if a tool does decide to immolate itself (I'm looking at YOU, thirty-year-old Black and Decker pad sander), it's a quick toss outside.

4 OTHER SHOP ITEMS

There are a number of items that fall into the netherland between tools and aircraft parts. The best description for them might be shop supplies.

When building the airplane on the worktable, the parts must occasionally be temporarily held in place. Hence, a supply of scrap 1x2 or 2x4 lumber is a good start. The 1x2 is commonly called a furring strip; the 2x4s are called studs. Set aside a convenient location to store these scraps. Cut as necessary, then reuse them. Similarly, you'll need nails to hold the pieces in place. Six- or eight-penny nails are about right.

Scrap plywood comes in handy. You can build forms for bending tubing, or make templates out of it.

In fact, much of the preceding should be left over from building your worktable and workbench. As you build, you'll find it comes in handy, buy more as needed.

One handy thing from the hardware store is threaded rod, sometimes called readi-bolt. It's like a very long (typically 3 feet) bolt without a head. Combined with a couple of blocks of wood or some scrap aluminum, it can be used to apply significant tension during the building process. Pick up a length of 3/16-inch readi-bolt, just to have around. Do not install it on the aircraft as a permanent part. It doesn't have much strength.

Set up a scrap pile to dump your mistakes. There are two reasons for hanging onto scrap. First, there might be enough good material for another, smaller part. I've often taken tubing from the scrap pile, cut off the ruined portions, and had sufficient material for a different item. Second, the aluminum scraps are recyclable. You can get a small return when your project is finished. Selected recycling centers won't take aluminum alloy, though, so check before taking it in.

You'll also need pens, pencils and markers to draw lines, sharpeners for the pencils, and the like. Garbage cans. Brooms. Dustpans, and a dozen other small items that meet individual needs.

5 FINDING THE MATERIALS

The Fly Baby Home Page includes a complete materials list. This includes the hardware, aluminum, and steel, as well as the wood required. Most of the items can be purchased from either Aircraft Spruce and Specialty or Wick's Aircraft. You can even order complete sub-kits from Aircraft Spruce. Here is the price list as of early 2018:

Description	Part Number	Price
FLYBABY SPRUCE KIT	01-00977	$2366.88
FLYBABY PLYWOOD KIT	01-00974	$1465.93
FLYBABY METALS KIT	01-00976	$915.49
FLYBABY HARDWARE KIT	01-00975	$2305.05

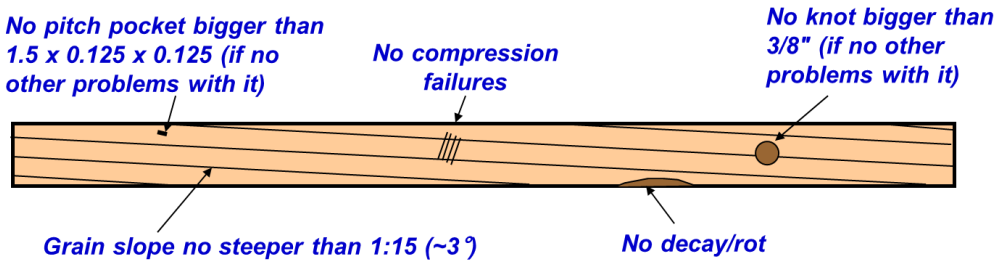
Aircraft Spruce is currently the only known supplier of aircraft-quality spars. They are available, but the lead time is pretty long…several months. Wicks still sells the other spruce.

5.1 Wood Substitution

FAA Advisory Circular AC 43.13-1B can be downloaded from several places. The first chapter includes extensive information about substitutes for spruce on wooden aircraft. The following table is from the AC:

Species of Wood	Strength properties as compared to spruce	Maximum permissible grain deviation (slope of grain)	Remarks
1.	2.	3.	4.
Spruce(Picea) Sitka (P. Sitchensis) Red (P. Rubra) White (P. Glauca).	100%	1:15	Excellent for all uses. Considered as standard for this table.
Douglas Fir (Pseudotsuga Taxifolia).	Exceeds spruce.	1:15	May be used as substitute for spruce in same sizes or in slightly reduced sizes providing reductions are substantiated. Difficult to work with handtools. Some tendency to split and splinter during fabrication and considerable more care in manufacture is necessary. Large solid pieces should be avoided due to inspection difficulties. Gluing satisfactory.
Noble Fir (Abies Nobiles).	Slightly exceeds spruce except 8% deficient in shear.	1:15	Satisfactory characteristics with respect to workability, warping, and splitting. May be used as direct substitute for spruce in same sizes providing shear does not become critical. Hardness somewhat less than spruce. Gluing satisfactory.
Western Hemlock (Tsuga Heterpphylla).	Slightly exceeds spruce.	1:15	Less uniform in texture than spruce. May be used as direct substitute for spruce. Upland growth superior to lowland growth. Gluing satisfactory.
Pine, Northern White (Pinus Strobus).	Properties between 85 % and 96 % those of spruce.	1:15	Excellent working qualities and uniform in properties, but somewhat low in hardness and shock-resisting capacity. Cannot be used as substitute for spruce without increase in sizes to compensate for lesser strength. Gluing satisfactory.
White Cedar, Port Orford (Charaecyparis Lawsoniana).	Exceeds spruce.	1:15	May be used as substitute for spruce in same sizes or in slightly reduced sizes providing reductions are substantiated. Easy to work with handtools. Gluing difficult, but satisfactory joints can be obtained if suitable precautions are taken.
Poplar, Yellow (Liriodendrow Tulipifera).	Slightly less than spruce except in compression (crushing) and shear.	1:15	Excellent working qualities. Should not be used as a direct substitute for spruce without carefully accounting for slightly reduced strength properties. Somewhat low in shock-resisting capacity. Gluing satisfactory.

As you can see, most species of wood can be substituted for Spruce. The key point is that the wood must meet the requirements for aircraft use. See the AC for details, but this figure summarizes the requirements:



5.2 Glue

In the plans, Pete specifies Weldwood glue. It's a fine product…but it's a product of the 1940s. This Resorcinol-formaldehyde product is still one of the few FAA-approved glues for aircraft.

But it has problems for amateur builders. It had limited gap-filling abilities (meaning that parts much fit very exactly) and requires a lot of clamping support while it cures (which can be awkward, with some parts.

In contrast, modern homebuilt aircraft use a variety of epoxy glues. These have excellent gap-filling abilities, and just have to be held together…not clamped…while they cure.

They're a bit more expensive, not really a drawback, these days. However, they should not be used in low temperature conditions. Their ultimate strength depends on the temperature when they cured. So if you're working in the cold climes in a garage, might want to add some heat.

5.3 The Welding Decision

One difference between a Fly Baby and a modern kit aircraft is the welded components are not available. Back in the 60s, there were many EAA members with welding skills and equipment. Not so much, nowadays.

Either you're going to have to learn to weld (nothing wrong with that) and buy a whole lot of expensive welding gear, or you're going to have to find folks to weld your parts for you.

This is a major decision point: Unless you can come up with a workable solution, there's not much reason to start building.

Part of the problem is easier to solve, nowadays. You can hand an electronic template to a company and have them cut out the steel parts with a laser cutter.

5.4 Commercial Parts

The Fly Baby was designed to use a lot of components from a J-3 Cub…everything forward of the firewall, and stuff like wheels and brakes.

"Truly" Cub parts are expensive these days. But most of them are pretty generic, and can be found at Aircraft Spruce, Wicks, or any number of other vendors.

For many of them, you might be better off scrounging. Wheels and brakes, especially…my Fly Baby was originally built with Goodyear units that were taken from a

wrecked Cessna 172. I replaced them long ago with a quality unit from Grove Aircraft and have been perfectly happy with them.

Work with your EAA Chapter and the Fly Baby Online community before buckling down and buying brand-new commercial components.

5.5 The Kit-That-Isn't-A-Kit

Fly Babies are scratch-built airplanes. You can buy materials and hardware kits from places like Wicks or Aircraft Spruce, but there are no completed components on the market.

Well…actually, there are. Over the past ~55 years, a lot of folks have started building Fly Babies. Most of them were never completed.

As these builders age, more and more unfinished Fly Baby projects end up on the marketplace.

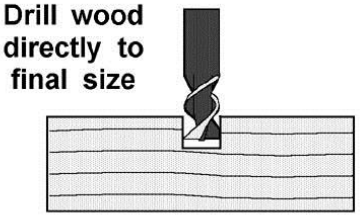
"But I don't want to trust someone woodworking skills, especially when it's been sitting in a damp basement for the last fifty years!"

I don't argue with that. But that partially-completed project may have a LOT of hardware included. Just getting the welded parts is going to be a big boost. Wheels/tires/brakes may run $1000 or so, new. The Fly Baby uses 40 turnbuckles, and they're running $35-$40 each. That's another $1500 or so.

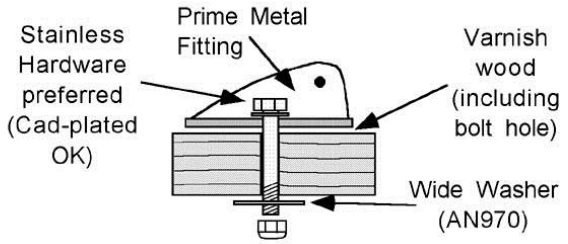
Obviously, if you can buy a partially-completed project for $1,000 or $1,500, if it comes with these components, you're ahead of the game.

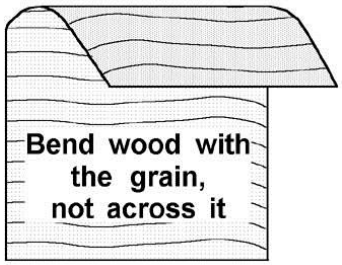
ShopSheet
By Ron Wanttaja

Wood Hints

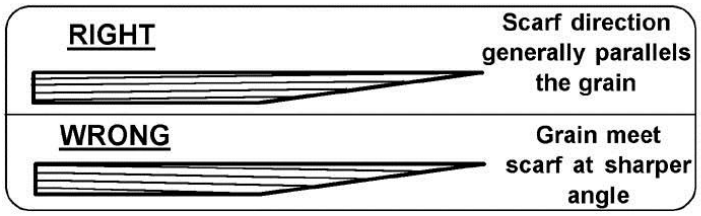


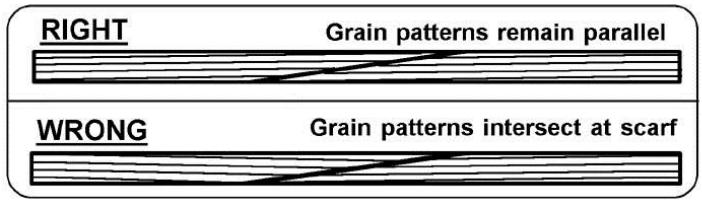
Wood/Metal Interfaces





Scarf Joints





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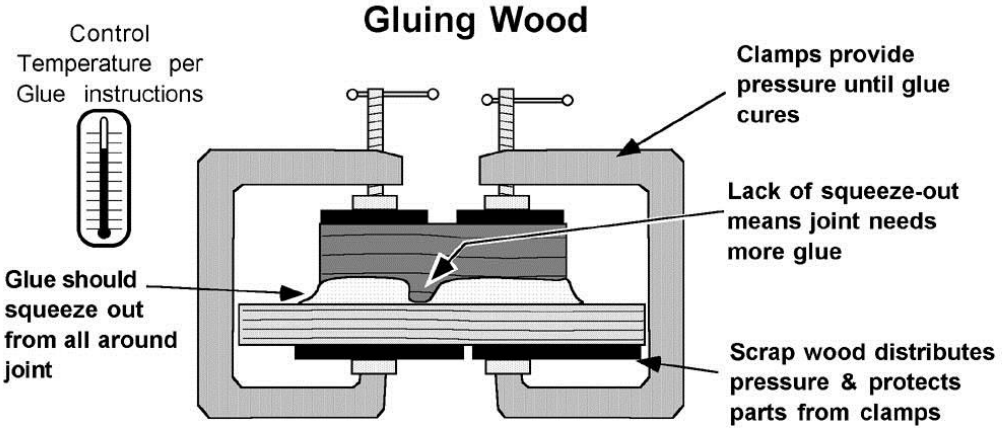
Gluing Wood



6 PAPERWORK PREPARATIONS

You don't have to notify the FAA about your project until it's ready for inspection. However, at that time, the inspector will want proof that you built the aircraft.

The first item of proof is the builder's log. These are available on the market, or you can just buy a spiral-bound notebook. Make a log entry every time you work on the aircraft. Include the date, the number of hours worked, and the tasks performed. Especially note any variation from the plans. For example, my aircraft's plans call for the installation of a tail skid instead of a tailwheel. I designed and built a steerable tailwheel assembly, and included drawings and descriptions in the log.

Keeping a log on a computer is fine, but like all valuable files, keep backups.

The second proof is pictures. Take photos of various stages of construction, including the changes. These don't have to be magazine quality photos.

One very high-tech way to take pictures of your building process is to set up a web camera. These are so cheap that they're often just given away with a new computer. I know a man who rigged up a web camera to take a photo every minute whenever the shop lights were on. At the end, he had a very rapid "movie" showing his airplane going together. When the inspector came to sign off his airplane, the first thing the builder did was sit him in front of the computer and watch the movie. When it was over, the inspector didn't even bother to look at his hard-copy building logs....

7 FINDING HELP

One last thing to take care of before starting: Where are you going to find help when you need it?

The Fly Baby Facebook page is a popular online group, as is the Fly Baby mailing list on Yahoo.

Each group has almost a thousand participants. Some are building their own planes, others fly purchased Fly Babies, and others are A&Ps with vast experience in aircraft maintenance.

If you have a question…ask there.

Also, visit your local chapter of the Experimental Aircraft Association. There may not be other Fly Baby builders there, but they have some very experience people eager to help. Call EAA headquarters at (414) 426-4800 and ask for chapter information.

Most chapters also include an EAA Technical Counselor. These are experienced builders and/or A&P mechanics who have volunteered to guide people through the building process. The counselors are available to answer questions over the phone, and will come to your shop to inspect the plane in progress. Have them over often--the sooner problems are found, the easier correction will be. The counselor's suggestions have no legal bearing, but the counselors have vast experience, and their recommendations should be followed.