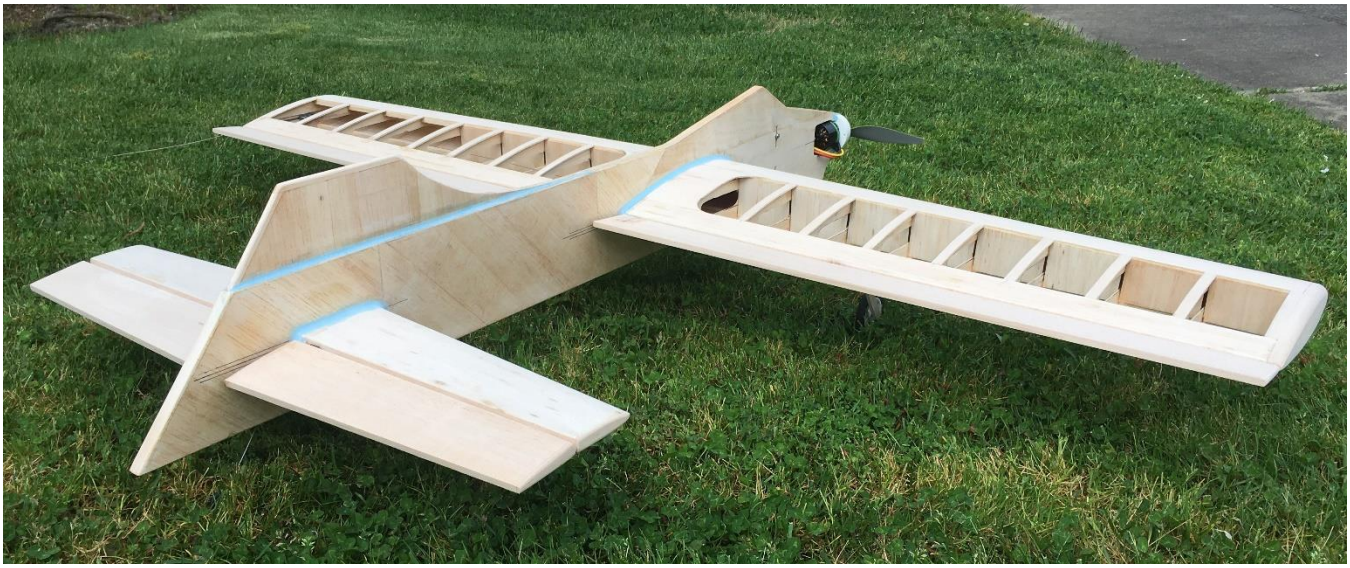
Turning to the Dark Side

The Building of Circulas 46 IIe

Part 1 – Introduction



A Precision Aerobatic Control Line Model Airplane

– Electric Profile –

Written by Dennis S. Nunes

April 2020
Revised July 2020

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Turning to the Dark Side

Part 1 – Introduction

Where it all started - Circulas 46 with an OS 46LA and well over 160 flights

INTRODUCTION:

I thought I would write (though I'm not a writer) and maintain a diary-like document (ramblings) about my adventures in the designing, developing and building of my first *electric powered* control line model airplane. This adventure got started back in August of 2019.

Throughout this entire process I found it difficult to keep everything straight when you're (1) building the plane, (2) taking pictures during construction, (3) trying to write about it and (4) updating the CAD drawings all at the same time.

Changes happen during construction and I tried my best to keep the CAD drawings, pictures and documentation up to date. Believe me, it's not easy to do! Hopefully someone will find a little humor in this adventure as well as something informative.

However, my real hope is that this adventure might encourage someone who might be like me – a *diehard* user of internal combustion engines to power control line model airplanes –

who may be hesitant to take a step to what I labeled as a *"Turning to the Dark Side"*, changing to an *electric* powered model.

THE ISSUES: There are several issues that I needed to deal with in making this transformation. As I returned to control line flying and competition in 2015 from a 40+ year layoff, *all* my planes have been built using internal combustion (IC) engines. Though I've seen many electric powered planes while competing, I never thought of giving up my *"Slimmers"* and turning to the dark side with an electric powered plane.

With the success of my *Circulas 46* profile, powered with an OS 46LA engine, and the unique privilege to have this plane published in *Stunt News* (Issue 1 of 2019), I felt it was time to move on and over to the "dark side" and give electric power a try. *But where do I begin? Where do I start?* This is beginning of my adventure…

As I started to think about and analyze this adventure, I looked at the pros and cons, the good and bad, the advantages and the disadvantages. Everything kept leaning in favor of electric power. However, a large *"disadvantage"* keeps standing out like a sore thumb. The kind of thing that keeps you up late at night. Strangely enough, in my analysis, it wasn't the lack of knowledge of not knowing what to do or what not to do, although that is a concern. It wasn't the cost …. Well may be a little (just don't ask by my wife of 46 years). I found that the biggest disadvantage was ….

Ready for this? …. ***ME!***

And here's why. Give me a plane with an IC engine and I am as comfortable and happy as the proverbial *"pig in slop"*.

Figure 1 – One Very Happy Pig!

But with electric power there are some big unknowns. *(Well …. I know enough to look for the arming plug if I retrieved an electric model and hopefully it has one because I'm going to pull something!)*

But deep down inside, I know that there's going to be a tremendous learning curve. But trying to become familiar and comfortable with electric power is one thing, to be successful and competitive at the same time is a quite another. Perhaps this may be attributed to the fear of the unknown or the fear of failure. I'm not sure which.

There is also the sizeable investment it's going to take to switch from IC to electric, such as new planes, batteries, battery chargers, power supplies, timers, ESC's, programmers, cables, connectors, etc. And 2 years ago I just gave my right arm along with a sizable sum of money for my new RO-Jett .61 engine with a tuned pipe setup and a new plane named *Circulas 61!*

Until recently I didn't have any problems obtaining the appropriate fuel I needed for my IC engines. Now, I'm starting to experience this issue more frequently. And when it is available it's becoming much more expensive. I'm sure as time goes by this situation will only become worst before it gets better. So I'm starting to see

the *'writing on the wall'…. I'm getting the message.*

Now for a *"strange"* issue ….. *The Sound.*

What sound you may ask? Electric planes are fairly quiet. ***That's the issue!***

To me, there is nothing better than the sound of a PA or RO-Jett engine on a tuned pipe and the smell of burning fuel as it leaves its exhaust trail all over the sky. To listen and watch Dave Fitzgerald's Thunder Gazer or Brett Buck's Infinity as they put their planes through their paces, its full testosterone to the max, and that's music to my ears!

Figure 2 - David Fitzgerald's Thunder Gazer

Figure 3 - Brett Buck's Infinity

My issue with electric power is this annoying …… buzz *(sounds like a mosquito ….. albeit a rather large mosquito!).* I guess I'll just have to get over it, but it's going to take some time.

I get a good chuckle when I see Tim Wescott's signature on StuntHanger.com where he states, *"The problem with electric is that once you get the smoke generator and sound system installed, the plane is too heavy!"* Oh well, I guess you just can't have everything in making this *"turn to the dark side".*

I've had the privilege to see firsthand many of the finest electric models in person. From Paul Walker's Predator's, his P-47's as well as his latest Impact, Chris Cox's Hellcat's, and Jim Aron's beautiful Systrema v2e.

Figure 4 - Jim Aron's Systrema v2e

These planes fly and perform extremely well and are some of the most advanced, sophisticated and beautiful electric power planes there are. When you look at these models you easily become overwhelmed and/or discouraged and say to yourself, *"I can't do something like this"*. That may be true or not, but I need to get started somewhere.

Then again, there's the issue I mentioned earlier. It's taken me two years to purchase a powerful Ro-Jett .61 engine, header, tuned pipe, carbon fiber props, etc. and build *Circulas 61*. Now I'm just starting to become very comfortable with this setup. I keep asking myself, *why change now?*

Figure 5 - Circulas 61 with RO-Jett 61

Turning to the Dark Side

Part 1 – Introduction

The last issue my little brain had to contend with was that I've "seen" many electric planes fly….. *But I've never "flown" one.*

This issue was taken care of thanks to Chris Cox at the *2019 Western Canadian Stunt Championships* in British Columbia on August of 2019. At this contest Chris brought out his old electric Crossfire that was being used in competition by two visiting modelers from Australia and New Zealand. After the end of the contest I was given the opportunity and privilege to fly Chris' Crossfire.

Figure 6 – 2019 Western Canadian Stunt Championship Bruce Hoffman from Australia (left) and Kevin Barnes from New Zealand used Chris Cox's backup Crossfire

After a few level laps, some climbs and dives to get use to the controls, I was off doing the entire pattern on the first flight. *That Crossfire and me became as one ….. instantly!* I've never became so comfortable on a first flight with any plane like I did with this one. What a unique experience to fly, not only a well-trimmed airplane, but one that had plenty of power throughout the entire pattern. I was extremely impressed to say the least, even though the *"buzz"* of the motor still got to me!

Note: Somebody please tell Chris if he ever needs to get rid of that Crossfire to let me know, I know of someone who will gladly take it of his hands …. ME!

Ok, this is good therapy! The more I ramble (write) about this, the more convinced I'm becoming in making this *turn to the dark side!*

COUNTING THE COST: My mom always told me to, "count the cost of everything" especially when you are trying to make decisions on where you are going to spend your cash. Great advice Mom!

Several months beforehand, I drew up CAD plans and started to build a new modified version of *Circulas 46* for what *"was"* to be *Circulas 46 II* using an OS 46 LA engine. So I decided to modify these CAD drawings for a new plane using an electric setup. I would call this plane *Circulas 46 IIe* ("e" for electric).

I guess I'll need to rethink how I come up with new names for my electric planes. All my IC planes were named with the engine size as part of the name, Circulas 25, Circulas 46, Circulas 60 and Circulas 61. *Oh well…*

I sent Chris Cox an email with a preliminary PDF file of my plans and told him I wanted to try electric, but to keep my initial expense down as much as possible. Being my first electric plane I thought a profile that had everything open and exposed was a good idea. My thinking was to use an E-Flite 25 motor, but wasn't sure if that was good enough for this plane and after that I wasn't sure what else I needed.

Chris followed up with a list of items that he thought would work. He also suggested that I should not skimp on a battery charger, that I should *'bite the bullet'* and spend the necessary money for a good one (Revolectrix™ Cellpro PowerLab 8) as this will pay for itself in the long run. Here is a partial list of items Chris recommended for *Circulas 46 IIe*:

- E-flite 25®, 870Kv Motor *(Later changed to a Cobra 3515/18, 740Kv Motor)*
- Hobby King Zippy 4S 2650 45C Batteries *(Later changed to Thunder Power 5S 25C 2800mAh Batteries)*
- Hubin FM-9 Timer with Start Button

- Hubin Programmer
- YEP 60A (2~6S) SBEC Brushless Speed Controller
- APC 11x5.5e Thin Electric Propeller
- Revolectrix™ Cellpro PowerLab 8 Battery Charger
- ProgressiveRC® Multi-Port Safe Parallel Board

As I looked over the list I saw some items that were needed and some items that I was not aware of. I convinced myself that it's all part of that *large* learning experience.

I started getting prices to see what this adventure was going to cost. Interestingly, the majority of my expense was shelling out for a Revolectrix™ Cellpro PowerLab 8 Battery Charger, a Multi-port Parallel Board, Programmers and a 24v Power Supply. *This would be about two-thirds of my total cost of this investment but only a <u>one-time expense</u>*.

This proved to be very interesting because the total cost of all the items required for this project was almost the exact amount that I spent for my Ro-Jett 61 setup with its carbon fiber pipe, aluminum header, extra venturi's, carbon fiber props*, my right arm*, etc. So the initial outlay of cash was there, but future expenses looked very bright and promising *(Except when you take a look at the latest prices for balsa wood …. Oh my!).*

Now for the batteries. Chris recommended using the Zippy 4S 2650 45C batteries with the E-flite 25 motor, these are not too expensive and perhaps may not be the best or lightest batteries available, but should do the job. However, in the middle of construction I decided to change to a Cobra 3515/18 motor and use Thunder Power 5S 2800 batteries as these were considerably lighter, even though they are more expensive *(So much for trying to keep the cost down).*

You can order the batteries directly from Thunder Power and will set you back about $70 each. But during the holidays Thunder Power will usually have a special with discounts anywhere from 30% to 50% *(I'm currently waiting for a holiday to get the discount to order my batteries!)*.

I'm not sure how many charges I can get out of these batteries. But, if I can manage to get 100 flights out of them, that runs about $0.70 per flight. The last gallon of PowerMaster fuel I purchased for my RO-Jett cost me $28. I use almost 7 oz. of fuel per flight, a gallon of fuel is good for about 18 flights. That breaks down to $1.55 per flight. I know, I'm not quite comparing apples with apples here, a RO-Jett 61 engine versus a Cobra 3515/18 motor, but I think it makes the point. It's going to cost me less per flight using electric power. Cool!

GETTING STARTED: Enough rambling about the issues and cost! Let's get back to my original question ….

Where do I begin?

As mentioned earlier, I wanted to try and keep my initial investment cost down as much as possible. I even had the thought of perhaps "converting" my original *Circulas 46* to electric. No way …. That wasn't going to happen, I like this airplane too much and I still enjoy flying it!

Figure 7 - My Original Circulas 46

Turning to the Dark Side

Part 1 – Introduction

Well…. In my workshop and under construction just happened to be a new wing framed up for what *"was"* to be a new *Circulas 46 II* profile for an OS 46 LA engine.

Figure 8 –New Wing "was" for Circulas 46 II

I ran out of some needed wood and needed to order some more. At the same time I was getting ready to have shoulder surgery. I knew I wouldn't be able to do much of anything after the surgery. So the project was put on hold and just sat there.

Then it hit me…. *Why not make it electric?*

The decision was made – ***we're going electric!***

So let's go a little further and take a look at some of the design features of *Circulas 46 IIe* as I continue to make this journey and *"turn to the dark side"*.

THE DESIGN: The original intent of the *Circulas 46* was to design an IC powered profile that is easy to build using simple building techniques and methods, yet still be used as a plane that is very competitive.

The wing utilizes a wider than normal rib spacing (~3") but also employs the use of 3/32" thick leading and trailing edge sheeting and 3/8" wide cap strips, rather than using 1/16" thick material. On several planes where I used the traditional 2" rib spacing with 1/16" sheeting, I would always get the "starved horse" look after some time. So far, after 3 years, no starved horse look on the 3" rib spacing.

For those familiar with the original *Circulas 46*, there are some subtle and not so subtle changes. For example, the leading edge rake of the wing was increased from 1-1/4" to 1-3/4", along with changes to the width of the Flaps. This reduced the total wing area from 605 sq. in. to 586 sq. in. The tail size and tail length for *Circulas 46 IIe* has been enlarged. The tail area is now about 25% of the wing area with a tail length of 18" from flap hinge line to the elevator hinge line.

With the larger tail and long tail length, this tends to make the plane tail heavy. Some have said that an electric plane needs to have the center of gravity more forward, along with leadout location further back than an IC counterpart. We'll see. Again, part of the large learning curve.

Even though the additional combined weight of the Zippy battery, E-Flite motor and the rest of the electrical paraphernalia being a little heavier that the IC version, I still decided to increase the nose length to 11". My thinking is that it's lighter to add tail weight than it is to add nose weight when it comes to getting the center of gravity (CG) at the correct location. However, if I guess correctly, I won't have to add any weight at all. We'll see.

The profile fuselage still utilizes the built up method that requires a little more work to build, but is lighter than using a solid 1/2" plank. The original *Circulas 46* used a carbon fiber 'fuselage mounted' landing gear that was removable and adjustable. The fuselage on

Circulas 46 is not very tall and getting the profile landing gear back far enough was an issue. Also, after more than 160 flights, I noticed stress cracks developing between the landing gear bolts and wing root due to some *not-so-soft* landings. So one of the changes for *Circulas 46 IIe* was to ditch the fuselage mounted landing gear and switch to a wing mounted landing gear. I also increased the height of the fuselage to try and get away from the "yard stick" look.

Also gone is the built-up cheek cowl on the inboard side of the nose as this should not be required as an electric motor doesn't have the vibration issues as an IC engine. Besides, in talking to several individuals they thought there was a small advantage of having the battery mounted on the inboard side of the fuselage with the rest of the electrical paraphernalia mounted on the outboard side. It makes it less stressful on the battery mount/straps of holding the battery in position as centrifugal force help keep the battery in place.

Originally I was going to use the E-flite 25, 870 Kv motor along with Bob Hunt's Hard Nose Motor Mount. But after talking on the phone with Russell Honea of Okie Air Model Products, who took over Stunt Hanger Hobbies, showed me a 3D custom printed motor mount which greatly simplified the motor installation on a profile fuselage.

Figure 9 - 3D Custom Motor Mount

Russel also talked me into buying a Cobra 3515/18 740 Kv motor instead of the E-flite 25 motor. The Cobra motor was actually less expensive than the E-flite motor and in his opinion the Cobra motor would be a better choice than the E-flite motor. Also Cobra's website is extremely helpful and has a very useful Propeller Data Chart to help in the selection of the ideal propeller at various voltages along with more data that I will probably never understand. You know, that large learning curve thing again.

Another change I implemented that's different from the original *Circulas 46* is that the built-up fuselage now contains two laminated rails, one for the top of the fuselage and one for the bottom fuselage. These rails are made up from two pieces of 1/4" x 1/2" balsa strips, with a 1/2" wide strip of carbon fiber laminated with thin CA in between the two balsa strips. These rails form the "backbone" of the profile fuselage. I found some carbon fiber strip from Dave Brown Products which is available at Ohio Superstar Products. The original *Circulas 46* fuselage was a little flimsy and it is hopeful that these rails with the carbon fiber strip will take care of this issue and still make for a light fuselage construction.

As with the design of *Circulas 46*, as well as *Circulas 46IIe*, I tried to make everything either adjustable or removable. The flaps and elevators are removable, if needed, by using nylon hinges, removing the pins and installing a continuous piano wire hinge. The tail wheel and landing gear are removable. When traveling to a contest, getting several large size planes to fit into the back seat of a car can be quite a challenge; having things removable is a huge advantage.

A word about the controls for *Circulas 46 IIe*. I enjoy making my own hardware, from the 4" bellcrank to my control horns and pushrods. Along the way I've purchased some power tools to make this task easier, but basic hand tools can be used with the same results. The beauty of this is that it allows me the flexibility to make items to my liking that are either difficult to obtain, too expensive or are just no longer available.

Turning to the Dark Side

Part 1 – Introduction

One thing I now incorporate in all my planes is a *Walker Flap Adjustment Device* (WFAD). This gives you the ability to adjust the flaps individually with very small adjustments with a turn of a ball driver. No more need to "tweak" the flaps by trying to twist 1/8" wire. This works really slick!

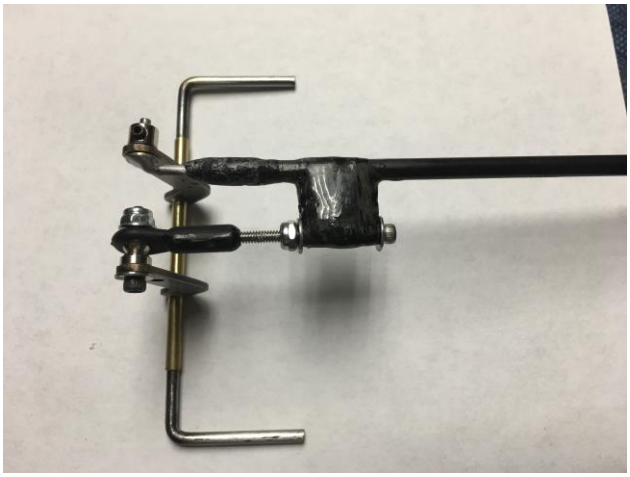

Figure 10- Walker Flap Adjustment Device

Also, my control horns employ 1/8" diameter wire. It is *not* piano wire. Piano wire is too brittle and tends to crack on a tight radius bend. I use 1/8" air hardened drill rod available through Zoro.com or McMaster-Carr. As an alternative to the custom control horns, one could use control horns made available by Okie Air Model Products without the WFAD. The same is true with the custom bellcrank. Again a Okie Air Model Products unit should work fine.

You will also notice that *Circulas 46 IIe* is an all *"in-line"* configuration. That is, the centerline of the motor, wing and stabilizer are all in line with each other. Paul Walker wrote about this in the development of the *Warbirds of the Northwest* article in *Stunt News* sometime back that was very interesting. So I thought I give it a try.

At the suggestion of Paul Walker, I now use a "reverse" bellcrank where the up line is in front of the down line.

(Personal Note: You may have noticed that for some odd reason, when individuals like Paul Walker and Dave Fitzgerald give suggestions or advice I tend to listen and go with it, even if I may not or don't fully understand the reasons. There's something about 12-time National Champions that seem to know what they are doing or talking about!)

With the reverse bellcrank, I employ a longer-than-normal leadout guide that has independently sliding adjustable leadouts where the leadout spacing can be adjusted down to 1/4" between the lines if desired. How far back do the leadouts need to move? Currently this is unknown. We'll find out. Again, another one of those large learning curve things.

Keep in mind that staggered length leadouts are required to keep the line clips from snagging with this type of setup. So for your flying lines you will have one line longer that the other. One of the benefits of this setup is if you connect your lines up backwards, you will know *instantly* that it's wrong when you pick up your handle.

Lastly, I would say that this is *NOT* a Beginner's project. But it is a step or two up above a basic trainer. If you built a basic trainer and/or can built a kit plane such as a Skyray, a Ringmaster or a Flite Streak – you can build a *Circulas 46 IIe*. I've flown *Circulas 46* (IC version) when I was an Intermediate class flyer and has been my "go to" practice plane. I wouldn't hesitate to fly *Circulas 46* in the Advanced class. Of course, it also makes for a great plane to fly in Profile events.

For those who like numbers, here are some of the basic design numbers for *Circulas 46 IIe*:

- Total Wingspan: 56.25"
- Total Wing Area: 586 sq. in.
- Wing Aspect Ratio: 5.39:1
- Tail Wingspan: 26"
- Total Tail Area: 149.5 sq. in.
- Overall Length: 45.25"
- Nose Length: 11"
- Flap Hinge Line to Elevator Hinge Line: 18"

Turning to the Dark Side

Part 1 – Introduction

Now it's time to spend some cash (and lose my left arm) in order to continue on this journey as I *turn to the dark side*.

If you have any questions or comments please send an email at: circulas46iie.2020@gmail.com. I will try to respond back to you as soon as I can.

Also, I would appreciate any feedback that you may have on any of the articles.

The adventure continues…Next, on to the Wing Construction!

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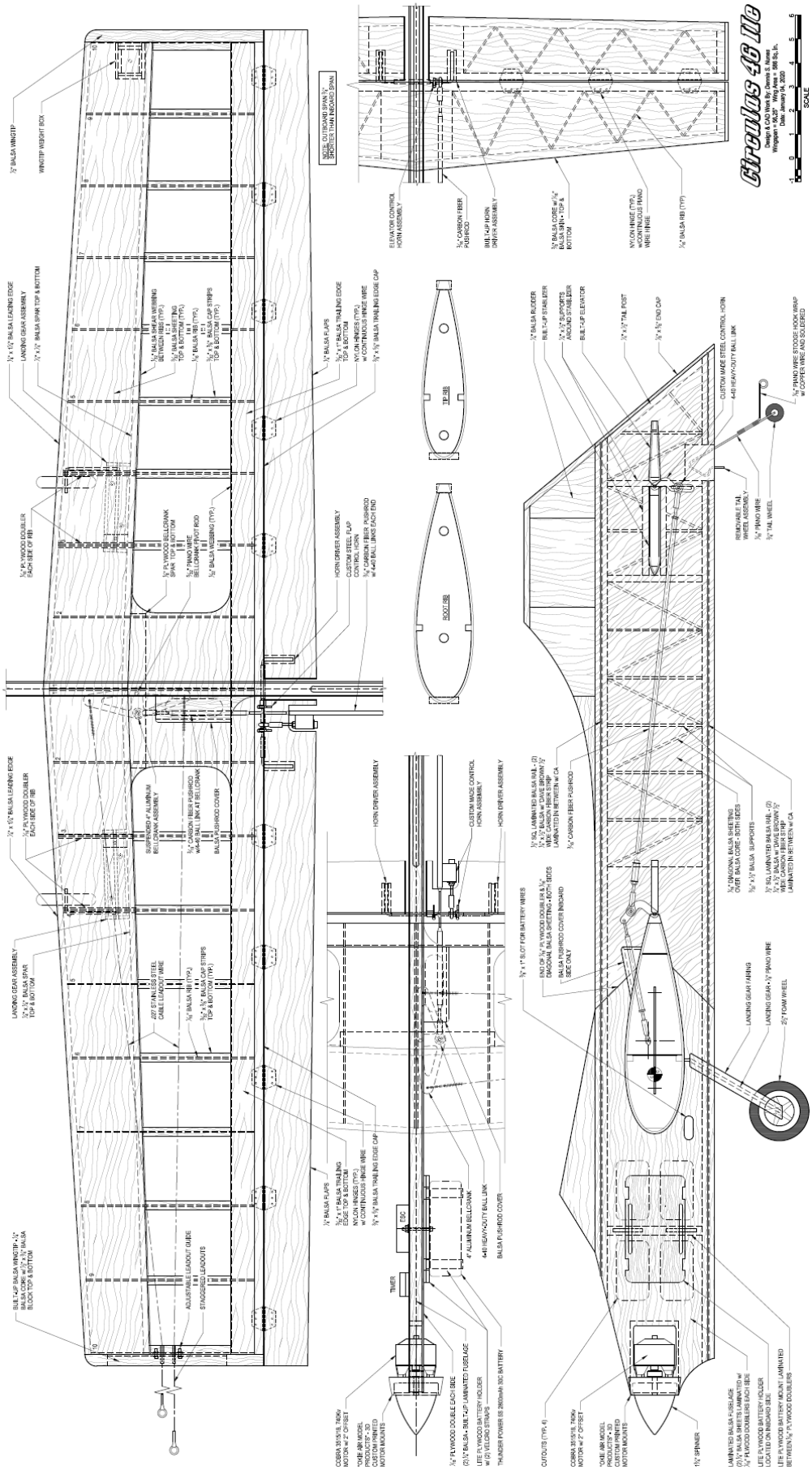
Turning to the Dark Side

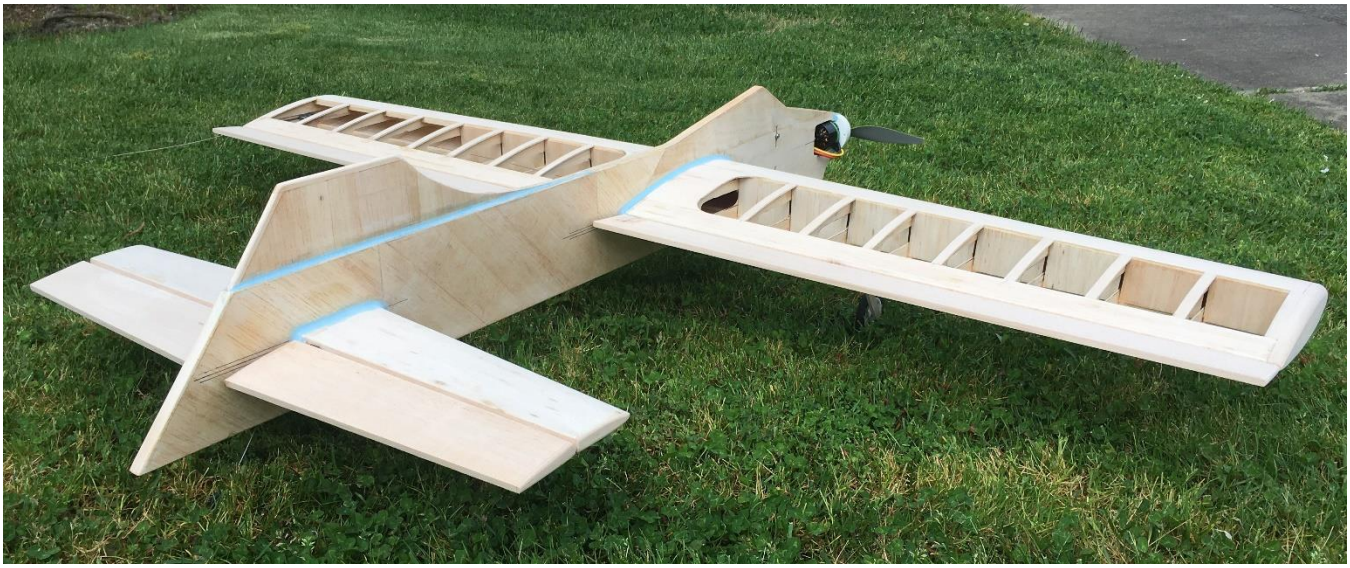
Part 1 – Introduction



Turning to the Dark Side

The Building of Circulas 46 IIe

Part 2 – Wing Construction



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WING CONSTRUCTION:

As this adventure of "*Turning to the Dark Side*" continues, it's time to start building. For some strange reason when I start to build a new plane I always start with the wing. Why? I have no idea. I may start off with the wing, but will switch to the fuselage or stabilizer and elevators at any given moment. It depends on my 'mood-and-condition'.

That will explain why you will see other parts of the plane at various stages in some of the photographs. Believe me, it's not trick photography!

The other thing is that sometimes I'm so focused on the construction that I forget that I need to take some pictures. On some occasions this requires me to go back and 'stage' some of the photos at a later time, if I can.

So let's look at the wing construction for *Circulas 46 IIe*. We'll start with making the wing jig.

MAKING THE WING JIG

For the wing construction I use the 2-rod jig method and a level work surface. Several year ago I was able to purchase two 3/8" dia. x 72" type 316 seamless stainless steel tubing from

Zoro.com. The steel tubing is supported above the work surface using T-type supports made of 1/8” Masonite® or 1/8” plywood.

Before using the tubing and to keep most glues from permanently sticking to tubing, I apply several coats of automobile paste wax and “polish” the tubing.

I like building the entire wing at one time using this method. Afterward when I’m done using the tubing, I clean them off, “re-polish” and store them in the nice heavy duty shipping container that the tubing came in.

To support the tubing off the work surface, make some T-type supports made from 1/8” Masonite® or 1/8” plywood. Cut (6) 2 1/2" x 12” long strips using a table saw and make (3) T-type supports. I used medium CA to glue the support together. Make sure that the height of all the supports are exactly the same. Take one of the glued T-type supports and cut into (7) 1-1/2” long sections for midpoint supports.

I normally attach a T-type supports at each end of my wood workbench using some small wood screws. But since I received my 1/2" glass top for my workbench I just tape them to the glass. The 1-1/2" long mid supports are not attached to the workbench or glass top. This way you can move the supports to various locations along the 3/8” tubing as needed.

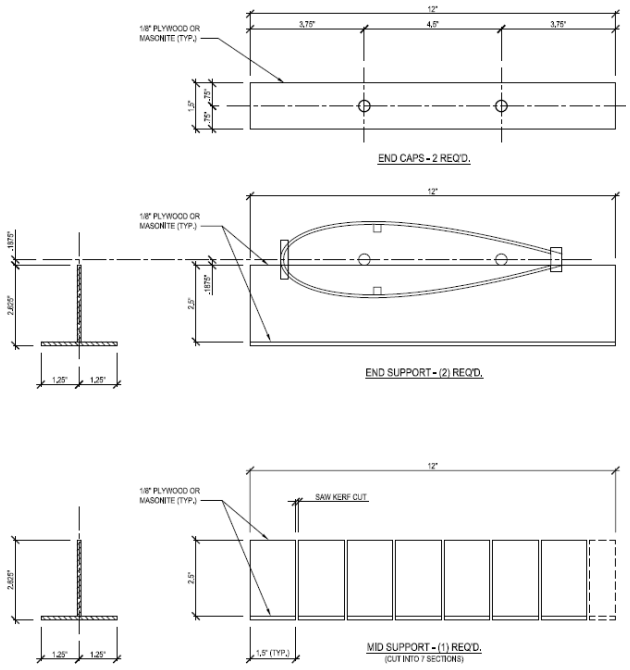


Figure 1 - Jig Rod T-type Supports

Figure 2 - T-type Supports

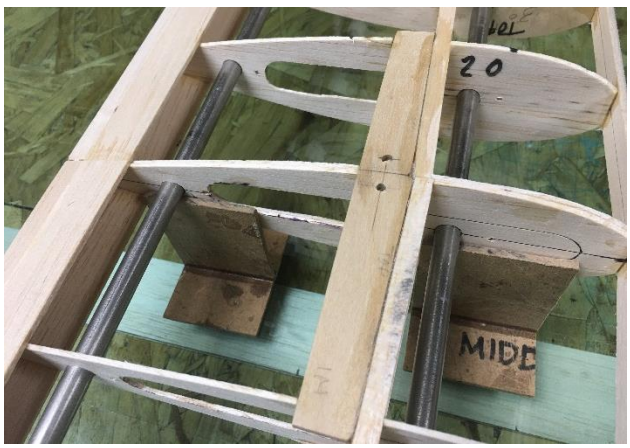


Figure 3 - T-type Mid Supports

Again, using 1/8” Masonite® or 1/8” plywood, cut (2) 1-1/2” x 12” long strips for end plates with 3/8” hole matching the spacing for the stainless steel tubing. Once the ribs are slid on to the tubing, the tubing pretty much stay in place. But I like to clamp the end plates to the T-support to keep the wing from moving on the work table.

Figure 4 - Wing Jig End Cap Clamped to End Support

Once the ends of the leading and trailing edges are trimmed to length, I will slide the end supports up against the tip rib and use a 3/8” shaft collar with set screw on each end of the tubes along with the spring clamps and “lock” the wing into place to keep it from sliding on the jig tubes.

Figure 5 - Wing Jig End Caps Locked Down

One of the nice features of using this jig is that you can flip the wing over to work on the other side when necessary. Just exercise care in doing so as the wing is still fragile until the leading edge sheeting is applied. Let’s move on and start building the wing.

BUILDING THE WING

THE RIBS: The ribs are made using the “sandwich” method, make a set of ribs for the inboard panel and then another set for the outboard panel.

Make a root and tip template from 1/16” plywood (or aluminum) and sandwich (10) 1/16” balsa blanks between the templates and bolt them together.

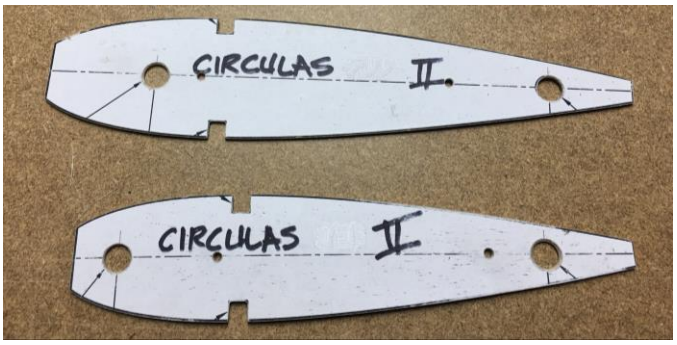


Figure 6 - Rib Templates

Make sure to align the templates so that the notches of the 1/4" spars on both templates line up with each other. I used (2) 4-40 x 1” bolts to hold the assembly together. *Do not drill the 3/8” holes for the tubing at this time*.

Carve and sand the ribs to shape. Next, use a Zona® saw and make a small cut on the sides for the 1/4” spar. Cut down just shy of the bottom of the spar. Keep the saw blade 90 degrees perpendicular to the ribs. Chip out the balsa portion of the notch for the spar. Take some 320 grit sandpaper and attach it to a 1/4" wide piece of spar and sand the bottom of the spar notch to the final shape.

Lastly, take a Sharpie® and draw a single line across the top of the ribs. This indicates the “top” of the rib and allows you to verify if all the ribs are slid on to the rods in the same orientation.

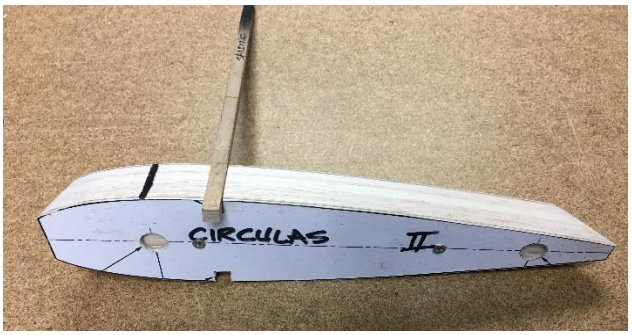


Figure 7 - Carved and Sanded Ribs Stack

Once complete, unbolt the rib templates. Very careful re-align the ribs so that all the trailing edges of the ribs are aligned. Keep the leading edge of each rib aligned and using the tip template clamp the assembly together.

Take a 2” length of 3/8” brass tubing and sharpen the inside end with an X-ACTO® knife. Using a drill press, chuck up the 3/8” brass tubing (do not over-tighten the chuck and crush the brass tubing) and “drill” the 3/8” hole for the jig tubing.

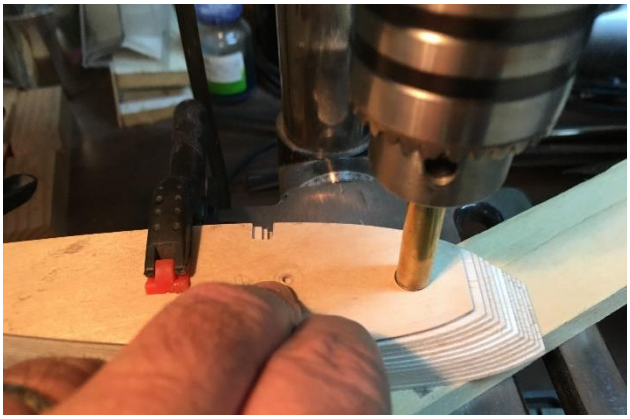


Figure 8 - Realign the Ribs and Drill Holes

This could be done by hand with a longer length of 3/8” brass tubing, but it may be difficult to keep these holes perpendicular at 90 degrees to the ribs. A drill press makes the task much easier.

Cut out the center portion of each rib between the 3/8” rods.

Figure 9 – Cut Out the Center Portion of the Ribs

Now put a number on each rib starting with #1 at the root rib to #10 on the tip rib. I add the letter “I” along with a number (7I) for the ribs that are for the inboard panel.

LANDING GEAR DOUBLERS: Take ribs #3 & #4 and on a piece of 1/16” plywood, carefully trace around the leading edge of each rib back to the 1/4" spar. Add a 1” wide notch for the landing gear blocks that starts against the front of the 1/4" spar and is 1/2" below the centerline of the rib. Drill 1/2" hole for the jig rods. This hole is slightly larger than the jig rods. Make a set of plywood doublers for each rib, one set for the inboard and another set for the outboard wing panels (8 total).

Laminate the 1/16” plywood doublers to the balsa ribs. Make sure that the notch for the landing gear block is located on the bottom side of the wing. I use 5-minute epoxy, but Sig® “Super-Weld” or Titebond® glue can be used.

Figure 10 - Landing Gear Doublers

ASSEMBLING THE WING ON THE JIG:
Prepare two length of 1/4" x 1-1 1/4" balsa for the leading edge. For the trailing edge sheeting, a splice is need for the 3/32” x 1” balsa to make the entire length of the wing. Cut eight 1/4" square balsa spars. Layout and mark off the rib locations on the trailing edge sheeting. Please note that the rib spacing is different for the inboard and outboard panels. *Remember, the outboard wing is 3/4” shorter than the inboard wing panel.*

Start threading and sliding the ribs into position on to the 3/8” jig tubing keeping the top “mark” up. Take your time! If you don’t, you could break some of the ribs sliding them into position. Keep all the ribs perpendicular and square to the trailing edge sheeting. Now, temporarily tack the 1/4" x 1-1/4” balsa leading edge in a couple of locations and the 3/32” x 1” balsa trailing edge sheeting on the bottom side in a couple of spot.

Add the 1/4” square balsa spars and temporarily tack them in a couple of location on the top and bottom. Now’s the time to check and double-check alignment and spacing of everything. Once satisfied, glue everything in place. I use thin CA for this. *Make sure not to get any glue where the ribs come in contact with the 3/8” jig tubing!* If you don’t know why, just wait until you need to slide the jig tubing out. *You did remember to polish the rods? If not,* my mama always said, *“You live and learn”!*

Install the 3/8” x 5/8” balsa trailing edge cap.

From 1/8” plywood make the (2) bellcrank spars. Notch ribs #1 & #2 on the top and bottom of the ribs to accept the bellcrank spar. Keep the top of the bellcrank spar flush with the top 1/4" balsa spar. Using medium CA and glue the bellcrank spar into location. Make sure to apply CA at every joint. I don’t like using activator on this joint as it can weaken the joint. If you don’t like using CA for this type of joint, use 15 minute epoxy.

Figure 11 - Bellcrank Spar Top and Bottom

Carefully carve and shape the leading edge to match the airfoil shape of the ribs. Remember the 3/32” leading edge sheeting attaches over the top of leading edge. Also shape the trailing edge end cap flush with the trailing edge sheeting.

Now would be a good time to make up the landing gear blocks and make sure that they fit into the notches on the bottom of the wing. Doing one block at a time, partially slide the front jig rod out of the way to make sure the blocks fits. *DO NOT glue the landing gear blocks in place at this time.*

Once the landing gear block fits, remove them and slide jig tube back into position on the jig. Take a piece of 1/16” balsa and fill in the gap of the rib where the landing gear block assembly will be install and match the shape of the airfoil for the leading edge sheeting. This balsa filler helps maintain the shape of the airfoil when the wing sheeting is applied. They will be removed when the landing gear assembly is finally installed after the wing is sheeted. Fit the landing gear block for the other panel of the wing.

Figure 12 - Temporary Fill-in Landing Gear Assembly Slot

LEADING EDGE SHEETING: Now comes the fun part of installing the 3/32" leading edge sheeting. Select several sheets of 3/32" balsa, try to find the lightest and straightest grain of the bunch. I normally start with the underside or bottom of the wing. One 4" sheet is wide enough to cover each section of the leading edge without splicing the sheet. Fit the sheeting to the back edge of the 1/4" spar. The sheeting will need to a cut at a slight angle to fit over rib #1. Cut the length of the sheet to extend pass the tip rib #10 about 1".

To allow the sheeting to bend around the leading edge, I use Windex® with ammonia. Spray both sides of the sheet. Allow a couple of minutes for the Windex® to penetrate the wood and then wipe off any excess. While still damp, tack the sheeting to the spar at a couple location with CA. Make sure that the end of the sheeting fits squarely on rib #1. When satisfied, glue the sheeting to the spar.

Once the sheeting is attached to the spar, flip the wing over on the jig. At this point, the sheeting should be very flexible and bend very easily. Wrap the sheeting around the shaped leading edge and tack it at several location. Make sure that the sheeting is in full contact with the edge of each rib. Start in the middle of the sheeting and work your way out in each direction.

Apply CA all along the sheeting of the leading edge. Next, run a bead of CA along the rib to attach the sheeting to the ribs. Again, make sure that the sheeting is in full contact with the edge of each rib.

Once dry, trim the front edge of the sheeting as needed and sand the leading edge to match the airfoil shape before installing top side sheeting.

Repeat these steps and install the sheeting on the top side. Overlap the top sheeting at the leading edge with the bottom sheeting. Once this sheeting is on the entire length of the leading edge, you will no longer be able to use the mid T-type support on the forward jig rod any longer. To provide support, I made a couple of supports out of 2" thick Styrofoam® that I had laying around and cut it to match the shape of the leading edge sheeting.

Figure 13 - 2" Thick Styrofoam® Supports

Repeat these steps and put the sheeting on for the other wing panel.

Usually I allow the leading edge sheeting is dry overnight. Trim all the leading edge sheets as needed. It's time to put the final shape on the leading edge. Because the 3/32" leading edge sheeting overlaps the carved shaped leading edge there is plenty of "meat" to form a nicely shaped "blunt" leading edge.

REMOVING THE JIG RODS FROM THE WING: It's now time to remove the jig rods from the wing. Make sure the rods rotate freely before removing. Also check that there are no glue droplets on the rods. Slide the rods out carefully. Hopefully you didn't glue any of the ribs to the rods! *You did remember to polish the rods?* Now the wing is starting to take shape.

Figure 14 - Sheeted Leading Edge (Look….The Fuselage and Tail are Magically Finished!)

INSTALL THE BELLCRANK: Once the jig tubes are removed, the 4” bellcrank with leadouts needs to be installed along with the carbon fiber pushrod.

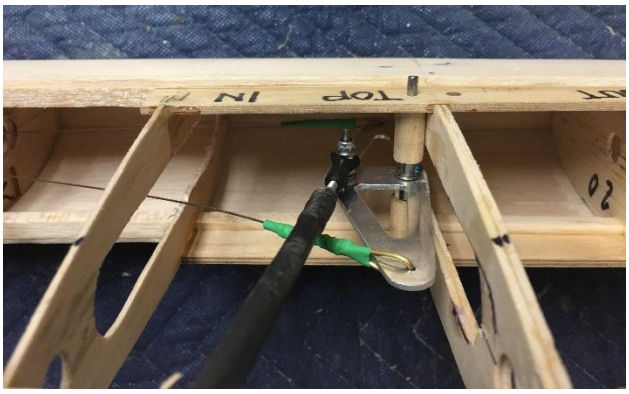


Figure 15 - Aluminum Bellcrank Installed

The cutouts in the ribs on the inboard wing panel will need to be lengthen towards the leading edge of the wing to allow the bellcrank and the forward leadout line to be installed. I used a Dremel® rotary tool equipped with a flex shaft and a sanding drum for removing the balsa and a tungsten carbide burr rotary cutter for clearing away the plywood doublers where the landing gear blocks will be mounted. Carefully remove the material in these areas.

When ready to tighten the 1/8” wheel collars above and below the bellcrank for the last time, add a dab of Locktite® Threadlocker (Blue) on the setscrew. Even though I use a 4-40 nylon locknut to secure the bolt holding the ball link, I also put a small dap of JB Weld® on top of the locknut at the end of the bolt. It lets me sleep well at night!

Once the bellcrank is installed, attach the bottom center section sheeting. I’ll leave the top center section exposed for the time being.

WING MOUNTED LANDING GEAR BLOCKS: The wing mounted landing gear blocks were done using a method that Bob Hunt detailed in the *2010 Stunt News* magazine for March/April and May/June articles entitled, *“Removable Landing Gear Plate System”*. The only modification I made was using 2-56 mounting bolts and blind nuts instead of the 4-40 bolts and blind nuts which allowed me to narrow up the entire assembly.

Cut the leading edge sheet and remove the temporary 1/16” balsa support below the sheeting very carefully to install the landing gear blocks. I’ll use 15-minute epoxy to attach the platform to the ribs and spar. Add the 1/8” balsa edging and make the land gear covers.

The land gear cover is made with 1/16” plywood as the base plate with a balsa filler glued to the plywood base. Short lengths of some very thin wall aluminum tubing is used to protect the edges of the holes for the 2-56 bolts.

A notch in the end of the cover is needed to clear the vertical landing gear wire. Cut the notch after you bend up the landing gear wires. Sand the cover and edging to match the shape of the leading edge sheeting.

Figure 16 - Land Gear Plate

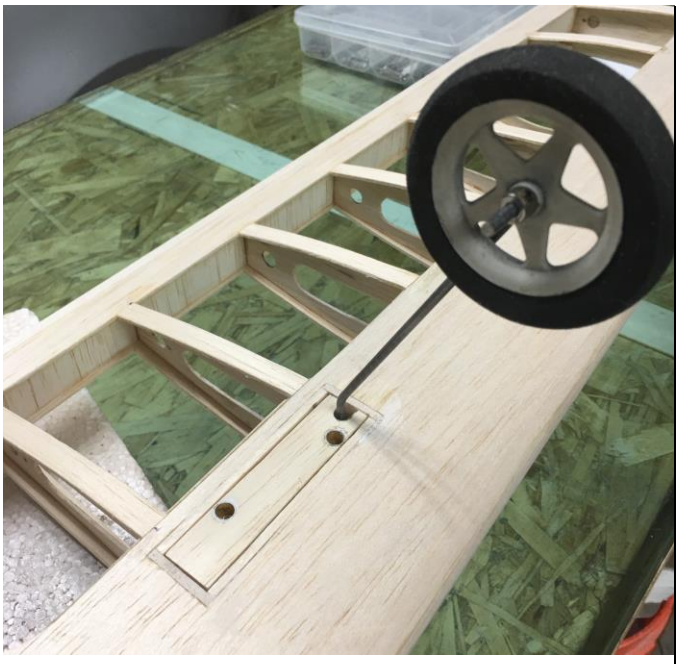


Figure 17 – Finished Land Gear Cover

WINGTIP WEIGHT BOX: This is just a simple box made of 1/8” lite plywood with 1/8” balsa edging. The cover has a 1/16” plywood base with balsa filler for the cover. The cover is held on with a recessed 4-40 x 1-1/2” long socket head bolt and blind nut. The recessed hole in the cover has a short length of aluminum tubing to protect the edge of the hole.

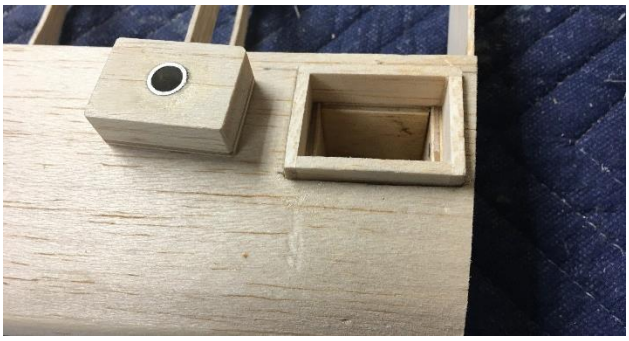


Figure 18 - Weight Box Prior to Sanding

Figure 19 - Finished Weight Box

ADJUSTABLE LEADOUT GUIDE: There are several “things” that are done in *“Turning to the Dark Side”* that I needed to allow for, yet not fully knowing what to expect – part of that large learning curve thing. The adjustable leadout guide is an example of that.

In talking with several of the top electric flyers, they are discovering that the leadout location for electric planes is considerably different when compared to the IC equivalent. Electric models tend to have their leadout position further aft of the center of gravity.

So the design of the adjustable leadout guide is a bit longer than normal to accommodate this movement. This gives a wide range of adjustability when deciding were the final leadout location needs to be.

The main part of the leadout guide is made from 1/16” plywood with a slot. At the recommendation of Paul Walker, each leadout is independently adjustable from one another.

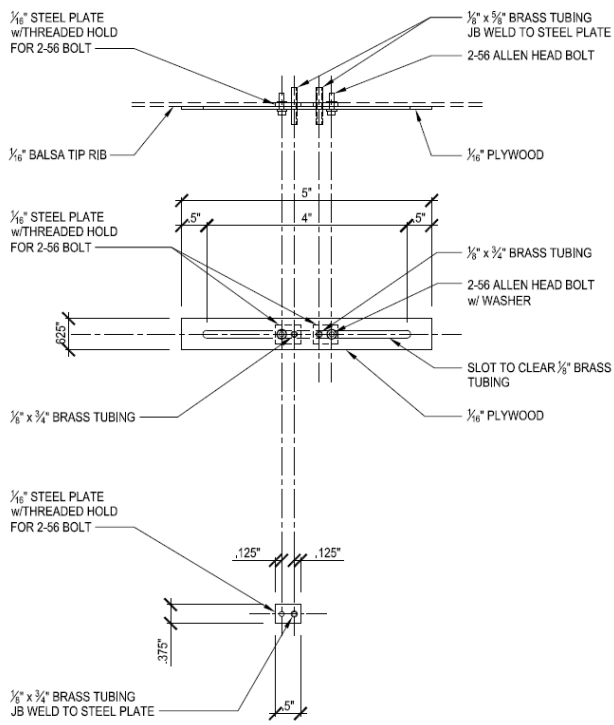


Figure 20 – Adjustable Leadout Guide

I cut two pieces of 1/16” thick x 3/8” wide x 1/2” long mild steel and drill a hole that will accept a 3/4" length of 1/8” brass tubing that will be epoxied to the steel with JB Weld®. Another hole is drilled and tapped for a 2-56 Allen head bolt and washer. This allows the leadout to be separated to within a 1/4" if so desired.

BEWARE: Because of the closeness of each leadout, the ends of the leadouts will need to be staggered so the line clips do not snag on one another.

Figure 21 - Finished Leadout Guide

Figure 22 – Installed Adjustable Leadout Guide

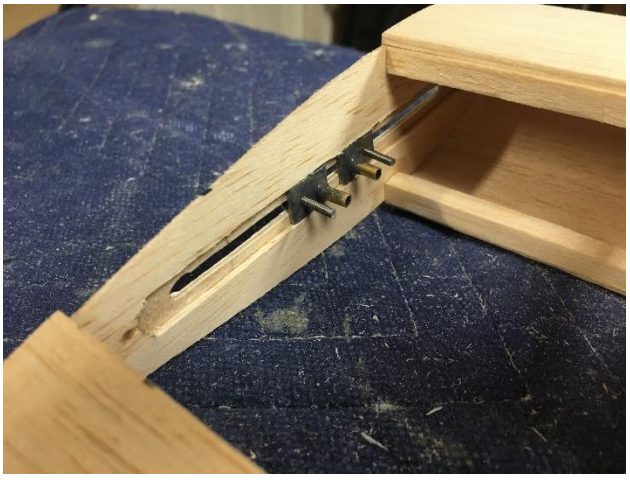


Figure 23 - Backside of Installed Leadout Guide

SHEAR WEBBING: Full height shear webbing made of 1/32” vertical grain balsa is installed in all bays of the trailing edge between each rib and between the spars and the ribs. However, the two center bays and the last four bays of the inboard wing will not get any shear webbing between the spars as these will interfere with the bellcrank and the forward leadout wire.

Before installing the shear webbing for the trailing edge, now would be a good time to cut the slots for the nylon hinges in the trailing edge cap as needed.

Figure 24 - Shear Webbing at Trailing Edge

Figure 25 - Shear Webbing Between the Spars

Figure 26 - No Shear Webbing at Last 4 Bays of Inboard Wing

WINGTIPS: The wingtips are very simple and straight forward. They are made from 1/2” thick balsa and squared off to match the shape of the airfoil. Then round off the outside edges of the wingtip.

The inboard wingtip requires a slot for the leadouts. I used 1/4” balsa core with 1/2" thick balsa on the top and bottom. I make the slot about 1/4” longer than the slot in the adjustable leadout guide slot on each end. To protect the leadout slot, I’ll use 1/64” plywood to line the leadout opening. Make sure that the adjustable leadout guide still slides smoothly.

I added a cap strip on the top and bottom next to the wingtip and roughly carve the shape of the wingtip.

Figure 27 –Carved Inboard Wingtip with Opening for Leadouts

CENTER SECTION & CAP STRIPS: Install the 3/32” center section sheeting. Don’t forget the flap pushrod and/or the opening!

Cut 5 lengths of 3/32” x 3/8” balsa strips for the cap strips. The cap strips are wider because of the wider than normal rib spacing.

Figure 28 - Center Section Sheeting and Cap Strips

Install the cap strips flush with the leading and trailing edge sheeting. They should be perpendicular to the trailing edge sheeting. When done use a long sanding block and sand all the cap strips flush.

CONTROL HORN DRIVERS: Four control horn drivers are required for the 1/8 control horn

wire, two for the flaps and two for the elevators. These are made by sandwiching a piece of 5/32” brass tubing between two pieces of 1/16” plywood on the top and bottom.

Take a piece of 1/16” plywood and cut two strips of plywood that are 3/8” x 6” long. Cut a length of 5/32” brass tubing 6” long. Rough up the outside of the brass tubing with sandpaper. Take one of the plywood strips and glue the brass tubing straight down the middle of the plywood strip with CA.

Then take a 6” length of 1/8” balsa about a 1/2" wide and laminate a matching size of 1/32” balsa. This balsa needs to match the thickness of the 5/32” brass tubing. CA the balsa along each side of the brass tubing. Once dry, trim the excess balsa along the edge of the plywood and glue the other length of 1/16” plywood on top. Basically what you have made is a 6” long horn driver.

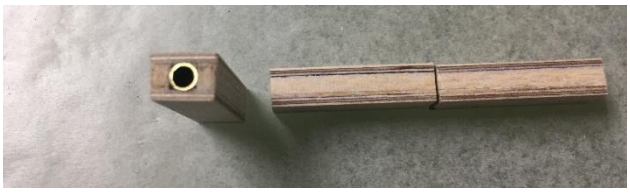


Figure 29 - Control Horn Drivers Cut to Length

Now all that is left to do is to cut the horn drivers to length to match the length of the control horn wire and notch the end of the driver to allow the bent control wire to fit.

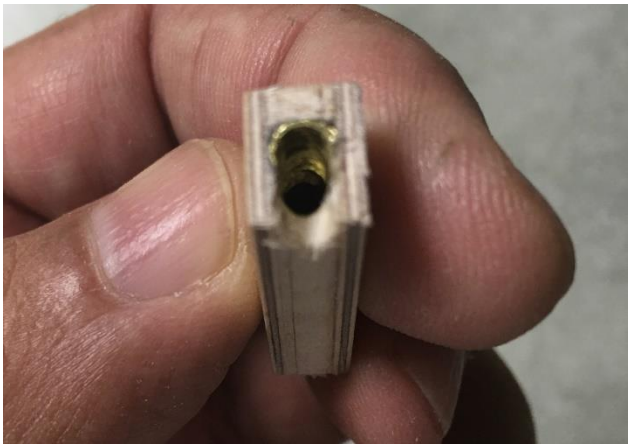


Figure 30 - Notch for Control Horn Wire

The horn driver assemblies are centered with the thickness of the flaps/elevators. For the flaps, the top and bottom of the horn drivers will be sanded flush with the flap. For the elevators, fill in the recessed area with balsa and sanded flush with the core.

FLAPS: The flaps are made from 1/4" thick straight grain balsa and are very simple. There is no tapering of the thickness of the flaps and the trailing edge of the flap is left square.

Cut a notch in the flaps to receive the control horn drivers and fit the flaps for the control horn assembly. Small notches in the trailing edge of the wing will be required to clear the control horn.

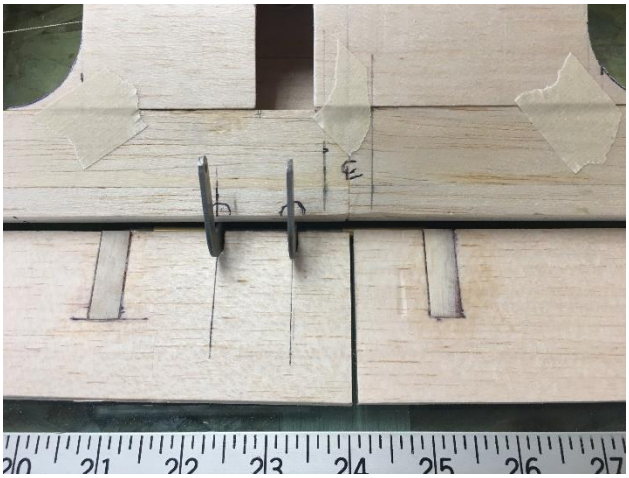


Figure 31 - Installation of Control Horn and Control Horn Drivers for Flaps

Once the control horn is fitted to the flaps, trim the ends of the flaps as needed to clear the profile fuselage.

Cut the slots in the flaps for the nylon hinges. Make sure that the slots are aligned with the slots in the trailing edge hinge cap. Temporarily install the nylon hinges for fitting the flaps to the wing. Remember the nylon hinges will be modified by removing the hinge pins and installing a continuous piano wire hinge after the model is painted.

Figure 32 - Fitting of the Flap Horn (Note the notch in the flap to clear the WFAD)

Once satisfied with the how the flaps fit, bevel the entire leading edge of the flaps at a 30 degrees on each side to clear the trailing edge cap as the flap pivot up or down and check the fit again.

Lastly, once everything fits to your liking and is sanded to shape, coat the entire flap with Z-poxy® Finish Resin. This does two things, (1) seals the wood and (2) adds a little strength to the flaps.

To get the very thinnest layer of epoxy, brush on the epoxy all over the surface and spread it around using a plastic spreader and a little heat from a heat gun. Allow the epoxy to soak into the wood for about 5 minutes or so.

Afterwards, take the heat gun and the plastic spreader and scrape off any excess epoxy. Then with paper towels wipe off all the remaining epoxy. Continue apply heat and wiping off as much of the epoxy as you can.

Now, a little more sanding, a little more shaping, a little more fixing of all the dents and dings and – *Voila!* .... The wing should be ready to install.

Figure 33 – The Finished Wing with Flaps Ready for Installation

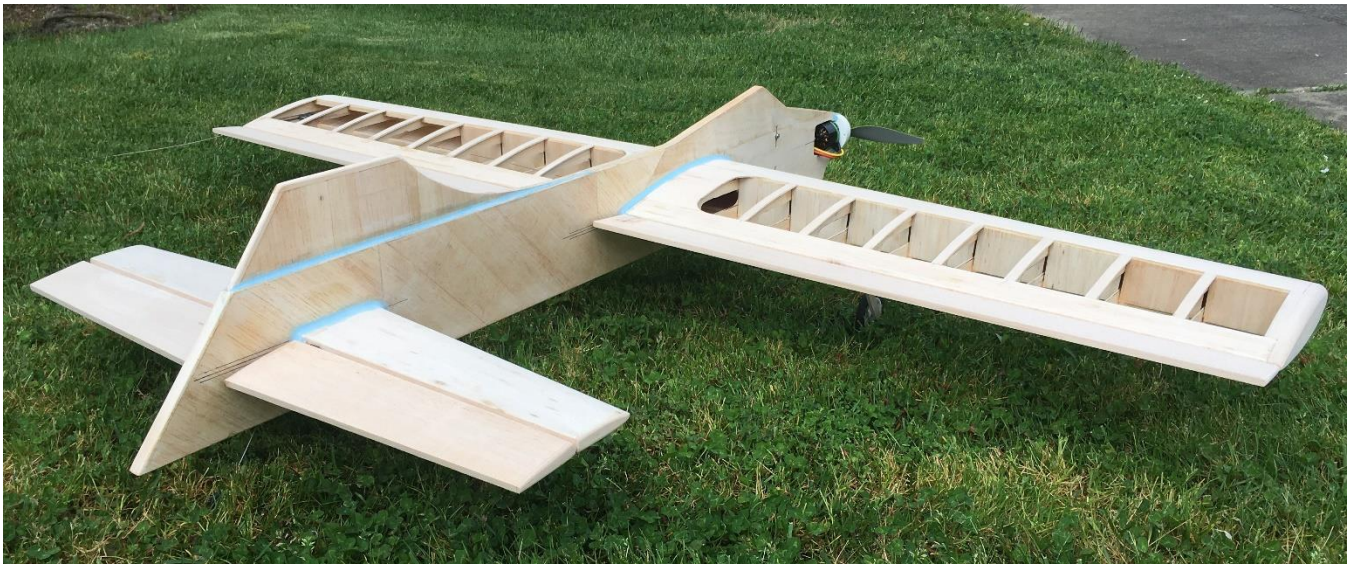
As always, if you have any questions, comments or feedback please send an email to: circulas46iie.2020@gmail.com. I will try to respond as soon as I can.

The adventure continues… Next, on to the Fuselage and Tail Construction!

Turning to the Dark Side

The Building of Circulas 46 IIe

Part 3 – Fuselage & Tail Construction



A Precision Aerobatic Control Line Model Airplane

– Electric Profile –

Written by Dennis S. Nunes

April 2020

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FUSELAGE & TAIL CONSTRUCTION:

The adventure of *"Turning to the Dark Side"* now takes on the building of the fuselage and the tail, this includes the stabilizer, elevators and rudder. The built–up profile fuselage for *Circulas 46 IIe* requires a little more work than just using a solid 1/2" plank. However, it is relatively simple in construction and very strong.

The nose of this fuselage for electric power is constructed very differently than the IC counterpart. The use of the 3D motor mount available through Okie Model Air Products makes for a very clean and simple installation for mounting the motor and the makes the construction of the fuselage even easier. Surprisingly, this construction method makes for a very strong yet light fuselage. When built on a flat surface the fuselage should come out straight!

BUILDING THE FUSELAGE

FUSELAGE CORE: Cutout all the necessary parts to assemble the fuselage. This would include the lite plywood battery mount and the tail wheel assembly.

If you only have access to 36” long balsa sheets, cut (5) 1/4" x 1/2" wide x 36” long balsa strips that will be used to make the laminated balsa rails. One of the strips will be used to splice a 9” long piece at the end of each strip to get the 45” length. Save the leftover balsa strip. If you have access to 48” length balsa no splicing is required.

The 1/2" wide carbon fiber strip is from “Dave Brown Products, Inc.” that can be ordered directly through Ohio Superstar Products.

Figure 1 – 1/2" Wide Carbon Fiber Strip from Ohio Superstar Products

The carbon fiber strip is actually about 5/8” wide by 66” long and is only about .007”–.008” thick. The excess width will get trimmed as the final step.

Place some wax paper on a flat work surface and a straightedge on top of the wax paper. Lay the 1/2” balsa strips on edge against the straight edge and stagger the splice joints at opposite ends of each other. Slip the carbon fiber strip in between the two balsa strips.

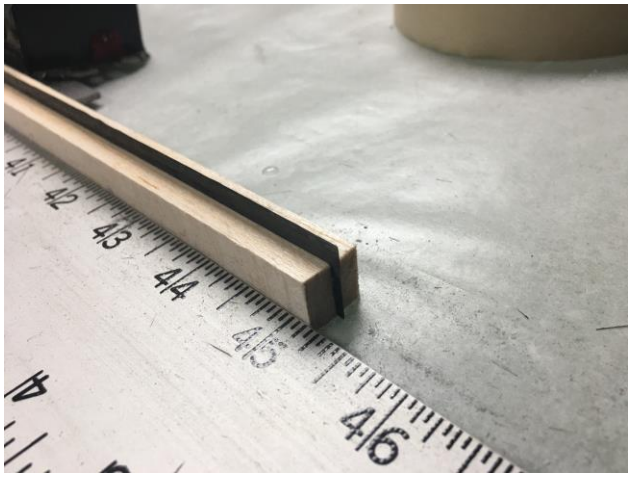

Figure 2 – Laminated Rails with Carbon Fiber Strip

Tack glue the carbon fiber strip to the balsa strips in several places with thin CA. Make sure everything is straight as an arrow. Once straight, run a heavy bead of thin CA down both side of the carbon fiber strip and allow the CA to penetrate to the opposite side of the balsa strips.

When dry, bend the excess strip over the edge the balsa and trim with a knife if required. Sand the “rails” smooth.

Caution – Beware of any carbon fiber slivers and any dust that may be generated by sanding.

Figure 3 – Finished Laminated Rail

It’s incredible just how much strength is added by laminating these balsa strips with the carbon fiber material and how light they turned out!

Turning to the Dark Side

Part 3 – Fuselage & Tail Construction

The main core of the fuselage is made up by laminating (2) 1/4" x 4” x 22” long balsa sheets together. This core starts at the nose of the fuselage and extends about 2” past the trailing edge of the wing. Use 30–minute epoxy to laminate the 1/4" balsa cores together.

Make up the battery mount. The battery mount is made of 1/8” x 1/2" wide lite plywood strips and spacers and is assembled with CA. Cut the main core in two as shown on the plans and install the plywood battery mount to the core. Use either 30–minute epoxy or thick CA to install the battery mount.

When cured or dried, cut the notch to accept the 3D motor mount and the wing opening. There are also four cutouts, two on each side of the battery mount that need to be made. These are just to remove some excess material and to lighten the main core.

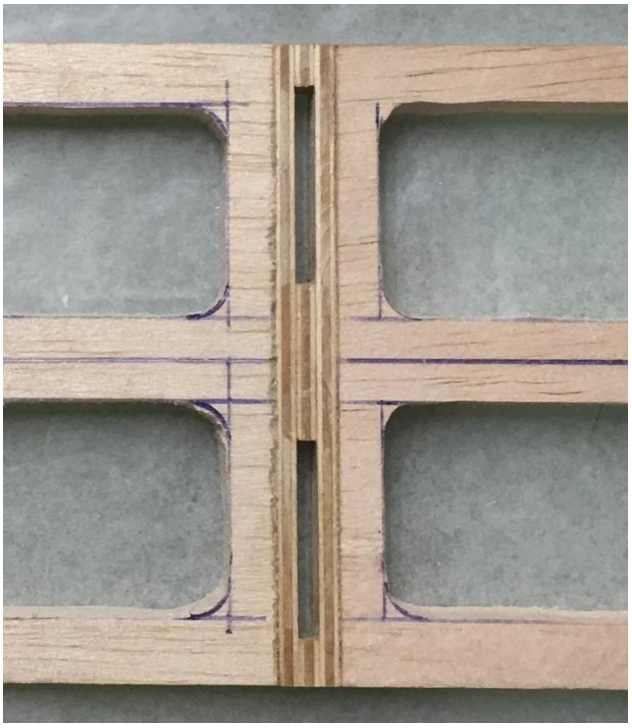

Figure 4 – Battery Mount

Attach the laminated balsa rails to the top and bottom of the fuselage core using 30–minute epoxy.

Figure 5 – Fuselage Core, Rails, Battery Mount and 3D Motor Mount

With a leftover piece of 1/4” x 1/2" balsa strip (you did save the leftover balsa strip?), glue the vertical and horizontal pieces that outline the edges of the stabilizer into place. Add the 3/32” x 1/2" vertical balsa support at 2” on center between the end of the main laminated core and the vertical support for the leading edge of the stabilizer.

Add the 3/32” x 1/2" diagonal balsa stiffeners between the top and bottom laminated rails along with the 1/4"x 1/2" tail post and trim the end of the laminated balsa rails to length.

A portion of the bottom rail need to be removed to install the removable tail wheel assembly into place.

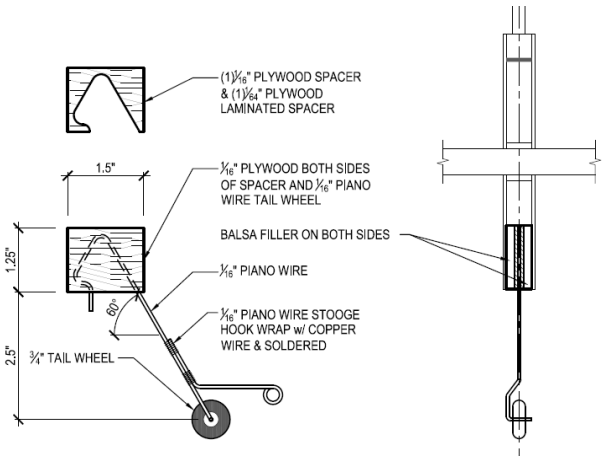

Figure 6 – Tail Wheel Assembly

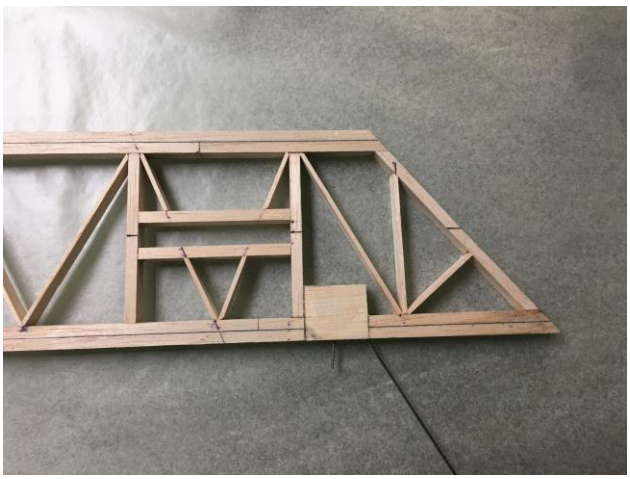

Figure 7 – Adding Vertical and Horizontal Supports and the Removable Tail Wheel Assembly

Add a piece of 1/2” thick balsa for the canopy to the top of the fuselage core.

Figure 8 – Adding Canopy to Fuselage Core

Prior to installing the 3D motor mount, I enlarged and deepened the indentations around the perimeter of the mount by using a 1/8” drill bit. I wanted to make sure when I epoxied the unit into place that it was going to stay. Probably an overkill, but I wanted to sleep good at night.

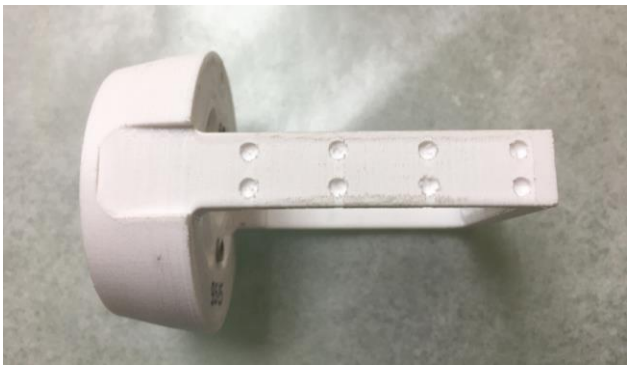

Figure 9 – Enlarged Indentations in 3D Motor Mount

Sand the entire fuselage core nice and flat on both sides.

FUSELAGE DOUBLERS AND SHEETING: At the time when I ordered the 1/16” plywood, I normally order a 12” x 48” size sheet. However that size was not available at the time. All I could get was 4” x 36” plywood strips. In order to accommodate the 7” height of the fuselage (top of canopy to the bottom of the fuselage) I had to splice the plywood sheets together. This was done using thin CA, when dry, sand the joint smooth.

Trace the outline of the fuselage core on to the 1/16” plywood by laying the fuselage core against the plywood doublers, then cut to shape. Attach one of the 1/16” plywood doubler on one side of the fuselage with 30–minute epoxy. When cured, cut out the two vertical slots for the battery holder.

Attach the other 1/16” plywood doubler for the other side. Again, when cured, cut out for the two vertical slots.

Cut out the 3/8” x 1” horizontal slot below the leading edge of the wing. This slot is needed to allow the XT–60 battery connector to pass through to the other side of the fuselage and connect to the ESC.

Figure 10 – Fuselage with Plywood Doublers

To finish off the fuselage, add the 1/16” balsa sheeting at 45 degree angle from the end of the 1/16” plywood doublers to end of the fuselage on both sides of the fuselage.

Figure 11 – Finished Installation of 3D Motor Mount

Don't forget to cut out the sheeting for the stabilizer and don't forget to add the 1/8" x 5/8" balsa end cap at the rear of the fuselage.

Once complete, I added a bead of thin CA along the outside edge of the 1/16" diagonal balsa sheeting and the edge of the laminated rails to harden up the balsa edge.

ESC HOLDER: The ESC holder is made from a piece of 1/8" lite plywood. The holder is mounted on the outboard side of the fuselage. The 4–40 bolts holding the battery holder (on the inboard side) are also used to hold the ESC holder.

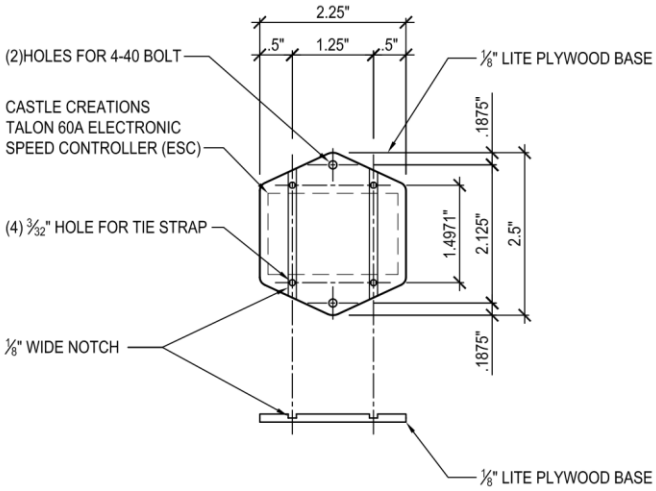

Figure 12 – ESC Holder
(Viewed from the Back Side)

On the back side of the ESC holder there is two vertical 1/8" wide notches. These slots allow the ESC holder to lay flat against the fuselage when the nylon cable ties are threaded into the 3/32" holes and slide between the fuselage and the holder to keep the ESC it in place. These notches were cut using a table saw.

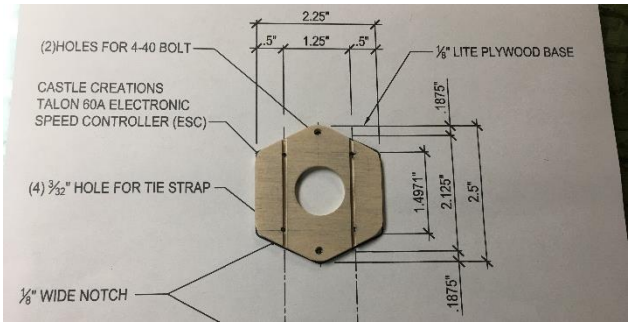

Figure 13 – Backside of ESC Holder

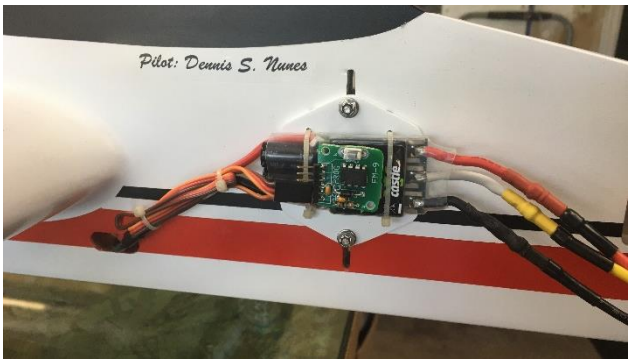

Figure 14 – Installed ESC Holder

BATTERY HOLDER: With the battery being the single heaviest piece of equipment on the plane, this can have an effect on both the vertical and horizontal CG of the plane. In *"Turning to the Dark Side"* the entire battery mounting assembly is designed to allow for the vertical and horizontal movement of battery so that the vertical and horizontal CG can be adjusted as needed. Is this necessary or needed? I don't know – another one of those learning things.

The battery holder is also designed to allow for easy changing of the battery by using 2 narrow Velcro straps to keep the battery in place. The battery holder assembly is made up of two components, the battery mount which was

shown and installed earlier, and the battery holder.

The battery holder is made from 1/8” lite plywood with strips of 1/8” x 3/8” lite plywood around the perimeter attached to the backside. The slots for the 4–40 bolts allow the battery to be adjusted fore or aft to change the CG. The battery holder uses two Velcro® straps to hold the battery in place along with a 4” strip of 5/8" wide Scotch™ 3M™ SJ4570 Dual Lock Low Profile Adhesive Fastener that attaches to the holder and another strip is placed on each battery. This fastener prevents the battery from sliding back and forth on the holder.

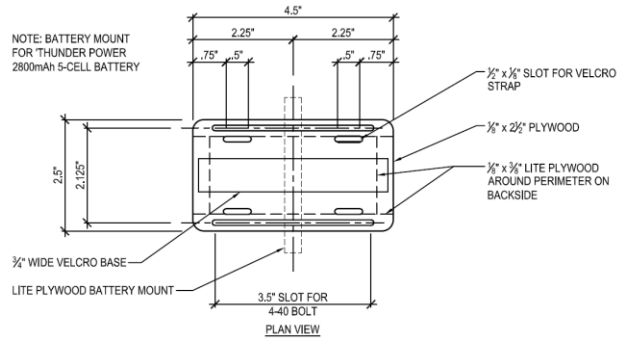

Figure 15 – Battery Holder

Figure 16 – Finished Battery Holder

MAKING THE RUDDER: The rudder is real simple and is made of 1/4” balsa sheets that is spliced together and capped with 1/4" square balsa. Though the rudder is only 3” tall, its length is roughly 18–1/2” long. Glue all the pieces together on a flat surface and sand all the splice joints smooth. Attach the rudder to the fuselage with CA.

To some this may seem strange, but none of the *Circulas* series planes use any rudder offset. I haven’t found a need for it —— yet.

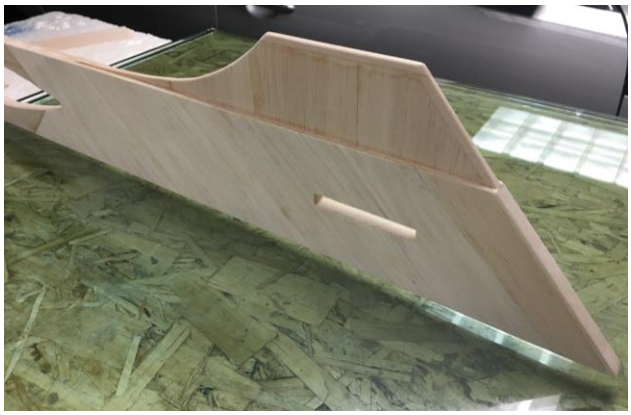

Figure 17 – Finish Rudder Installed

SEALING THE FUSELAGE: Once the rudder is attached, apply an extremely thin layer of Z–Poxy® Finishing Resin to the entire fuselage assembly. I like doing this “before” assembling the plane together as it easy to sand with everything out of the way. This not only seals the wood but adds a little strength to the fuselage.

To get the very thinnest layer of Z–Poxy®, brush on the Z–Poxy® all over the surface and spread it around using a plastic spreader and a little heat from a heat gun. Allow the Z–Poxy® to soak into the wood, especially the raw balsa for about 5 minutes or so. Afterwards, take the heat gun and the plastic spreader and scrape off any excess Z–Poxy®. Then with paper towels wipe off all the remaining Z–Poxy®. Continue apply heat and wiping off as much of the Z–Poxy® as you can.

Remember Z–Poxy® is heavy so all you want is enough remaining to “seal” the raw wood. After the Z–Poxy® cures, lightly sand everything smooth.

BUILDING THE TAIL

MAKING THE CORES: Cut 3/8” square balsa strips for the core frame and the 1/16” x 3/8” balsa strips for the ribs. From 3/8” balsa sheets cut the center sections for the stabilizer and the elevators. Using CA, glue the assembly together. You will notice that the elevators are built as a single unit that will get cut apart just prior to apply the 1/16” balsa sheeting.

After gluing the assemblies together, I draw a centerline on the outside edge of the leading and trailing edges of the stabilizer and elevators. DO NOT sand to shape – yet!

Figure 18 – Stabilizer and Elevators

It’s at this point that I prefer to locate and cut the slots for the nylon hinges. I cut the slots using a drill press and an abrasive cutting wheel. *Do not glue the nylon hinges into place at this time.* The nylon hinges will be installed with a continuous piano wire hinge “after” the plane is painted.

Figure 19 – Cutting Hinge Slots with a Drill Press

CONTROL HORN DRIVERS: See *Part 2 Wing Construction* for the making of the control horn drivers. Remember that the control horn drivers are “centered” in the elevator core. This will leave a recessed areas on the top and bottom of the elevators. Fill these areas in with balsa and sanded smooth.

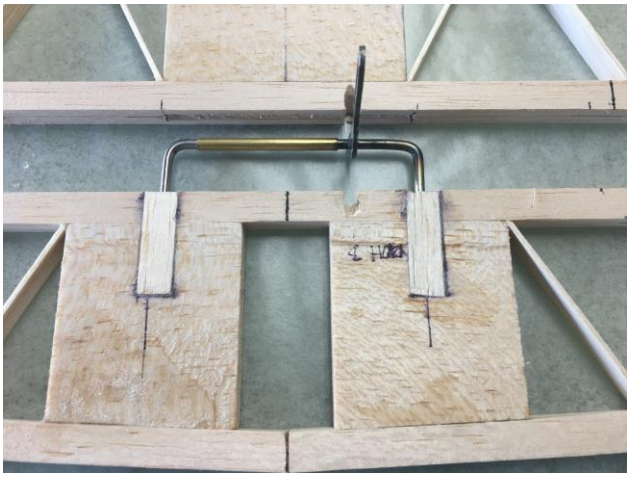

Figure 20 – Elevator Control Horn and Horn Drivers

Now, sand the stabilizer and elevator cores to shape as shown on the plans. In shaping the leading edge of the stabilizer, it is not rounded over but has a very sharp leading edge as shown below. Please note that the dimensions shown below are “after” the 1/16” balsa sheeting is installed.

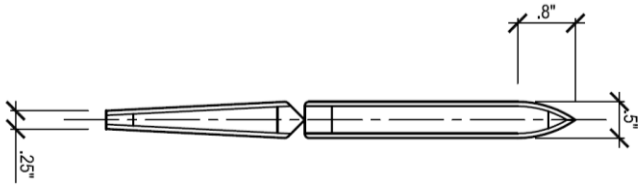

Figure 21 – Shape of Stabilizer and Elevators

SHEETING THE CORES: Next, cut the elevators apart and trim to length. Sheet both sides of the stabilizer and the elevators with 1/16” balsa sheets. Sand the ends flush and add the 1/8” balsa end caps. I also add 1/64” plywood edging on the end of the elevators nearest the fuselage. Sand to their final shape.

At this point I would normally Z–Poxy® the stabilizer and elevators the same way as the fuselage. For *Circulas 46 IIe* I decided to forgo the Z–Poxy® and try a dope only finish.

Figure 22 – Finished Stabilizer and Elevators

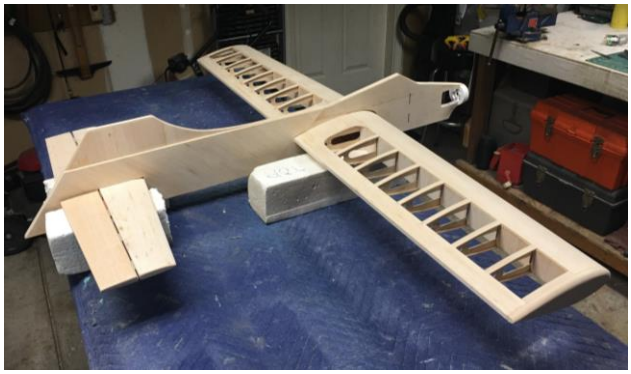

Figure 23 – Starting to Fit the Pieces Together

There you have it, one fuselage with rudder, a stabilizer and elevators ready for installation!

If you have any questions, comments or feedback please send an email to: circulas46iie.2020@gmail.com. I will try to respond back to you as soon as I can.

The adventure continues… Next up – the Control System!

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Turning to the Dark Side

The Building of Circulas 46 IIe

Part 4 – Control System

A Precision Aerobatic Control Line Model Airplane

– Electric Profile –

Written by Dennis S. Nunes

April 2020

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CONTROLS:

As mentioned in *"Turning to the Dark Side Part 1 – Introduction"*, I enjoy making my own bellcranks and control horns. It's not that difficult to do and can be accomplish with ordinary hand tools. A few power tools does make the task a little easier. For those who may be hesitant about making your own control assemblies, Okie Air Products has the necessary parts you will need, except without the WFAD (Walker Flap Adjusting Device).

Note: No matter if you make your own controls or buy them, when the controls are finally installed, they should operate very smoothly. This is especially important with electric powered models.

BELLCRANK: The 4" suspended bellcrank for *Circulas 46IIe* is made from a piece of 0.063" 2024-T3 aluminum and is quite simple. The 4" bellcrank is my first attempt at using a "reverse" style bellcrank. I still wanted to maintain the offset pivot rod. So we have kind of a unique shape to this bellcrank. A hole is drilled in the bellcrank for a 5/32" brass bushing for the 1/8" pivot rod

The 0.027 leadout wires are bushed with a 1-1/2" long length 1/16" brass tubing bent into a U-shape and then wrapped with 28 ga. copper wire. A piece of heat shrink tubing is installed over the brass tubing and copper wrapping.

I cut the aluminum using a variable speed scroll saw equipped with a 32 TPI blade. Again, a coping saw with the same blade will work just

as well. Drill the various size holes needed and afterwards clean thing up with a file(s).

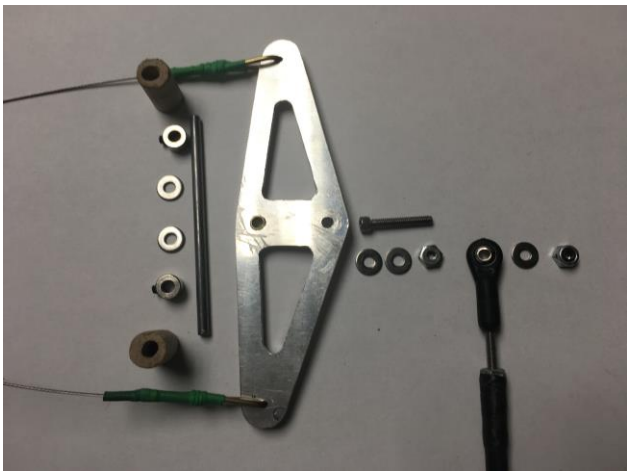

Figure 1 - Bellcrank and All Hardware

For the bellcrank mounting, two 1/8” lite plywood bellcrank spar are attached to the ribs and flush with the top of 1/4" balsa spar, one of the top and the other on the bottom spar.

Figure 2 - 1/8" Plywood Bellcrank Spars

A 1/8” piano wire pivot rod is used along with two 1/8” wheel collars and #4 washers placed above and below the suspended aluminum bellcrank. When installing the bellcrank for the final time, once the pivot rod is in place, put a drop of oil on the pivot rod bushing. Also, I use a drop of “Permatex® High Strength Threadlocker Blue” on the setscrew of the wheel collars.

The space between the top of the wheel collar and the bottom of the 1/8” plywood bellcrank spar is filled with a length of 3/8” hardwood dowel with a 5/32” hole the length of the dowel. Keep the 1/8” pivot rod longer than the thickness of the wing and allow it to extend through the 3/32” balsa wing sheeting. I will trim the 1/8” pivot rod flush with the wing sheeting when complete. Make a small cut out in the wing sheeting around the pivot rod and put a dab of 5 minute epoxy on the top and bottom to keep the pivot rod firmly in place.

BALL LINKS (BEWARE): In the past I’ve used Rocket City 4-40 ball links on the bellcrank and pushrods with no problems. Sadly these ball links are no longer available. I have switched to using the Dubro® heavy-duty 4-40 ball links and I’ve had issues with these ball links “seizing” after some time for no apparent reason.

Just make sure if you use a Dubro® ball link that the metal ball in the plastic housing is completely loose and rotates freely. *If the metal ball binds anywhere --- DO NOT use it!* I’ve purchase a pack of 12 Dubro® ball links and half of them did not rotate freely, some didn’t rotate at all! Avoid the thinking that the ball joint will free itself up after some use. More than likely that ball link will become worst rather than better.

Sadly, in one of my full fuselage stunt ships, after a month of flying, the controls started to become sloppy. When ball links are installed properly there shouldn’t be any “slop” in the controls. Well my controls had become loose. Peering down the leadout slot, we could see the pivot screw, holding the ball link to bellcrank moving back and forth when the leadout wires were held in place and when we moved the flaps manually. We cut into the fuselage and wing to tighten the pivot screw, only to find out that after tighten the screw the controls locked up. This lead to replacing all four ball links because for whatever reason the metal ball had tighten up in the plastic housing in all of them

and the ball link installed at the bellcrank had seized up completely loosening the pivot bolt!

The nice advantage of profiles are that the pushrods to the flap control horn and the elevators control horn are exposed. So, you may decide to use a 3/32" piano wire connection at the bellcrank connection instead of a ball link. Now, as part of my pre-flight inspection routine before a flying session, I always check the ball link connections.

I use a 4-40 socket head bolts on all my ball link connections. At the bellcrank connection I will use a standard nut and washers to secure the pivot bolt to the bellcrank. The standard nut becomes a "standoff" for the ball joint and I get this nut as tight as I possibly can. I place the ball link over the bolt, add a #4 washer and another standard nut *temporarily*. *DO NOT overtighten this nut!*

During construction of the wing I'm always installing and removing the control system many times. On the "final" assembly I always replace the standard nut with a brand new 4-40 nylon locknut. If for some reason I need to remove the nylon locknut I always replace it with a new one. I never reuse a nylon locknut.

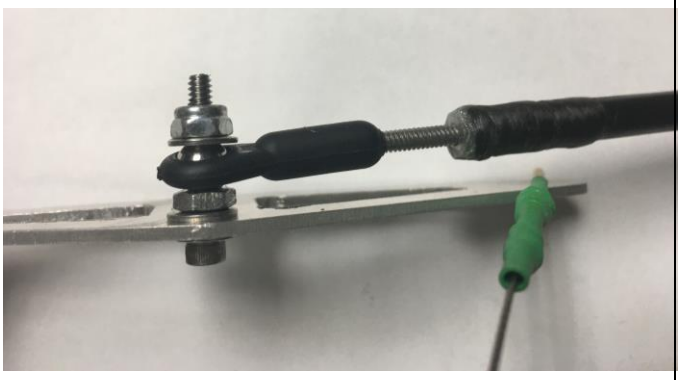

Figure 3 – Final Ball Link Assembly

Lastly, *do not overtighten the locknut that attaches the ball link to the bellcrank or control horn*.

As a safety precaution for a concealed installations, I'll use a dab of JB Weld® on the end of the nylon locknut and bolt.

There is an excellent article written by Paul Walker that discusses his issue with ball links and what he now uses for the pushrod connection at the elevator control horn. This article can be found on the *Flying Lines – News of the Northwest Control Line Model Aviation* website entitled Ball Links.

CONTROL HORNS: My control horns employ 1/8" diameter wire. It is *NOT* piano wire. Piano wire is too brittle and tends to crack on a tight radius bend. I use 1/8" air harden drill rod available through Zoro.com or McMaster-Carr.

The arms of the control horn are "offset" because of the profile fuselage. They are made from 0.063" x 2" wide piece of 4130 mild steel available from Aircraft Spruce in 36" or 72" lengths.

Attaching the steel control arms to the 1/8" air harden drill rod is done by using Alpha Fry 3/16 oz. Lead-Free Specialty Brazing Kit available from Ace Hardware. Do not use Sta-Brite® silver solder as there is not enough silver content in the solder for a strong joint.

Though the brazing can be done with a propane torch, I've had better results using a small Bernzomatic Torch Kit that I purchased several years ago at Home Depot. This system uses the small MAP and Oxygen bottles also available at Home Depot or Lowes.

Only basic hand tools are needed to build your own control horns. A hacksaw with a 32 TPI blade, drill various drill bits, tungsten carbide cutter rotary burr set for a Dremel rotary tool and various metal files. I also have a 1" x 30" belt sander with an 80 grit belt that I use to grind some of the metal away. Though not necessary as the same thing can be accomplished with set of proper metal files, the belt sander makes things a little easier.

Figure 4 - Tools Required

Figure 5 - Various Metal Files Used

Figure 6 - 1" x 30" Belt Sander (Optional)

Create a full size paper template of the steel arms. I happen to be well versed in using AutoCAD and able to make several copies and print them to a sheet of paper. I'll usually make several horns at the same time.

Attach the paper template to a piece of 1/16" mild steel. I use 3M Super 77 Multipurpose Adhesive spray for this available at Home Depot or Lowes.

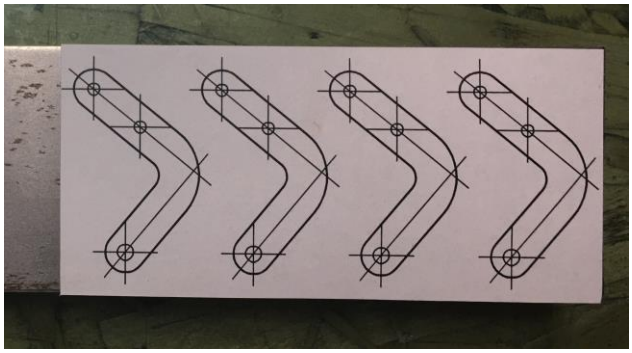

Figure 7 – Attach Paper Template to Steel

Next, using a center punch, mark the center of each hole

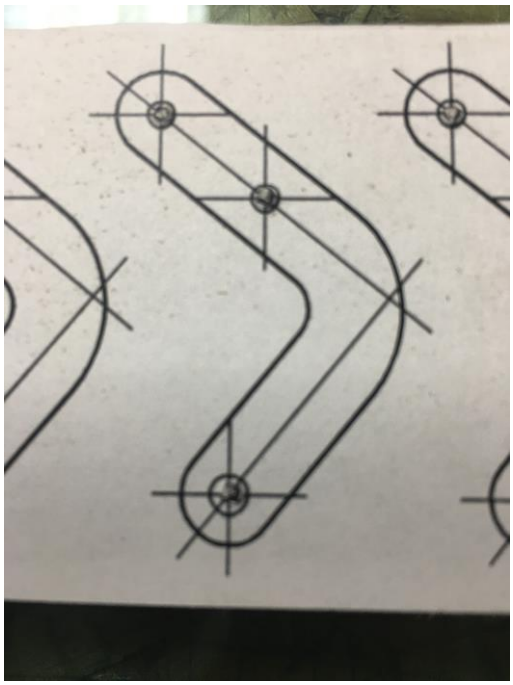

Figure 8 - Center Punch Holes to be Drilled

TIP: Before doing any further work, I soak the paper attached to the steel with CA glue. As you start drilling and cutting the steel, the steel

can get very hot and loosens the 3M adhesive allowing the paper template to shift. The CA glue helps to keep the paper template attached to the steel a little longer that just the 3M adhesive alone.

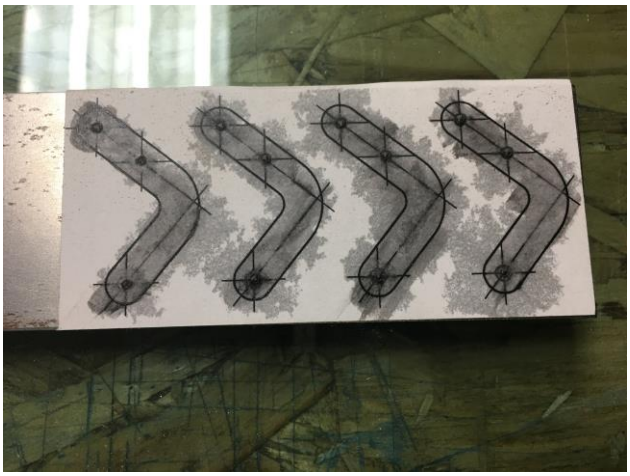

Figure 9 - Template Soaked with CA Glue

Drill all the various size holes needed for your installation.

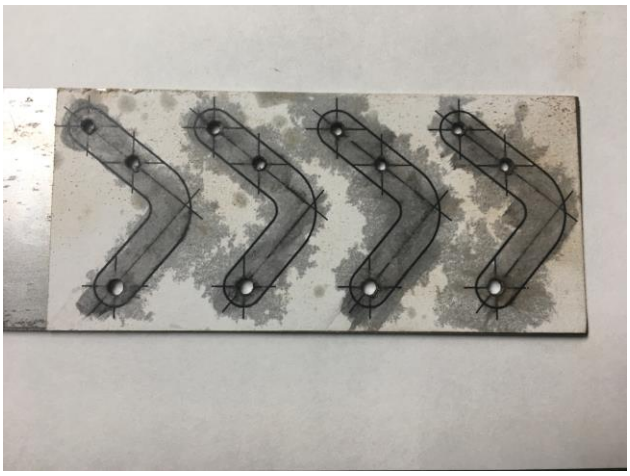

Figure 10 - All Holes Drilled

With a hacksaw equip with a 32 TPI blade cut out the individual parts. The closer you can get to the line the less filing/grinding you will need to do.

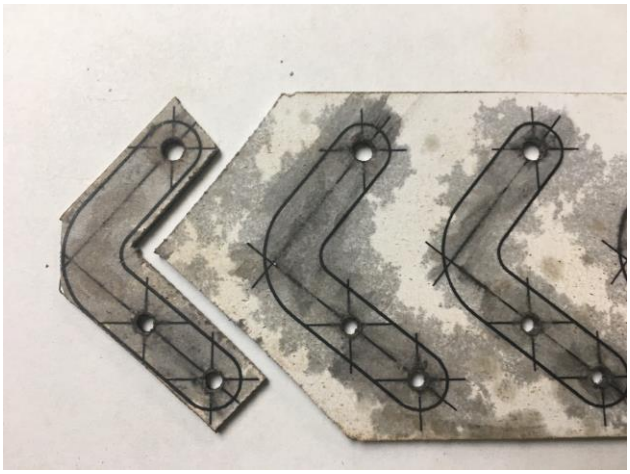

Figure 11 - Rough Cut with Hacksaw

The final trimming and cleanup is done with files (and/or 1” sanding belt).

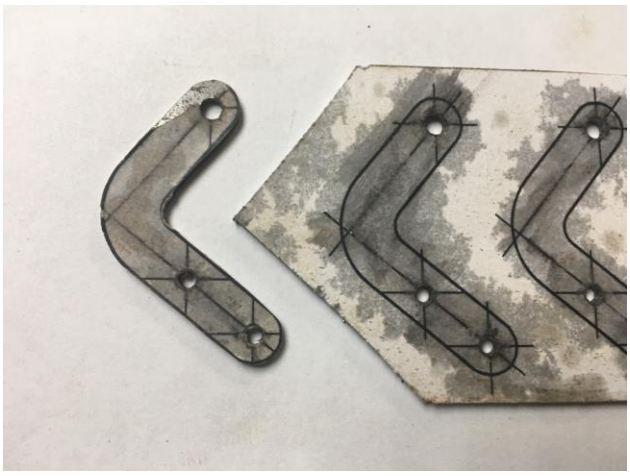

Figure 12 – Filed/Ground to Final Shape

Ease all the edges with a file and cleanup the control arm. It should be free from all adhesive, rust and oil. I use some 320 grit sandpaper or emery cloth to clean off the control arm. Use lacquer thinner or acetone to remove all oil. Avoid touching around the holes for the control wire as oil from your finger can make it difficult to properly braze the parts together.

Figure 13 - Finished Control Arm

I made a very simple holding jig out of some steel strap and plate to hold the control arm and drill rod in place to allow me to do the silver brazing.

Figure 14 – Holding Jig
(Photo from VCB Weekly NAG 8-14-17)

After brazing, clean the connection thoroughly with paste of baking soda and water using a wire brush. This flap control horn is ready to be split for use with a WAFD device.

Figure 15 - The Finished WAFD Flap Control Horn (Before Being Split)

The elevator control horn follows the same procedure as the flap horn with the exception of using a slot rather than holes for the ball link connection.

For the slot I drill 3/32” holes for the beginning and the end of the slot. Then drill a series of 3/32 holes about a 1/8” apart in between. I’ll use a 1/16" tungsten carbide cutter rotary burr in my Dremel tool to remove the metal between the holes. The Dremel tool and metal files are used to clean up the slot to allow a 4-40 bolt to slide up and down the slot.

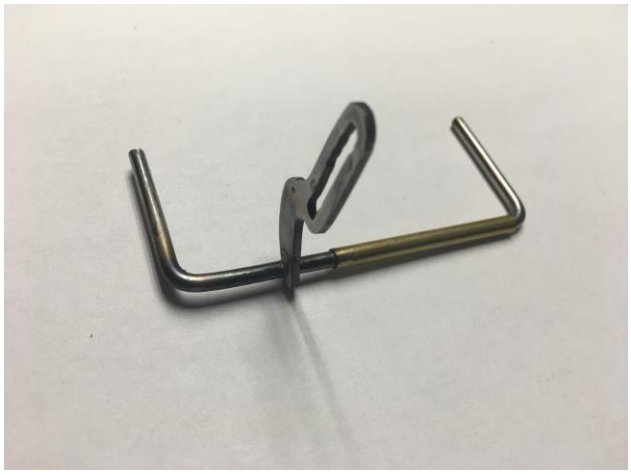

Figure 16 - Finished Elevator Control Horn

Again as mentioned earlier, as an alternative to the custom bellcrank, control horns and

pushrods, one could use these items that are available from Okie Air Model Products (without the WFAD).

CONTROL HORN DRIVERS: Connection of the control horn to the flaps and elevators are done using a simple to make control horn drivers. These are nothing more than a length of 5/32 brass tubing along with 5/32" balsa on each side of the brass tubing and sandwiched together between to two pieces of 1/16" plywood and cut into the flap or elevator core. For further information, see *"Turning to the Dark Side – Part 3" Fuselage & Tail Construction*.

CONTROL HINGES: I like to have the ability to be able to remove the flaps and the elevators. In the event of damage or warpage these components can be replace rather easily. Or if you are the adventurous type you may want to experiment with various flap/elevator sizes.

To have the flaps/elevators removable, take the Dubro nylon hinges and remove the hinge pin. The hinge pins are replace with a continuous length of piano wire that runs the length of each wing panel or elevator.

The end of the piano wire is bent at 90 degrees and cut off about a 1/4" long. I cut a small recess area for the wire to fit into the wing or stabilizer and place a small piece of clear tape over the end of the wire to hold it in place.

I also "seal" the flap/elevator the hinge line with clear tape for the entire length.

PUSHRODS: I like to make my own carbon fiber pushrods and it's not that difficult. Again, everything can be order from Okie Model Air Products from the components to a complete pushrod. I just happened to have all the necessary hardware to make my own. It all starts with the carbon fiber tube which can be a little expensive. However….

Here's a little story on how I get mine. Many years ago I read about using fiberglass arrow shafts, and now carbon fiber shafts for pushrods. I just happen to have an archery shop nearby that has a small practice range. I wanted to see what it would cost to order carbon fiber "arrow" shafts.

In speaking with the owner, I told him that I'm not an archer but I'm interested in carbon fiber arrow shafts to use for another purpose. He pulled out a catalog and shown me a wide range of carbon fiber arrow shafts along with a hefty price tag. I told him that I was hoping for something less expensive, you know "cheap". So I explained to him a little further what my intent was and he said, "Hang on a second". He goes to the back of his shop and pulls out a container of so called "broken or bad" arrows.

Mind you most of these arrows may lose a vane (feather), a broken arrowhead or nock. Why they don't fix them I don't know.

Inside this container was about 50 so called "broken" carbon fiber arrows. Nothing wrong with the carbon fiber shafts! He had about a dozen 3/16" diameter shafts that were perfect! I asked, "How much do you what for these?" He said, "Free …. Take all that you need, normally we throw them away". My jaw almost hit the floor!

Moral of the story, check with your local archery shop and see what they have. You might be surprised.

Take a look at your arrow. Cut off the nock and the arrowhead. Wrap the area you are going to cut with masking tape. This keeps the carbon fiber shaft from splitting when you make the cut. I use a Dremel abrasive cutting wheel to do this. When done you should be left with about an 18-20" length of carbon fiber shaft that can be used to make a pushrod.

Warning: Carbon fiber dust is not healthy for you. Take the necessary precautions to avoid breathing in the dust.

The 3/16" diameter arrow shaft fits a 4-40 bolt inside the shaft perfectly. I next take a 4-40 x 1-1/2" long partially threaded socket head bolt (any partially threaded 4-40 x 1-1/2" long bolt

will work) and I thread on a 4-40 hex nut and thread it all the way on and tighten it as tight as I can against the shank.

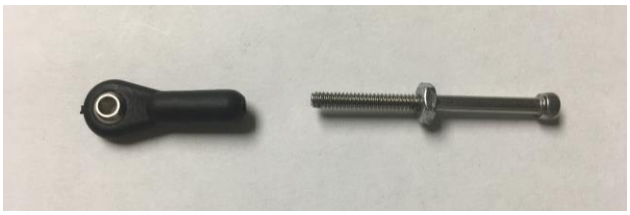

Figure 17 - 4-40 Ball Link, 4-40 Bolt and Hex Nut

With a cutting disk, I will cut off the head of the bolt and add notches all around the shank of the bolt.

Figure 18 – Modified 4-40 Bolt

Figure 19 - Pushrod End and Shaft

Mix up some JB Weld. Using a toothpick, I try to get as much JB Weld inside the end of the tube as possible. Put some JB Weld on the shaft of the bolt and insert it into the carbon fiber shaft, twisting the bolt as you insert it into the shaft. Wipe of any excess epoxy, stand it up vertically on the 4-40 bolt and let it dry.

Once dry, wrap the end of the shaft with carbon tow and then soak the tow with thin CA glue. This will keep the carbon fiber shaft from splitting.

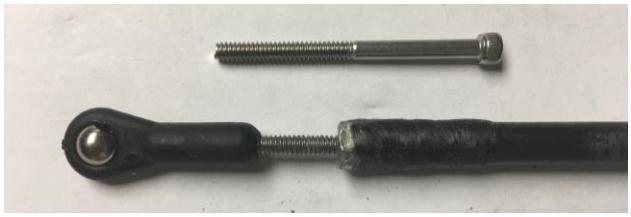

Figure 20 - Finished Pushrod

The 4-40 hex nut does two things. (1) It prevents the bolt from sliding too far or not enough into the shaft. And (2) if you keep the carbon fiber tow off the nut when wrapping, you can fit a 1/4" wrench onto the end of shaft to hold it and/or turn the ball link or shaft in or out as needed. This can be very handy in tight areas where you have trouble getting your fingers on the ball link to adjust.

WALKER FLAP ADJUSTMENT DEVICE (WFAD): For the WFAD, a 3/4" length of 3/16" carbon fiber pushrod and a 3/4" long 3/16" balsa spacer is CA'd to the main carbon fiber pushrod. The spacing between the two pushrods is critical. Currently, the flap control horn is still one piece and has not been split in two yet.

Figure 21 - Balsa Spacer and Carbon Fiber Tube

Once everything fits correctly, wrapped carbon fiber tow around the balsa and pushrods and soak the carbon tow with thin CA.

Figure 22 - Wrapping with Carbon Fiber Tow and Soaked with Thin CA

When dry, coat the outside with 5-minute epoxy and smooth out with the use of a heat gun.

Figure 23 – WFAD Pushrod – Note Notch in Flap

A final word on the controls. As mentioned at the beginning of this article, when the controls are installed for the final time, they should operate very smoothly. If anything binds, sticks, rubs, etc. find out what it is and fix it! This is important on all models but is especially important with electric powered models.

The adventure continues… Next, something different – a Charging Station.

As always, if you have any questions, comments or feedback please send an email to: circulas46iie.2020@gmail.com. I will try to respond back to you as soon as I can.

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Turning to the Dark Side

The Building of Circulas 46 IIe

Part 5 – Charging Station

A Precision Aerobatic Control Line Model Airplane

– Electric Profile –

Written by Dennis S. Nunes

April 2020

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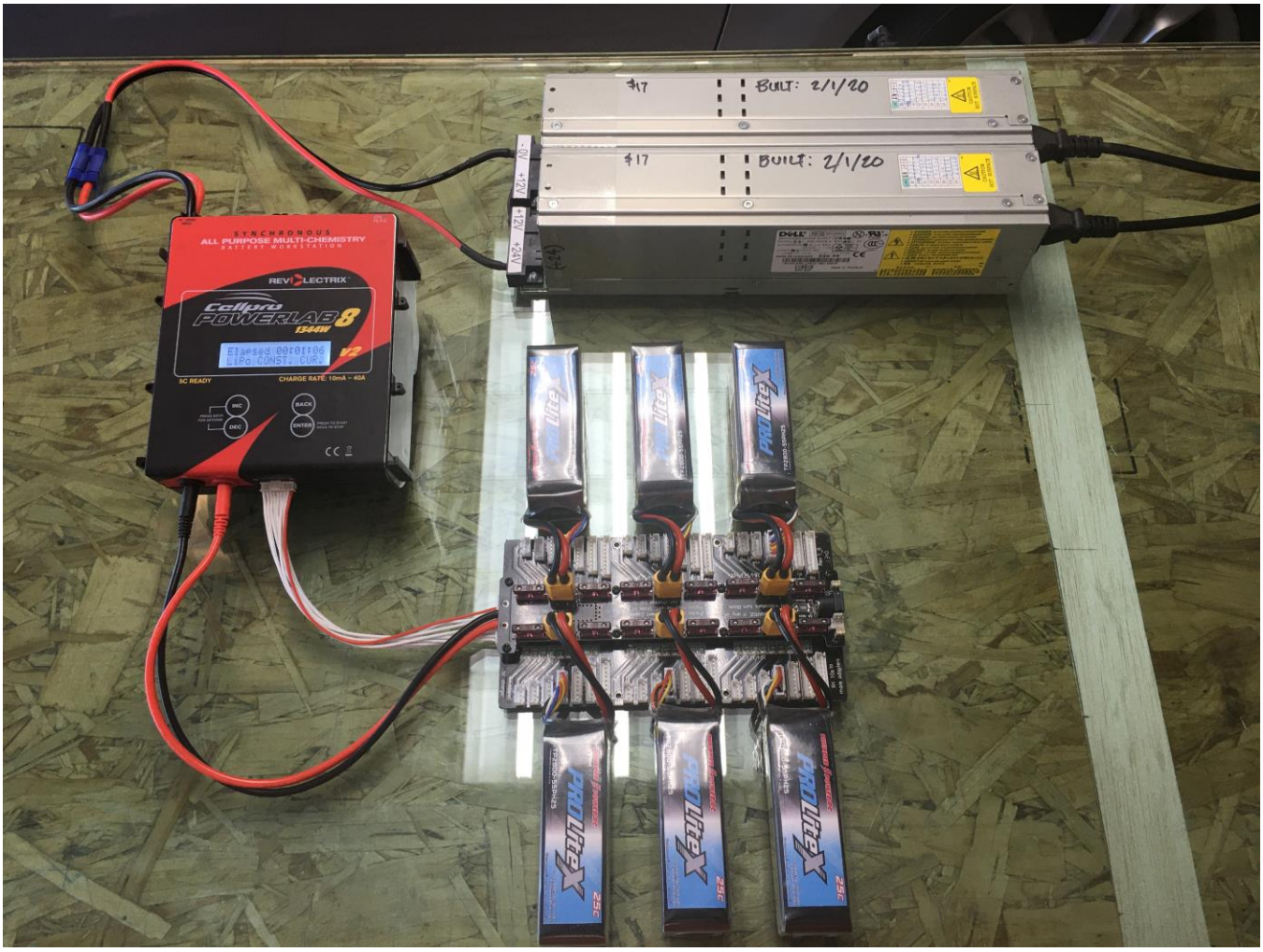
Turning to the Dark Side

Part 5 – Charging Station



CHARGING STATION:

With this issue of "*Turning to the Dark Side"* we'll go with the old Superman introduction. *It's a bird, no. It's a plane, no. It's —— a Charging Station?* So much for the TV metaphors.

With an electric plane, at some point you will need to charge batteries. You could buy an all-encompassing unit to charge your batteries. The choice is endless with various chargers, power supplies, balancing boards, etc.

In the beginning of this adventure Chris Cox gave me a very solid recommendation for the battery charger, a Revolectrix™ Cellpro PowerLab 8. Expensive? Yes! Worth it? Yes, in the long run. Complete? Not quite.

This battery charger is only one piece of what will become a *"charging station"*. To take full advantage of the Revolectrix™ Cellpro PowerLab 8 unit you still need other components, such as a power supply. Ask yourself —— Do I want or need a 12 volt or 24 volt power supply? Do I want to charge just one battery at a time or several batteries? Here's what I did.

WARNING: Be extremely careful when dealing with electricity. There is the RISK OF ELECTRIC SHOCK if not handled properly.

12 VOLT OR 24 VOLT POWER SUPPLY – WHICH? I started looking at commercially available power supplies. You have a choice between 12 volts or 24 volts. To take *"full advantage"* of the Revolectrix™ Cellpro PowerLab 8 charger requires a 24 volt power supply. The consensus was that the "Mean Well®" power supplies seemed to be the preferred choice. However, the price range ran anywhere from $200 to $1000, depending on how crazy you want to get. Remember I'm trying to keep my initial expense down as much as possible. *At least that's what I keep telling my wife.*

In doing a little research and for those who may be *uncomfortable* in dealing with electrical devices, I found a 24V-47A-1100W power supply at Radiocontronics for $94. They took two 12V-550W file server power supplies and with a little 'magic', converted them into a very usable power supply. But, could I get something less expensive, you know, cheaper?

Well, on YouTube I found several videos on how to convert two 12v rack-mounted power supplies used in file servers (computers) into a 24V-40A-1000W behemoth power supply for my charging station.

Electronic Adventures has an excellent 8-part step-by-step videos on YouTube on how to convert two 12V-41A-500W Dell® DPS-500CB rack-mounted power supplies into a 24V-40A-1000W power supply for $20. This certainly caught my interest.

I couldn't locate two Dell® power supplies for $20 that the video mentioned. But I was able to roundup two refurbished Dell® power supplies on eBay for $34 including shipping. I watched these videos very carefully every step of the way. The only change I made was with insulating the exposed pins near the soldered connection. More on that latter.

In watching these videos I found that it didn't look too difficult and didn't require any special tools to do this. In fact I had everything needed with exception of the #6 nylon isolation washers. These you can purchase at any Lowe's or Home Depot.

So for less than $45 I now have a 24V-1000W-41A power supply. Not too shabby!

WARNING: Be extremely careful when dealing with electricity. There is the RISK OF ELECTRIC SHOCK if not handled properly.

MAKING THE 24V POWER SUPPLY: To start, follow the videos and make sure that the cases of the Dell® power supplies are properly grounded using a volt/OHM meter.

Figure 1 – Two Dell® DPS-500CB Power Supplies

Figure 2 – Power Supply Type

Turning to the Dark Side

Part 5 – Charging Station

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The next step is to verify that the power supplies are not dead-on-arrival (DOA). This requires that the jumper shunts be installed as directed in the video.

Figure 3 – Install Jumper Shunts

Connect a power cord from the power supply to a surge protector that is tuned off or unplugged. Turn on the power to the surge protector. You should hear a 'click' and hear the fans power up. If not, double check everything, especially the jumpers and make sure they are installed properly. If this still does not work the power supply is DOA and will need to be returned and replaced.

If the fan is running, check the voltage across the negative and positive terminals with a volt meter. It should read over 12 volts. Both of my read 12.55 volts. Do this for both power supplies.

INSTALLING THE #6 ISOLATION NYLON WASHERS: Now it's time to get inside each power supply and install the #6 isolation nylon washers. Before opening a power supply, *"disconnect all power cords"* from the power supply!

I recommend doing one power supply at a time.

Everything was done just as was shown in the videos. Take your time and make sure to test "*everything*".

When done with the modifications, I taped the two Dell® power supplies together using 2" wide clear packaging tape at each end.

After everything was done with exception to shielding the exposed jumper pins, I tested the voltage and got 25V. Cool!

Figure 4 – Test Output Voltage – 25 Volts!

SHIELDING THE EXPOSED PINS: The only change I made from the video was how I shield the exposed pins on the power supply connector. The video showed adding heat shrink tubing over the four pins by the soldered connectors. I didn't have any heat shrink tubing small enough to stay on the pins (either did he), plus I didn't like the way he put a blob of silicon sealant on the loose tubing and pins.

What I did was make isolation covers made from a strip of a plastic key card. Cut a strip just wide enough to fit inside the large power supply connector and bend the ends to cover all the pins.

To cut the plastic, just score the plastic several time with a utility knife and bent the card back and forth until it snapped in two.

Figure 5 – Scoring Plastic Key Card

I next took a scrap piece of maple motor mount and place the strip of plastic and motor mount in a vice, heat the plastic with a heat gun. It doesn't take a lot of heat to soften the plastic. Bend the plastic across the motor mount.

Figure 6 – Bending Plastic

Do the same for the other leg of the plastic. Trim the ends as necessary. Make sure that the plastic isolator covers all the pins.

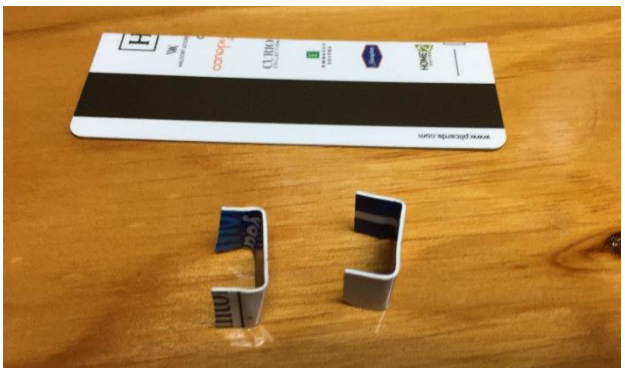

Figure 7 – Completed Plastic Isolators

Take a file or sandpaper and rough up the inside of the plastic. Then apply some clear silicon sealant on top of the pins and on the inside of the plastic isolators and press down over the pins

Figure 8 – Plastic Isolators over Pins

Finally apply some clear silicon sealant on the edges of the plastic isolators.

Figure 9 – Apply Sealant over Plastic Isolators

The last thing to do once the silicon sealant dries is to test all the connections a final time.

WARNING: Be extremely careful when dealing with electricity. There is the RISK OF ELECTRIC SHOCK if not handled properly.

If everything test out fine, solder a 10 GA AWS 'Black' wire for the negative terminal and a 'Red' wire for the positive terminal for the power leads. Covered the wire and connector with heat-shrink tubing.

Figure 10 – Finished Connection at Power Supply

On the other end of the 10 AWS wire install an EC5 female connector that will allow you to connect to the EC5 male connector furnished with the Cellpro PowerLab 8 charger.

Figure 11 – EC5 Connector
Female (left) and Male (right)

Also, rather than run a separate power cord to each power supply, I purchased a Black IEC320-C14 to 2C13 Y-shaped Power Cord from eBay. This allow you to use one power cord to supply power to both power supplies.

Figure 12 – Y-shaped Power Cord

What do you know —— My first 24V-40A-1000W power supply for less than $45. That's hard to beat. Now I hope I just don't burn down the house!

BATTERY CHARGER: The Revolectrix™ Cellpro PowerLab 8 v2 battery charger is the "Cadillac" of battery chargers! It is also the heart of the charging system.

But it does come with a hefty price tag (around $240). This was my largest single expense in this adventure. But this should take care of my charging needs for years to come.

Figure 13 – Cellpro PowerLab 8 Version 2 Charger

The charger can take advantage of my 24V 40A 1000W power supply. *Now I just have to figure out how to use it!*

There were no instructions that came with the charger. You will have to go to ProgressiveRC

website and download the *"FMA PowerLab 8v2 User Manual".*

As you will soon see, there are several buttons to press and a multitude of menus to go through to select what is needed ***before*** putting this charger to use. It can be very intimidating as you start out. I was very fortunate to have Jim Aron (aka Uncle Jimby) who patiently walked me through setting up not only my charger, but also helped me with the programming of the ESC and timer. This was extremely helpful. *Thanks Jim!*

About the only thing I remember from the session with Jim was, because I'm using a ProgressiveRC Multi-port Parallel Board with this charger and NOT using Revolectrix brand batteries directly, this requires changing the mode of the charger from FMA Wiring to XH/EH Wiring. Please read and re-read the manual very carefully or do what I did and contact someone who is very experienced at using this charger.

MULTI-PORT SAFE PARALLEL BOARD: This is something that you will eventually need to purchase as well. This is used to charge multiple batteries at the same time. The Progressive RC Multi-Port Safe Parallel Board is the parallel board of parallel boards!

The board comes fully fuse protected, with 40A blade fuses on the main circuit and self-resetting polyfuses protecting your balance plugs. The board can handle battery packs from 2S to 6S and is capable of charging up to six packs at once at up to 40A.

This particular parallel board come with various JST-XH and XT60 connectors. It also has 4 mm male banana plugs to connect to your charger.

The beauty of using this component is that nothing needs to be programmed or configured. Plug it in and go!

Figure 14 – ProgressiveRC Multi-Port Safe Parallel Board

There you have it. All the main components for a charging station that should last for many years to come.

Someday I would like to put all of these components in to some type of carrying case to make it easier to haul around. But for now a cardboard box will have to do.

If you have any questions, comments or feedback please send an email to: circulas46iie.2020@gmail.com. I will try to respond back to you as soon as I can.

The adventure continues… Next, will take a look at more Electrical Stuff

WARNING: Be extremely careful when dealing with electricity. There is the RISK OF ELECTRIC SHOCK if not handled properly.

Turning to the Dark Side

The Building of Circulas 46 IIe

Part 6 – More Electrical Stuff

A Precision Aerobatic Control Line Model Airplane

– Electric Profile –

Written by Dennis S. Nunes

April 2020

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Figure 1 - Wiring Confusion - Really?

WIRES, CONNECTORS & CABLES – OH MY

Remember the line in the movie The Wizard of Oz, *"Lions, tigers and bear – Oh my"*? That's how I felt when it comes to all the different types and sizes of wires, connectors and cables.

Now, you shouldn't need a biology lesson in determining the differences between 'male' versus 'female' connectors. But looking at some of the pictures on the internet can make you question if you need a biology lesson or not, as it can be difficult to differentiate between the two for the first time. Here are a few of the different type of connectors that I had to become familiar with.

EC5 CONNECTORS: This connector was needed to connect my 24V power supply to the Cellpro Power Lab 8 Battery Charger.

Figure 2 – Female (left) and Male (right) EC5 Connector

I found a short video on YouTube on installing EC5 connectors that was very helpful as these type of connectors can be difficult to assemble.

DEANS CONNECTORS: These are a very popular connector. They are also known as "T" plugs or connectors. A newer version is the Ultra Deans connectors. However, these connectors have been the source of frustration for many pilots because the sprung tabs tends to lose their contact pressure over time after many cycles.

Figure 3 - Female (left) and Male (right) Dean's Connector

BULLET CONNECTORS: These type of connectors are used with most electric motors.

Figure 4 - Female (left) and Male (right)

XT60 CONNECTORS: In an email from Chris Cox, he recommends using XT60 connectors for all battery connectors rather than the Deans connectors. When ordering batteries, you may need to verify what type of connector comes with your batteries. Some battery companies will ask you to specify the type of connector you want to use. Most batteries have power leads long enough that will allow you to cut off the connector and replace it with XT60 connectors if desired. If you choose to do this, n*ever, repeat never, cut both leads of a lipo battery at the same time! Do one at a time.*

WARNING: Be extremely careful when dealing with electricity. There is the RISK OF ELECTRIC SHOCK if not handled properly.

There are several YouTube video that will show you how to replace an existing connector with an XT60 connector. *This was one of those connectors where I thought I needed a biology lesson!*

Figure 5 - Male (left) and Female (right) XT60 Connector

JST-XH CONNECTORS: These come in a variety of configurations such as 2 pin, 3 pin, 4 pin, etc.

Figure 6 - Various JST-XH Connectors (Male on Left – Female on Right)

The *JST-XH* connectors are provided with the batteries and are used when charging or to connect to a battery checker.

BANANA PLUGS: The Progressive RC Multi-Port Safe Parallel Board is supplied with two 4 mm male banana plugs, one red and one black that will connect to the Revolectrix™ Cellpro PowerLab 8 v2 battery charger.

Figure 7 - 4 mm (male) Banana Plugs

OTHER DEVICES:

ESC: An electronic speed control or ESC is an electronic circuit that controls and regulates the speed of an electric motor. Chris Cox recommended the YEP 60A unit ($35) to start with. A programming card ($7) is required which allows you to change the parameters of the ESC.

Figure 8 - YEP 60A Brushless ESC

However, the YEP 60A unit was out of stock at the time I needed one. It was later recommended to use a Castle Creation Talon 60 ESC. This of course required a Castle Link USB Programming Kit that included a small circuit board and USB cable that allows you to program the ESC with a computer. This was a bit more expensive than the YEP unit. Total cost of the Talon 60 ESC and kit was $100.

Figure 9 - Castle Creation Talon 60A ESC

Thanks goes to Jim Aron (aka Uncle Jimby) for the help with selecting, setup and configuration of this ESC. I had to download Castle Link software before we could do anything and get the ESC connected to my laptop with the use of the Castle Creation USB kit.

Once all the parameter were set, we were able to save the configuration file to my laptop and send it to the ESC. Again, I am grateful to Jim for assisting me in setting this up as I had no idea what was required.

TIMER: The Will Hubin FM-9 timer seems to be a very popular choice for starting out. They are available with an onboard start button ($8) for profiles or with a remote start button with 8” leads ($10). Contact Will Hubin at mailto:whubin@kent.edu to order either items.

Figure 10 - Will Hubin FM-9 Timer with Onboard Start Button

You will also need to purchase a programming unit which is a little expensive for around $75. This will allow you to change the parameters of the timer.

Figure 11 - Will Hubin Programming Unit

Programming this timer was fairly easy especially when the programmer has settings for the Talon ESC. However, it is extremely important to connect the wiring correctly.

WARNING: Connecting the FM-9 timer incorrectly can damage the timer.

There was a little confusion at first as my timer came with a ribbon cable rather than the wire cable shown in the pictures of the documentation that I received. But it was fairly easy to determine how the cable should to be connected.

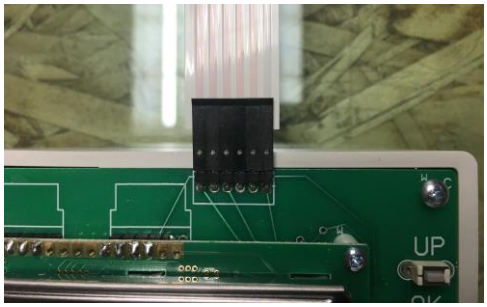

Figure 12 - Ribbon Cable to Programming Unit (Note the one Dark Wire)

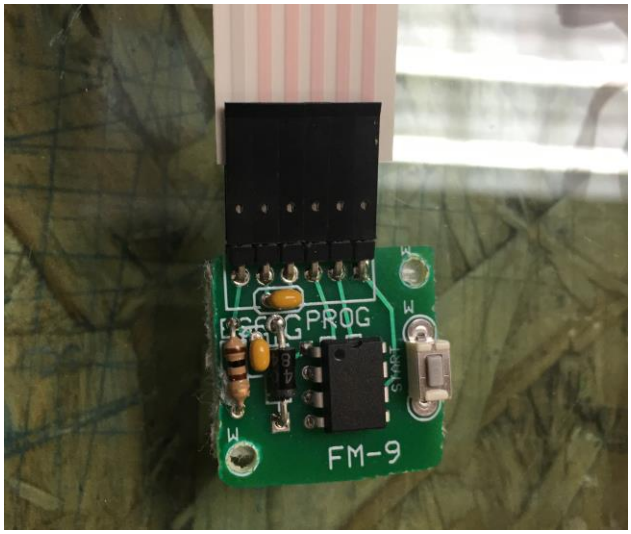

Figure 13 – Ribbon Cable to Timer (Note the one dark wire on the Ribbon Cable)

When it comes time to connect the ESC to the timer be very careful. Make sure to connect the “brown” wire from the ESC to the correct pin on the timer. Please see the instructions for this information. Again, failure to connect the ESC to the timer correctly will damage the timer.

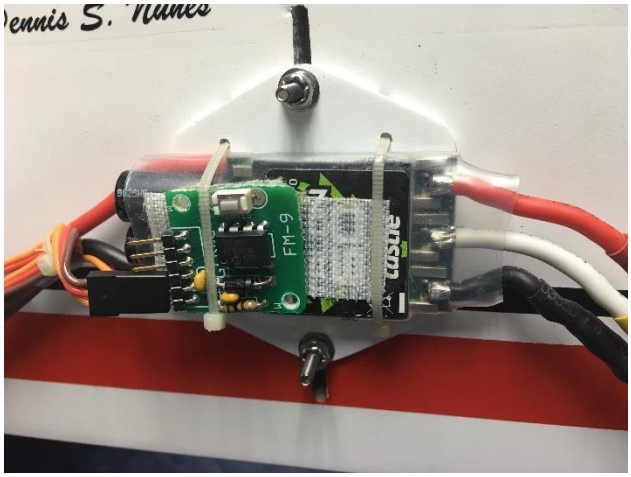

Figure 14 - Installation of ESC and Timer

ARMING PLUG: Because this is a profile with all the electrical components exposed, I’ve opted to not use an arming plug and just connect or disconnect the battery.

BATTERIES: Lastly, there are the batteries. At first this was an easy decision. I let Chris Cox make the recommendation. His recommendation was to use the Hobby King Zippy 4S 2650mAh 45c for the E-flite 25 870Kv motor. These batteries weigh 285 grams or 10 oz. and are rather inexpensive at around $28 a piece. Fine!

But later, I decided to change the motor and go with a Cobra 3515-18 740Kv unit. Then the question came up *"What size battery did I need?"* That opened a whole can of worms because as I asked different individuals I received different answers. But they were not necessarily the wrong answers.

One thing I learned very quickly when it comes to battery selection, there are a number of variables that can effect what battery is required. That includes such things as, the motor size and Kv rating, propeller size, rpm, the weight and size of the plane, etc., just to name a few.

The last thing I wanted to do is order a set of batteries then find out that they don't have enough capacity to do the job and then have to order another set. So in asking around I was wondering if there was any type of formula or chart to help determine the battery size required.

Brent Williams sent me an email with some information from Dean Pappas on Stunthanger.com that stated *"the rule of thumb is that an airplane on the full length (lines) allowed in F2B consumes approximately 0.7 watt-hours of energy per ounce of airframe weight in order to fly the F2B schedule".*

From there Brent shared with me a formula to determine the approximate battery size. The formula is as follows:

$$\frac{Wt.of\ Plane\ (oz.) \times 0.7\ Watt\ Hours}{Total\ Voltage} = Amp\ Hours$$

Then adding in a 25% safety factor because you never want to completely drain a battery:

$$Amp\ Hours + 25\% = Total\ Amp\ Hours$$

Let's say we have a plane that weight 58 oz. What size 4 cell battery would we need?

4 Cell Battery Calculation:

$$\frac{58\ oz. \times 0.7\ Watt\ Hours}{14.8\ Volts\ (4\ cell)} = 2.74\ Amp\ Hours$$

$$2.74\ Amp\ Hr + .68\ (25\%) = \mathbf{3.42\ Total\ Amp\ Hours}$$

So for a 4 cell battery I would need a battery somewhere around 3.42 amp hours or **3420 mAh**.

What about using a 5 cell battery?

5 Cell Battery Calculation:

$$\frac{58\ oz. \times 0.7\ Watt\ Hours}{18.5\ Volts\ (5\ cell)} = 2.19\ Amp\ Hours$$

$$2.19\ Amp\ Hr + .55\ (25\%) = \mathbf{2.74\ Total\ Amp\ Hours}$$

For a 5 cell battery I'm looking at 2.74 amp hours or **2740 mAh**.

DECISION TIME: So for a 4 cell battery we're looking at around a 3400-3500 mAh battery. For the 5 cell battery somewhere around a 2700-2800 mAh battery should get the job done.

Thunder Power PROLiteX Series 25C batteries are the battery of batteries! Yes, they are expensive, but are high quality and probably the lightest batteries around.

Their website makes it very easy to select your battery once you know your mAh rating and the number of cells needed. Find the nearest mAh rating that you need and select your battery.

For a 5 cell battery we selected the 2800 mAh rating. That gave us a TP2800-5SPX5 battery with an approximate weight of 290 grams or

10.2 oz. With an XT60 connector the price is $70 each plus shipping*. OUCH!*

I want to start out with at least 4 batteries. At $70 a piece plus $24 for shipping we are looking at a total cost of $304. *That's a really big OUCH!*

Well, let's look at a 4 cell battery. It has to be less expensive because it has less cells – Right?

In this instance we selected the 3400 mAh rating. So we're looking at a TP3400-4SX25 with a weight around 326 grams or 11.5 oz. With an XT60 connector the price is $75 a piece plus shipping or a total of $324, *an even bigger OUCH!*

Figure 15 - Thunder Power PROLiteX 2800 mAh Battery

To me this was surprising. I would think that a 4 cell battery would weigh less and cost less than a 5 cell battery. Less cells should mean less weight, and lower cost – Right? ——— *WRONG!*

In this situation, the Thunder Power 5 cell battery is lighter and less expensive than the 4 cell battery! Chalk this one up to another one of those "large learning curve" moments …. Again. *Go figure!*

So the decision is to use the Thunder Power TP2800-5SPX5 5 cell battery for *Circulas 46 IIe*. Now all I need to do is to wait until Thunder Power has a large discount sale (hopefully very soon!), where the "OUCH" will be about half and won't be as painful.

When it came time to order my batteries, Thunder Power was having their Memorial Day sale with a 30% discount and I couldn't wait any longer. So instead of ordering four batteries as I originally planned, I decided to go for six. The total cost of (6) TP2800-5SPX5 5 cell battery was $366 including shipping. The sale saved me $126. *This is still a big "OUCH"* but I shouldn't need any more batteries for a while.

I should have stuck with my original plan of ordering just 4 batteries. This now became my largest single expense for this adventure. I'll blame this choice on a "senior moment". The only side effect of this purchase so far is that I now walk with a limp! Did I make the correct decision at far as the batteries that I selected? I'm sure I'll I find out very soon.

Something to consider: Weight is only one of several factors involved in selecting a battery and so is price. You pay a premium for Thunder Power batteries. Other manufactures can be used but most will be 2 to 3 oz. heavier than Thunder Power batteries. That is a considerable amount of weight to be added to the nose of any plane. *I just have to convince my wife that the Thunder Power batteries are worth it!*

BATTERY CHECKER: For the last item. I wanted to find an inexpensive battery checker/tester. This allows you to check the voltage of the battery pack and the voltage on each cell of the battery very quickly. These come in a variety of options and prices. I found a very inexpensive unit on eBay for $5.

Figure 16 - Battery Checker

CONNECTING EVERYTHING TOGETHER: This being my first electric model, how is everything supposed to be hooked up and wired? Am I going to get everything connected, turn the switch on and start sending up smoke signals? *I sure hope not!*

Below is a simple wiring diagram showing the components and the wire routing. Because *Circulas 46 IIe* is a profile fuselage with everything exposed, I choose to use the Will Hubin's FM-9 Timer that has the onboard On/Off switch. Also there is no arming plug, the XT60 connector from the battery is exposed and easily accessible and will serve that purpose.

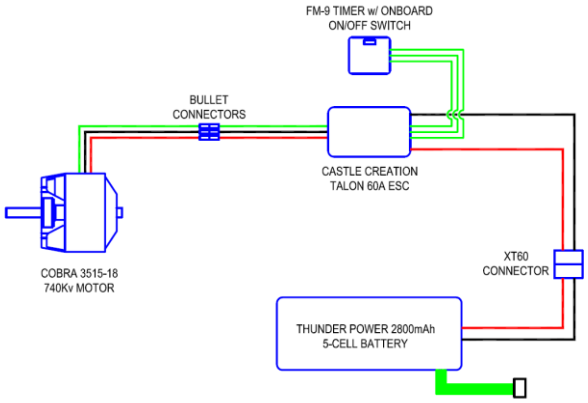

Figure 17 - Wiring Diagram

So …. Is your head now spinning after all this electrical stuff? *Mine certainly is!* Don't freak out when you go to sleep and wake up in the middle of the night in a cold sweat because in your nightmare you're holding in your hands a bunch of electrical parts and wires and asking, *"What did I get into?"* Don't worry the nightmares will go away —— *I hope!*

Again, if you have any questions, comments or feedback please send an email to: circulas46iie.2020@gmail.com. I will try to respond back to you as soon as I can.

The adventure continues…Let's get the plane assembled and finished.

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Turning to the Dark Side

The Building of Circulas 46 IIe

Part 7 – Final Assembly & Finish

A Precision Aerobatic Control Line Model Airplane

– Electric Profile –

Written by Dennis S. Nunes

April 2020

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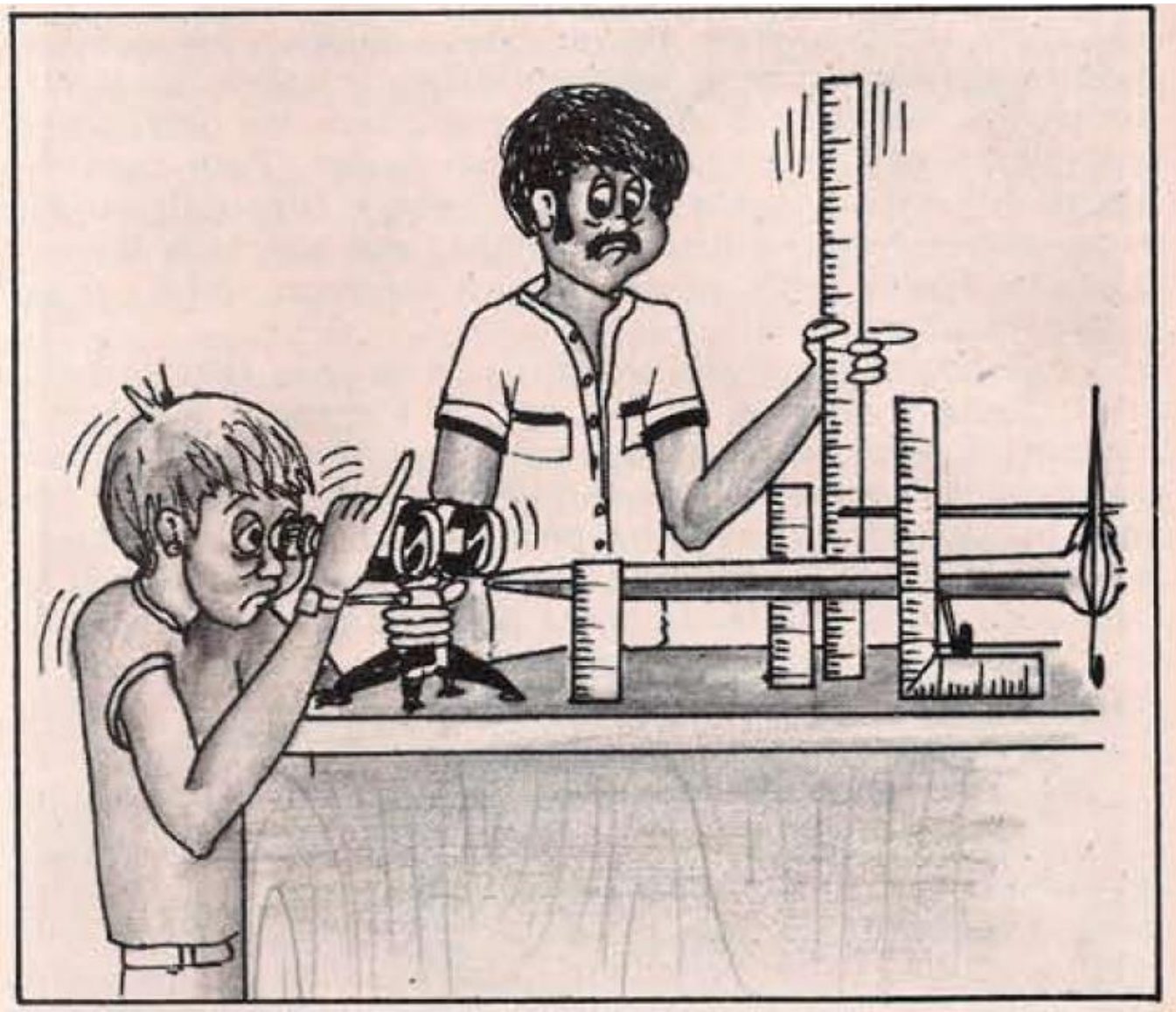


Avenger by Don Shultz – Originally published in the July 1974 issue of American Aircraft Modeler

ASSEMBLY:

Boy, has this been quite an adventure. But now it's time to put all the pieces together. This is where all the fun begins and all the concerns start creeping into one's mind. Is the wing straight, did the fuselage twist, did the flaps warp, etc.? The list goes on and on and on.

There's also excitement in the air because as you put the pieces together it start to look like a real airplane! Now comes the "bench flying" sessions. In your mind you see the perfect takeoff and level flight followed by loops and figure 8's that are to die for. You nail all four corners of the hourglass and you perform the most beautiful four-leaf clover ever possible. You visualize your score sheet. You see that you just put up a 600+ score! Then….The wife yells at you to quit playing around and go throw out the trash. You come back to reality. Oh well….It was good while it lasted.

Turning to the Dark Side

Part 7 – Final Assembly & Finish

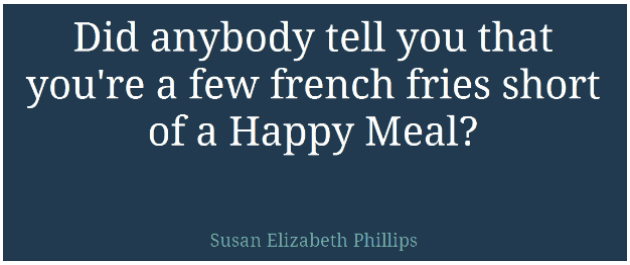
This is the stage of construction that is *extremely* critical. Everything needs to be installed straight and true. The wing is parallel with the fuselage, no negative or positive incidence. The flap and elevator hinge lines are parallel with each other. There is a whole host of things that must be correct in order to have a good flying ship.

My workshop is part of my garage and on a beautiful day I will open the garage door to allow for some fresh air and natural light to come in. My neighbors can see me measuring and re-measuring, everything everywhere. Over and over again and again. And similar to the cartoon at the beginning of this article, I'll use triangles of various sizes, a tape measure, rulers, etc., anything that will help verify that all things are aligned and true. Some are even using laser levels to do this.

But as my neighbors peer into my garage and see me go through this "ritual", I can almost hear them say, *"He's got to be a few French fries short of a Happy Meal".*

Why go through all this trouble? Very simply, ***ALIGNMENT IS CRITICAL!***

You'd be surprised how many trim issues are created as a result of poor alignment. Check and double check the alignment very carefully, just like the cartoon at the beginning of this article.



INSTALLING THE WING: Though the control horns are not yet permanently installed, Always check to make sure that all the controls fit, work properly and smoothly. There shouldn't be any binding in the controls. For several days I will go through this "ritual" before I apply a single drop of glue.

At this stage the wing, flaps and controls should all be complete. I don't know how many times I've slid the wing in and out of the fuselage during construction. I normally leave the bellcrank pushrod off as long as possible. I've gotten pretty good at threading the pushrod onto the ball link that's installed on the bellcrank through the pushrod opening. It must be one of Murphy's Laws, leave the bellcrank pushrod in and you will end up banging it around and cracking the center sheeting. *I hate whoever Murphy is!*

Take a combination square and lay it against the trailing edge of the wing, draw reference lines off the centerline of the wing where the outer edges of the fuselage should lay.

Figure 1 - Reference Lines for Fuselage Location

On a full-body fuselage I normally would remove a section of the fuselage sides below the wing, slip the wing into place from underneath with the flap control horn permanently attached to the trailing edge of the wing. Add the cutout pieces of the fuselage sides back into position and glue the assembly back together again. Piece of cake.

However, I like the benefits of the WFAD but this makes the installation of the flap control horn a little tricky because of the profile fuselage. I don't attach the flap horn to the wing

until the wing is in position and ready to glue to the fuselage. As I slide the wing from the outboard side of the fuselage into position, when it's a several inches from where the wing needs to be located, I slip the control horn into the opening in the fuselage from the inboard side of the fuselage and continue sliding the wing into position while holding the control horn at the same time. It's a tight fit but it does fit.

Once the wing is in place and everything is aligned, tack glue the wing in several locations. DO NOT glue the control horn into place yet.

Verify, verify, and verify that the trailing edge is perpendicular to the fuselage, that the profile fuselage is perpendicular to the wing and that the centerline of the wing is on the centerline of the fuselage, both from above and from the side. *Take your time.* Remember, a*lignment and accuracy are critical!*

Now it is time to permanently glue everything into place. For this I use medium CA with no activator. When gluing the flap control horn into place, DO NOT get any CA on the 1/8" control wire, only the brass bushings. Allow the CA to dry naturally, no activator.

Once the CA is dry, verify that the flap horn works smoothly. Then add a thin strip of 1/2 oz. fiberglass cloth using 15-minute epoxy around the brass bushings and the trailing edge of the wing. I'll use a heat gun to smooth out the epoxy over the trailing edge. Again, be careful and DO NOT get any epoxy on the control wire!

Figure 2 - Install Control Horn with WFAD

With all my IC planes I always added a 1-1/2" wide strip of 1/2 oz. fiberglass cloth with epoxy all around the wing and fuselage joint. This helps to maintain a solid connection between the fuselage and the wing as the vibration from the IC engine can wreak havoc with fillets, especially around the leading edge of the wing.

However, with electric motors we don't have near the vibration issues as we do with IC engines. So I chose not to apply fiberglass cloth at the wing joint. Make sure though that you have a good solid joint between the wing and fuselage.

INSTALLING THE STABLIZER: The same procedure for installing the wing is used for installing the stabilizer.

Again, verify, verify, and verify that the trailing edge of the stabilizer is perpendicular to the fuselage and parallel with the trailing edge of the wing. Check that the centerline of the stabilizer is on the centerline of the fuselage, both from above and from the side. Alignment and accuracy are critical.

FILLETS: I use SuperFil®, an ultra-lightweight epoxy filler available from Aircraft Spruce and Specialty and add fillets all around the wing, stabilizer and rudder joints. SuperFil® is very light, easy to sand and is compatible with a dope finish.

Turning to the Dark Side

Part 7 – Final Assembly & Finish

The key to getting great looking fillets that require very little sanding is relatively easy. Using a narrow wooden Popsicle sticks, apply SuperFil® to the joint. Don't be shy, make sure to put enough SuperFil® into the joint. With a stainless steel cake decorator ball stylus smooth out the SuperFil® to form the fillet and scrape off the excess. Then just before the SuperFil® starts to harden, dip the tip of your finger in some Isopropyl alcohol and smooth out the edges and surface of the fillet. SuperFil® is great stuff – try it you'll like it!

Figure 3 - Everything Assembled

PREPARING FOR THE FINISH: The beginning of a good finish begins with the wood selected and the preparation of the wood. Poor workmanship will result in a poor finish. There are no shortcuts to this. It's up to you.

Sanding, sanding and more sanding. It seems like you never stop sanding. All my finish sanding to the airframe is done using 320 grit sandpaper with a sanding block of some type. I avoid using a piece of sandpaper with just my bare hand. But even when sanding with a block you have to exercise caution not to dig an edge into the adjacent area where you're sanding. Be on the lookout for dents and dings.

For small dents and dings I use DAP® *Patch-n-Paint* lightweight spackling. The fixing of dents and dings seems to be an ongoing process throughout the life of the model.

Figure 4 - DAP® Patch-n-Paint Lightweight Spackling

LANDING GEAR: Now is as good as any time to bend up a set of landing gear wires. The landing gear wire is made of 1/8" piano wire. In the past I used a K&S® Wire Bender for 1/8" wire. The only problem with this device is that the radius at the bend is a little large. But if you try bend the wire on the sharp edge of a vice the radius is too small and most of the time will fracture the piano wire. To get around this I filed a small notch in one of the jaws of my vice to give me a radius that is just right, just like *Goldilocks and the Three Bears!*

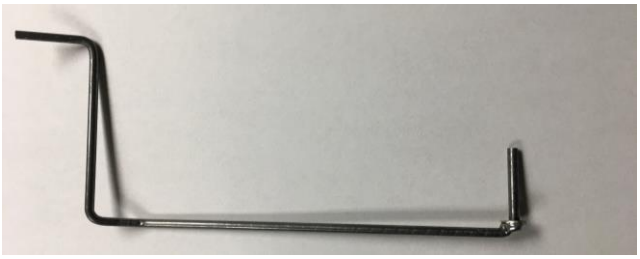


Figure 5 - Bent Landing Gear Wire

Because most of my flying sites are grass I try to maintain 7” of ground clearance. I measure the ground clearance with the fuselage level. This allows me to run up to a 12” diameter propeller. For those times that I have the opportunity to fly off an asphalt or concrete circle, I’ll make another set of landing gear wires to maintain a 6-1/2” ground clearance.

How far forward should the wheels be? Ideally, the wheels should contact the ground at a 15 degrees angle in front of the center of gravity (CG) from the centerline of the wing. *For Circulas 46 IIe* this is about 1-7/8” for the grass gear and approximately 1-3/4” for the asphalt gear.

The simple landing gear fairings are made from 1/8” hard balsa attached to each side of the 1/8” piano wire. A piece of 1/64” plywood is laminated on both sides of the balsa and wire with 5-minute epoxy. The landing gear fairings are 1/2" wide.

Figure 6 - Installed Landing Gear with Fairing and Cover

With the design of *Circulas 46 IIe,* being an “inline” design (motor, wing and stabilizer all in line with on another) the wing is mounted a little higher in the fuselage than a low wing model. Because of this, the landing gear needs to be a bit longer to maintain the ground clearance for the propeller.

CHOOSE YOU’RE COVERING MATERIAL: It’s now decision time. Iron on covering? Polyspan? Silkspan? The choice of covering material and finish is up to you. The original *Circulas 46* was covered using Polyspan. Polyspan is fine and extremely strong. However I don’t like the amount of dope that is required to fill the grain or dealing with the pinholes that popped up in the open bays. It is notoriously known for the “fuzzies” when or if you sand through the dope and into the Polyspan.

Iron on covering? I’ve seen some planes with iron on covering that were extremely well done. Some of them were done so well that I had to take a very close look to determine the covering. However, for me the choice was simple. I was never good at using any of the iron covering materials, so I’ve stayed away from them.

For me, it’s silkspan and dope. Why? For one, I’m very comfortable with this type of finish. Is it more work? Yes it is. So I’m going to describe the silkspan and dope finish that I used for *Circulas 46 IIe*.

WHERE IN THE WORLD DO YOU GET SILKSPAN? For covering the wing I use silkspan ---- well sort of. Where in the world did I find silkspan especially since the K&S silkspan that I remember back in the 60’s is no longer available? Sometimes you may find it on eBay, but be prepared to shell out about $10 for a sheet! *Ouch!* Or you can try using the silkspan that’s available from Brodak, but to me, this paper is not the same as the old K&S silkspan.

For the diehard silkspan users there is something else that is available that, in my opinion, is the same as the old K&S silkspan. Thanks goes to the group on Stunthanger.com who shared this tidbit of information about what has been called “Doctor’s Paper” or “Exam Table Paper”. You know the stuff. It’s the white

paper you find in your doctor's office when you lie or sit down on their exam tables. Don't laugh, it's true!

Just be aware that not all doctor's or exam table paper are the same. There are two types, the "smooth" paper and the "crepe" paper. Just make sure it is the "crepe" type table paper.

This paper works the same way as the old K&S lightweight silkspan that is no longer available. I've now used it on several planes without any issues. The paper I ordered is manufacture by Tidi® Products, #981004 White Crepe Table Paper. It's available in 18" or 21" wide x 125' long rolls at McKesson Medical or any medical supply company. I've even seen it on eBay.

If you want a heavier weight paper order the Tidi Products®, #916213 Crepe Table Paper. This is more like medium weight silkspan and is also available at McKesson Medical. The paper is available in 14", 18", 21" and 24" wide rolls and 12', 125' and 250' length rolls.

Several years ago when I placed my order, you couldn't buy just a roll or two, you had to order an entire case of 12 rolls. I paid $25 for a case and that included shipping. Let me tell you, a case of paper will cover many, many planes! Each roll is 125' long! I've given half of it away and still have a lifetime supply.

CHOICE OF DOPE: For the dope, both color and clear, I used butyrate tautening dope from Aircraft Spruce mainly because I still have some and again I'm very familiar with it. However, with electric models you don't need the minimal fuel protection that butyrate dope provides. Therefore nitrate dope can be used entirely if so desired or a combination of both. Just remember – if you use both, you can apply butyrate dope over nitrate dope, but not the other way around.

But here's another thought for using butyrate dope. If you still have IC powered models or are around them, it may be beneficial to use butyrate dope to provide a little protection to the finish from any inadvertent spray or drops of glow fuel from you or from others.

Before I begin, take two wide mouth quart Mason® jars and fill the jars half way with the butyrate dope. The remaining half of the jar is fill with butyrate thinner to make a 50/50 dope/thinner mixture. In one of the jars, add 3 or 4 tablespoons of zinc serrate powder and shake well and set it to the side.

For those who may not be familiar with zinc serrate powder, it is a very light weight material similar to talcum powder but even lighter. When mixed with dope this makes for an excellent filler and sand extremely easy. A couple of years ago I order 100 grams of "pure" zinc serrate powder from eBay. 100 grams doesn't sound like much. Believe me – 100 grams of zinc serrate powder goes a long way!

Always spray paint with proper protective gear. There are no impression points for color-coordinated lungs.

SEALING THE WOOD: Once satisfied with the wood surface (remember wood preparation is the key to a good finish), this is what I do to for the *bare wood areas*:

1. Brush on two coat of the 50/50 clear dope mixture over the entire airframe. Allow sufficient time for the dope to dry between each coat. Sand the entire airframe smooth.
2. For all areas, including those that were sealed with the Z-Poxy® finishing resin, take the 50/50 dope mixture with zinc serrate and brush on two coats over the entire airframe. Then guess what? More sanding. It's at this stage that the wood grain should be filled. If not, brush on another coat of the mixture as needed and sand some more.
3. When your satisfied that the wood is sealed, apply a coat of 50/50 dope mixture without the zinc serrate. Allow to dry thoroughly and lightly sand with 500 grit sandpaper. This allows any remaining zinc serrate to be "sealed" to the surface of the wood.

Once completed, there should be a satin sheen to all the wood surfaces. It's at this point the wing is ready to cover.

Some go through great lengths to seal the wood grain. Some will apply silkspan or carbon veil to cover the exposed wood surfaces. This not only helps to seal the wood but provides some additional strength and protection to the wood surfaces. The choice is yours. For *Circulas 46 IIe* no silkspan or carbon veil was applied over the wood surfaces accept for the wing.

COVERING OF THE WING: Before I begin to cover the wing I take my air hose and blow of the model and then use a tack cloth and wipe down the model completely.

Cut the silkspan several inches larger than each panel of the wing. I always keep the "curl" side down toward the wood. I start with the underside of one of the wing panels. I take an old spray bottle and fill it with water and wet the silkspan on both sides. With a brush, apply a 1" wide strip of dope/thinner mixture (50/50) along the perimeter of the wing, DO NOT put any dope on the cap strips. Drape the silkspan into position and gently pull the silkspan to remove any wrinkles or bubbles. Once all the wrinkles and bubbles are removed, with the 50/50 mixture of dope/thinner, brush the silkspan down around the outside edges of the wing. Ideally you want to "push" the dope/thinner mixture into the silkspan and allow it to penetrate through the silkspan and dissolve the filler coat of dope below the silkspan and bond to the airframe.

It doesn't take long for the dope/thinner mixture to dry. Once the dope starts to dry, I take a razor blade and trim off the excess silkspan. Brush on more dope to seal the edges. With my finger I'll rub the dope onto the edges of the silkspan to make sure the edges are sealed. When complete, flip the plane over and cover the panel on the top side. Repeat this process for the other wing panel. Allow the silkspan and dope to dry thoroughly.

With the 50/50 dope mixture brush on two coats of dope over the silkspan that is in contact with wood, except to the cap strips. When dry take some 320 grit sandpaper and lightly touch all the edges of the silkspan and any lumps and bumps that you come across. Be extremely careful when sanding around the edges of the open bays of the wing.

It's at this point that I apply two coats of the 50/50 dope mixture to the entire wing, including the cap strips. Allow the silkspan and dope to dry thoroughly between coats. When dry lightly sand with 320 grit sandpaper.

With a mixture of dope 50/50 with zinc serrate, apply two additional coats until the grain of the silkspan is filled. I gently sand with 600 grit sandpaper between each coat. Again, give the dope a change to dry completely between each successive coat. Remember the thinner in the

dope needs to evaporate (gas off) and allow the dope to do its thing!

After a light sanding, with a narrow brush I apply two light coats of 50/50 dope with no zinc serrate to all the cap strips and edges of the open bays. These edges can become thin due to the sanding and giving them a coat of dope helps to build up those edges.

Lastly, I apply a very light coat with a spray gun of the 50/50 dope mixture without the zinc serrate over the entire model. When dry sand as necessary. When done properly, there should be a sheen to the silkspan. Now *Circulas 46 IIe* is ready for primer.

Figure 7 - Circulas 46 IIe Ready for Primer

WHAT PRIMER SHOULD I USE? I've been a big fan of Napa DC-540 gray primer for years, until they recently changed their formula. I've heard rumors that Harbor Freight has a product that is very similar to the DC-540 primer. I'm not a big fan of trying something new but I bit the bullet on this and gave it a try. *How did it work?*

What an uneasy feeling to test something that you're not sure how it's going to turn out. Well, to my delight ---- the Harbor Freight Sandable Primer is ***exactly*** like the old formula Napa DC-540! It smells the same, sprays on and covers nicely, dries quickly and sands off just like the Napa DC-540 of old. It's like the old Alka-Seltzer® commercial, "Plop, plop, fizz, fizz oh what a relief it is"! And at $3.99 for a 10 oz. can, that's hard to beat.

Figure 8 - Harbor Freight Primer

Now for a couple of recommendations when using automotive primer on model airplanes. (1) Spray it on, let it dry and remove as much as you possibly can by sanding the primer off and (2) DO NOT spray primer on the open bays of the wing. That's it.

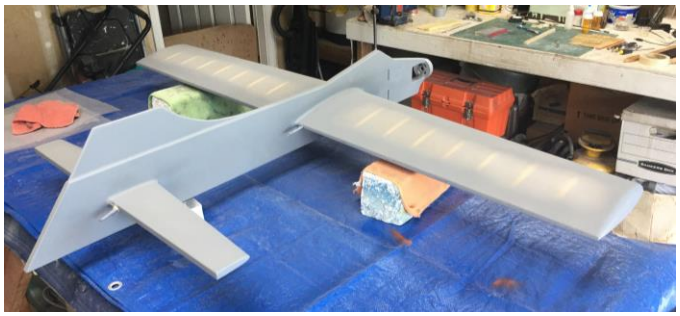


Figure 9 - Harbor Freight Primer Applied

Keep in mind that automotive primer is *very heavy!* The purpose of using the gray primer is to reveal and/or expose the high and low spots or areas in the wood that you may have missed when sealing the surface. If you find, or should I say, you *will* find, some high/low or missing areas —— don't panic! Or, when sanding the

primer off you may (will) sand through the filler coat. Again, don't panic!

Sand the area smooth and apply the dope mixture with zinc serrate and sand smooth. Apply the primer to that area and sand again. Repeat as necessary. If you have filled the grain of the wood and silkspan properly, very little primer will remain on the plane.

This is what *Circulas 46 IIe* looks like after sanding off the primer and before spraying on the base color coat.

Figure 10 - Very Little Primer Should Remain

This entire process reminds me of the movie *The Karate Kid*, where Mr. Miyagi tells young Daniel, "Wax on – Wax off!" For us it's, "Spray on – Sand off"!

For those who may not be comfortable or have issues using automotive primer, take a bottle of clear dope and add some silver or black dope for tinting and the zinc serrate.

Now, how far do you go with the primer and/or dope along with all the sanding? Are you after that allusive 20 point finish? Remember the more primer and dope you use the heavier the plane becomes. So be careful. The final finish is all up to you. A beautiful finish takes a lot of work and time, there are no shortcuts.

So you've sanded and sanded and sanded. I've been told when you think you're done sanding, sand some more. It seems like you can never sand enough. Make sure all areas are to your liking. Take the plane out into the sunlight and go over every inch. Don't develop the thinking, "I'll take care of this later." No, now is the time, not later!

Once you are satisfied with the automotive primer, spray the entire plane with a coat of 50/50 clear dope. This seals the primer and provide a good base for the color coat to attach itself to. It's time to apply your base color.

APPLYING THE BASE COLOR: I like to wait several days or even a week to allow all the dope to "gas off" and dry thoroughly before spraying on the base coat.

For the base color I used Q10503 Insignia White butyrate dope from Aircraft Spruce. I make a mixture of 50/50 dope/thinner. Spray on a very, very light coat, I'll usually spray all the edges first and then the rest of the plane. Wait about 10 or 15 minutes for the dope to become tacky. Then apply a smooth and even light coat over the entire plane and all the pieces.

If you can, take the plane out into the sunlight and very carefully look for area that may not have been properly covered and touch up as necessary.

Using the gray primer may not have revealed all the areas that needed to be fixed. After the first color coat of white you will notice a few areas the need some attention. Fix these areas before apply the second coat.

I'll repeat the process again for the second coat.

After waiting a day or two for the dope to gas off, very lightly "wet" sand the entire plane. I use 2000 grit sandpaper. But if you have some heavy "orange peel" you may need to wet sand with 800-1000 grit sandpaper to knock it down, followed by using the 2000 grit. DO NOT use anything less than 800 grit sandpaper! If you sand through the base coat, touch it up as needed.

FYI, if you are getting large areas of "orange peel" this is usually a result of two things. Either the dope is too thick and/or using too much air to spray the dope on. Temperature and

humidity are also a factor. In central California humidity is usually not an issue, but temperatures can reach will over a 100 degrees during the summer. I have a couple of thermometers in my workshop and I never spray dope if the temperature rises about 75 degrees. In some cases that means I had to spray at 3 or 4 o'clock in the morning when the temperature was cooler.

DON'T go crazy with the color base coat. Colored dope is heavy and you can start adding unnecessary weight to the plane by using too much. All you want is an even coverage and no more. Once you're satisfied with the base coat, it's time to add the trim colors.

Figure 11 - Base Color Applied - Ready for Trim Colors

APPLYING THE TRIM COLORS: I'm no artist and not very imaginative when it comes to color schemes and layouts. For me it's the KISS principle (Keep It Simple Stupid). I'm not familiar or experienced with paint mask. So straight lines are simple and easy to do. The trim design on the wing and stabilizer for the *Circulas* series came from one of Bob Hunt's models, the remake of the Stunt Machine I by Gene Schaffer, affectionately nicknamed Oosa-Amma.

Figure 12 - Stunt Machine I Affectionately Nicknamed Oosa-Amma

I sent Bob an email letting him know that I couldn't find the picture or remember the name of the plane that I "plagiarized" the paint scheme from. I asked if he could help. He was kind enough to send me several pictures along with the name of the plane. But I really loved his response when he said, "Imitation is the most sincere form of flattery!" That being said, now I don't feel too bad for "borrowing" the paint scheme. Thanks Bob!

Before applying the trim colors, make sure that the base coat is thoroughly dry. There is nothing worse than to mask off an area, paint it and then peel off the tape and have the base coat underneath come off with the tape. This can happen when the base coat is not thoroughly dry or bonded properly to the subsurface. Depending on the air temperature and humidity, I may allow the base coat to dry for several days or even a week before apply the trim colors.

In the past I've used the blue 3M™ Fine Line Vinyl tape for outlining the trim colors. But I've found that the 3M tape really adheres to butyrate dope really well, in fact, too well and at times pulled some of the base coat up with the tape.

I switched to the orange color TCP Global K-Tape Poly Series Fine Line Tape. This tape works really well, is a little less aggressive in sticking to the base coat. The tape comes in a

variety of widths. I used both the 1/4" and 1/2" widths for outlining the trim colors.

One of the things I do after laying out the tape on the surface, is to take my spray gun with some clear dope and lightly spray the edges of the tape to seal the edges so I don't get any bleeding of the color underneath the tape. Once the clear dope is dried I'll spray on the trim color.

I don't like leaving the trim tape on overnight. So I will normally spray the clear and trim color in the morning and later that afternoon or evening remove the trim tape very carefully.

Figure 13 – Laying out the Trim Tape

Figure 14 - Applying the Madrid Red Trim Color (Circulas 61)

Figure 15 - Applying the Black Trim Color (Circulas 61)

Figure 16 - Finished Trim Colors

After removing the trim tape there will be some "flash" on the edges of the trim color. The next morning I will take an old credit card or plastic hotel key card and very carefully scrape the edges and remove the flash. Be careful! With a white base color this can be tricky as the red or black trim color can stain the white base if you get too wild when scraping off the flash.

There is usually some touch up work that will need to be done. Now is a good time to go over the plane very thoroughly before applying the decals and the clearcoat finish.

MAKING DECALS: I happen to have Microsoft® *Word* on my computer and used it to make my own decals. I believe most computers that use Microsoft® *Windows* has a program called *WordPad* that comes with the operating system. This program will work just as well as Microsoft® *Word* for making decals. Sorry for

the Macintosh® users, but I'm sure there's a program to do the same thing as *Word*.

I also order *"clear water soluble"* decal paper for LaserJet printers. DO NOT get InkJet decal paper!

Let your imagination go wild! You can become very creative. The internet is loaded with various images and fonts that can be used. For me, it's once again the KISS principle. The name of the plane, my AMA number, along with the build date all done in black and white using the *Brush Script MT* font.

Here's what I place on the side of the fuselage:

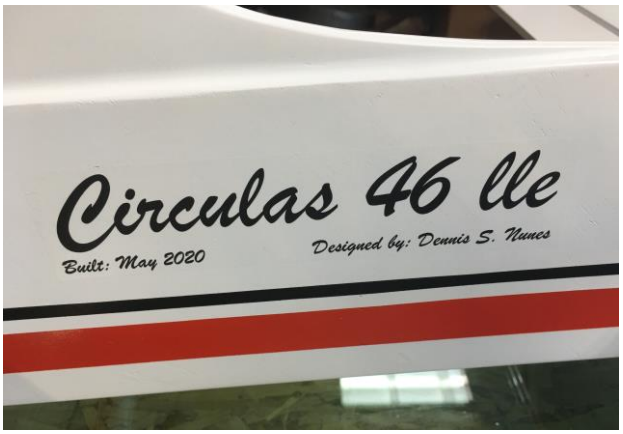


Figure 17 - Decal on Side of Fuselage

Once I'm satisfied with what I need, I create a PDF file of the *Word* document and transfer the files to a flash drive, grab my water soluble decal paper and head out to the nearest Office Depot and have them print the decals for me on their high end laser printers. I believe the last time I had them print black and white decals it cost me a whole 13 cents a sheet. Not too bad.

Most high end LaserJets have a higher resolution and a higher temperature setting to bond the toner to the decal paper over the inexpensive LaserJets designed for home or personal use.

When applying the decals, I work one decal at a time, cut them out of the sheet, and soak it in a pan of water until it becomes loose from the backing. Locate the decal on the plane where you want it. When satisfied with the location of the decal, take a paper towel and gently remove any air bubbles and excess water. Once all the air bubbles and water are removed, I take Walthers® Solvaset Decal Setting Solution and brush it on all the edges of the decal. The Solvaset solution soften the decal and removes the "hard edge" of the decals. Beware —— Don't be fooled just because the decal appears to be dry. I usually wait a full day or longer for the decal to fully adhere to the surface.

The decals are not fuel proof or dope proof! Once dry, I take my airbrush with clear dope and very lightly spray the edges of the decal. When that dries, I spray a couple of very light coats over the entire decal. *DO NOT spray on a heavy coat over the decal as this will blister and/or dissolve the decal!* The purpose of this coating is to seal and protect the decal from the clearcoat

APPLYING THE CLEARCOAT: At the 2018 Northwest Regionals in Roseburg, Oregon, Alan Resinger shared with us the he and Chris Cox started using the *Certified Coating Products* clear butyrate dope for their clearcoat instead of the *Randolph* butyrate dope. The *Certified* butyrate dope is a little on the thick side and that he said to thin it at 4:1 thinner/dope mixture. This dope dries faster and hardens quicker than the *Randolph* butyrate dope.

It was very interesting when I place a jar of the *Randolph* clear next to a jar of the *Certified* clear. The *Certified* clear is as clear as water, where the *Randolph* has a yellowish tint (It looks like …. you know what). It's like night and day.

Figure 18 - Certified Dope (left) Randolf Dope (right)

Spray on a very light coat and allow it to setup just a little bit followed by another light coat. Beware that this mixture is very thin with a lot of thinner and will run very easily. After several hours, I apply a second coat.

The next day I repeat the same steps as the day before and apply a third coat. You want to gradually build up the clearcoat as this is going to protect the base color coat and the decals when it's time to start buffing and polishing.

BUFFING AND POLISHING: With the *Randolph* clearcoat, I'd had to wait a month or so for the dope to gas off, dry and harden before I would start the wet sanding, buffing and polishing. According to Alan, with the *Certified* clearcoat you can do this in a couple of days. I haven't had the guts to try that yet as I usually wait a week or so to start this process.

I start off by wet sanding the entire plane with 2000 grit sandpaper. There should be a nice even sheen on the entire model. If you notice some low spots that can't be sanded out, spray the area with the clearcoat to build it up and wet sand again.

I purchased a Micro-Mesh Acrylic Restoral Kit for Aircraft Spruce and will wet sand the entire plane starting with the 2400 grit mesh with the 3" x 3" foam block and work my way up to the 6000 grit mesh. When done there should be a dull sheen over the entire model. You may be asking, "What happened? The plane was shinier before I started". Now what?

A couple of years ago I found a used Griot's 3" Random Orbital polisher along with some foam pads and microfiber finishing pads. Using the Turtle Wax® Premium Polishing Compound with the polisher will take the dull sheen to a nice shinny finish with very little effort. Take your time, beware of any edges and always keep the orbital polisher moving. Afterwards, take a soft clean microfiber cloth and remove any leftover residue. You should have a nice shine.

Lastly, to make it really shine, get some carnauba paste wax and with the microfiber finishing pad and polisher, make it sparkle like a diamond! I usually apply 3 coats of wax. Then as the old song entitled *This Little Light of Mine* says, "Let it shine, let it shine, let it shine…"

TIME FOR FINAL ASSEMBLY: Now the exciting part begins! It's time to put everything back together for the final time.

Nylon Hinges: It's time to permanently glue in the nylon hinges using a continuous piano wire pin. Work one wing panel at a time. After removing the manufactures pins, slide both halves of the hinges on to the continuous piano wire pin. Keep the nylon hinges all in the same orientation and put a mark on them with a Sharpie®.

Apply a very small amount of 5-minute epoxy on one side of half the hinge and insert the hinge into the trailing edge of the wing one at a time. It does take much epoxy to hold the hinges into place. Once all the hinges are inserted into the wing, make sure they are all evenly aligned.

Figure 19 – Nylon Hinge with Continuous Piano Wire Pin

Figure 20 – Installing Nylon Hinge with Continuous Piano Wire Pin

Clean up any excess epoxy around the barrel of the hinges with rubbing alcohol. Rotate the piano wire pin continuously and back and forth. Move the free end of the hinges up and down until the epoxy sets up. Make sure that the hinges rotate freely and haven't shifted.

When the epoxy cures, repeat the same steps to install the flap. DO NOT put epoxy on the control wire that inserts into the control horn drivers! Then move on to the next flap and then to the elevators.

Once the epoxy has cured completely, take a Q-tip® and dip it in some light weight oil and "brush" it on the both sides of the barrel of the hinges and wipe off any excess oil. Again the hinges should be free from any stickiness or binding.

Taping Hinge Gap: Before taping the hinge gaps the controls should be really smooth with no binding. I'm a firm believer in taping the hinge gaps at the flaps and elevators on all my planes. I've used 3/4" wide Scotch® Transparent tape but now use 2" clear sealing or packaging tape. I layout a length of tape a little longer than the inboard wing flap on my glass table top workbench and cut it right down the middle making two 1" strips. The packing tape is just a hair thicker than the transparent tape but I find it easier to apply. After taping the hinge gaps the flaps/elevator may be a little tight. Keep working the controls and they should loosen up. There should be no binding in the controls!

Pushrod: Install and connect the pushrods. I use the blue *Loctite*® on the setscrew for the wheel collars and new locknuts everywhere else.

How are the controls working? Are they still *"buttery"* smooth? If not, find out where the problem is and fix it.

Leadout Wires: Tie off the ends of the leadout wires. Again because of the narrow spacing that can be obtained by the adjustable leadout guide, stagger the ends of the leadouts 4" so the line clips do not interfere with each other.

Electrics: Install the Cobra motor, weaving all the wiring from the motor to the ESC to the Hubin FM-9 Timer and to the Thunder Power battery. *Boy there's a lot of wires!*

The Hubin FM-9 timer is attached to the ESC using a strip of Velcro®. Attach the ESC to the ESC mount using two nylon cable ties. With one of the nylon cable ties have it loop around the ESC and the Hubin FM-9 timer.

To keep the (3) motor lead wires from flopping around in the wind, I drilled a small hole near the bottom of the motor mount and made a small cable clamp from a plastic key card. Attached the clamp to the side of the fuselage with a small wood screw.

Bolt the ESC mount and the battery holder using 4-40 bolts with washers and nylon locknuts.

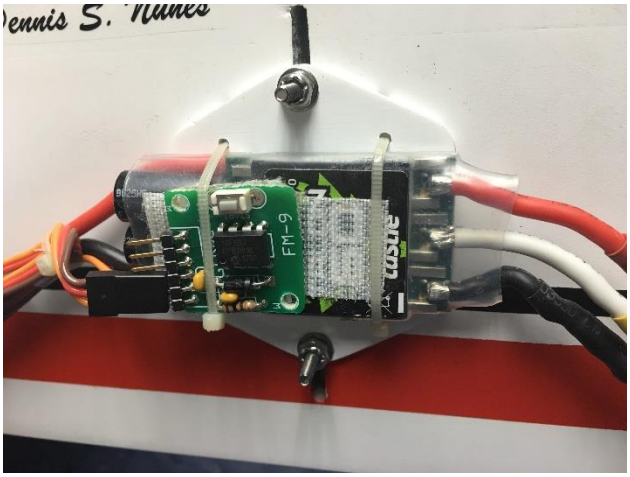


Figure 21 - Installation of ESC, Timer & Motor

Figure 22 - Battery Holder Ready for a Battery

Are the settings for the ESC and the Hubin FM-9 timer been set? For the first several flights I set the timer for 60-90 second flights. This is done just to insure that everything is working properly and make whatever trim adjustments that need to be made.

Tip Weight: Add about 3/4 oz. of tip weight to start with, adjusting the leadout about 3/4" behind the CG.

Center of Gravity: Make sure that the CG is where it is shown on the plans, you may want the CG a hair further forward to start with. Hopefully you can adjust the battery to get the CG where it needs to be and not have to add any additional nose or tail weight.

Line and Handle: For every new plane I make or purchase a new set of lines and a new Cox/Resinger carbon fiber handle. Remember if you used the staggered leadouts you will have one line longer than the other. I'll start out with lines that are .015" x 63' long (one line 4" longer that the other). At home in my yard, I'll unreal the lines and attach them to the handle and give each line a good strong pull and give everything a good stretch.

Then attach the lines to the plane, check and adjust for neutral and give everything a "pull test". If it going to come apart, I rather have it come apart at home then at the field (*less embarrassment*).

Take your time! Dot your "I's", cross your "T's", check and double-check everything. There is nothing worse than to hurry up to put a plane together and forget to do something really critical that leads to the demise of a new plane on its maiden flight. *Again, check everything!*

IT'S TIME: Now it's time to have some fun and make that maiden flight and enjoy the fruits of one's labor. One of the advantages of electric power is that you can program the timer for short 1-minute flights. And with a series of "test" flights have *Circulas 46 IIe* trimmed in no time. Remember all those "bench flying" sessions you had? Now's the time to put it all together and let it rip and enjoy the moment!

And it's also time to bring this adventure of *"Turning to the Dark Side"* to an end.

Turning to the Dark Side

Part 7 – Final Assembly & Finish

IS IT *REALLY* TIME TO BRING THIS ADVENTURE TO AN END? As they say, *"All good things must come to an end"*. And what an adventure it has been! I hope you've *enjoyed* it, found some *humor* in it, as well as something *informative*.

There are certainly many roads to this adventure. I've just taken you down one of those roads – *My road*. You may choose to do things differently and that because there are many roads to choose from. It's up to you – *it's "your" road.*

Is everything that I talked written about or shown in these series of articles the way things have to be done? Of course not. Are there things that I would change if I started all over again? Absolutely. These series of articles is just about what I went through in designing, building and getting everything together for my first electric powered plane.

My main objective in documenting all this —— Is for someone, perhaps you, who may be in the same situation that I was in, where you are hesitant for whatever reasons to make the switch from IC power to electric power – ***DON'T BE!***

But is this really the end of the adventure? No. In fact, it's the beginning of a new and an exciting one – the flying and trimming of an electric powered plane – *Circulas 46 IIe!* In any case, I hope you to decide to make the same adventure as I did by *"Turning to the Dark Side"* and build something, perhaps a *Circulas 46 IIe* for yourself.

There is a huge *gratitude of thanks* that I owe to a number of individuals in carrying out this adventure.

First and foremost, is to my wife of 47 years, Cynthia. I appreciate how the golf commentator David Feherty always refers to his wife as, *"She Who Must Be Obeyed"*.

Well, *She Who Must Be Obeyed* has allowed me the opportunity to take this adventure. But what I appreciate most about her is, first of all, she's are a caring person. Second, she's an unbelievable wife. Third, she is an outstanding mother. And lastly, she's a loving grandmother. But the "best" thing I've discovered is our 47 years of marriage is this – *She is the "greatest" partner in life that I could ask for!* – ***I LOVE YOU!***

To those who have helped and assisted me during the past 5 years as I returned to this outstanding hobby and got me hooked on *Precision Aerobatics*, and to those who "held my hand" during this adventure, Chris Cox, Alan Resinger, Jim Aron, Paul Walker, Ted Fancher, David Fitzgerald, Brett Buck and Lanny Shorts, just to name a few —— ***THANK YOU!***

And a special ***"THANK YOU"*** goes to Al Heiger, for putting up with me and who made these articles available to you in the Valley Circle Burner's *NAG Newsletter*. Keep up the great work Al!

I anticipate at some point in time to hopefully write a follow-up article on the trimming and flying of *Circulas 46 IIe*.

As my favorite cartoon character Bugs Bunny would say – *That's all folks!*

As always, if you have any questions, comments or feedback, please send an email to: circulas46iie.2020@gmail.com. I will try to respond back to you as soon as I can.

———— *SPECIAL OFFER* ————

An updated 86-page single PDF file of the entire series is available for *"free"* for those who are interested. This PDF file has been formatted for double-sided printing. Contact me at the email address provided to receive it. You will need to have an email service that can handle a file size of 11.5mb.

Also, for those who may be interested in purchasing full-size PDF plans of *Circulas 46 IIe:* A full-size single sheet PDF file, as show at the end of *"Turning to the Dark Side – Part 1 Introduction"*, is available for $5.00. A 5-sheet fully detailed PDF file is also available for $10.00.

For more information, send an email to: circulas46iie.2020@gmail.com.

In the meantime, enjoy the journey and may there always be light winds at your back with a plane tight at the end of the lines.

Dennis S. Nunes

THE "COST" OF THIS ADVENTURE: For those who may be interested. How much did this adventure cost? Here is the breakdown. The prices shown are "rough" numbers that do not include shipping expense or sales tax. This is not a detailed list but is only provided just to give a general idea of the expense involved in starting out from scratch, with nothing, and building a new electric powered planes. Your cost may vary. Just remember the old saying, *"The difference between men and boys is the price of their toys!"*

Description	**Amount**
Wood Materials (balsa and plywood)	$145.00
Miscellaneous Hardware (bellcrank, pushrods, wheels, spinner, etc.)	$100.00
Electrical Items (motor, timer, ESC, batteries)	$450.00
Electrical Items – *One Time Expense* (Timer, Programmers, USB Kit, Battery Charger, Parallel Board, Power Supply)	$400.00
Finishing Materials (Dope, Thinner, etc.)	$150.00
Total Expense	**$1245.00**

Designer, Builder & Writer (though not a Writer) with Circulas 46 IIe (left) and Circulas 46 (right)

Designer, Builder & Writer with Circulas 46 IIe

Turning to the Dark Side

The Building of Circulas 46 IIe

Part 8 – Trimming & Adjustments

A Precision Aerobatic Control Line Model Airplane

– Electric Profile –

Written by Dennis S. Nunes

October 2020

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TRIMMING & ADJUSTMENTS

It's taken some time to put *Part 8 – Trimming & Adjustments* of *"Turning to the Dark Side"* together but I finally got it done.

It was on June 8, 2020 that *Circulas 46 IIe* took to the air for the first time on a very short maiden flight. However, prior to this flight a through preflight check and inspection was done by two area experts, Dave Fitzgerald and Jim Aron. I was asked a whole host of questions and as a result I needed to make a couple of last minute adjustments before the maiden flight. Here were some of the questions that I was asked that needed to be answered before putting *Circulas 46 IIe* in the air.

Where the CG located? First, I thought that the CG was about right, but because of my inexperience with electric planes (that large learning curve again) it was recommended to move the CG even further forward than I thought it needed to be. No problem. With the adjustable battery holder, I loosen the bolts slid the unit forward about 1". Checked the CG and it wasn't enough. Move the battery holder another 1/4" and it still wasn't enough. We ended up moving the battery and the battery holder as far as it would move to the forward position and it was determined that it should be good to go. It was mentioned to me that all dimensions in locating the C/G should be measured from the trailing edge of the wing. So the C/G is now 6.25" forward of the trailing edge.

How far back did you place the C/L of the leadouts? Initially I had it about 3/4" behind the original C/G. It was recommended to move the leadouts back further than I had them. Measuring this distance from the trailing edge of the wing, the centerline of the leadouts was set to 3.375" forward of the trailing edge. An interesting problem resulted because of this location. More on this later.

How much tip weight was installed? Three quarters of an ounce was initially installed in the weight box. However when I checked the tip weight at home by balancing the plane near the centerline of the fuselage and notice how fast the outboard wing drops. It was good. However the only problem was that I didn't do this test with a 10.5 oz. battery strapped to the inboard side of the fuselage where the battery holder is located. I was very surprised how much the inboard battery effected the amount of tip

weight required. In fact when doing the simple test with the battery installed, the outboard wing did not drop at all! So it was determined to add an additional 3/4 oz. of tip weight to start with. Again, more on this later.

How much does the plane weigh? It was at 64.25 oz. with the additional tip weight.

What prop was I using and did I have the motor rotation correct? For the first flight I used an APC 11 x 5.5e 2-blade tractor prop and I had to prop rotation set correctly.

What was the motor RPM and flight time set to? The motor was set to 9702 RPM. A 1-minute flight time was set which was the timer's lowest setting.

This sounds like I was bombarded with a ton of questions – and I was. But these were some very pertinent questions that needed to be asked and answered in order to make sure everything is correct in order to have a successful maiden flight.

THE MAIDEN FLIGHT: With all the adjustments done and all questions asked and answered it was time to roll out the lines and put *Circulas 46 IIe* in the air for its first maiden flight. The wind was starting to pick up but steady at around 8-10 mph. I was hoping for a little less wind but you can't have everything.

Jim Aron and I pulled the plane out into the circle. I connected the battery and got the correct beeps. Pressed the timer button and got the proper melody (beeps) and a short, quick rotation of the prop (in the correct direction!) and I was off to the handle. Thirty seconds later the motor started to spin up but I could barely hear it. If you recall, the sound was one of several of my issues with electric planes. *Oh well!*

I gave Jim my hand signal to release the plane and off it went to a very nice roll and takeoff. It was a little sensitive and bounced around in the wind a little. *Circulas 46 IIe* was airborne for the first time!

Circulas 46 IIe looked pretty good on the end of the lines from what I could see and had good line tension but was flying too slow. Then someone yelled out 5.8 seconds for the lap time. I was hoping to be around 5.2 to 5.3 second laps.

According to my watch I had 30 seconds of flight time left. I decided to take *Circulas 46 IIe* inverted. I did a nice slow easy turn and flew inverted for 2 laps and then brought it back around with another slow and easy turn. It appeared to turn the same amount in both directions. This still needs to be checked out further once we get the lap speed adjusted.

The Cobra 3515/18 motor did it's "sag" in RPM and 5 seconds later the motor stopped. *Circulas 46 IIe* floated in for a very nice landing. A successful maiden flight and a very good feeling as we didn't crash!

For the second flight it was decided to increase the RPM of the motor from 9702 to 9830. The lap time increase but was still too slow at 5.7 second laps. I did the same maneuvers as the first flight, but this time I noticed that the outboard wing was up when *Circulas 46 IIe* was inverted and appeared to be a little low when upright.

We were done for the day as the wind started to whip up and blow really hard. *Circulas 46 IIe* made its first flight and we knew we had to make some adjustments. We were looking forward to the next flying session.

POST FLIGHT ADJUSTMENTS: When I got home I gave some thought to the battery holder located that is on the inboard side of the fuselage. The whole purpose of placing the battery on this side was to take advantage of centrifugal force assisting in keeping the battery in place and reduce the stress to the Velcro® straps. But having to add additional tip weight to offset the battery location wasn't ideal. Could I move the battery to the outboard side and the ESC/Timer to the inboard side of the fuselage?

Part of the design of the battery holder was to make it very adjustable. But what I didn't count on was making it *reversible*! Again, looking at it I reasoned – *Why not?*

Figure 1 - Battery Now on the Outboard Side

Sometimes is better to be more fortunate than good. Fortune was on my side as I was able to move everything and place the battery on the outboard side of the fuselage and move the ESC and timer to the inboard side with no issues at all.

What about the extra tip weight? I'm going to leave the extra tip weight in for now, but hopefully I should be able to remove some of that additional weight.

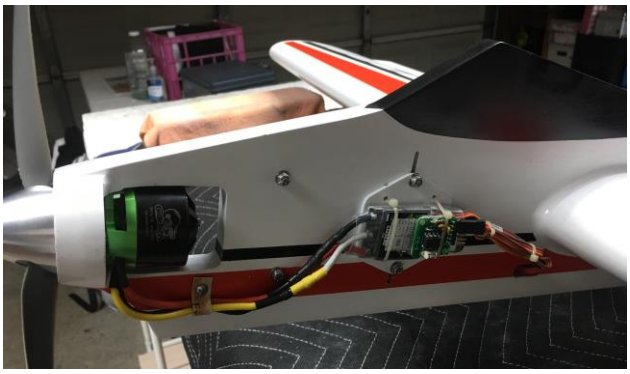

Figure 2 – ESC/Timer Now on the Inboard Side

The other thing I decided to change was to replace the single strip of 5/8" Scotch™ 3M™ SJ4570 Dual Lock Low Profile Adhesive Fastener on the battery holder and my batteries with a double strip. This increased the area of attachment between the battery holder and the battery allowing the battery to be firmly attached to the battery holder. I surely do not want a battery to come detached in the middle of a flight! Surprisingly, now when I press the battery into the battery holder it "snaps" solidly into place and doesn't move at all.

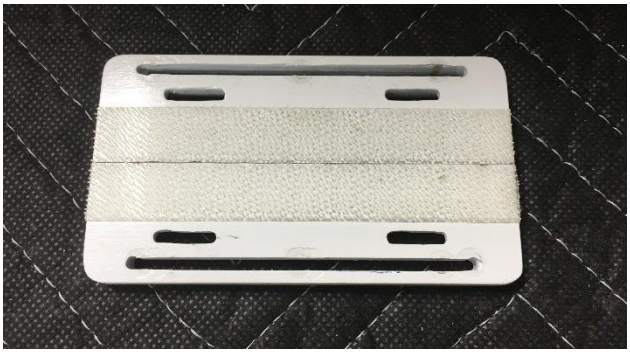

Figure 3 – Double Strip of Dual Lock Fastener

This arrangement reduces the strain that would be put on the Velcro® straps due to centrifugal force. The Velcro® straps now became the secondary means of keeping the battery in place.

Next, rather than using plain Velcro® straps, it was recommended to use the Scorpion® Lock Straps (small size) with a buckle at one end. These straps make it easier to cinch down the battery to the battery holder. The battery is not going anywhere!

Figure 4 –Scorpion® Lock Strap

I also wanted to move the battery holder as far forward as it would possibly move. This placed the original two 4-40 mounting bolts of the rear end of the battery holder with no support on the front end of the holder. So I decided to add two more holes for another set of 4-40 bolts nearest the motor mount on the opposite end of the battery holder. The battery holder is now soundly mounted to the fuselage.

The other adjustment made to *Circulas 46 IIe* was to "tweak" the flaps using the Walker Flap Adjustment Device (WFAD) to get the wing level. A full turn of the 4-40 bolt and the flaps were adjusted. No bending of the flap control horn or any odd facial expressions. This device is the cat's meow!

AUGUST 31, 2020: In preparation for attending my first NATs in July my trimming and adjustments on *Circulas 46 IIe* had come to a screeching halt.

Finally a small group of us (Jim Aron, Brett Buck, Dave Fitzgerald and yours truly) got together in Napa to do some flying. Jim brought out a new SV-11 ARF. This of course was not your ordinary-every-day-run-of-the-mill SV-11 ARF. No this ARF was modified for, not just one electric motor – no not for Jim. He decided to install two electric motors! Yes a twin and to describe it in Jim's own words —– *Twins are very cool!*

Strangely enough Jim was experiencing the exact same issue that I was dealing with – slow lap times. For my next two 1-minute flights I tried a 3-blade Cox/Resinger 11" x 5.5" carbon fiber prop. I bumped up the RPM on the timer to 10542 but this would only giving me 5.6 second laps. My goal was to be at 5.3 seconds.

I changed the timer again and increased the RPM to 10716 but the lap times remained the same. Something was wrong! Jim decided to check the actual RPM with a tachometer. With the 3-blade Cox/Resinger 11" x 5.5" prop all we could obtain on the ground was 9600 RPM. We were nowhere near the 10716 RPM that the timer was set to!

Not making any other changes, we then put on the original 2-blade APC 11" x 5.5" prop and we got 10,700 RPM! This was quite a difference between the two props. So we head over to the circle, get the plane in the air and now I'm getting 5.2 second lap time and *Circulas 46 IIe* has come to life! The next flight, I reduced the timer's RPM down to 10620 and was at my goal of 5.3 second laps. *Fantastic!*

One of the advantages when it comes to trimming and adjusting an electric model over an IC model is that I can set the timer for a very short 1-minute flights. This is more than enough time to test lap times and/or check what the plane is doing. This allowed me to get (3) 1-minute flights on a single battery with no issues and still had 33% battery capacity remaining.

I was very concerned with the battery capacity especially when adjusting the RPM higher and higher. I next adjusted the timer for 3-minute flights and was able to get 2 flights per battery with 30% capacity remaining. Battery capacity seem to be pretty good.

Now with the lap time's set and battery capacity looking good, we continued to trim *Circulas 46 IIe* even further. The first thing I noticed was the plane was "hunting" quite a bit and was very difficult to keep level. Hunting in an IC model is *usually* the result of something rubbing or binding in the controls. This also applies to electric planes as well, in fact, it effects seemed to be more pronounced with electric planes.

Now get this. Brett and Dave said they could hear something rubbing when Circulas 46 IIe turned. If I were flying an IC plane they would have never heard that noise. Maybe there is another advantage after all with a "quite" electric setup?

After the flight we checked out the controls again. In moving the leadout cables back and forth it sounded like the noise was coming from the cables passing through the leadout guide. However, upon peering down the leadout slot we discovered that the forward leadout cable

was rubbing against the vertical shear web located between the upper and lower spars. If you recall, we moved the leadouts back a large distance *prior* to the maiden flight. For whatever reason I didn't check the clearance as I thought I had enough room to move them back. *That's what I get for thinking – rather than checking!*

The leadout position was 3.375" from the trailing edge. The plane was flying in a "yawed out" position that was very noticeable, which I didn't like. But due to a lack of clearance from the shear web and no way to fix it in the field I decided to move the leadouts forward in order to keep flying. This also gave me the opportunity to see how *Circulas 46 IIe* would respond to a "forward" leadout position.

The C/L of leadouts was set at 4.50" from the trailing edge and cleared the vertical shear web. On the next flight, most of the hunting along with most of the yaw was gone and I still had good line tension. I will need to cut out the vertical shear webbing if I want to move the leadouts further back.

On the previous flight I noticed that the control response was a little slow to my input, but this was quickly remedied by moving the line spacing out further to the next two set of holes in my Cox/Resinger carbon fiber handle. I also needed to adjust the handle for a more neutral setting. The up line was just a tad long, a shorter line clip fixed that issue. It was nice to see that *Circulas 46 IIe* is turning equally in both directions with exceptionally sharp corners on the square maneuvers!

Now it was time to put *Circulas 46 IIe* through a full pattern. The wind was starting to pick up and I felt this would be a good test to see how the plane handled the wind. I set the timer for a 5:15 flight, put in a fresh battery and put *Circulas 46 IIe* through a full pattern. I was extremely pleased how *Circulas 46 IIe* was performing. The square corners were a delight as I hit them pretty hard to see what would happen. She just snapped around with a slight wobbling due to too much tip weight but no stalling and tracked really well coming out of the corners. Line tension was a little light at the top of the circle, but flyable. The first pattern was successful and I was very satisfied.

After the flight I checked the battery capacity and was at 25%, which was good. Motor and battery temperature was slightly warm to the touch but not hot. That concluded our flying session for the day.

LESSONS LEARNED: So what was the *"Lessons Learned"* for this session? There were several things. (1) Apparently we either exceeded the limits of the system with the Cox/Resinger 3-blade prop or the prop is inefficient, not sure which. (2) The RPM setting on the timer and the actual RPM can be different depending on the prop that is used. We adjusted the RPM on the timer until we got the needed lap times and wasn't too concerned as to how high we needed to adjust the RPM on the timer as long as he have sufficient battery capacity. (3) The APC 11" x 5.5" prop appears to be a very efficient prop as it was very close to the RPM set on the timer and worked very well.

Though the first flying session was extremely short with just two 1-minute flights and with my lack of experience in dealing with electric models, it was still a very valuable lesson. Of course I was hoping for a better and longer "maiden" flying session. With a new plane, the wind picking up and lack of time, that's all that could be done during this session. But it gave me an appreciation of the "large learning curve" that I would be experiencing and that *patients* would be needed *(though this in not one of my better virtues)*. I have to keep telling myself that Rome wasn't built overnight and certainly *Circulas 46 IIe* was not going to become like its predecessor in one or two flying session.

POST FLIGHT ADJUSTMENTS: Before the next flying session I need to do a several adjustments. First, I will need to remove some of tip weight. If you recall, I added 3/4 oz. of tip weight when the battery was located on the

inboard side of the profile fuselage. The battery is now located on the outboard side of the fuselage.

Second, is to cutout the vertical shear web to clear the forward leadout cable just in case I want to move the leadouts further back. BTW, to remove the shear web I took a 36” long length of brass tubing and sharping the end and sliding it through the leadout guide opening and chipping away at the shear web. Yes, I have some balsa chips floating around in the wing!

Third, to help with the hunting issue in level flight, it was recommended to add “trip strips” along the length of the leading edge on both the top and bottom of the stabilizer. Jim Aron happened to have a set of trip strips that he gave me. What are “trip strips” you may ask and what do they do?

These trip strips were made of a vinyl product from Decorative Films listed as SX-SC0060 Crystal Clear Vinyl Static Cling film which is used on glass windows. They are attached to the stabilizer by means of “static cling”, which makes them simple to install.

The serrated edge is cut with a rotary cutter equip with a “pinking” shear blade and a straightedge. This cutter gives the zigzag edge. The trip strips are about 3/8” wide.

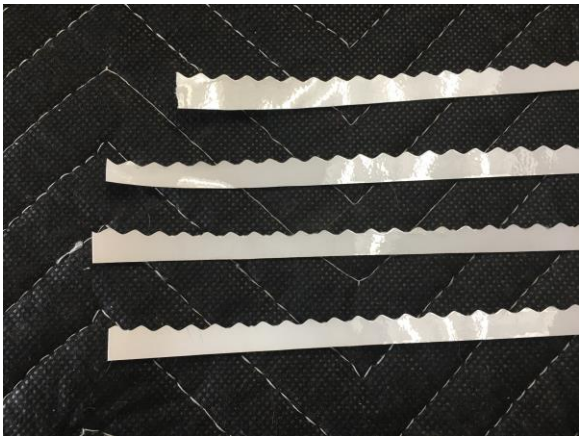

Figure 5 – Trip Strips

To install the trip strips you need to have a very smooth and clean surface. Next, spray the surface with some window cleaner, peel the backing, and lay the strip in place. Squeegee the strips into place to removing the excess cleaner and any air bubbles trapped underneath the strip. My strips were laid 1/4" behind the leading edge of the stabilizer.

Figure 6 – Installed Trip Strip (maybe difficult to see)

What do the trip strips actually do? As far as what trip strips do and how they work other than to disturb the airflow of the surface is beyond my simple mind. All I know is that they work. But more on this later as something interesting happens.

Lastly, currently I have zero motor offset. I have decent line tension up to about 75 degrees, but lost some tension at the top on the overhead eights, hourglass and the upper portions of the 4-leaf clover. So I want to add about 2 degrees of motor offset.

So here is a list of changes done to *Circulas 46 IIe* that will be tested the next time out:

- Removed 1/2 oz. of tip weight
- Moved leadouts forward to 4.75” from trailing edge
- Added about 2 degrees of motor offset
- Chipped away vertical shear web for leadout clearance
- Added trip strips to the leading edge of the stabilizer on both the top and bottom

LESSONS LEARNED: With the second flying session, once we got the proper lap times, I

was given a sneak preview of the full potential of *Circulas 46 IIe*. And now I can't wait for the next flying session!

SEPTEMBER 14, 2020: I decided to take a trip to Napa by myself. I put in six flights to see if the latest changes did any good. I would have liked to have done more but all I had was six batteries and didn't have any means to recharge them!

Circulas 46 IIe was still hunting a bit. It's hard to tell if the trip strips made any difference. On the third flight I did move the lines attached at the handle one hole closer together and that helped a little. The 2 degrees of motor offset did help improve the overhead line tension.

On the fifth flight I decided to move the battery on the holder as close as I could get it to the motor and stuck on an additional 1/2 oz. of weight to the nose. I also move the leadouts a 1/4" forward. *This resulted in a huge improvement!* No more hunting and *Circulas 46 IIe* was very steady at the end of the lines. I really noticed the difference once the motor stopped. It just glided down nice and smooth and made a very nice landing. Before when the motor stopped, it would "float" on me during the landing and was difficult to control.

I sure wished I had some more batteries as I was really enjoying flying plane. Oh well!

When I got home I wanted to verify "exactly" where the C/G is located. To do this I made up a simple "trapeze hanger" with a plum bob. The C/G is located exactly at 6.75" behind the trailing edge of the wing. The C/L of the leadouts are now at 5.00" from the trailing edge of the wing.

Figure 7 – Circulas 46 IIe Suspended from Trapeze

As a result I'll make a new battery holder with new strap locations so I can better secure the battery further forward but not touching the back of the motor. I also want to try and hide any additional nose weight between the battery holder and the fuselage, if possible.

Figure 8 – Plum Bob Indicating C/G

LESSONS LEARNED: I firmly believe that the majority of the hunting issues that I was experiencing was the result of being too tail heavy and the leadout to far aft. Once I got the C/G forward *Circulas 46 IIe* settled down very nicely. Interestingly, in my initial research of electric planes, the forward location of the C/G was one item that stood out as different from its IC counterpart. So far I'm finding out that this is still true.

Also the location of the C/L of the leadouts being well behind the C/G was also another area that that would be different than an IC plane. The C/L of the leadouts are now 1.75" behind the C/G, which is further back than my original IC *Circulas 46*, but nowhere near what was suggested on the maiden flight. For the maiden flight we located the leadouts 3.375" from trailing edge which was several inches behind the C/G. I my opinion, this was too far back.

SEPTEMBER 19, 2020: I met up with Fred Constantine and James Dean who is new to the area to do some flying. Again I put in six flights because that's all the batteries I currently have. The new battery holder worked out well as I can move the battery closer to the motor.

Circulas 46 IIe is flying extremely well and continues to turn really tight. I'm getting a really good feel for this plane and it's quickly becoming one of my favorite planes to fly.

I still want to move the C/G further forward and try to hit that "point of no return". I'm going to add another 1/2 oz. of weight to the nose and see how the plane responds. And I still need to "play" with the leadout location as well.

SEPTEMBER 26, 2020: A small group of us that included Fred Constantine, James Dean, Jim Aron, Dave Fitzgerald and myself showed up at Napa to do some flying. This proved to be a very interesting day with some very strange things happening. Jim Aron was trying to exorcise whatever it was in his twin engine (or is that motor?) SV-11. He was still having issues with too slow of lap times and trying to figure out Igor's system all at the same time. All I can hear was Jim saying, *"This setting can't be that high, it doesn't make any sense"!*

Fred was buzzing around the circle with electric Oriental and he was talking out loud saying, *"I got to slow this thing down"!*

James was getting the engine in his 30-year old plane acclimated to the near sea level elevation. He previously had been flying at 4400 foot elevation! Things were going really well until the wind shifted expectantly on coming up out of the reverse wingover. The plane stalled and he lost complete control. The plane power dived straight in and left a golf-ball size divot in the asphalt. The plane was completely totaled! I'm not sure if he was even able to save the engine. Bummer!

Dave Fitzgerald was experimenting with trip strips made of .005" low-tac transfer tape on the wing and removed the vortex generators. He wasn't very pleased with the results after the first two flights. Dave decided add another layer of strips made out of clear packing tape on top of the existing ones.

So out comes the cutting board, cutting wheel and straight edge and makes another set to lay on top of the existing strips. This increased the total thickness to .008". He puts up a flight and I'll let Dave explain his results as he put it in his email.

"Wow, holy cow what a difference! Major increase in stability, more corner, less control loading, I could pop the corners, or fly through them. The outside squares, had a VERY hard flat bottom. Almost Ryan like. In short, I liked it a lot".

Figure 9 – Cutting Trip Strips in the Field

Dave was satisfied with the outcome of this test. After two flights Dave placed his plane in the pits and allowed the rest of us to put in our flights.

It was a fairly warm day in Napa. After others put in their flights, it was Dave's turn again to fly. He starts his engine and off he goes. Then something happened that I never seen before. As Dave is flying the pattern he does one inside square loop and then levels off. After a couple of laps tries outside square loop and then flies level until he runs out of fuel. The first thing I asked was, *"What's wrong? I've never seen you stop flying the pattern and fly out the tank".*

Something happened alright. Dave said the plane rolled violently in the first corner of the square loop. He thought that he may have lost the trip strips on the top of the outboard wing. However upon an examination all the strips were intact. This can be very frustrating when something unexpected happens and you don't know what it is.

It was later when Dave was home that he discovered that the warm temperature heated up the strips and softened the adhesive that allowed a partial separation at one spot on the top of the outboard wing, causing the strip to act like a spoiler. What a relief to find out what the problem was! Dave's next step is to make the strips out of Gorilla® packing tape which he used on the strips for the stabilizer all of last year with no separation issues.

It was now my turn to fly. I was pretty confident that the changes I made prior to the last flying session shouldn't have made a big difference. However, on my first two flights my "hunting" issue returned, I couldn't keep the plane level! What's going on now? Nothing I did should have caused the hunting issue to return.

Jim recommended adding 1/4" wide vinyl tape to the top and bottom near trailing edge of the elevators. I also decided to add a 1/2 oz. stick on weight to the nose. Dave had overheard us talking about the hunting issue and decided to run his fingers over the leading edge of the stabilizer and notice that there wasn't a trip strip on the bottom side of the outboard stabilizer. He says, "*You know you need these on both sides of the stabilizer, right?"* We all had a good chuckle. But sure enough the trip strip was gone *(Don't you hate it when someone states the obvious and is right?).* The trip strips were on the top and bottom on the inboard side of the stabilizer. Somewhere I lost the trip strip on the bottom of the outboard stabilizer. Who knows where or when it departed.

Jim comes to the rescue with another trip strip and puts it on. I take a couple of small pieces of clear tape and tape down the ends of the existing strips so they don't come off. I put up another flight – the hunting problem is completely gone! *Circulas 46 IIe* is flying well again even as the wind starts to pick up. Trip strips rock!

However, I did notice that the additional 1/2 oz. of nose weight was a bit too much as controls were became sluggish. Ah, I finally hit the "point of no return" with the forward C/G location.

For the fourth and final flight I removed the 1/2 oz. nose weight, check all the trip strips and *Circulas 46 IIe* is now flying extremely well again. I'm a very happy camper!

Turning to the Dark Side

Part 8 – Trimming & Adjustments

LESSONS LEARNED: This was a very interesting day to say the least, especially with the use of the trip strips. What Dave and I went through I thought was truly amazing on just how something so small and insignificant can have such a powerful and dynamic effect on our planes.

I'm still not sure if the 1/4" wide vinyl tape improved the flying characteristics of my plane. I'm going to remove the tape and fly the plane again and see if I can detect any difference.

In this instance I firmly believe that the missing trip strip was the sole cause of my hunting issue. I just wish I could have found out when the trip strip came off and where it went.

I going to make another set of trip strips using clear Gorilla® tape. This tape is thicker than the normal packing tape and should stick better to the stabilizer/wing surfaces. I also want to experiment with the trip strips by added them to the wing instead of using VG's. For me, VG's are a pain to deal with, if you just look at them the wrong way they fall off. They also make it difficult when it comes to wiping down the plane.

So now I need to buy some Gorilla® tape, a cutting wheel and special cutting wheel blade and start making my own trip strips.

IN CONCLUSION: In hindsight I asked myself, is there anything that I would do differently if I were to build another *Circulas 46 IIe*? Not much! The only thing I come up with is that I would give some serious consideration to extending the nose of the fuselage. I think an additional 1" would be sufficient, making it 12" long instead of 11". This should allow the C/G to be more forward without having to add additional nose weight. It will also give plenty of room for the battery as now it is almost touching the back of the motor

The trimming and adjustments of a control line model airplane is an ongoing process that never ends. But I need to stop somewhere in writing about this unique experience.

I am ecstatic with the outcome of this adventure of "*Turning to the Dark Side",* the developing, building and flying of my first electric plane! It's time to put *Circulas 46 IIe* to the full test and enter a contest somewhere to see how it performs under pressure. I can't wait!

I hope that you have enjoyed reading about my wayward adventure and that you to will try *"Turning to the Dark Side"* if you haven't done so already.

Enjoy,

Dennis S. Nunes