F.8L Falco Construction Manual

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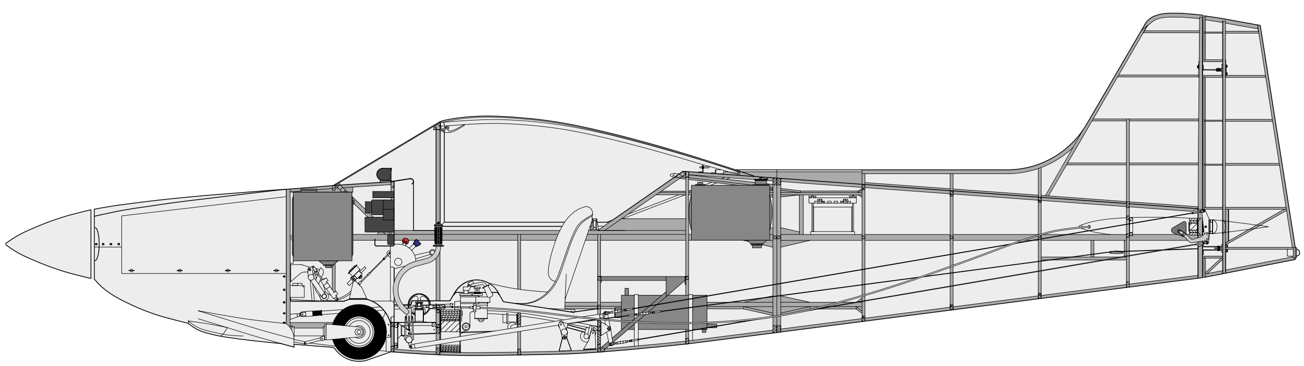

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List of Effective Pages
Revision 4
March 1, 2002

The F.8L Falco Construction Manual was originally written in 1984, and since then portions of the manual have been revised in 1986 and 1989 to correct minor deficiencies. At the time of these revisions, a system of tracking revisions had not been fully adopted, and Revision 1 and 2 were identified only by dates on the bottom of each page.

Revision 3 is a completely new version of the manual because the illustrations, previously pasted onto the master pages with rubber cement, are now all an integral part of the document on our computers, and the manual has been extensively reformated with a new typeface and layout style. However, the content of the manual is essentially unchanged from Revision 2.

Revision 4 is a further refinement with larger type, formatting changes and minor changes to the manual.

This construction manual includes what we have written to date. In the future, it will be expanded to add more chapters. When we have the time, Chapters 11, 12 and 13 will be expanded to take you through the construction of the wood parts on a step-by-step basis with many illustrations. Other than that, the construction manual is essentially complete through Chapter 28.

For additional information, please visit the Falco Skunkworks at our website. There we have a large collection of articles, notes, hints and tips on building a Falco.

Dates of issue for original and revised pages are:

Original	June 10, 1984
Revision 1	June 10, 1986
Revision 2	April 4, 1989
Revision 3	October 10, 1995
Revision 4	March 1, 2002

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Preface

It is customary to acknowledge those who have assisted in the writing of a book, however this manual is the result of assistance from hundreds of Falco builders. Indeed, it is a rare builder who has not made some contribution to our collective understanding of the construction of the Falco. We are all indebted to those who have contributed their ideas and comments. If you find this manual of assistance, remember that much of what you are reading has been the result of lessons passed on to us by Falco builders. If you have any comments, ideas or new procedures for assembling the Falco, please let us hear from you so that future builders can benefit from the lessons learned by previous builders.

Alfred P. Scott
President
Sequoia Aircraft Corporation

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Preparing for Construction

"Perfection is finally attained not when there is no longer anything to add, but when there is no longer anything to take away."
Antoine de Saint Exupéry
Wind, Sand and Stars

Welcome!

Welcome to the Falco. Like many others before you, you have fallen under the spell of this lovely airplane. You are about to embark on a unique and enjoyable experience.

We look forward to working with you, hearing of your progress and finally that you have flown your Falco. We hope you will find, as we have, that the Falco attracts a special type of person.

Where to Start?

The hardest part of building a Falco is getting started, so if you want to build the Falco, send your order off now for the tail group kits and go to work.

The first step is to study the construction manual and the plans. You can expect to feel completely overwhelmed at first. As you go over the drawings, your mind will go on "overload". Don't worry, this happens to everyone… and it doesn't last. At some point, you will begin to understand the drawings. Little details which escaped your notice at first will start to make sense. You can expect the project to become something of an obsession, and eventually, as all Falco builder have done, you will even find that you will see the airplane in your dreams!

A lot of the Falco drawings are for parts which you will buy, so don't spend a lot of time studying them. Concentrate on the parts you will make and the assembly work you will do. There will be many details which will not be clear at first, but they will come into focus as you approach the assembly. So don't spend a lot of time worrying about things that lie far in the future. Concentrate on the first stages of the construction, which will be the tail group.

Family and Friends

It would be a good idea to discuss the Falco project with your family in advance. While you may be thinking of the project simply as something that you want to do, you should not forget that the Falco is likely to consume a lot of your time and energies. It will be a happier experience if everyone in your family is behind the project and understands that you will be spending a lot of time in the shop.

Friends are a different matter. In the early stages of the project, you will find friends and acquaintances will not readily understand what you are doing. The notion of building an airplane is foreign to them, and it will tend to sound like a pipe dream. Once the project is underway, however, you will find that people can relate to an actual airplane under construction better than they can to an idea. As the Falco takes shape, you will even find that visitors become something of a distraction.

Your Shop

You will need a nest for your bird to hatch, so you should make plans for the shop and equip it with tools. If you are able to have the shop at home, you will be able to spend more time on the project. Your family will enjoy having you around and being able to check in on you. Nothing is worse than building an airplane at the airport or some other remote location. Traveling to and from the project will become a problem, and your family will come to resent the thing that keeps you from them.

What to Make?

One of your early decisions will be which kits to buy and which parts to make. For most builders, the decision is whether to make the wood parts or to buy them. We would like to offer some advice.

Except for the main wing spar, making all of the wood parts is fairly easy; however, they take a *lot* of time. It is difficult to understand from looking at the plans how such parts could take so much time, but they do! In fact, building all of your own wood parts can nearly double the building time.

On the average, builders take from nine months to a year and a half to make the wood parts. This is the average— some have taken over three years. You should not underestimate the length of time that it takes to make these parts.

A funny thing happens to builders who build all of the wood parts. At first, they send us lively letters about how easy it was to do. Later the letters slow down. Some builders stick with it and go on to finish the airplane, but a lot just burn out.

Many builders are tempted to build all wood parts because they arrive at the conclusion that the kits are too expensive. While we hear this from potential builders and from those just embarking on the construction of the wood parts, we have yet to hear it from someone who has actually made the Falco wood components. In fact, we have heard many such builders confess that they find the prices of the wood parts very fair, now that they know what it takes to build the parts. Most builders report that they save about $1.00 to $1.50 per hour by making their own wood parts.

There are, however, those builders who should make their own wood parts. If you simply do not have the money, then the only way that you can build a Falco is to make as much as you can. If you just *want* to make all the parts, then do it. Some builders find woodwork extremely pleasurable. If you find pleasure in working with wood, you will have plenty of pleasure just assembling the aircraft, even if you purchase all of the wood kits.

Our advice is to not worry too much about all of this. Take things one step at a time. Start with the tail group. Our experience is that builders who purchase the tail group kit never revert to making their own wood parts. The project takes shape much faster. On the other hand, we notice that the longer builders work on the Falco, the more kits they buy. It seems to be easy to get tired of making things.

We remember the Falco builder who decided to make his own tail group. Nine months later, all of the parts were finished and ready for assembly. The builder has since purchased all of the remaining wood kits. In the same length of time, we have seen kit builders complete the entire wood structure of the Falco.

Setting Standards

Before you begin your Falco, it is a good idea to make a resolution on the quality of the workmanship to go into your airplane. You cannot build a perfect airplane—there are bound to be little errors—but you should set your standards early. We suggest that you set them very high.

If you take great care to do everything well, you will enjoy the construction of the aircraft much more than if you are sloppy.

When your Falco is finished, you will find it difficult to look at the airplane without seeing the errors. Your eyes will naturally focus on the little mistakes that others will not notice. The fewer errors you have to see, the more you will enjoy owning the airplane. If your workmanship is very good, you will find the FAA easier to work with—there are few things that give FAA inspectors more pleasure than walking into a homebuilder's shop and inspecting a beautifully-built aircraft. You will also find assistance easier to come by at every turn if you are building a beautiful airplane.

Also, keep in mind that one day you might want to sell your Falco. A beautifully-built Falco will bring a very good price. A sloppy one will be difficult to sell even at a very low price. You will find your friends and family hesitant to ride in a crudely-built aircraft, but if it looks professional, you will have little trouble.

While few builders give much thought to the subject of resale value, you really should think about this. It's a good feeling to have built something that others would like to have. The market for homebuilt aircraft is a little paranoid. We like to make the analogy that it is the way Spanish men regard their women: they are either ladies or "ladies of the night"—nothing in between. With a production aircraft, such as a Bonanza, the price will reflect the condition of the plane. If the plane needs a new paint job, you will get less for it. But with a homebuilt aircraft, the situation is different. The typical buyer knows relatively little about the construction of an airplane. All he knows is that he likes the Falco and would like to buy a nice one. In the back of his mind is this nagging worry about the workmanship that went into the airplane. When everything is perfect, you can almost name your price. A beautifully-built Falco makes normal production aircraft look really sad. But what happens if the paint is poorly done? Immediately, the buyer starts worrying about what *else* is wrong. Are the glue joints sound? When this process starts, the sale is off—and price is not the issue. Once this happens, you can cut the price in half, and you will still not sell the airplane.

One last thought on this subject. All of us, no matter how intelligent or independent, bask in the admiration of others. The way others see your Falco will materially affect the enjoyment you get out of building and owning the Falco.

Modifications

As you go over the plans for the Falco and begin construction, you will think about changes that you would like to make. As the plane comes into focus, it looks very simple. It is, but it is *also* extremely sophisticated. The Falco is a very good example of the "Swiss watch" syndrome. Things fit together beautifully, but if you change one little thing, your life can become misery. "One change makes a million" is the old phrase, and it is quite true. The Falco plans show you what to do. They do not tell you why you should not do it another way. Also, the plans often do not show you the potential interference problems.

As you build the Falco, you will begin to have an appreciation for these little things. You will suddenly notice how nicely things fit together. The plans do not tell you, for example, how the aileron control cables clear the rudder and elevator controls at the center of the airplane. It's one of those little things that will have you saying "Well, I'll be. Isn't that neat." The Falco is literally chock-full of that sort of thing.

There is no way to adequately explain the horrible way this "Swiss watch" syndrome grows as the airplane nears completion. When you have all of the flight controls installed, you will think that you understand, but you will not. After the instrument panel and the electrical system are installed, you will have a very good idea. You will not completely understand the degree of systems integration until you have the Falco ready to fly. Only after you have all of the mess that goes with the engine installation completed will you finally understand how integrated everything is. If you don't care to believe us, ask a builder who has completed a Falco or one who is nearly finished.

The tendency to dream about "little" changes is only human nature. Everyone goes through this stage. *Please*, keep yourself under control, take a cold shower, and concentrate on building the Falco to the plans. Over the years, a lot of builders have written us about potential changes to the Falco. Our experience has been that the more modifications proposed the less likely it is that the builder will proceed with the aircraft to completion. In all cases, the individual is quite sincere about the perceived need for such a change, but *every single builder who has proposed a number of modifications has eventually given up on the project*. Those builders who continue to work on their aircraft have been exceptionally devoid of such proposals. Thus, when we receive a letter proposing a number of changes to the Falco, we interpret the letter to mean "I am not going to build a Falco... just engaging in a pleasant daydream". Please excuse the language, but our description for this is "mental masturbation", and we answer such inquiries in the briefest possible manner.

The amount of time spent designing the Falco is difficult to comprehend if you have not been in the design business. The design of the electrical system took about 3,000 hours, more time than most of you will spend building the Falco. You will install parts and assemblies in your Falco in a matter of a few hours. The design of these same things frequently runs into months. Please try to keep this in mind before demanding that we tell you why you cannot install your new idea.

Part of the design process is the critiquing of your own work. You need to spend a lot of time studying the design, playing the devil's advocate, trying to simplify the thing, comparing the part to other designs, etc. You need to be able to look at the design with a cold, rational attitude. You ask yourself if the most brilliant designer in the world could not do better. You pin the drawing on the wall and spend weeks of studying the design at odd moments. This process of objectively critiquing your own design is one that we have noticed is usually lacking from the many proposals that we have received. Remember, *it doesn't make it a good idea just because you thought of it!* If you find yourself holding on to an idea for this reason, it is irrational, emotional thinking, and it has no place in good design. As an example, take our cabin heat valve. Compare our design to those of production aircraft, and you will find that none is as compact, as simple or gives full flow. It's a brilliant piece of design. For us, it involved months of work studying every possible way of doing this, looking at every production aircraft we could find. We are proud of this little feature of the Falco design—proud that we have the best little cabin heat valve in aviation, and proud that we *copied* this design from a 1971 Messerschmitt BO-209 Monsun. Lord knows who Messerschmitt copied it from! So... don't hang on to an idea just because it came out of *your* head.

There is also the subject of the danger involved in modifications. Few builders are qualified to do the engineering required to make changes, and fewer still are aware if the dangers involved. It has been a constant source of amazement to us to see the many ways that builders can get into trouble without realizing it. As a result of our experience, and after witnessing the safety record (dismal) of other modified homebuilt aircraft, we have become inflexibly opposed to modifications. The subject, frankly, is anathema to us. There is no question that any number of modifications can safely be installed on the Falco. Indeed, we have spent years and huge sums on engineering the many improvements we have made on the Falco. These improvements *are* modifications to the original design, but we have done the engineering and spent the time to check out interference problems. If you are not prepared to spend the time and money on engineering, then you should not expect us to be enthusiastic about the design change. Also, to do this type of thing properly will involve a lot of our time. We do not have the time available.

Our policy is that we will not supply any parts for a modified Falco. We will not allow the name "Falco" to be used for the airplane, and you may not use our paint schemes, which are copyrighted. We have found that the vast majority of Falco builders approve of this policy. It is easy for an airplane to get a bad reputation because of a crash of a modified design. The public only knows that it was a "Starflight" that crashed and so assumes that all such airplanes by the same name share the problem inherent in the design. This affects the reputation and resale value of the airplane—something none of us needs.

You will also find that potential buyers will be interested only in a standard Falco. They will not be interested in a highly-modified airplane. If you don't believe us, take a look at the ads in *Trade-A-Plane*. One-of-a-kind aircraft never seem to sell, despite the fantastic performance claims and the publicity inevitably given to such unique aircraft. It will be the same with the Falco, people will want a Stelio Frati-designed Falco—not one designed by Frati *and* you. Think about it, would *you* want a Falco that some amateur built using his own ideas on how the wing spar should be designed? Stick with the plans.

Visit a Falco Builder

If there is a Falco builder near you, by all means pay a visit. It is best to visit a builder who has the basic structure put together but has not yet started skinning the fuselage or wing. Take a camera and shoot at least two rolls of color print film. You will find that black and white film does not work well, as it is hard to see the details in the wood. Shoot photographs from every conceivable angle. You will feel foolish doing this, but you will be amazed how helpful these photographs will be later on. You will be able to look at the photographs and see things that you did not notice while you were with the airplane.

Plan Ahead

You should begin to order the tools and materials you will need. By planning ahead and ordering well in advance, you will always have something to do. One of the most frustrating aspects of building an airplane is watching the mail for something that hasn't arrived. If you find yourself in this predicament, it is your own fault. There are bound to be little delays in delivery, but if you plan far enough in advance, these delays will not hinder your progress.

In Search of Experts

You should be on the lookout for a helper. There are going to be many times when you will need two people, and a partner will be a big help, and the work will go faster.

If you do not belong to the Experimental Aircraft Association (EAA) you should join. This organization is dedicated to the subject of homebuilt aircraft. Their magazine, *Sport Aviation*, is good, and you will find something of interest in every issue. (You should also be warned that you will also find a lot of very amateurish ideas published in the magazine.) Above all, you should join and support this organization since they are the primary reason we have the freedom to build and fly our own aircraft. No other country allows such freedom as we have in the U.S., and your support of the EAA is the best way to see that we keep our freedom.

You might also consider joining a local EAA chapter. Most EAA chapters are nothing more than social gatherings of people who do not build airplanes. In general, you will find that the aircraft that they are building are not of the same class as the Falco. You will find an occasional expert among the ranks of the chapter members; however, our experience is that the true experts tend to be lone wolves. They do not tend to be joiners or socializers. You must seek them out, and you can expect their enthusiasm to rise only after they have seen your aircraft under construction.

Contacting Sequoia Aircraft Corporation

From time to time, you will have a question for us. Usually, you will find that the question will answer itself in time. If it is urgent, please feel free to call. Ordinarily, we prefer that you write in your questions. There are several reasons for this. First, our day at the office is sometimes hectic, and we can serve you better by taking the time necessary to answer the question in writing. When you write, we ask that you number your questions and refer specifically to the drawing number or sheet number. We can answer your questions quicker and easier this way, and it eliminates any possible confusion.

Also, when you ask a question, you might not completely understand what we are saying in our answer. If the answer is in writing, you will be able to refer to the letter and study the answer in detail. It is much better for all concerned if you write in your questions. We make it a point to answer questions from builders on the day the letter is received, so there will not be a long delay in getting an answer.

Lastly, remember the adage "There are no dumb questions… only dumb answers". Many builders are reluctant to bother us with questions that they think are "dumb". If you seek out the advice of others, it is a good possibility that they will not be aware of the proper way of doing something, particularly as it relates to the Falco. In particular, we have found that other homebuilders are frequently the worst source for answers. Their experience may be based on building an amateur-designed airplane, or they have learned a lot of short-cuts and bad habits which they obligingly pass on. We would prefer to be the source of all of your answers. This way we can be sure that you are getting the correct answers. If we don't know what is confusing to you, we will not know the sort of things to put in future editions of this manual.

Plans Assumption

If you lose interest in building a Falco, we would like to remind you that the plans purchase agreement specifically prohibits the sale, gift or transfer of the F.8L Falco plans without written consent of Sequoia Aircraft. In addition, all of the Falco drawings contain a notice to this effect. The F.8L Falco aircraft design is the property of Stelio Frati, the designer of the aircraft, and it is available from Sequoia Aircraft Corporation by contract between Mr. Frati and Sequoia Aircraft and this contract prohibits the resale or transfer. All Falco builders should be aware of this condition of the plans purchase agreement. Unfortunately, a few choose to ignore the terms of their contract. This leads to a difficult situation to all concerned.

The usual situation comes up when a Falco project is sold. Personal finances, change in employment, or death of the builder sometimes forces the sale of a project. In most circumstances, we are consulted and offer advice. We always remind the seller of the prohibition of the resale of the plans. In most cases this is not a problem for either party, and the transaction is handled smoothly and properly by all concerned. In a few cases, the seller chooses to ignore the terms of the contract and sells the plans anyway. This is a simple case of fraud, and we are always happy to assist in any litigation or prosectution. Some publication, such as the EAA's *Sport Aviation*, will not accept advertisements for used plans for the Falco, Pitts or other designs that are sold with this condition.

If you wish to sell your Falco plans, the purchaser purchase the drawing by paying $300.00 to Sequoia Aircraft and signing a Plans Assumption Agreement. We have this form available on request. For your information, the price of the Falco plans is broken down as follows: roughly $100.00 covers the cost of printing the drawings and construction manual, $100.00 goes to Mr. Frati (his only compensation), and $200.00 remains for Sequoia Aircraft Corporation to cover its costs. Thus, for us, the transfer of a set of plans is the same as the sale of a set of plans except that we do not have to print and ship another set of drawings. Particularly in the case of overseals builders, it makes more sense for everyone if plans are resold since no additional shipping costs are incurred.

For those occasional situations where a set of plans has been sold to an unsuspecting purchaser, these terms and conditions come as a shock. For this situation, we offer the following:

- Sequoia Aircraft Corporation is a business. We support all of our builders, and in return we expect to have the plans purchased from us.

- We make every effort to avoid such situations, but if a potential builder does not contact us in advance, there is no way that we can help him. We regret any trouble or problems that may arise from such a situation.

- We are entirely inflexible on the subject. There is nothing to be gained by attempted negotiation or protracted correspondence. We have never negotiated on this point, and we never will.

- We don't understand why someone would want to build a Falco and not buy the plans from Sequoia Aircraft, thereby depriving Mr. Frati and us compensation for the work we have done with the airplane.

- On a positive note, we look forward to working with all Falco builders on the completion of their aircraft and hope that any unpleasantness caused by any misfortune will be quickly forgotten.

Chapter 2
Reading the Plans

The Falco Plans

You may not be aware of it, but almost everything you purchase has been made from plans—your car, your house, the pen you write with, etc. Over the years, manufacturers have found that a drawing is the single best way of defining an item to be made.

The Falco plans are production drawings. This means that the drawings which define each part are separate from the drawings which show the installation of the part. In production, a machinist (or some other trade) is given a single drawing to follow. The drawing will contain all of the information needed to make that one part. In almost all cases, the man making a part in production will have little idea of what the part is for, or what it does. The only hint might be the name of the part.

Typical of aircraft production drawings, the Falco plans were originally drawn on a huge variety of sheet sizes. It was completely impractical for us to deal with such a mess, so we made new drawings using only two sizes. The large drawings are 24”x36” sheets. These are supplied to you in a series of blueprints. The smaller drawings are included in the construction manual notebook.

Drawings have both a number and a name. To keep things in order, we have added sheet numbers as well. The drawings are arranged and numbered in categories. The first category is the main installation drawings. These are numbered with a three digit number beginning with the number one (Drawing No. 102, 105, 134, etc.). The sheet number for these “one hundred series” drawings begin with the letter A (sheet A1, A2, A3, etc.). The larger sheets are numbered with single-A (sheet A1, A2, A3, etc.), while the smaller drawings are numbered with double-A (sheet AA1, AA2, AA3, etc.). This convention is used for all of the drawings. Whenever you see a sheet number with a single letter, the drawing is a large drawing. All of the smaller sheets in the construction manual notebook are numbered with double letters. The following table lists the relationship of all of the drawing numbers, sheet numbers and subjects.

Drawing	Sheet	Subject
100-199	A1 & up, AA1 & up	Installation
200-299	B1 & up, BB1 & up	Wing
300-399	C1 & up, CC1 & up	Fuselage
400-499	D1 & up, DD1 & up	Tail group
500-599	E1 & up, EE1 & up	Main landing gear
600-699	F1 & up, FF1 & up	Nose gear
700 & up	G1 & up, GG1 & up	Other

You may note from looking at the plans that with some of the series only larger drawings are used. We presently do not have any small drawings for the wing, fuselage or tail group, but the convention is there and available for use.

To keep track of this huge list of drawings, you have a plans index. This index lists the sheet numbers in order in the first section. The second section lists the drawing numbers in order and gives you the sheet numbers. You will find this index invaluable.

Many people are initially intimidated by the number of drawings and the amount of detail shown on the Falco drawings. As you begin the construction of the Falco, you will appreciate how important it is that you have complete details. There is an old saying that something is only as hard to build as the plans are poor. There is a great deal of truth to this. You will find that your greatest difficulties will arise when you are not given sufficient details.

The Basic Views

The Falco drawings are shown in the European projection. This projection is the opposite of that used in the U.S., but you will quickly learn to read it. The basic views are shown in Figure 1. With the European projection, the top view of a part is shown below it, and the side view is shown to one side. The best way to remember how the projection works is to remember that you “grab it from behind”. Imagine that you are holding the little house in Figure 1 from the back so that your hand is away from you. The view that you now see can be considered the main view of the part. Now, turn your hand so that you are looking at the top of the part. This is the top view on a drawing, and because you have grasped the house from the rear, the house has moved below where you were last holding it. Now bring the house back up so that you are looking at the bottom of the house. This is the bottom view, and because your hand works the way that it does, the house has moved above the original view. Each side view works the same way. The view from the left is shown on the right, and the view from the right is shown on the left. Whenever you are confused, you can always resort to this method to help you understand which view you are seeing.

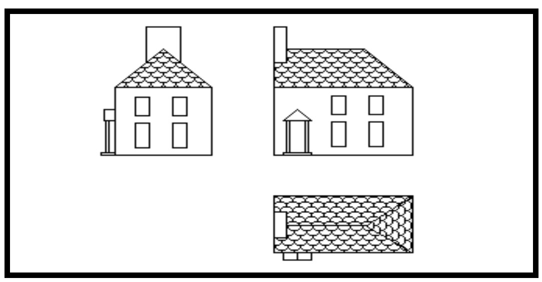


Figure 1

A drawing for a part may consist of a single view of a part, or two, three or more views. The normal practice is to draw only as much as is needed to show the part.

The best way to understand a drawing is to use it. We will normally refer only to the drawing number. Take a look at Drawing No. 708.

Before you start flipping through everything looking for this drawing, use the plans index! As you can see, it is shown on sheet GG2. This means that you will find it in the construction manual notebook.

Back to Drawing No. 708. The main view is shown on the upper left side of the sheet of paper. To its right is a side view of the part as seen from the its left side. Below the main view is the top view of the part. Confused? Don't worry, in time you will be able to read these drawings like a book.

Let's look at Drawing No. 605. (We are not going to help you any more with the plans index. You will have to get in the habit of using the index.) In this drawing, the part is shown in only two views.

Sections & Views

Now take a look at Drawing No. 838-2. Here we have something new. In this case there are two views, but the thing that looks like a side view doesn't make any sense. This is known as a *section*. A section is a view through the part. Returning to our example of the little house, Figure 2 shows an example of a section.

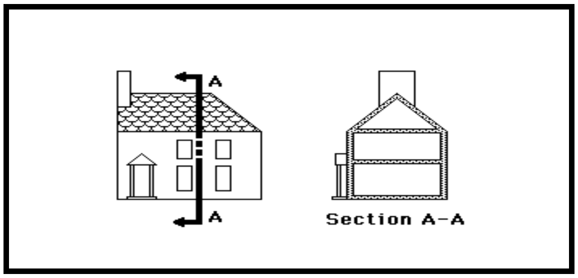


Figure 2

Because the designer wants to show you something, he has sliced the part in two at the section line. This is the designer's way of saying "This is what the part would look like if you cut it through here". Note the heavy line with two dashes. This is the *section line*, and it indicates where the part is "cut" in two. The arrows on the ends of the section line indicate which way you are looking at the sliced part. A section may be shown anywhere on the drawing, but the practice is that a section is never "rotated". By this, we mean that the top of the part is still shown at the top. With your hand open, pretend that it is a knife. Bring your hand down on the section line as if you were cutting the part, then turn your hand so that your palm is facing your face. This is the way sections are shown. This view will retain its orientation and will be shown elsewhere on the drawing. A rotated section would result if you turned your hand clockwise or counter-clockwise, but this is not done in proper drafting practice.

A drafting technique known as *hatching* is used to indicate the cross-sectional area of the part. The hatching is the diagonal line pattern, although a pattern of dots may be used as in Figure 2. Hatching is used in all sectional views, except when the material is extremely thin, as in sheet metal. To differentiate between two different parts, the hatching pattern is usually changed. There is an example of this on Drawing No. 720. On this drawing, the section is through the center of the part, and a section line is not used.

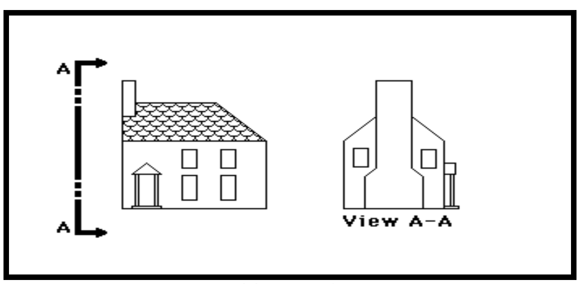


Figure 3

You will also find that in many cases the drawing convention is to show a part in partial cross-section. Drawing No. 520-3 is an example. This is a half-section. Above the centerline, the part is shown as a section view, while it is a normal side view below the center line.

A *view* is just like a section, but the part is not cut through. A view is a designer's way of saying "This is what the part would look like if you looked at it from here". Figure 3 shows an example of a view of our little house.

Dimensioning

Take a look at Drawing No. 807. The dimensions for the Falco are given in millimeters unless otherwise specified. In general, you will find that all dimensions are given in millimeters, except those that are generically English measure (inches).

If you have never worked with metric dimensions before, you are in for a real surprise. They are much nicer to work with than with the inches we are all accustomed to. The only problem arises when something is made in inches. When we want you to drill a 1/4" diameter hole, we just call out the hole as .250"Ø. This is simple and easy to understand.

While it is not required that you do many conversions of millimeters to inches, you should still know how. A millimeter is .03937", so to convert 35mm to inches, you multiply (example: 35mm x .03937 = 1.378"). To convert from inches to millimeters, you divide by .03937 (example: 4.75" ÷ .03937 = 120.65mm). In most cases you will not be concerned with the exact equivalent, and for quick and easy conversions you can use .04 as your conversion factor. If you see a material called out as 3mm, then you can quickly see that it is roughly .120", so the U.S. equivalent is .125" (1/8"). You will soon be thinking of 1mm steel as .040" steel, 1.5mm aluminum as .063", 2mm as .080", etc.

The plan convention for the Falco (and most other aircraft) is that the dimensions for the spars, ribs, fuselage frames, etc. are given for the *undersurface of the skin*. Thus, you do not have to make any allowance for the thickness of the skin of the aircraft.

Water Lines, Butt Lines & Stations

A "water line" is a horizontal plane through the airplane. The most important water line is *Water Line* 0, which is the primary horizontal reference plane on the airplane. This is abbreviated as W.L. 0 and may be seen on the fuselage frame drawings. All vertical dimensions in the fuselage are taken from W.L. 0. If we wish to indicate a plane 355mm below W.L. 0, we will refer to the point as W.L. –355. A plane 70mm above W.L. 0 would be referred to as W.L. 70. The normal practice is not to use a plus sign with water lines above W.L. 0.

A "butt line" is a vertical plane through the airplane. This convention is used to refer to a plane to the side of the aircraft centerline. The aircraft centerline is effectively B.L. 0, although this is never used.

The positions of the wing ribs, tail ribs and fuselage frames are referred to as Stations.

General Tolerances

The general tolerances for dimensions is ±0.1mm unless stated otherwise. These tolerances do not apply to the thickness of specified materials, and you must use the stated millimeter or inch measure material. When tolerances are important, the actual limits are given since the European tolerance system is confusing to anyone not accustomed to using the tolerance tables.

Not to Scale

Occasionally, you will find a dimension with a straight or wavy line beneath it. This means "not to scale". In all cases the dimensions on the plans take preference to the drawing itself, and you should not scale directly from the drawing unless you are instructed to do so. In some cases, the dimensions given do not match the part as drawn, and when a dimension is underlined you are being alerted to the discrepancy. In such cases you are to pay attention to the actual size of the drawn part but to use the dimension given. Even so, there are many cases where a dimension and a drawing do not match. You are *never* to use a drawing as a pattern or to scale off dimensions unless instructed to do so.

A Few Terms

Occasionally, you will see the notation (ref) which is the abbreviation for "shown in reference". This means that any part shown in reference takes second place to another dimension or part on the drawing. The notation is to draw your attention to the fact that other dimensions are to be used in constructing the part. The dimension given in the reference is only to help you understand what is being shown.

This term can apply to a part or a dimension. It is a basic rule of drafting that you are only given a specific dimension once. It may be helpful to know this dimension when you are looking at another drawing, and this is a frequent use of the abbreviation.

You will frequently see the abbreviation "N.B.". This is Latin for *nota bene*, or in English "note well". This is the designer's way of saying "Hey, look at this. This is important."

It is normal to abbreviate terms. Among the most common are:

Term	Abbreviation	As in
Radius	R	12R or .25"R
Diameter	Ø or dia	15Ø, .375"Ø, 12dia or .250"dia
Inside Diameter	I.D.	34 I.D. or .25" I.D
Outside Diameter	O.D.	12 O.D. or .625" O.D.

The Language of Lines

The Falco drawings are done with three line weights. The heaviest line weight is used for section lines and for view lines. A medium-weight line is used for the outlines of a part. A light-weight line is used for dimension lines, hidden lines, mold lines, extension lines and centerlines.

A *hidden line* is a line consisting entirely of dashes. This shows the outline or other features of a part hidden by the part you are seeing. The use of hidden lines allows the part to be shown as if the part hiding it were transparent. See Drawing No. 788A. In the top view, the channel that is riveted in place is shown entirely in hidden lines.

A *dimension line* is the familiar line with arrows on each end. The line is broken for the dimension. On this same drawing, the height of the part is shown as 67mm, and the dimension line shows that this dimension extends from the bottom to the top of the part.

Note that the dimension line does not actually point to either the top or bottom of the part. These are indicated by two *extension lines*.

A *centerline* is indicated by a thin line which is broken by short spaces and a single dot. This type of line is used to show the center of a part and the centers of holes and other features. On Drawing No. 788A again, the 13.5mm dimensions are all for the distances between centerlines.

A *mold line* will not be seen often, but it is the same pattern as is used for section and view lines, except that the line is a lightweight line. We will point out these and other special types of lines as they are used.

A Few Symbols

A line with double arrowheads on each end is used to indicate grain direction of wood. Please note that the grain direction of wood is not indicated by hatching, which is sometimes used to show an area covered by plywood. Some early builders went to great difficulty to put plywood on to match the hatching direction, when in fact the grain direction was not important.

For machined parts, surface finish is sometimes indicated by the following symbols.

> *Four triangles* indicate a surface finish of 2 to 4 RMS. This finish can be attained only be grinding, lapping, or honing. It is practically a mirror finish.
>
> *Three triangles* indicate a surface finish of 8 to 32 RMS. The roughest finish (32 RMS) can be attained by grinding, or careful face milling or turning.
>
> *Two triangles* indicate a surface finish of 63 to 250 RMS. This would be the normal finish of machining or turning.
>
> *One triangle* indicates a surface finish of 500 RMS or better. In general, this indication is used to indicate that no effort to obtain a smooth finish is necessary and to differentiate these areas from those which require a good finish. It is the designer's way of saying “don't bother”.
>
> An *equal sign* (=) is used quite frequently on the Falco plans. It is always used in conjunction with one or more equal signs, and it means that the dimensions shown are all to be equal.

Revisions

Like the plans for everything ever designed, there have been errors in the Falco plans. These errors are corrected through plans revisions. Revisions are also used to notify you of changes in the design, to add notes to the drawings, and to alert you that a new drawing has been issued. It is absolutely essential that you post all revisions. The normal practice is to write the latest revision number in the title block of the drawing once the revision has been posted.

You should post all revisions when received. It is a big mistake to leave it until you go to use the drawing. You may forget, and then you will find out the hard way why the revision was issued in the first place.

Some people regard the large number of revisions for the Falco drawings with horror. Mistakes and changes are a way of life with design drawings. You should be very thankful to have all of these revisions. The real horror is building something that has not had revisions noted.

At this time, the Falco plans are nearly error-free. Many builders have used these same drawings. You will also note from the latest revisions that most of these are in the way of refining the design because of something that came up later. So don't let the revisions frighten you. And please, if you find something that doesn't look right or confuses you, let us know so that we can correct the problem.

Need More Help?

You will find that the drawings will be easy to understand. If you should have trouble with them, ask someone to come over and give you a quick lesson. Engineers or machinists would be the best people to ask. Architects use different types of drawings from the engineer's. You will find that someone familiar with drawings will be able to set you straight in a hurry.

Where Do You Find Part Number...?

There will be times when you will think you are completely lost because an installation drawing does not have a detail that you need. Try looking up the part drawing first in the plans index.

Also, you should be aware that all of the individual drawings tell you where a part is to be found in an installation. Each drawing has a note that says "See Drawing No. XXX for installation". If you want to see where the part is installed, look at the installation drawing.

If you have difficulty imagining how everything fits together, you may find the isometric drawings in *The Falco Kits* booklet very helpful. Most builders end up tacking them up on the shop wall.

The Plans vs The Construction Manual

There may be times that you will find a contradiction between the plans and the construction manual. Remember this, the Falco is built from the *plans*. Any changes will be reflected in the plans revisions. The plans always take precedence over everything else.

Chapter 3
Your Shop

Close to Home

The most important thing about your shop is that it be located as close to home as possible. Working in a shop should be a pleasure, and it is no fun at all to have to pack off to the airport. If your shop is at home, you will be a few steps away from the Falco. This way you can go out and do some little job. There are many things that you can do at odd hours. Many builders spend a few minutes in the morning doing a little gluing. When they come home the glue is dry, and they are ready to start on something else.

From the standpoint of your family, there is nothing to beat having the shop at home. When the cat gets caught up in the tree, you will be there. If you are forever off working on the airplane, your family will grow to see the Falco as something of a threat to them. They do not think of the airplane as you do. The airplane is something that keeps you away from home. This may not seem to be a big thing now, but it can become a big problem.

Space Requirements

The amount of space that you have in the shop will make a big difference in how quickly you build the airplane. The ideal shop has enough room for you to assemble the entire airplane.

Most builders think of their garages as their shop, and indeed that is where most airplanes are built. A three-car garage, with clear span, is a very good shop. The only thing that will beat it is a custom-built shop.

You should not overlook the need for vertical clearance. Most garages are 8 feet tall inside. The ideal shop would have about 10 feet of clearance. The reason for this is that during the construction of the Falco you will have to turn the airplane over a few times. With ten feet of headroom, you can turn the plane over inside the shop. If you do not have this kind of room, then you will have to take the plane outside to turn it over.

We have Falcos being built in two car garages. This is very tight, but it can be done if you can add a small extension to accommodate one wing tip. Remember that the tail section of the airplane is removable. This can make a big difference when space is at a premium. If you have nothing more than a two car garage, then you will have to live with that as long as you can. Usually, you will find that as you near completion, you will have to move the airplane to larger quarters.

If you only have a single car garage, you can still do a lot of preliminary work, but you will have to forget about doing the major assembly of the airplane there.

In addition to all of the above, we have Falcos being built in all sorts of strange places, barns, warehouses, old sheds, hangars… almost any place that can be found. Many builders have built their own shops just for the Falco.

Lighting

You want to make sure that you have plenty of light. Normally, you will find that lots of fluorescent lighting is best. You will also find that you will need some additional portable lights to illuminate your work. Photographic stand lamps work well. Hardware stores sell clamp-on utility lights which are also very nice.

You will also find that if the shop is painted white, it will make the shop seem much brighter.

Temperature Control

The glues that are used for aircraft woodwork require a minimum temperature. Resorcinol requires 70°F, as does epoxy. Some manufacturers claim that their epoxy can be used at low temperatures, but most experts will tell you that you need 70°F for complete cross-linking of the molecules. Aerolite is usable down to about 56°F.

If you do not have any way of keeping the shop warm, then you will be restricted to working only in warm weather. The best kind of heat for shops is electric baseboard heat. If you do not have a heated shop, you can still resort to using heat lamps and wrapping the part in an electric blanket.

Humidity Control

It is not essential that you have control of the humidity in your shop. When you heat the shop in the winter, the air in the shop becomes dry. This causes the wood to dry and to shrink. Later, when the summer comes, the wood picks up moisture and expands. When you skin the airplane, the relative moisture content of the wood structure and the plywood skin becomes important if you want to have a smooth wing. Most builders do not have such humidity control, but a few do. You should be aware of humidity and its effect on wood.

Getting It In and Out

You should not forget that at some point the airplane must be taken out of the shop. You will be able to get the Falco out of a single car garage door by making a dolly with castering wheels. The tail section is normally removed and the fuselage is snaked out through the door.

As an alternative, you will be able to get the centersection out sideways if you have a door that is eight feet wide or more. If the entrance is not large enough, you may have to remove a section of wall or the center door post. It's already been done for a Falco.

Many builders worry about getting their Falco to the airport. Our advice is not to worry about it at this stage in the construction. If you can get the Falco out of the door, you will be perfectly capable of getting the Falco to the airport.

One final point. If you build a shop for a Falco, you will probably have an air compressor. These make a lot of noise, and you would be well advised to build a small shelter for it on the outside wall.

Chapter 4
Tools

Introduction

The availability of proper tools will make a huge difference in the speed that you build your Falco. If you visit a number of Falco builders, you will be amazed at the variety of tools that are used. Some builders have completely equipped shops, while others make do with only a few hand tools.

In this chapter, we will discuss the tools that you should consider buying for your shop. Many of these tools should be purchased right away, but others will not be needed until later.

Tools are one of those things in life where you get what you pay for. The price range from the bottom to the top can be huge. You can buy a small bench-top "table saw" for less than $100.00 while prices for professional table saws sell for $5,000.00 and more. Many builders buy high quality tools, and there is no question that they are a real pleasure. On the other hand, it is a waste of money to buy an expensive tool that you will rarely use. Remember, you can always take your parts to someone else's shop and use their tools!

You should also consider that if you make all of your own wood parts, you will need better equipment. While a kit builder can do without a table or radial arm saw, it is unlikely that you will be able to make all of your own wood parts without one.

Measuring Tools

You will need a wide assortment of measuring devices. The best of these will be available at machine tool supply stores. These companies specialize in selling such tools to industrial customers. Accordingly, you will not find them in your local shopping center. Browse around the store and find what else they sell. If you are not able to locate such a company, call a machine shop near you and ask where to buy rulers, calipers, drill bits and reamers.

There are also a number of companies which sell high quality wood working tools to amateur and professional craftsmen. Woodworking is a passion that consumes a large number of our population, and a large industry has grown to serve it. In larger cities, you will find specialized woodworking shops, but most of you will be dealing with mail order firms. See Appendix A for sources of such things.

You will also be able to buy tools through normal retail stores, such as Sears, and hardware stores have a good assortment of low and medium priced tools.

You will need at least one *ruler*, to measure in both millimeters and inches. Many rulers have both scales on them. We prefer the Starrett rulers, which are used in machine shops and are high quality rulers. We normally have a couple of them. For inch measures, we prefer the "aircraft quick-reading hundredth" scale. If such a scale is available in combination with a millimeter scale, it would be ideal. We have one ruler about 12" long and another about 36" long. The Starrett rulers are stainless steel and can also be used as accurate straight edges.

A *drafting pencil* will be very handy for marking the wood. These are inexpensive and can be purchased at a drafting supply company. A Pentel drafting pencil with a .5mm lead is recommended.

A dial or vernier *caliper* is extremely handy. We prefer the dial type, and we have one in inches only.

For conversions we use a hand-held *calculator*. You will find such a calculator extremely handy. We prefer the Hewlett-Packard HP11C programmable calculator. Available for about $60.00 at discount stores, this calculator is second to nothing. There are other manufacturers of calculators, but the "reverse Polish notation" system that Hewlett-Packard uses is far superior. It will take some getting used to, but once you are comfortable with the system, you will never want anything else. These calculators are the overwhelming favorite of engineers. Since they are programmable, you can easily program the calculator to convert from millimeters to inches and back. Key in the millimeter dimension, hit one button, and you have the inch equivalent displayed in an instant. We would not be without one of these, but you can certainly do with a simpler calculator. As you will see later, you will find the programming feature a very nice thing to have if you are going to make your own fuselage frames.

If possible, you should have a long *straightedge*. These are difficult to find. The only source we know of is carpet and tile installation supply companies. These eight foot steel straight edges are used for cutting soft sheet tile. If you search through your local hardware store, you will probably be able to find some extruded aluminum that will work nearly as well. When you are gluing trailing edge strips on ribs you will need a way of keeping the ribs in perfect alignment. An extruded aluminum angle is very handy for this sort of thing, but a straight piece of wood will also work.

You will need at least one *plumb bob*. They are absolutely essential and are used for aligning the ribs, fuselage frames and other things. Plumb bobs are cheap, and we suggest you purchase at least four of them. When you get to the wing, fuselage and tail jigs, you will end up with plumb bobs hanging from everything. You can always use one plumb bob and take it from place to place, but since they are so cheap, it seems a waste of time to do this.

Equally essential is a *water level*. You can use carpenters levels, but they are nearly useless for the kinds of leveling you will be doing. You will have to make your own water level, but it is very simple. All you need is a length of clear plastic tubing—3/8" or 1/2" inside diameter is best. You can purchase this kind of tubing at a local hardware store or refrigeration/air conditioning supply company. You might get enough tubing to make two levels. For the wing, you will need one that will stretch from one end of the wing to the other, so this will require at least 30 feet of tubing. For other applications, a shorter tube is easier to handle. The water level is made by filling the tubing with water. Then put some ink in the water, and add some alcohol to keep down the growth of fungi and mold. A couple drops of dishwasher detergent should be added to break the surface tension so that reading the level will be easier.

You will also need to make some sort of *water level stand*. The simplest stand is made with a wood dowel and a heavy board for the base. To hold the tubing, use a piece of aluminum or wood which is drilled so that the tubing will just push through the hole without slipping. Drill a hole for the dowel, slot with a saw and use a bolt and wing nut to clamp it tight to the dowel.

You will need some *nylon fishing line*, which you will use to align leading edges, trailing edges, fuselage centerline, etc.

A *combination square* is a handy thing to have. These are exceptionally versatile instruments. We like the Starrett squares best. In addition, you will probably also want to buy a *carpenters square*, a *drafting triangle*, and a *carpenters level*.

Clamps

Oh, boy! Are you going to need clamps! Rare is the builder who has enough of them. Generally, you will need many different types. The *C-clamp* is the most common type and is available almost everywhere. A better alternative for small jobs is the *Kant-Twist* clamp. These are used by machine shops, and they are very nice clamps. C-clamps tend to twist the material being clamped, but these clamps overcome the problem with their unique design.

You will find a wide variety of clamps advertised in *Fine Woodworking* magazine and in woodworking mail order catalogues. The clamps include such things as *bar clamps*, *pipe clamps*, *Jorgensen wood screws*, and beechwood *cam-clamps*. Each clamp has its place.

Don't overlook the fact that you can make your own clamps. In some cases you will find it easier to use threaded rod from the local hardware store and some two-by-four lumber. There are also a number of companies which sell kits and instructions for making Jorgensen-type wood screw and cam-clamps. The wood screw kits can also be adapted for clamps of your own design.

A number of Falco builders have used large paper clips as clamps. This type of clip is a piece of steel sheet bent so that it pinches the paper. There are two wire handles which are used to spring it open and which fold down when you want them out of the way. The sample we have seen is 2" long and will clamp about 3/4" thick. You can buy them at office supply stores. These clips are used for clamping small parts like ribs to a jig or laminations of fuselage frames to the jig.

Drilling Tools

You will have to drill a lot of holes. The first thing you will need is an *electric hand drill*. As you will be drilling some holes in metal, a variable speed drill is preferable. For most jobs, a 1/4" drill is adequate, but a 3/8" drill is also nice to have around. Drills are available in a big price range, and you get what you pay for! Some of the cheaper Black & Decker, Sears, and Rockwell-Delta drills are ridiculously inexpensive. We prefer the higher quality Rockwell-Delta variable speed drills.

You can build a Falco without a *drill press*, but we would not want to try it. Most of your drilling will be to install hinges. These are most easily installed using a drill press. There are many jobs which can be done on a small inexpensive drill press, and for these jobs you can use almost anything. The largest drilling job will be to install the landing gear fittings in the main wing spar. This will require that you drill through about 4 inches of wood. A good solid table is essential. We prefer the Rockwell-Delta variable speed drill press with a table raiser attachment, but this is fairly expensive. If you don't mind moving the belts, then a cheaper drill press will do. There are a number of bench-mounted drill presses, many imported, that will work nicely.

There is a unique tool known as a *Shopsmith*. The shopsmith is the "Swiss army knife" of woodworking. The Shopsmith will do an amazing number of things. It will work as a table saw, disc sander, horizontal boring machine, vertical drill press and lathe. It is a versatile, quality tool. The only disadvantage of this tool is that you have to change the set-up to do different jobs. Professional woodworkers prefer to have a single tool for each job. This way, if they want to drill a hole, they go over to the drill press and do it. With the Shopsmith, you have to set the thing up as a vertical drill press if you have it in the "disc sander mode". From the demonstrations we have seen, the Shopsmith can be quickly changed from one set-up to another. These demonstrations were done by skillful people who waste no time, and we are not sure if the average person would be as quick. We know a few people who have them, and they all swear by the thing.

You will need an assortment of drill bits for both metal and wood. You will not want to build a Falco without a set of *brad point bits*. These bits cut a very clean, smooth hole in wood, unlike normal twist bits which tear their way through the wood. Be sure to buy a set which has a 3/16" bit as this will be the one that you will use the most. The set sold by The Fine Tool Shops is highly recommended—drill bit sizes are 1/8", 3/16", 1/4", 5/16", 3/8", 7/16" and 1/2".

For metal, you will need an assortment of *high speed steel drills*. We recommend getting a set of bits in fractional-inch and number sizes. The following fractional-inch size bits are required: 1/16", 3/32", 1/8", 5/32". 11/64", 3/16" and 1/4". The following number size bits are required: #43, #40, #30, #21, #19 and #3.

In addition, you will also need a .1875" and a .250" *reamer*. This is used for reaming the bushings for the hinges. You may use a twist drill bit for this, but a reamer does a much nicer job.

You will need the following *taps*: 4-40, 10-32 and 1/4-28.

You will need a 100° included angle *countersink*. You do not need the fancy stop countersinks sold for aircraft sheet metal work. The one that you want is a single flute countersink. It looks like a stubby drill bit.

To install the taper pins for the retraction system, you will need a *Brown and Sharp No. 1 tapered reamer*. This may be purchased from a local machine tool supply company or from Travers Tool Company (see F.8L Falco Kit Price List).

You will need a few *transfer punches*. A transfer punch is a special type of punch used to locate the center of a hole. It works like a centerpunch but the punch is the exact diameter of the hole and has a small point at the center. You need two sizes, 3/16" diameter and 1/4" diameter. Obtain from Travers Tool Company or locally.

Band Saw

A small band saw is invaluable. Rockwell-Delta makes one that will cut both metal and wood. This type of band saw is essential if you are going to make many metal parts. If you are only going to cut wood, then you can stick with a cheaper saw. Black & Decker makes a small bench-top band saw that sells for less than $100.00. There are a lot of similar saws sold through mail order catalogues and advertised in *Fine Woodworking* magazine.

Table Saw

This is a big maybe. If you make all of your own wood parts, you will need a table saw (or a radial arm saw). Given the choice between a table saw and a radial arm saw, we would go with the radial arm saw.

Radial Arm Saw

A radial arm saw is much more versatile than a table saw, and it is more desirable for a Falco builder. One of the principal advantages is that you can use the saw for scarfing plywood. Make sure that the saw that you buy has a spindle on the back of the motor. This is used for installing a 3" diameter drum sander. If you cannot do this, do not buy the saw.

Coping Saw

One Falco builder recommends the Garrett Wade "precision fret and coping saw". The frame is a nearly rigid aluminum casting, and the blades are held in place by small steel blocks into which they're clamped with hex-head set screws and then the blade-plus-blocks assemblage is put into the frame and tightened with a knurled knob. “A highly recommended tool for those fed up with K-mart coping saws”.

Stationary Belt/Disc Sander

This is an essential tool, which you will use very often. It is not particularly important whether the sander is a belt, disc or combination of the two. We prefer the stationary belt type as it cuts more evenly due to the fact that the cutting speed of the sanding paper is the same across the belt, something not true of a disc sander. The disc sander has the advantage of being able to sand a wider piece, and this may weigh your decision in that direction. You will use this sander to do the final fitting of wood pieces.

It is very important that the sander have an adjustable table so that you can set the angle of the table. The table should have a “way” machined in it for a table square. This feature is very important when you are doing the final sanding on the ribs. Without this feature you will have to work free-hand (not a good idea). We prefer the Rockwell-Delta combination belt/disc sander, which has adjustable tables for both sanding faces.

Scarfing Jig

A scarf is a tapered joint of two pieces of wood. You will need some way to scarf plywood and spruce. Plywood scarfs are normally sanded. Many builders make their own scarfing jigs, using a hand drill or an electric motor with a drum sander. You make a table with a fence, and the drum is positioned so that it sands the plywood as it is pushed by the sanding drum. The simplest way is to use a radial arm saw, with a sanding drum mounted on the “other” end of the motor.

If you are working from the complete kits, there will be few occasions when you have to scarf spruce. Scarfs for spruce are normally cut with a saw set at the correct angle and may be finished with a sanding block.

Air Compressor

Before you finish your Falco, you will own an air compressor. This is essential for painting the airplane and is also an invaluable thing to have around. It is handy for blowing away sawdust, cleaning yourself off before tramping into your living room, pumping up your car tires, using a long list of pneumatic tools, etc. We would not have a shop without an air compressor. Be sure to get a tire valve to inflate the tires and oleo struts.

If you plan to paint your Falco, you should size the air compressor to the requirements of the spray gun. The best spray gun is a Binks No. 7, which requires 14 CFM. Since you will be triggering the gun, the gun will not be used continuously. For a professional set-up, you should have a 3 hp compressor (Quincy is a recommended brand), with a load-less start 220 volt motor and a 60 gallon tank. You can paint an aircraft with a smaller compressor by going to a smaller nozzle and intermittent use of the gun. This method, however, will defeat the design of the paint system and detract from the appearance of the paint job.

Pneumatic Staple Gun

When you build a Falco, one of the most essential tools is a pneumatic staple gun, in fact most builders will tell you that you are out of your flipping mind if you don't have one. To skin the Falco, you will have to use small nails or staples to hold the skin in place while gluing. Most hand staple guns use large staples that will split the spruce. You could use an office stapler, but this is very slow and tedious and the staples would not go through the thicker birch plywood. Similarly, small aircraft nails take forever. The pneumatic guns will shoot staples as fast as you can pull the trigger, and you want to be sure to get a staple gun that will shoot fine-wire staples that will not split the wood.

The premier manufacturer is Senco Products, and they have two staplers which shoot fine-wire staples. The Senco BO4, BO6 and BO8 staples have a 1/2" crown and are made of .030” by .0215” wire and are 1/4”, 3/8” and 1/2” in length. Senco CO4, CO6 and CO8 staples have a 3/8" crown and are more common.

Another good choice is the *Paslode PI-W30 stapler* which uses 30 gauge staples. These are about .024” by .032” wire, and the staples are 1/2” wide and 3/8” or 1/2” in length. The stapler is available with a safety interlock, which you don't need.

Hand-Operated Stapler

If you don't have an air compressor yet, one Falco builder recommends the “Staple Gun Tacker” sold by Aircraft Spruce & Specialty Co. It uses small, U-shaped staples that are about midway in gauge between common hardware-store staples (which are too large and split the wood) and ordinary paper staples (which are too weak and crumple).

Staple Lifter

One Falco builder recommends the Woodcraft Supply #09N41-BO staple lifter. This has a tongue-like point that can easily be filed to a fine enough thickness to slide under small staples.

Die Grinders

If you have an air compressor, you might want a pneumatic die grinder. This is hardly essential, but it is a useful tool. It works like the Dremel Moto-tool, but it is much more powerful. If you need to scoop out a little wood, just reach for the die grinder. You have to be careful, since the grinder will eat wood in a hurry.

Electric Hand Sander

An electric hand sander is handy to have around. One that you should like is the *Skil No. 593 “Sand-Cat”*. This sander has a 2-1/2” wide belt. It is about the size of a steam iron, and since it is small and light-weight, it is extremely versatile and easy to handle. The sander sells for about $50.00. Most sanders have the motor between the grip and the belt, making them awkward to use with one hand. The Sand-Cat has the motor at the aft end, and the hand grip is down low near the belt. This makes the sander easy to use with one hand.

A number of Falco builders have mounted their Sand-Cats on a board when they sanded the fuselage frames to the final angle required for the skin. The board extends behind the sander and rests on the next fuselage frame, thereby aligning the sander. This works well, but you must always be careful since the sanders can cut very quickly.

It might be possible to mount a Sand-Cat on a long board and use it to float sand the wing. We are suspicious of this technique and suggest extreme caution. Any trials should be done on very high spots, and we think the final sanding should always be done by hand.

Carbide Abraders

A perennial favorite of Falco builders is a special kind of sanding tool. These are strips of metal coated with carbide grit, and they work like a file or rasp. They are very handy for sanding spruce and plywood, and they don't wear out or clog up. They cut spruce like there's no tomorrow and make ordinary sandpaper seem like a tool from the stone age. They are made by a variety of companies. Disston offered a line of "Abraders", but these have since been discontinued. D. G.

Products makes a line of Perma-Grit tools. Most are round or triangular file-like devices but they also sell flat sheets of thin steel with carbide brazed to them. The flat sheets can be bonded to a board and this makes a great float-sanding device. We suggest you buy one of each of the Perma-Grit sanding tools and four of the sheets.

Sanding Blocks

There are many times when you have to sand in weird places. The simplest thing is to make a series of sanding blocks. These are usually rectangular pieces of wood with strips of sandpaper glued to one surface. To float sand the wing, you will need a long smooth board with a fairly wide piece of sandpaper. Ordinarily, you will find that the best solution is to buy the 6”x48” belts used for stationary belt sanders. Cut the belt—it is a continuous loop—and glue it to a planed board of the same width. Use contact cement to glue the paper. The same hardware store that sells the belts will also sell a contact cement used to cement sandpaper to disc sanders.

For smaller places, you will want a series of standing sticks. You will need a number of different sizes depending on what you are trying to do. To finish out the longeron cutouts in the fuselage frames, you should have a sanding stick about 20x20 in cross-section and long enough so that one end will rest in the cutout of the next frame to align the stick. For the sandpaper, you can use normal sheets of sandpaper and cut them to the required width.

Gil-Bilt Power Tool Kits

For those who would like to save some money and take on another kit, you can make your own power tools. See the entry for Gilliom Manufacturing in Appendix A. There is a wide assortment of tools from band saws to lathes.

Laminate Trimmer

A laminate trimmer bit in a router is very handy for cutting birch plywood after gluing. It cuts right up to the edge of the wood underneath, follows curves and does not splinter the plywood as saws do.

Offset Screwdriver

There will be many time when you will want to get at a screw in very close quarters. An offset screwdriver will take care of this. Available in Phillips head or the normal flat blade type, an offset screwdriver looks like any other screwdriver except that there is no handle—instead the shaft is bent at 90° on each end, and the normal screwdriver tip is on each bent end. When you get to the electrical kit, you'll *have* to have one since there is no other way to get to the screw terminals of the circuit breakers.

Moisture Meters

Several companies make moisture meters. These are handy when you are skinning the airplane. If the plywood is too dry, you will have a wavy skin. The best type of meter has a dial or digital indicator. You do not want the type with LED indicator lights. Also, purchase the type with small pins for electrodes. The larger electrodes (medium-sized “nails” mounted on a hammer) are used for sawmills.

If you would like to save some money and spend some time tinkering, you can make your own moisture meter. Jackson Wood Technology sells kits, but we've not seen one. Also, the July-August 1985 issue of *Fine Woodworking* carried an article on making your own moisture meter. The meter costs about $30.00 and features a meter type of indicator.

Torque Wrench

You will need one torque wrench during the construction of your Falco. This will be required eventually for the spark plugs for your engine. Check with your local FBO for a recommended type.

Gluing Supplies

When you work with glue, you have a messy substance on your hands. The glues are often toxic as well. You can obtain *disposable rubber gloves* from a medical supply company. These are very cheap and come a thousand to a box. To mix and spread glue, you can use wood sticks (tongue depressors) which can be obtained from medical supply companies or Fiber Glast Developments. Fiber Glast Developments also carries wax-less paper cups and your local pharmacy supply company will sell 30cc plastic cups with 5cc graduations. These are handy for mixing glue.

Chapter 5
Planning Ahead

The FAA and You

The Federal Aviation Administration (FAA) is part of the United States Department of Transportation. As a pilot, you are aware of its role in certifying production aircraft, licensing pilots, operating the air traffic control system, aviation navigations aids, etc. The FAA is also in charge of licensing aircraft in the "Experimental, Amateur-Built" category.

The inspectors with whom you will work spend most of their time looking over production aircraft for defects in workmanship, approving repairs, etc. The inspection of amateur-built aircraft is not their principal mission. Due to the huge growth of amateur-built aircraft in the past decade, the FAA is swamped with requests for inspecting these airplanes.

All inspectors have seen horrible design and workmanship and can tell you "horror stories" about homebuilt airplanes. One inspector told us of an experience he had. A mountain man in the western part of Virginia was building an airplane that he was going to "fly around the world". The airplane—if you care to call it that—was appallingly crude. The builder had some idea of what an airplane should look like, but no idea whatsoever of the requirements for internal structure. Thus, he built a normal-looking wing, but there was no spar! To demonstrate the need for a spar, the inspector lifted one wing tip while the builder did the same on the other end. The wing broke under this light load—even before the wheels had left the shop floor. The engine was something off of a lawn mower, and the propeller was a single canoe paddle. The builder had made a wooden ramp down the side of the mountain to use for takeoff.

At the same time, these inspectors will also tell you that the finest examples of workmanship that they have seen have been in amateur-built aircraft. Thus, you should understand that your announcement that you are building an airplane may be met with some caution.

The Experimental, Amateur-Built Category

Since the beginning of aviation, there have been homebuilt airplanes. Indeed, the Wright brothers were homebuilders, and they succeeded while the government-sponsored Professor Langley never managed to get into the air. As aviation grew, the government became involved in the approval of aircraft. This was partially because aircraft were being used for public transport, and also because aviation seems to frighten the general public—as it still does. Accidents are bound to happen, and even today, it is all-too-common to see a television reporter asking why the government does not do more to stop such things from happening. The public attitude toward aviation is the principal reason for the regulation we have today.

We regard the inspection of homebuilt aircraft as one of the prices we pay to live in an imperfect world. You may, for example, build a boat with a hole in the bottom, and you may set sail with your entire family on board. No one will stop you, but if you wish to build an airplane, the craft must be inspected by our federal government.

You may not be pleased to learn that the justification to "give" you this freedom to build and fly your own airplane is that your talents with aircraft construction may come in handy during time of war. Thus, you are eligible to have your aircraft licensed only if you are building the airplane for your own "education and enjoyment."

To keep rascals from producing aircraft on production lines and licensing them in the amateur-built category, the regulations state that a builder must do the majority of the work himself. This has been widely interpreted as the now-common "fifty-one percent rule", even though the rule does not actually exist.

With the growth of kits, the question has often come up if a certain kit complies with the "51% rule". Thus, the FAA began a process of approving kits. Many of the kits that have been approved are simple materials kits over which there is no controversy. The Rotorway helicopter kits are very complete—with all of the fabrication done for the builder. The builder must still assemble the kit, but many experts feel that these kits are close to, if not over, the 50% line.

When the Christen Eagle kits were introduced, the opening advertisement showed a finished airplane with all of the kit parts laid out on the runway. Even though Christen Industries had worked closely with the local GADO office, the head of the Van Nuys office saw the advertisement. As it turned out, this individual was not known for his love of homebuilts. In the meetings that followed, Christen was able to prove without any doubt that the Christen Eagle kit did not violate the "51% rule". Nevertheless, the objection had been raised, and Christen was forced to take the completed wing ribs out of the kit to pacify the man and qualify.

We have made no effort to have our Falco kits approved. The reason for this is that we have been adding to the kits as we go along. We do not want to have ourselves in the position of having our kits "frozen" at a certain configuration. If we later decided to add the wing fillet to the kit, we would have to go back through the approval process all over, and we would be in risk of being turned down. There is really no question that you will be doing more than 51% of the work on the airplane. If the Rotorway helicopter kits can be approved, then we should have little difficulty. In our conversations with the FAA, they have indicated that they do not see any difficulty in getting the Falco kits approved.

So far, our builders have had no trouble with the FAA inspectors. It is important for you to realize that the way you conduct yourself and your workmanship will make a big difference. You should understand that the inspectors are primarily interested in safety. This is their overriding concern, and many will tell you privately that they are less interested in the "51% rule", and that they are more interested in seeing professional quality parts used. At the same time, they are obligated to enforce the regulations.

Thus, it is important that you understand their position. You should avoid any discussion of the "51% rule". When an inspector comes into your shop, you should ask him to inspect the airplane. Have an airframe logbook handy for him to sign. Show an interest in quality workmanship, and tell him that you would appreciate it if he would point out anything that he doesn't like, since *you* want everything right. He is going to do that anyway, but the sentiment is a welcome one.

You should *never* ask the inspector if the parts you purchased bring the airplane within the 51% rule. If you ask the question, he will have to read you the rule book. This is something that he would like to avoid as much as you.

Most builders regard the inspection with a degree of fear, but the event usually turns out to be a wonderful experience for the homebuilder. Our Falco builders have consistently turned out superior workmanship. The odds are that your workmanship will be better than that on the production aircraft the inspector sees every day. The usual inspection goes something like this. The inspector enters the shop and begins quietly to look over the airplane. At some point, you will hear something like "Boy, this is really nice work!". The next thing you know you have a new friend who is offering a few suggestions and telling you about the horrible thing he saw the other day.

Perhaps the most telling experience was that of a Falco builder who had the head of the local GADO office do his inspection. The man was very impressed, not only with the workmanship but also with the design of the Falco. He unexpectedly broke off the inspection and left. Shortly thereafter, he reappeared with the *entire GADO office* in tow. He made them all come see the Falco (in his words) "to see how an airplane should be designed and how an airplane should be built".

Because of the load of inspection work put on these inspectors by the popularity of amateur-built aircraft, the number of inspections has been reduced to a minimum and some of the inspection is farmed out to local mechanics who hold Airframe Inspector ("AI") certificates.

Notifying the FAA

Before you begin your Falco, you should notify the nearest GADO or EMDO office that you are building a Falco. They will assign an inspector to your project. They will want to talk to you about the airplane, its construction (if they are not familiar with it) and tell you when they will want to see it. They will also tell you how much lead time they will need to schedule the inspection.

The number of inspections has changed from one office to another and over time. In the past, the normal was two or three inspections. In some cases, they would schedule an early inspection to determine the quality of your work. If this inspection is satisfactory, the inspector would usually turn over subsequent inspections to a local mechanic, or he will ask to see the airplane before you put the skin on the airplane. There is always a final inspection just prior to the first flight. This is usually done by the FAA inspectors.

In recent years, the FAA has been swamped by inspections of homebuilt aircraft and they have also found that the workmanship was so good that nothing was gained by interim inspections. As a result, the current policy is to inspect the airplane only once, just before the first flight. Typically, they will want the weight-and-balance done, the engine running and initial taxi tests done and with all inspection panels off the plane. They also like to see a photo album of the construction process.

The key to your relationship with the FAA is the quality of your workmanship and your conduct. Your contact with the inspector is not the time to express your rugged individualism or your dislike for government. Take the proper attitude, and you will be able to turn the situation into an enjoyable and informative session.

Chapter 6
Machining, Welding & Fabrication

Introduction
This chapter is devoted to the construction of the various parts which are included in the kits that we offer. Accordingly, if you purchase these kits, this chapter may be skipped.

The notes in this section will be rather brief. For one thing, we are of the opinion that if you don't know how to weld you should not attempt to construct the welded parts for the Falco. The notes included in this chapter are primarily for those builders with a background in metal working. If you do not have any experience, there is a wealth of information contained in the books listed in Appendix B.

Aluminum Alloys
With few exceptions, the aluminum parts for the Falco are made of 2024 aluminum. This is the standard aluminum alloy used in light aircraft construction. When compound bends or tight bend radiuses are used, annealed material is used. In the annealed state, the alloy is known as 2024-0. After forming, the part is heat treated to the "T" condition. Depending on the heat treating process and the material involved, this will be either 2024-T4 (heat treated and quenched only, no work after treatment), 2024-T3 (sheet, heat treated and rolled) or 2024-T3511 (extrusions, heat treated and stretched).

You may not substitute another aluminum alloy for 2024-T3 unless it is of equal or greater strength such as 2014-T6 and 7075-T6. These are commonly available in extruded form and may be used.

There are a number of machined parts which are made of 2024-T4 aluminum. For your information, we always call out the minimum acceptable alloy. The "T" specification for aluminum refers to the heat treating process, and the number is not a measure of it hardness or strength as are Rockwell hardness numbers for steel. 2024-T4 aluminum is about 2% weaker than 2024-T3 aluminum, so you may use 2024-T3 in those cases, but 2024-T4 is more commonly available in round bars.

The weaker alloys are 6061, 1100, 5052 and 3003, and none of these alloys may be used in place of 2024. Some of these alloys are used in the Falco. For example, 5052 is used for the fuel tanks, since it is weldable alloy (2024 is not), and 6061 is used for some parts where great strength is not important. You may use 2024 in place of 6061, but you must observe the bend radius requirements of 2024.

Steel Alloys
Almost all of the steel parts in the Falco are made from 4130 steel. This steel is available in three conditions: annealed, normalized and heat treated.

Annealed 4130 steel is used on some parts of the Falco. Annealed steel bends more readily than normalized 4130. When tight bend radiuses are specified (as in the upper side load struts), we make the parts from 4130 annealed sheet. After welding, the entire part is normalized.

Normalized 4130 ("4130N") is used for most of the parts in the Falco. The steel is available in the normalized condition in both tubing and sheet. When the steel is welded, internal stresses are built up, and the part must be stress relieved after welding. Failure to stress relieve any welded part can cause it to fail prematurely.

There are a few heat treated 4130 parts in the Falco. The normal heat treatment specification is to heat treat to 125,000 psi. When the part is machined only, you may use some other steel alloys such as 4140 or 4340, each heat treated to 125,000 psi. There will be a slight difference in the fatigue life of the part, but it is an extremely small difference and small enough to be ignored. For machined parts, you will find it easier to use pre-heat-treated steel. You should not use 4140 or 4340 or any other steel if the part is welded.

Bronze Alloys

The Falco uses a lot of bronze bearings. The original Falco used a bronze known as "UNI 1701 B14". All of the bronze parts in the original production Falco were made of this alloy, which has no exact equivalent in the U.S., but European builders may use the original alloy if available.

For bushings and similar applications, we use SAE 660 bronze, and for more highly-loaded parts, we use aluminum-bronze, spec: AMS-4631.

Plating

With few exceptions, the bronze and steel parts are cadmium plated. The reason for the use of cadmium is that cadmium is very close to aluminum on the galvanic scale. When two dissimilar metals are brought in contact they act like a battery in the presence of moisture. The more dissimilar the metals, the more electrical charge is created. Witness the use of nickel and cadmium to make Nicad batteries. The plating of steel and bronze is very important.

There are a few instances where steel parts should not be plated. Welded steel parts are not normally plated since the weld may have small holes which can trap the acids used during plating. If the acids are trapped, the acid begins to eat the part from the inside.

Welding

All welding must conform to AC *43.13-1*. It is suggested that all welding be done with TIG equipment. The specifications of AC *43.13-1* are confusing for TIG welding rod. Lindy 65 rod meets this specification, and we suggest its use.

All welded parts must be stress relieved after welding.

General Tolerance

When dimensions are given in millimeters, the general tolerance is ±0.1mm, unless stated otherwise.

Drill Sizes

When a hole is shown as *.250"±.001"dia* you are expected to ream the hole, but when a hole is shown as *drill 1/4"dia* you may drill using a 1/4" drill only. The customary letter and number drills may be used when the decimal size is given.

Bushings

The Falco uses a system of bronze bushings with the hinges. The bushings provide the clearances needed for pushrods, cables, etc. The bushings act as bearings for low friction, and they make the Falco less "jig-critical" since they may be adjusted slightly to make various parts fit together.

Because of their function in the aircraft, the installation and tolerances of the bushings is important. The bushings, in particular, must not be allowed to fit loosely in the hinges. (To guard against the possibility of the bushings being pushed completely out, the hinge bolts are installed with a washer under both the head of the bolt and the nut.)

All bushings are always chamfered at one end, although this is not shown on the plans. The appropriate note is “chamfer .01”x45° one end”.

The outside diameter of the bushings are given in nominal size only, but important close tolerances are involved. For all 7/16” diameter (nominal) bushings, the bushings must be .4395”±.0010” outside diameter after plating. The hinges must be reamed .4375”±.0010” diameter. The same fit applies to all other pressed bushings.

These tolerances are expressly intended for the use of Boston Gear’s “Bear-N-Bronz” solid bronze bearings. These are standard off-the-shelf bronze bushings of SAE 660 bronze. These bushings are supplied with the proper inside diameter, outside diameter and chamfer. They are supplied in various lengths. Contact your local Boston Gear distributor for details. You may *not* use the sintered bronze bushings made by Boston Gear, Oilite and other suppliers.

As a practical matter, we found that it was much cheaper for us to make our own bronze bushings on an automatic screw machine than it was to purchase the Boston Gear bushings. We offer these bushings, already cadmium plated, for less than you can buy the un-plated Boston Gear bushings. Press the bushings in place with an arbor press. Ream the I.D. after installation.

Hinge Fabrication

The drawings for the Falco hinges are shown in the simplest version that can be made from readily-available extrusions and sheet; however, the hinges may always be made of a single extrusion or from annealed sheet. If annealed sheet is used, the bend radius for the hinge is twice the thickness of the sheet, and the annealed sheet (2024-0) must be heat treated to T4 after forming.

Some builders want to substitute other extrusions or, if extrusions are not available, to machine the hinges from solid aluminum stock. It is very important that there be no sharp corners in the fillet radius between the hinge leg and the base of the hinge.

Spherical Bearings

Some early drawings show a 1/4”I.D. Southwest Product Co. bearing. This high quality aluminum bearing was specified before we realized what it cost ($27.00 in 1979). The more sensible choice is the Heim LSS-4 bearing which we now use. See drawing No. 743.

Nose Gear Fork

If you attempt to make the nose gear fork, you are in for a rude surprise. Even with the material purchased in the annealed condition, you will find that the material will crack. So far, no homebuilder has been able to make the part. We have worked out the problems and will be happy to ship you a part.

Landing Gear Mount Fittings

Before you make P/N 766 and P/N 768, see Chapter 23 for the method of jigging these fittings. The O.D. of P/N 768 should be made so that it exactly fits inside the I.D. of P/N 766.

Main Landing Gear Legs

If you make your own landing gear legs, you will find that the bearing surfaces of the upper tube will warp slightly during welding. For this reason, it is best to weld the upper tube completely, with the oleo brackets in place, then turn the bearing surfaces. After all of this is done, weld on the lower tube.

Chapter 7
Corrosion Protection

Introduction

The protection of aluminum, bronze and steel parts is a very complicated subject. For a complete discussion, the best publication is *Painting Aircraft for Corrosion Control* by Ray Stits. This manual is very complete. However, it is concerned primarily with metal aircraft refinishing, thus much of the manual does not apply to building the Falco. *Aircraft Painting and Finishing Manual* by Randolph Products and *Aircraft Corrosion Protection* by Aviation Maintenance Foundation will provide additional information.

Alodine Conversion Coating

All aluminum parts should be protected with an Alodine conversion coating. For simplicity, we specify DuPont products as they are widely available in almost every city. Any paint store that carries DuPont products can get you what you need. Stits Poly-Fiber Aircraft Coatings and others sell the same materials under other names.

The first step to alodine a part is to clean the aluminum. You may use MEK, toluol, acetone or lacquer thinner on paper toweling. Some people contend that MEK is too volatile to do much good as it flashes off before it removes the oil and grease. Be wary of sandpaper as it is coated with a wax to keep it from clogging, so you must clean after buffing any scratchs. Remember, fingerprints leave an oil film that keeps paint from sticking, so wear rubber gloves. Wear rubber gloves to protect your hands from the acids that you are about to use. These acids attack your skin, and it is particularly painful under your fingernails. If you do not use any of these cleaners, you may use a detergent solution and flush with water.

The second step is a phosphoric acid etchant treatment (DuPont No. 225S Cleaner) which cleans the aluminum of any remaining oil and grease, removes any corrosion and microscopically etches the surface of the aluminum. Use the cleaner as directed. We use photographic developing trays for the acid etchant and conversion coating. Scrub the aluminum with a Scotch Brite pad while the aluminum is in the acid bath. Flush the part with water.

The last step is the application of the alodine (DuPont No. 226S Conversion Coating) which is a chromic acid solution. This chemically stabilizes the aluminum for corrosion protection and promotes the adhesion of paint. Most experts feel that alodining is the most important thing you can do to stop corrosion, more important than priming—which isn't much good if the surface has not been alodined. The additional cost and time involved in these simple steps is small, and you will be making an important step in protecting your Falco. Like the phosphoric acid etch, alodine will attack your skin, particularly under your fingernails.

The alodine process leaves the aluminum with a slight gold color. The part is now ready for painting. The kit parts supplied by Sequoia Aircraft have already been alodined, so this process is not necessary for kit builders, but we do recommend that you clean the part with MEK prior to painting.

Zinc Chromate Primer

For years, the standard protection of steel and aluminum parts has been zinc chromate primer. This primer contains sacrificial pigments, which protect the base metal from corrosion. For the interior of the aircraft this is adequate. These primers may also be used on the landing gear and other parts which will be exposed to the elements. Zinc chromate primers do not have good adhesion. The primer is available in yellow or green. We prefer the yellow, simply because the lighter color makes inspection easier. Zinc chromate primer is available in spray cans, and our experience with these has been poor. We prefer the normal cans of paint, mixed with reducer and sprayed with a gun.

If you wish, you may paint over top of the zinc chromate primer. The paint should be a compatible enamel. You should *not* use epoxy or polyurethane enamels over this primer.

Polyurethane Enamels

Polyurethane enamels have become very popular in recent years, and justly so. These paints require special primers and precautions. If you wish, you may use polyurethane paints on the metal parts. The protection is superior and the paint will last a long time. These are not easy paints to use. You should obtain the manuals from the paint company you select and follow the instructions for that particular paint. Most builders choose DuPont's Imron, Ditzler or Stits paint.

Steel Parts

Steel parts may be painted with zinc chromate primer or polyurethane paint. While polyurethane paint may offer superior protection, it is not always the best thing to use in every application. If you have a part which is subject to frequent wearing or chipping of the paint (such as some of the parts in the landing gear retraction system) you may find that it is preferable to use zinc chromate. This is easily touched up, while polyurethane is not.

For additional protection of steel, you may use par-al-ketone. Par-al-ketone is a thick greasy mess that is used on the most difficult situations and where appearance is not important. It is normally used on carbon steel control cables in production aircraft (we use stainless steel, so you won't need it there). One place you might want to use par-al-ketone is inside the upper tube of the main landing gear leg. If you heat par-al-ketone it becomes liquid enough so that it can be brushed or sloshed in the tube. For maximum protection, we would suggest sloshing first with zinc chromate primer, then after it is dry, sloshing with par-al-ketone.

Do Not Paint...

It is important that you do not paint the ends of bushings and any other part which will be subject to wear and friction. If you paint the ends of bushings you will be creating unwanted friction in the control system. Also, the landing gear legs should not be painted where they fit in the bushings as it would prevent the landing gear from retracting smoothly.

Do Not Plate...

Builder can sometime get hung up on plating things. One builder—a very intelligent fellow but ignorant of the dangers involved—told us he was going to have his engine mount chrome plated. That sounds like a good idea until you know what will happen. You should not plate any welded part. Welds are always porous and the plating process involves acids. For chrome plating, the part is placed in chromic acid and the plating process converts the chromium in the acid to a deposit of chromium on the surface of the part. With a welded part, the acid will become trapped in the pores of the welding and will be completely covered up by the plating process. Then, the acid will eat away the metal—seriously weakening the weld. *Don't plate welded parts!*

Chapter 8
Aircraft Woodwork, Materials

Spruce

The Falco was originally designed and built with Sitka spruce for all of the spar caps. Poplar was used for the ribs, fuselage frames and all other places where we now use spruce. We are in the process of phasing out all mention of poplar in the Falco plans and use only spruce. It is important that you use only Sitka spruce for the spars. Spruce is the only wood commonly used in aircraft. It is the standard against which all other woods are judged. Spruce is slightly stronger than poplar and slightly lighter. If you build your Falco entirely out of spruce, you will have a lighter and stronger airplane. The entire aircraft wood technology has been built up around spruce. We suggest that you use only spruce in your Falco.

Aircraft quality spruce is very expensive, largely due to the amount of waste that is created in the grading process. The wood is kiln dried, then the wood is subjected to a series of inspections. Only the best wood is used for aircraft, and the waste is enormous. As a result, most mills do not want to bother with aircraft spruce. We suggest you only purchase spruce from companies that grade and certify their spruce. It is very important that you use only certified aircraft spruce for the spar caps. You can use lesser quality spruce for such things as blocking.

Other Woods

The Falco uses a small amount of other woods. There are a couple of blocks of Douglas fir used in the main wing spar at the landing gear fittings. This may be purchased locally from a lumber yard.

The leading edge cap strip of the ailerons are made of beech, walnut or oak. The reason for this is that the heavier wood is used as an aileron balance weight. These three woods weigh about the same. Beech was used on the original production Falcos. You should be careful if you use white oak with epoxy glue. Special instructions are included with Chem Tech's T-88 epoxy on gluing white oak.

Birch Plywood

The plans for the Falco specify birch plywood in metric sizes. Some of the sizes are not available in the U.S., and the builder will have to use the next larger size. In particular 1.2mm birch plywood seems to be rather hard to obtain in the U.S. First, you might check the thickness of the plywood you have purchased as “1mm”, and you may find that is actually measures to be 1.2mm. If you are unable to select such pieces, then you will have to use 1.5mm plywood. Birch plywood has a hard surface sheen as a result of the manufacturing process, and it must be lightly sanded before gluing. This is very important as the glue will not penetrate the wood fibers without a light scuff-sanding and will result in an unsafe joint. Mahogany plywood should not be used on the Falco as it is weaker than the birch plywood specified.

Birch plywood, by the way, is actually a combination of birch and poplar veneers. Birch is used on the face plys, while poplar is used for the core.

Moisture Content

The moisture content of wood is dependent upon the humidity and temperature of the surrounding air. When wood is subjected to a constant temperature and relative humidity it will in time come to a definite moisture content, which is called the equilibrium moisture content. This relationship between the moisture content of Sitka spruce and the surrounding atmospheric conditions is shown in Figure 1.

Note that under constant temperature conditions the moisture content increases as the relative humidity increases, and that under constant relative humidity conditions the moisture content decreases as the temperature increases. In general, relative humidities are lower in the spring and summer than during the autumn and winter, and seasoned wood exposed to these changes in humidity will absorb or lose moisture accordingly.

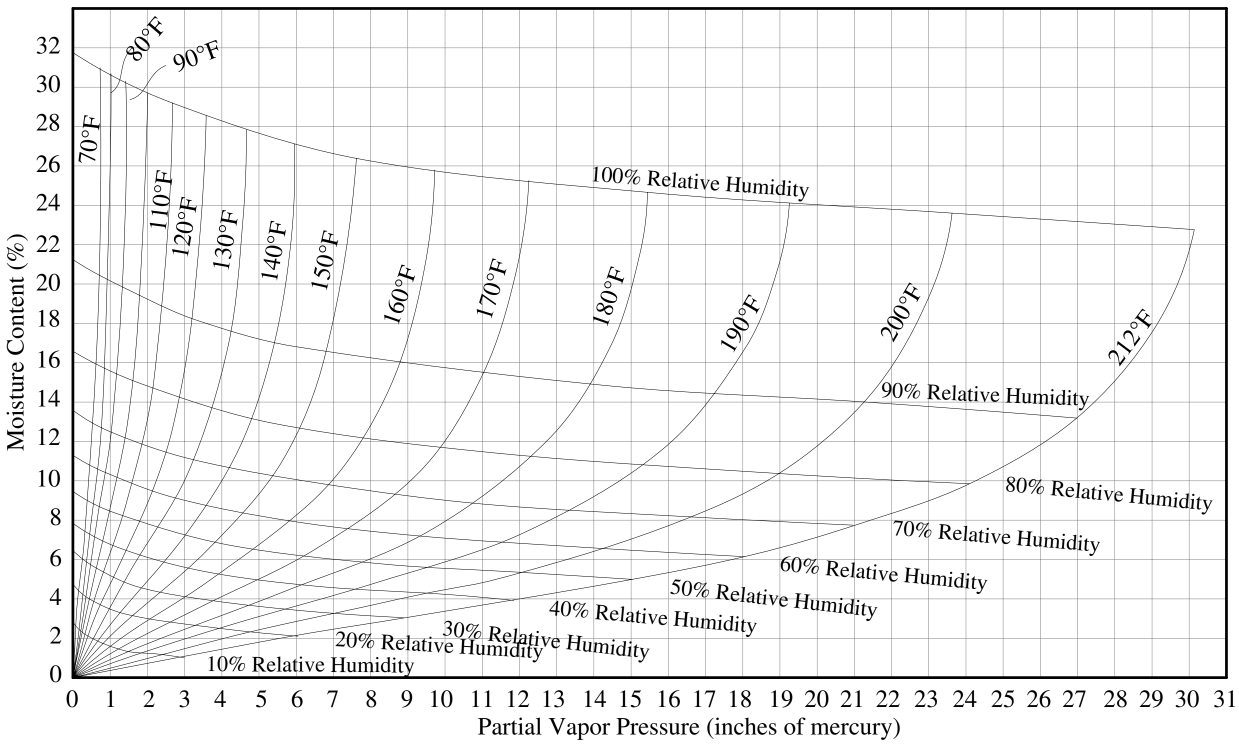


Figure 1

	Mean relative humidity in percent based on daytime readings			
City	**Winter**	**Spring**	**Summer**	**Autumn**
New York, NY	73	70	74	75
Cleveland, OH	77	72	70	74
Spokane, WA	82	61	47	67
Seattle, WA	83	73	69	81
Phoenix, AZ	47	32	32	41
San Diego, CA	74	78	81	78
San Francisco, CA	79	79	84	80
Denver, CO	54	51	49	46
Washington, D.C.	72	68	75	76
El Paso, TX	45	27	41	46
Galveston, TX	84	82	79	78
Jacksonville, FL	80	74	80	83

In addition to variation due to season, there is also a variation in relative humidity in different parts of the country as affected by altitude, proximity to the ocean, precipitation or some comparatively local condition. The table above shows the relative humidity for a number of widely separated cities in the United States at different times of the year. Similar seasonal variations occur in other parts of the world. In tropical and subtropical areas, where long rainy seasons are followed by long dry spells, the spread of equilibrium moisture content between seasons may be considerable. Low equilibrium moisture content conditions may be expected in desert areas, while in Europe generally the average equilibrium moisture content would be as high as, or higher than, that along the northeastern coast of the United States.

The approximate equilibrium moisture content for wood can be estimated for any section of the country and for any season by noting the relative humidity given in the table above and reading the corresponding moisture content from Figure 1 at the particular temperature under consideration.

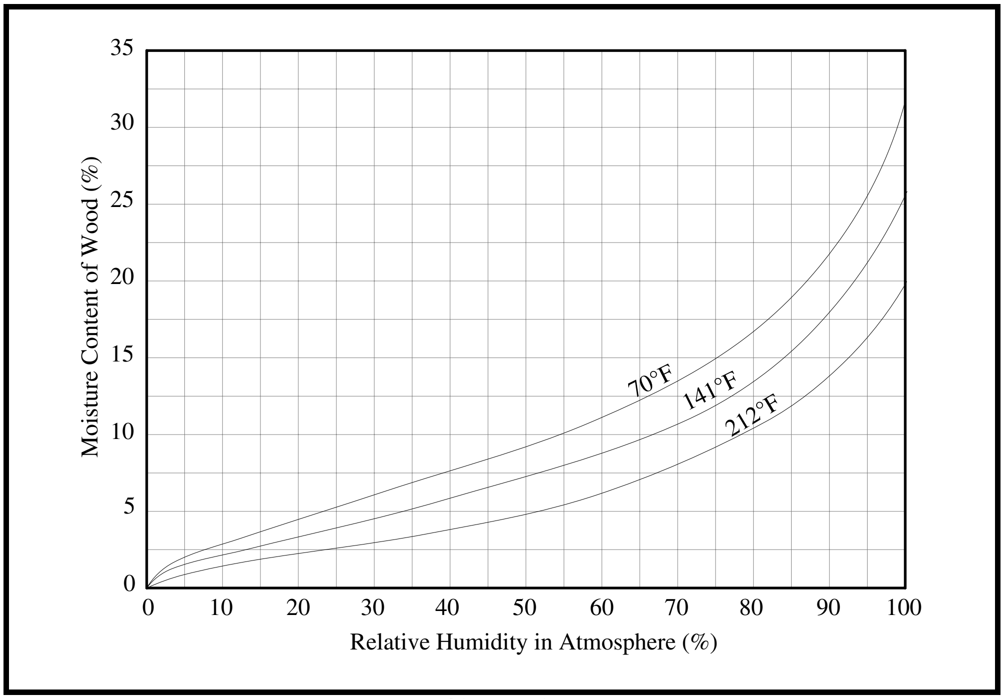


Figure 2

The relationship between relative humidity, temperature and the moisture content of wood is shown in Figure 2 in a form that may be easier to understand than Figure 1.

Most Falco builders pay little attention to the moisture content of the wood that goes into their aircraft. Since wood expands as it picks up moisture and contracts as it dries out the moisture content of the wood will have an effect on the appearance of your aircraft. In general, there are two things to watch out for.

First, the moisture content of spruce changes more quickly than that of birch plywood. The reason for this is that plywood has layers of waterproof glue, and these layers slow down the rate of change in plywood. Since aircraft plywood is manufactured in a hot press (the phenolic glue requires about 300°F to cure), it is very low in moisture content when first made. For most parts of the country, spruce and plywood will reach a moisture content of about 12% in time, regardless of the finish applied to the wood—for more on the subject of finishes, see Chapter 9 “Moisture Protection of Wood”.

When you purchase birch plywood, it is quite likely that the plywood will have a low moisture content, typically around 5 to 7%. If you use the plywood immediately, the plywood will be drier than the spruce. In time, the plywood will pick up moisture and expand. For most parts, this is of little consequence. If the plywood is used for skinning the wing however, the appearance of the airplane will be seriously degraded. The expansion of the plywood will cause depressions between the ribs. If you want a smooth finish on your Falco, you should order your plywood well in advance and let it equalize.

Tests have shown that the smoothest wings will result if the moisture content of the plywood is 1.25% to 1.50% greater than the airframe. This way, the skin will tighten slightly to give a smooth finish. To accomplish such precision, a wood moisture meter is essential.

The second thing to watch out for is that if you work in a heated shop in the winter, the wood in your airplane will become very dry. Because of the contraction of the dry wood, one Falco builder had corner blocks crack and pull away from the wing ribs. If you work in a heated shop in the winter, get a humidifier and hygrometer to moniter the relative humidity.

As a further guide to the moisture content of wood, Figure 3 shows the recommended moisture content averages for interior woodwork for use in various parts of the United States. This map was developed for residential housing construction, but the patterns of moisture content may be of assistance.

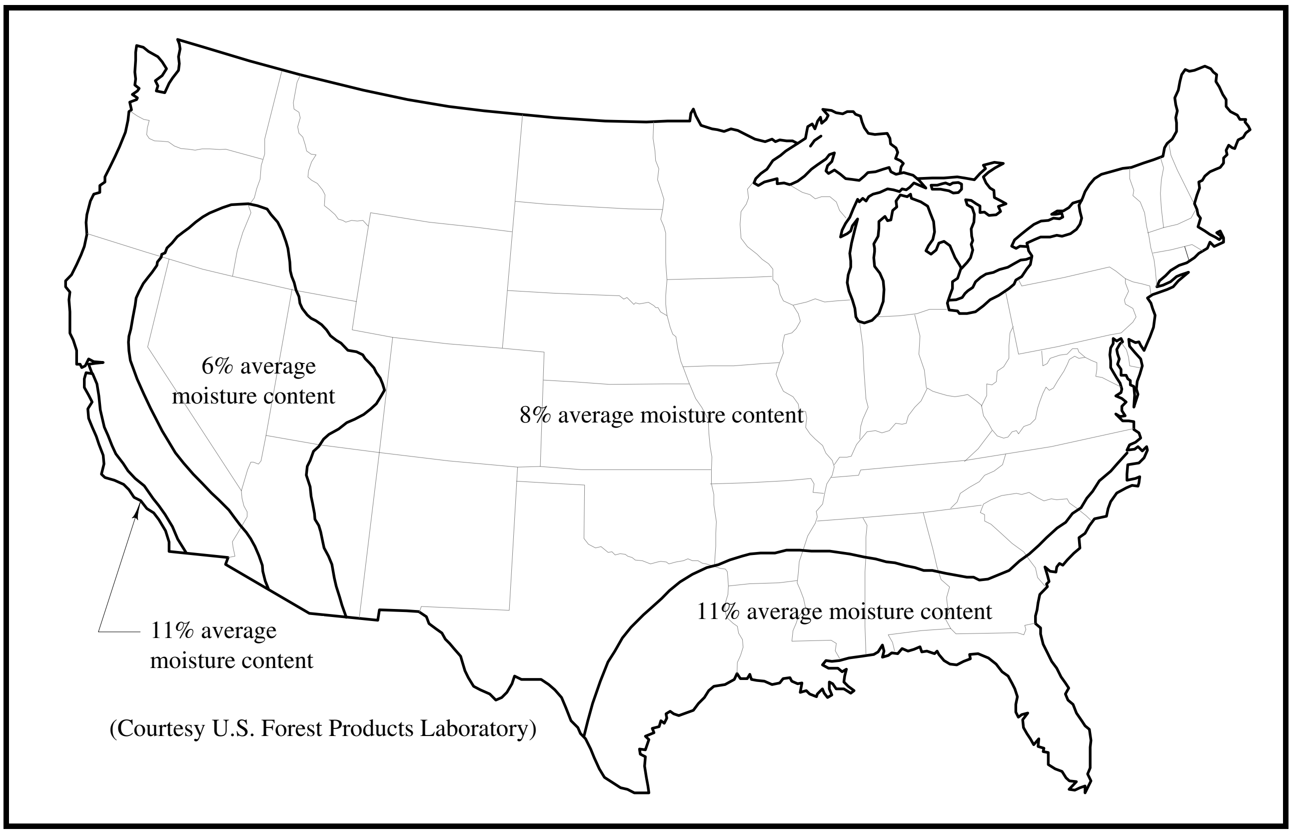


Figure 3

Glues

We recommend that Aerolite 306 glue be used to build the Falco. Aerolite is a gap-filling, water-resistant adhesive that is very easy to use. It sets up quickly, allowing—and requiring—quick assembly. Of all the glues available, this glue is the best choice for most builders. The original production Falcos were built entirely with Aerolite. Aerolite is highly recommended.

For those jobs where a longer working time is needed, we recommend Koppers Penacolite G-1131 resorcinol adhesive. Resorcinols are the most durable room-temperature-setting wood glues, and Penacolite G-1131 is the best choice among the many brands available. Used on the Bellanca Viking and the French Robin aircraft, Penacolite G-1131 is highly recommended. It isn't as easy to use as Aerolite, doesn't gap-fill as well and requires more clamping pressure.

Because of our concerns about the temperature performance of epoxy glues, we do not recommend their use in building the Falco. Many builders regard our concerns as excessively conservative and cite the lack of problems with homebuilt aircraft built with fiberglass, wood and epoxy. If you share that view and choose to use epoxy, you will not be taking any greater risk than those who build and fly fiberglass airplanes, and you will find the ease of use of epoxies impossible to beat—particularly because the glue can also be used as a moisture protection “varnish”.

A more complete discussion of these and other glues follows.

Aerolite

Aerolite is a urea-formaldehyde resin glue which was developed for use in the famous de Havilland Mosquito bombers. Aerolite is a two-part glue. The glue is a white powder which is mixed with water. This should be kept cool, and most builders keep the glue in a refrigerator. The hardener is diluted formic acid. The glue is put on one side of the joint, and the hardener is put on the other. The glue sets up when the two pieces of wood are brought together. The fumes from the hardener will cause the glue to set up, so you have to be careful about that.

There are two hardeners: one normal and one fast. The working time depends on the temperature and hardener used—you will have from 5 to 25 minutes on average. You must work quickly to use Aerolite for gluing large sheets of plywood. Use small nails as alignment pins to correctly locate the skin, and use a pneumatic staple gun to install all of the nailing strips quickly.

It is easy to forget to put on the hardener and never realize your omission—best to put some green food coloring in the hardener so that you can see that you have used the hardener. Don't use red since inspectors might take it for rot. An excellent applicator for the catalyst is one of the little wedge-shaped, sponge-like foam paint brushes sold in hardware stores as cheap substitutes for sash brushes. The head holds enough formic acid to wet most of a skin sheet, and the brushes are very cheap.

Aerolite may be ordered from Trimcraft Aero, Wicks Aircraft, Aircraft Spruce and Specialty and others. Ciba-Geigy's instruction sheet for the use of Aerolite 306 is reprinted in Appendix D of this manual.

Penacolite G-1131 Resorcinol

Ask any expert what room-temperature-setting wood glue will produce the most durable joint. The answer is always resorcinol, unless the expert is marketing another glue. Tests by the Forest Products Laboratory—the world's most authoritative experts on wood technology—confirm this. Properly glued, resorcinol results in a joint that is virtually unaffected by age, heat or moisture.

Best results do not always come in the same package with ease of use, even with Penacolite G-1131 which is probably the easiest and most forgiving resorcinol to use. Penacolite is a two-part adhesive, and a powdered hardener is mixed with a liquid resin. The mixing ratios are important and require weighing—measuring by volume is not recommended. A minimum temperature of

70°F is required, and this glue does not fill gaps as Aerolite does, thus the surfaces of the pieces of wood must be machined surfaces. Glue pressures are important with resorcinols and Penacolite is less sensitive to glue pressures that others.

The Bellanca Viking was made with Penacolite G-1131, as are the French Robin series of wood aircraft. Since it is ordered direct from the manufacturer, the glue is not widely known among homebuilders, but many Falco builders have used the glue, and they have sent in glowing reports. We are not aware of any Falco builders using Penacolite for the entire airplane—nor do we recommend it since Aerolite is a better choice for those poorly-fitting joints you don't like to admit having made. Use Aerolite for most of your work, and when you need more working time and have a good fit, use Penacolite—particularly for things like the spar and fuselage frame laminations.

Penacolite must be ordered direct from Koppers Company. See the F.8L Falco Kit Price List for ordering information. Koppers Technical Bulletin on the use of Penacolite G-1131 is reprinted in Appendix D of this manual. (Because Weldwood Resorcinol glue is also widely used, we have reprinted the Product Data Sheet in Appendix D as well.)

Plastic Resin Glues

Weldwood Plastic Resin glue is the best-known glue of this type, which is a urea-formaldehyde glue like Aerolite. Aerolite uses an acid as the hardening agent, while "plastic resin" glues use a dry powder catalyst that is activated in the presence of moisture. It is almost foolproof to use and economical. It requires moderate clamping pressure but is not sensitive to glue pressures. Like resorcinol, this glue does not have good gap-filling characteristics. This glue has been used for years on the Pitts Special and is used on the Christen Eagle. This was also used on the wood-wing Mooney aircraft.

We do *not* recommend the use of this glue with birch plywood. For reasons that are not understood, Weldwood Plastic Resin glue does not adhere well to birch plywood. With some of the first Falco ribs, this glue was used for the gussets. When the staples were removed, the gussets fell off!

Epoxy Glues

The development of epoxies has revolutionized the use of wood in boatbuilding, providing such moisture protection that it has virtually eliminated rot, paint peeling, warping and high maintenance. The Gougeon Brothers' West System is largely responsible for the revival of wood boats. The "latest generation" of homebuilt aircraft are built of fiberglass, which is epoxy and fiberglass cloth. Epoxy resins have much to recommend them. They are easy to use, require little clamping pressure and can be used as a "varnish" as well as the glue. Before you build a Falco using epoxy glues, you should know of their limitations.

The principal limitation is that epoxies soften with heat, and the room temperature cure epoxies used on boats and homebuilt airplanes have poor performance at elevated temperature. Tests by Bellanca Aircraft showed that the two most popular epoxies used by homebuilders, Chem-Tech T-88 and FPL-16A, begin to soften at 125°F, have about 25% of their original strength at 150°F, and have a shear strength of only 40 psi at 175°F—about the same strength as library paste. (The epoxy industry is notorious for its lack of ethics in sales literature: Chem-Tech's literature for T-88 claims a shear strength of 1,000 psi at 180°F. Don't believe any claims unless you have run tests.) Tests by others have indicated that the West System epoxies have slightly better performance.

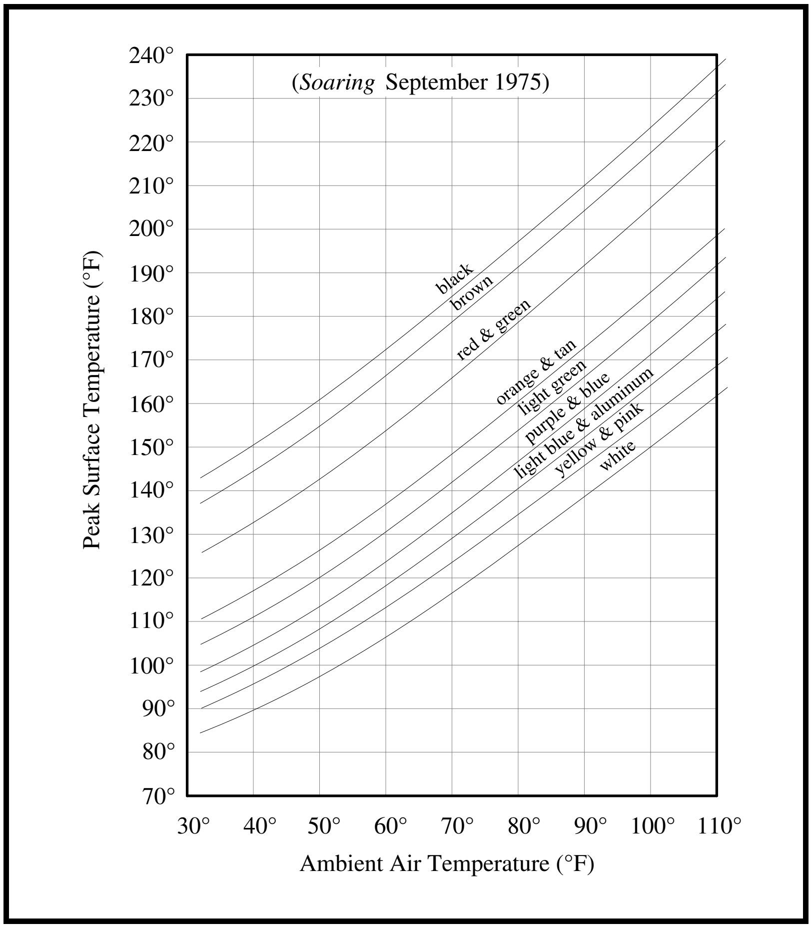


Figure 4

The September 1975 issue of *Soaring* magazine carried an article which reported on a series of tests done to determine the effect of the color of aircraft paint. A number of foam boxes were made and covered with fiberglass and then painted various colors. A thermometer was inserted into each box to record the surface temperature. The ambient air temperature was recorded as well. The results are shown in Figure 4. Note that at an ambient air temperature of 100°F, the white-painted surface reached a temperature of 150°F, while the black-painted surface recorded a temperature in excess of 220°F. Since the temperature performance of epoxy is marginal, if you build your Falco with epoxy you must paint the airplane white—to use any other color is foolish and dangerous.

The experience of wooden boats and homebuilt aircraft has been better than the engineering tests would indicate. We have had two epoxy glue joints fail in the engine compartment of the Falco. One was the wood blocks for the landing light installation, and the other was a bonded block on the nose gear door. Other than these two failures, we are not aware of a single glue failure in a wood boat or homebuilt aircraft that can be attributed to heat. We have talked to a boat builder who has used West System epoxy for 15 years—even in the engine compartment of racing boats—without a single glue failure.

The second major limitation of epoxy is the health hazard of using it. All epoxies are toxic substances and you must observe the manufacturer's recommendations for shop safety. This usually means a well-ventilated shop, so that you will not breathe the fumes. You should protect your hands with rubber gloves or a barrier creme—PR88 is the best available.

The effects of epoxy are cumulative. When you first work with epoxy you will not be bothered, and you will wonder what all the fuss is about—then one day you will become sensitized. When that happens, you will have burns on your hands from the epoxy, and you are in trouble for the rest of your life. The problem never goes away.

One Falco builder working with T-88 became sensitized. He continues to like epoxies and has bought a $400.00 "space suit" that painters use—supplied with air from a compressor. Tony Bingelis is sensitized, and unmentionable parts of his body itch when he works around epoxy! We once heard from a man whose father built a "Vari-Eze". In the process of building this fiberglass airplane, the man became sensitized. Unwilling to give up his project and with no alternative adhesives available, he continued to work with epoxies. In the end, all of the hair on his body fell out and has never grown back. It is possible to work with epoxies for your entire life without becoming sensitized, but this always depends on observing the required safety precautions.

You should be aware that there is a problem with combining Aerolite and epoxy glues. Aerolite glue uses an acid as a hardener, and some acid is left over after the glue joint is made. The acid is normally evaporated within a few days, but if an epoxy joint is made over a fresh Aerolite joint, the left-over acid can neutralize the epoxy hardening process.

Now, let's review some of the most popular epoxy glues. FPL-16A was designed by the Forest Products Laboratory for use with wood. While the glue has excellent characteristics, it has some significant disadvantages. The vapor is very toxic, and a number of builders working in enclosed spaces have had serious health problems (involving the central and peripheral nervous systems). The mixture is quite critical and requires careful measurement of the two parts—difficult when small quantities are involved. The glue does not gap fill as well as some other epoxies. The glue dries white and then yellows with age. FPL-16A glue may be purchased from Aircraft Spruce, Wicks, and other suppliers.

Among homebuilders, the most popular epoxy is Chem-Tech T-88. It isn't hard to see why—the glue is a one-to-one mixture ratio and comes in plastic squeeze bottles. For small batches, you just squeeze out equal-length beads of each part, mix and apply. The glue dries clear and stays clear. Chem-Tech says that T-88 will cure down to 35°F, although hardening takes about a week.

T-88 can be thinned with lacquer thinner and used as a sealer in place of the more traditional varnish, but the thinner evaporates and creates a porous film. Chem-Tech sells a low-viscosity epoxy called L-26 for just this purpose. Chem-Tech T-88 may be purchased direct from the manufacturer: Chem-Tech Inc., 4669 Lander Road, Chagrin Falls, Ohio, 44022. Telephone (216) 248-0770.

Applied Plastics (APCO) has developed a structural adhesive that is similar to T-88. This glue is sold by Aircraft Spruce, Wicks and others. No testing reports are available to assure us that it is any different from T-88 in performance.

Builders thinking of using an epoxy should consider the West System sold by Gougeon Brothers Inc. This company is largely responsible for the resurgence of interest in wooden boats. As such, Gougeon Brothers is probably the world's leading authority on the moisture protection of wood. We are very impressed with the professionalism of this company. They maintain a large testing facility and have done pioneering work on fatigue testing of wood and fiberglass—wood wins by a large margin.

The West System epoxies are low viscosity resins, designed primarily as a moisture protection coating that is adapted for use as a wood glue. They have little resistance to glue starvation caused by clamping, and Gougeon recommends the addition of Microfibers (cotton flox) to the resin to prevent glue starvation and for greater gap-filling capabilities.

The West System epoxies require a five-to-one mixing ratio, but this is not a problem since Gougeon sells dispensing pumps which provide the necessary ratios of resin and hardener. We highly recommend the West System for use as a moisture protection coating, both as an interior varnish and when covering the outside of the airplane with fiberglass cloth and epoxy. If it weren't for our concerns about the temperature performance of epoxies, we would recommend the West System without reservation for gluing wood.

And what does Gougeon Brothers say about our position on epoxy? The head of the testing department says that our position is exactly the same as theirs: that concerns about the temperature performance of room temperature cure epoxies are valid even though they are not aware of anyone having problems with white-painted epoxy-built wood aircraft. They know from tests that the temperature performance of West System is better than high viscosity flexible epoxies (such as T-88). They have not run enough tests at elevated temperatures to chart the performance of their epoxy system. They are hard at work developing an epoxy system with better temperature performance, but it is a difficult task. The reactive diluents which are needed to thin the epoxy for good penetration into the wood fibers lower the temperature performance, and the additives that raise the temperature performance have undesirable characteristics.

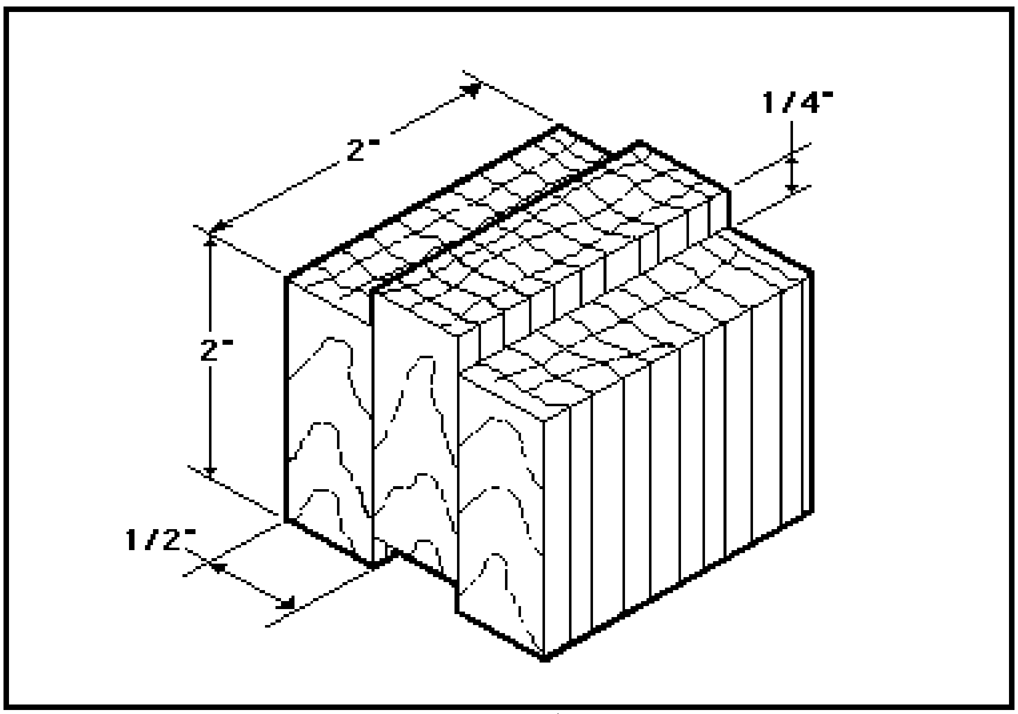


Figure 5

Test Blocks

All wood aircraft manufacturers test each batch of glue by gluing two blocks of maple wood together. When pulled apart, the wood must fail before the glue. Maple is used since it is stronger than spruce, so if the glue will hold until the maple breaks, then it will have plenty of strength with spruce. This technique of using test blocks is an excellent one, and something you should consider. Mark each test block for the FAA inspector to see.

The normal test used for wood aircraft is known as the "block shear test". This is described in *ANC-19* and many other texts. You will not be able to duplicate this test without the required testing equipment. A simple homebrew equivalent would be to glue three blocks of wood together, as shown in Figure 5. The glue blocks should be tested in shear, so you would put the blocks in a vise or arbor press, or just put them on the floor and hit them with a sledgehammer. A test is considered satisfactory if the wood fails over 75% of the area.

The first thing a Falco builder should do is a lot of practice gluing. Test every sample to destruction. The soundness of the glue joints should not be something that depends on luck. With such tests, you will quickly learn how to make glue joints that you can depend on. There is, in our opinion, no other way to go about it.

Chapter 9
Moisture Protection of Wood

Introduction
All of the interior and exterior wood surfaces must be covered with a coating to prevent the absorption of moisture. This chapter will deal only with the interior surfaces.

A complete discussion can be found in the "Finishing Wood in Aircraft" section of ANC-19. This publication describes the methods used on wood aircraft at the time of its publication (1951). The technology of finishing wood has been greatly advanced since then.

Requirements of Finishes
The primary objective of interior finishes is to afford protection of the wood against serious change in moisture content when exposed for a limited time to damp air or to water that gains access to closed spaces by condensation or by penetration of rain, mist or fog through joints, vent holes or imperfections in the covering. Coatings on contact areas between wood and metal protect the metal against corrosion from moisture in the wood.

Interior finishes must retain their protection for the life of the aircraft and throughout the great range in temperature to which the craft is subjected in service. They need not be capable of withstanding exposure to the weather, including sunshine, for any such length of time.

The primary objectives of exterior finishes are protection of the wood against weathering, sufficient smoothness of surface to minimize skin resistance during flight, suitable appearance and enough durability to retain these properties for several years of full exposure to the weather at all altitudes of flight even in the most severe climates. The finish should be easy to keep clean and should wear in such a way that it can be renewed when necessary with minimum increase in the weight of the coating.

Protective Power of Wood Finishes
When unprotected wood is exposed alternately to dampness and dryness, such as to rain and sunshine, the portions of the wood near the surface change in moisture content more rapidly and more widely than do the interior portions. Such unequal distribution of moisture within pieces of wood sets up internal stresses that are responsible for such processes of weathering as grain-raising, cupping, warping, checking and softening and disintegration of the surface. Protective finishes guard against weathering by retarding the rate at which moisture passes though them, either into or out of the wood surface, to such an extent that a reasonably uniform distribution of the moisture within the pieces of wood is always maintained and internal stresses are thereby avoided.

A finish entirely impermeable to moisture has not yet been found. Moreover, no finish alters the fiber-saturation point or swelling coefficient of wood. Many tests have proved that all finishes, including multiple coats of polyurethane and epoxy, do not stop the moisture content of the air from changing the moisture content of the wood. There are many finishes which will keep water in a liquid state from entering the wood, but water vapor in the air will penetrate all known finishes.

The 1950's Techniques
The techniques and materials included here are a summary of the suggested procedures from *ANC-19*.

The surface of wood is vascular and moderately absorptive of liquids. Wood surfaces, therefore, must be rendered nonabsorptive by applying sealer or primer, which penetrates only far enough to close the openings in the surface, before a uniform coating of finish can be spread over the surface. Hardwood with pores as large as those in birch require wood filler applied by wiping across the grain of the wood to plug the large pores. If a finish with a mirror-like smoothness is required, wood of any kind usually must be coated with a sanding surfacer, part of which is sanded away after it has dried, to yield a perfectly smooth surface for the application of the final coating.

To be durable, wood finishes must remain somewhat plastic throughout their useful life so that they can accommodate themselves to the changes in shape and dimensions of the surface. The required degree of plasticity usually runs counter to the desire for speed in drying and hardness of coating; plasticity is provided by drying oils or soft resins, whereas fast drying and hardness come from hard resins or cellulose esters.

Finishing systems when dry should add as little weight to the aircraft as is consistent with the attainment of their primary objectives.

The most effective coating of the 1950s was aluminum enamel, followed by gloss enamels and varnishes. Among the findings:

- Deeply penetrating finishes, such as water-repellent preservatives, afford relatively low moisture-excluding effectiveness but may provide a significant degree of water repellency.

- Slightly penetrating finishes that form little or no coating over the surface of the wood, such as sealers, are lower in water repellency than the better water-repellent preservatives when only one application is made, but a second application often results in somewhat higher water repellency than is obtained with water repellents, though the moisture-excluding effectiveness remains low. The sealers are designed primarily to render the surface of wood non-absorptive for the liquids in coating materials applied subsequently, but two or more applications of sealer are used also as a moderately protective finish for surfaces not exposed to the weather.

- Coatings of a porous nature, such as lusterless camouflage enamels and camouflage lacquers, do not provide much moisture-excluding effectiveness.

- Coatings of a nonporous nature, such as spar varnish, when so applied as to form a film of appreciable thickness (0.001” to 0.003”) over the surface of wood, achieve reasonably high moisture-excluding effectiveness.

- Pigmented coatings of a nonporous nature, such as semigloss or gloss enamel, have materially higher moisture-excluding effectiveness than otherwise similar coatings without pigments.

- Aluminized coatings, which are pigmented with aluminum in the form of thin flakes, are capable of attaining very high moisture-excluding effectiveness even in thin coatings of light weight. For full effectiveness, however, at least one aluminized coat should be a priming coat or an undercoat, that is, it should be sandwiched between the wood and succeeding coats or between coats. When the final coat only is aluminized the moisture-excluding effectiveness sometimes is no greater than that obtainable with the clear vehicle without the aluminum.

Recent Developments

In the past decade, polyurethane paints have been developed which have largely replaced the older enamels. For exterior surfaces, it is generally agreed that the best paint system is epoxy primers and polyurethane finish coats. These paints are exceptionally durable, and they maintain the "wet look" of a new paint job for many years. There are some confusing claims about the moisture-excluding characteristics of these paints. Sold as finish exterior coatings for aircraft, they are frequently referred to as being "totally impermeable to water". This is probably an accurate statement regarding liquid water, indeed, one of the problems created by polyurethane paints is that moisture trapped under the film coating causes corrosion in metal. Tests by the Forest Products Laboratory show however that polyurethane and epoxy paints have excellent moisture-excluding effectiveness, nearly equal to that of aluminum pigmented paints. In the tests, ponderosa pine sapwood was initially conditioned to 30% relative humidity at 80°F and then exposed to 90% humidity and 80°F. A value of 100% means that the coating is totally effective.

	Moisture-Excluding Effectiveness (%)		
Finish type	After 1 day	After 7 days	After 14 days
Spar varnish (soya alkyd/phenolic/tung)			
One coat	48	6	0
Two coats	80	36	15
Three coats	87	53	30
Polyurethane Varnish (one component/oil modified)			
One coat	55	10	2
Two coats	83	43	23
Three coats	90	64	44
Polyurethane paint (2 part)			
One coat	91	62	41
Two coats	94	77	61
Three coats	96	82	70
Epoxy paint (2 part)			
One coat	93	64	40
Two coats	98	88	78
Three coats	98	90	83
Enamel paint (soya/tung/alkyd)			
One coat	93	69	50
Two coats	96	83	70
Three coats	97	86	80
Aluminum pigmented varnish			
One coat	90	61	41
Two coats	97	87	77
Three coats	98	91	84
Paraffin wax dip	100	97	95

Note that aluminum pigmented varnish is still superior to polyurethane and epoxy paints. This does not take into account the greater life of polyurethane and epoxy coatings.

We recommend that epoxy or polyurethane coatings be used on the interior surfaces of the Falco. In addition, we recommend that two coats be used. There are a variety of products which may be used. Remember, it is the durability of the polyurethane and epoxy finishes which account for their popularity. The older-style paints do a very good job of moisture-exclusion, but in time the paints dry out and develop cracks.

We highly recommend the West System epoxies from the Gougeon Brothers, Inc. These epoxies are specifically designed for the maximum moisture protection of wood. The West system is the principal reason for the resurgence in popularity of wood boats. The maintenance problems long associated with wood boats completely disappear when the West System is used. We will also be recommending the use of West System epoxies for the exterior of the airplane. It is a wonderful system designed specifically for protecting wood from moisture—we think it is the best available in the world. Application instructions for West System epoxies are included in the Technical Manual offered by Gougeon Brothers, Inc.

The West System epoxies are 100% solids systems. The epoxies are thinned with reactive diluents—reactive means that the thinners become part of the chemical reaction and form part of the plastic film on the wood. The use of ordinary solvents in such a finish causes a porous film to develop since the solvent evaporate as the epoxy hardens.

Using epoxies as both wood glue and moisture-protection varnish eliminates the need for masking; however, if you are using other glues (resorcinol, Aerolite, etc) you must still mask as these glues will not adhere to epoxy. Only epoxy will adhere to epoxy.

Many builders use T-88 as a wood glue, and thin it with lacquer thinner and apply with a brush for moisture protection; however the solvent will evaporate and cause a porous film. Chem-Tech sells a low viscosity sheathing resin to protecting wood.

Stits Poly-Fiber's EV-400 epoxy spar varnish is a clear gloss exterior varnish which may be applied with brush or spray gun. Stits also makes a two-part urethane spar varnish, UV-550, for marine and aircraft wood surfaces. This clear gloss interior and exterior varnish may be applied with a brush or spray gun.

If you do not want to go to the trouble of using a two-part urethane or epoxy finish, then you should consider the one-part urethanes. These are sold under a variety of names—Verathane is one—and are sold by many boat yards. These are slightly better than spar varnish (see "polyurethane varnish, one component/oil modified" in table above) but they are not as good as the two-part finishes. The appeal of the one-part urethanes is obvious since you just grab your brush and go to work whenever you need to.

Application Procedures

The interior surfaces of the airplane are usually inaccessible after the plywood covering has been glued on both sides, yet the interior surfaces must be coated. Several methods have been used by manufacturers in the past. These include various sloshing and dipping methods; for example, the Bellanca Viking wing was given a single dip in a Glidden sealer. The methods used on production aircraft are normally inspired more by production efficiencies than by a desire to attain the best moisture protection.

The method you will use is to complete the assembly to a point at which the plywood skin has been glued on the top or bottom of the wing and the second skin has been cut and fitted accurately but has not yet been glued down. All glue lines for attaching the second skin must be located, marked off, and protected from contamination with finish either by covering them temporarily with masking tape or by special care in applying the finish. Finish is then applied to all interior surfaces except the glue lines and allowed to dry. The masking tape, if used, is then removed and the second skin is carefully glued in place.

Any inaccuracy in locating and adjusting glue lines may produce weak glue joints. The normal practice for homebuilders is to mark off the last skin to be installed with a pencil. This is normally held in place with "alignment pins", a nice way of saying *nails*. Two small nails can be used to accurately locate the skin at exactly the required position.

Care should be exercised in the choice of materials used for marking the wood. Grease-pencil and marking crayons containing wax are 4harmful to the finish. Ordinary soft graphite pencils and common stamp-pad inks made with water-soluble dyes may be used safely.

Flush-driven nails or screws left in the exterior surface to be finished are likely to prove points of premature failure of the finish, and this would also apply to the interior finish. The finish usually cracks over the junction of wood and metal and the failure progresses from the crack. This requires that the nail or screw heads be taped after application of varnish.

Nail holes left from nail-strip gluing or countersunk nails or screws should be filled before further finish is applied. Holes in woods on which the wood filler is applied should be filled sufficiently to protect the wood and the durability of the finish, but filler alone will not make them level enough to be entirely concealed from view. Very small holes may be leveled after the application and sanding of a surfacer. On woods having no pores large enough to require wood filler, and where slight depressions in the finish over nail holes will be acceptable, wood filler may be applied over the areas in which there are nail holes only. This may be done most easily on the bare wood before varnish is applied.

When seams in face veneers of plywood have been well glued with water-resistant glue, they have no effect on the behavior of the finish. The finish should remain as intact over the seam as it does over the parts of the surface having no seams, except where glue squeeze-out occurs.

Under Metal Fittings

One of the most critical places is under metal fittings. Whenever a wood airplane has rot, it is almost always under such a fitting. The fittings are always there for a purpose—to carry a load. This load causes the fitting to move, if it can. This causes the finish to crack. Worse yet is the fact that water is frequently trapped between a fitting and the wood. Moisture will collect in such a place by capillary action.

The best solution is to bed the fitting down in a substance that will exclude moisture from becoming trapped between the fitting and the wood. The type of sealant to be used will depend on the nature of the fitting. Does the fitting ever have to be removed?

If the fitting is permanently installed in the airplane (such as the channel-nuts) then epoxy may be brushed over the entire part. If the fitting may be removed on very infrequent occasions, then a pliable adhesive may be used. Silicon rubber RTV compound is a good choice. 3M makes a long list of suitable sealers.

Chapter 10
Woodworking Methods

Introduction

This chapter will cover the basic techniques you will be using to build the Falco. We will discuss methods that have been used for years, and we will also tell you about many techniques that Falco builders have found to be helpful. If you find a nice way of doing things, please let us know!

Scarf Joints

The scarf joint is one of the most important joints that you will be doing for the wood structure of the Falco. The wood must be machined accurately because the strength of the joint depends upon maximum contact between the surfaces to be glued. You should also consider the properties of the glue being used. Some glues (epoxies and Aerolite) have good gap filling characteristics and others (resorcinol and Weldwood plastic resin) do not. Remember also to consider that clamping pressures vary from one glue to another.

There are several important requirements for the scarf joints. First, the slope of the scarf joint is of primary importance. A slope not steeper than 1 in 15 is considered ideal. It is best if you can make all of your scarf joints with a 1 to 15 slope. You will have to make up a scarfing jig anyway, so it is usually simpler to make all of the scarf joints the same. The outer eighth of the depth of the spar caps may be no steeper than 1 in 15, while adjacent layers may have steeper slopes, but we would caution against this practice. Take your time and do it right. Of all of the wood structure of the Falco, the most important are the spar caps. Other things such as the fuselage frame laminated bows are less critical, and you may use a steeper slope for these parts (such as 1 to 12) if you wish. Plywood scarf joints may be 1 to 12, but with a minimum of 1 to 10.

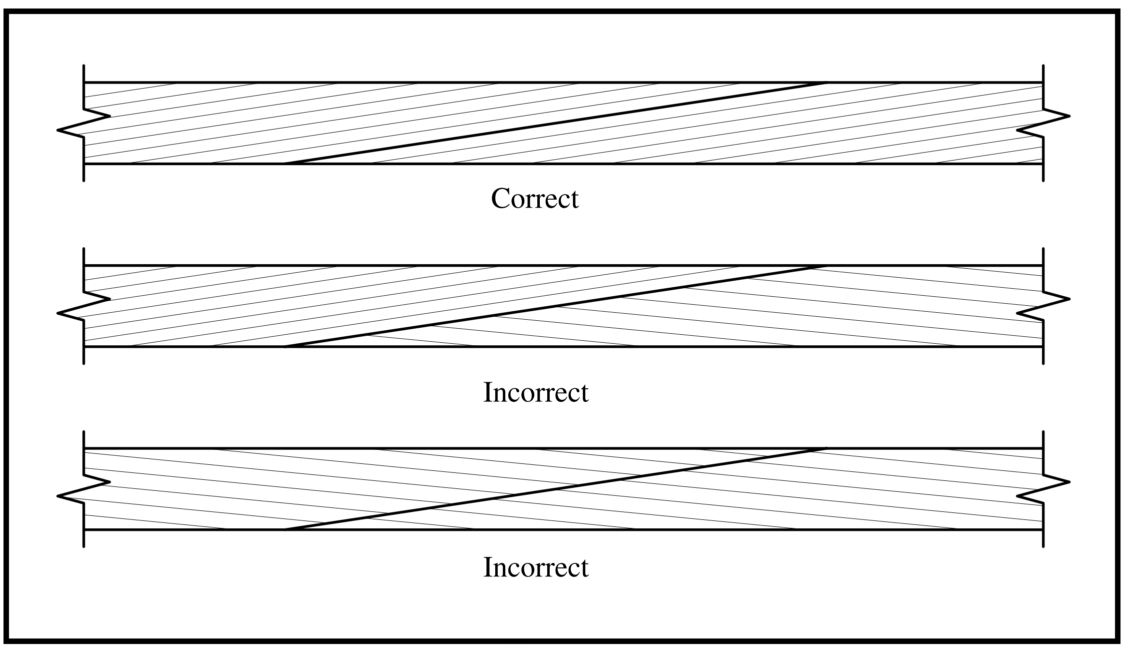


Figure 1

A second requirement of a scarf joint is the direction of the grain in relation to the scarf joint. Since end-grain gluing is more difficult (and results in a weaker joint) than side-grain gluing, it follows that where cross grain within the specified acceptable limits is present, all scarf cuts must be made in the general direction of the grain slope. The object is to make the cut in such a way as to minimize the amount of end grain showing on the face of the scarf joint. Figure 1 shows this requirement, but please note that the grain direction is greatly exaggerated.

Thirdly, in laminated members the longitudinal distance between the nearest tips of the scarf in adjacent laminations may not be less than 10 times the thickness of the thicker of the laminations (See Figure 2). All of the laminations in the Falco are made of strips of wood of equal thickness, so this means that if you are laminating a spar cap from 10mm boards (as with the main wing spar) the tips of the scarf joints may not be closer than 100mm in adjacent layers.

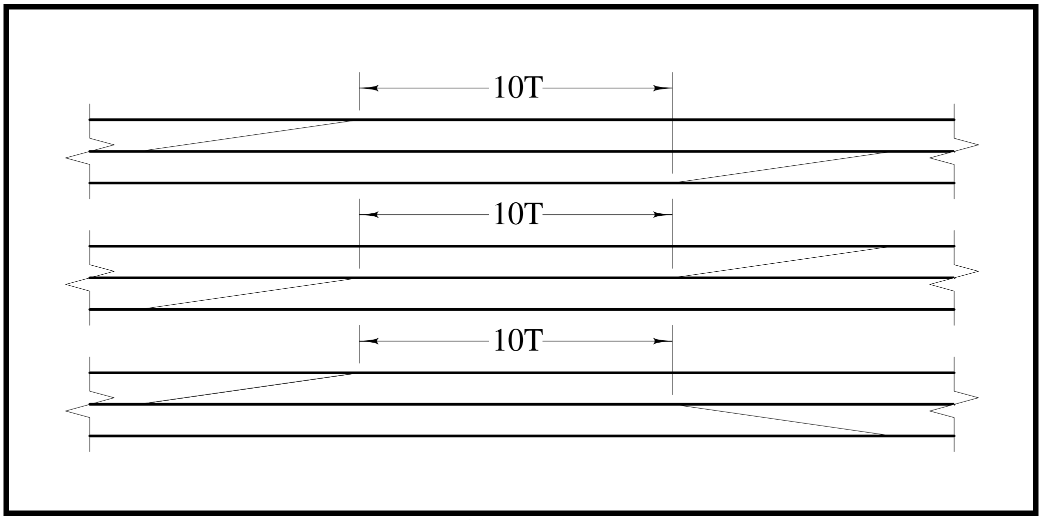


Figure 2

All of these requirements for scarf joints, laminations, and many other important aspects of wood construction (grain deviation, moisture content, grading of wood, etc.) are covered in *AC 43.13-1* and *ANC-19*.

Making a Scarf Joint

Every builder ends up using his own version of a scarfing jig. There are a huge number of such arrangements and these are shown in the many reference books listed in Appendix B.

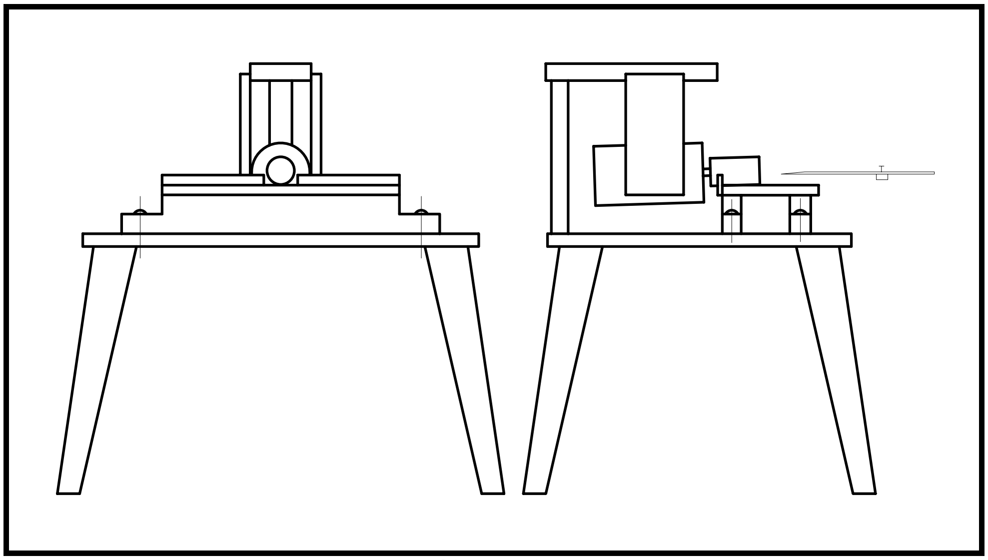


Figure 3

The simplest way to scarf plywood is by sanding with a drum sander mounted on the back of a radial arm saw as shown in Figure 3. To provide clearance for the motor, you will have to make up a raised table. Make up a gauge block from hardwood with a 15 to 1 slope. Every time you make a scarf joint, you can use the gauge block to set the angle of your sanding drum.

The board used for the top of the raised table should be a constant width, say 8 inches. For a straight scarf, a straight strip of wood can be attached to the plywood with small nails. This strip of wood will serve as a guide as it will rest against the edge of the board that is the top of the raised table.

The table will have a short fence on one side so that it will guide the plywood by the sanding drum. You need to cut an opening in the fence for the drum. This will be used for free-hand scarfs.

There are a number of variations of this sanding drum scheme that do not involve a radial arm saw. The sanding drum is usually mounted on an electric hand drill or an electric motor. This is mounted on a table (with a fence as before). You can also use the table of a table saw. The sanding drum is mounted on one side. The motor is hinged from the table, and the angle adjusted with a turnbuckle. A strip of wood tacked to the plywood is used to guide the plywood. The strip of wood fits in the table guide groove in the table saw top. (See "Shop Notes" in Tony Bingelis's *The Sportplane Builder* for such an arrangement.)

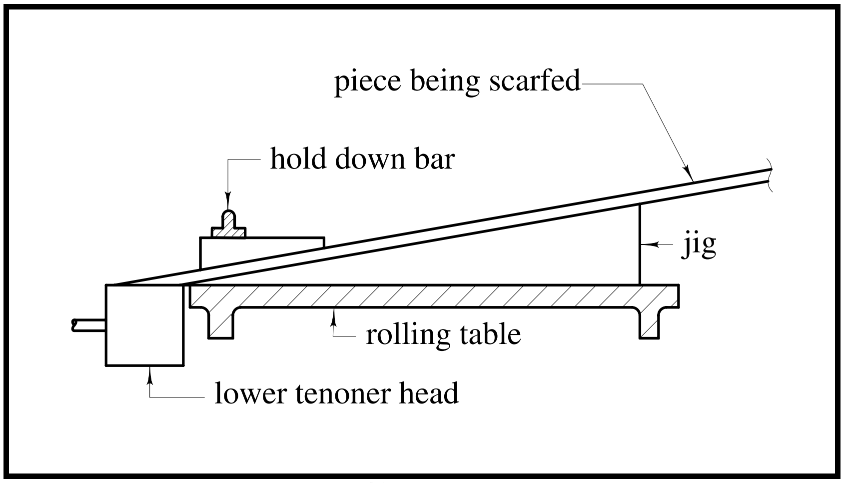


Figure 4

There are many other methods of scarfing plywood. A tenoner may be used as shown in Figure 4. This method may be used for spruce or plywood. While few Falco builders will have such equipment, you may be able to use other available equipment in a similar fashion.

Spruce is normally cut with a saw, and again the radial arm saw is the most convenient way of making this cut. The gauge block comes in handy to set the angle of the cut. A table saw may also be used.

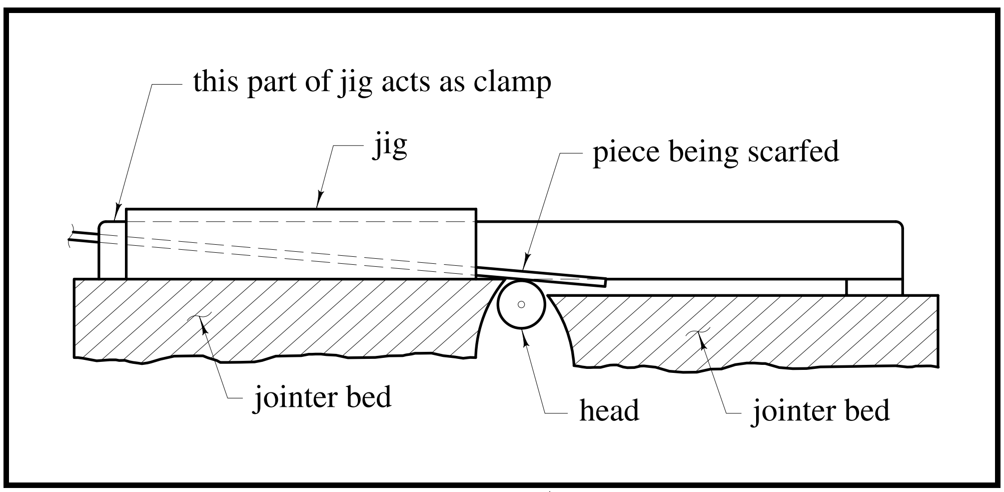


Figure 5

A jointer may be used for scarfing spruce as shown in Figure 5. Some builders have used a similar method by making a jig for scarfing spruce with a portable power plane. In these cases, the plane is guided by tracks so that it does not cut into the jig.

Generally, it is best to scarf the plywood in advance, but when this is not possible you have to make a scarf joint on the airplane. This often happens when you glue on a skin which will have to join with an adjacent skin panel. The skin should first be trimmed so that it is even with the edge of the underlying structure, usually a rib or fuselage frame. A laminate trimmer bit in a router does a nice clean job and doesn't splinter the plywood as saws do. This end of the plywood will determine one edge of the scarf. The other edge may be determined by measuring. Let's say, for example that you have a 1mm skin, and you want to make a 12 to 1 scarf. Obviously, the scarf will be 12mm wide. Measure off the 12mm dimension and draw a line. The scarf can then be sanded to this line. If you are very careful and skillful, you can do most of the scarf with a power sander. You should finish off the scarf with a sanding block or Disston abrader.

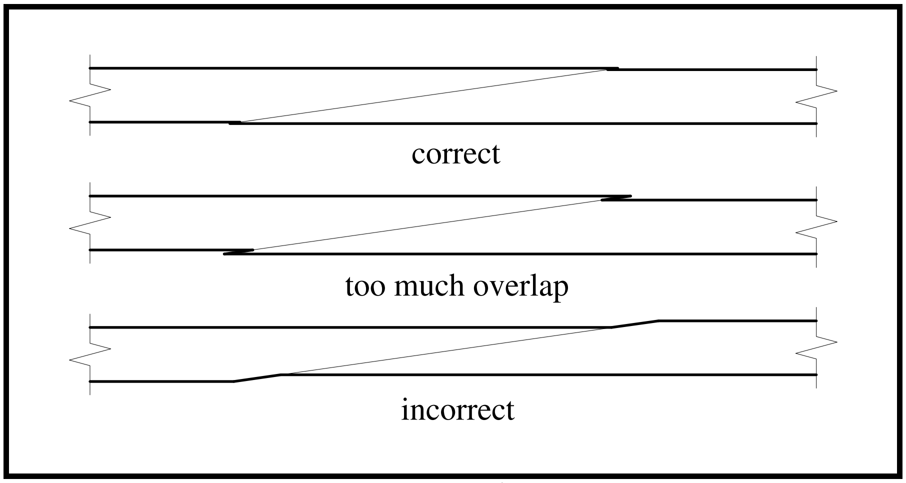


Figure 6

In gluing a scarf joint, one of the most important considerations is to prevent end slippage. An effort should be made to keep the parts in proper alignment as illustrated in Figure 6. A small amount of overlap as illustrated is desirable and insures that the joint will receive adequate pressure. If the members slip excessively endwise during the clamping operation, a condition will occur (illustrated as “incorrect”) in which the members will not receive sufficient and uniform pressure and erratic joint strength may be expected. The condition of too much overlap is to be preferred to insufficient overlap, however it is possible that the scarf joint will receive higher pressure than intended and some crushing may result, but it is probably that the quality of the glue joint will not be adversely affected. It is important to provide some method, such as blocking or clamping the ends of the members, to prevent end slippage. Blocking or clamping should also be arranged to minimize side slippage and thus prevent unnecessary waste of material. Wood pins of small diameter driven into drilled holes are sometimes used to prevent end and side slippage. These pins have an advantage over nails, sometimes used for the same purpose, in that they can be left in and do not interfere with subsequent machining operations.

Conditioning

With the exception of epoxy glues, cold gluing operations add moisture to the wood in varying percentages. Glue that has set in joints contains only a part of the water added at the time of mixing, the remainder having been absorbed by the wood or removed by evaporation. The absorbed moisture must be allowed to dry out or to distribute itself through the wood in order to insure the full strength of the joint and to reduce the tendency of the glued member to warp.

In gluing thick laminations, the moisture from the glue need not be eliminated but may simply be allowed to distribute itself throughout the construction. Complete equalization would require a very long time. For woods that permit a rapid distribution of moisture, such as spruce, a 3- to 5-day period should suffice under most conditions. When heavy constructions are glued from laminations one-eighth inch or less in thickness, however, they will normally contain too much moisture after gluing and should be dried for 1 to 3 weeks or longer, depending on their thickness and width and the conditions of drying.

Because the excess moisture around glue joints expands the wood, machining of the wood should be postponed until after the wood has been conditioned. Machining immediately after gluing will result in a depression at the glue joint after the wood has become conditioned.

Beveling Plywood

There are many instances in the Falco where plywood butts up against the skin of the airplane. An example of this would be the intersection of the plywood gussets on the wing and tail ribs butting against the skin. When the spruce dries, it contracts. Because of the grain orientation of plywood, it does not contract. The result is that the plywood will push against the skin as can be see in Figure 7. While this is not likely to cause a glue failure, it does introduce unnecessary and unwanted stresses. This will also cause the skin to be wavy. These indentations at ribs gives a wood wing the “starved horse” look.

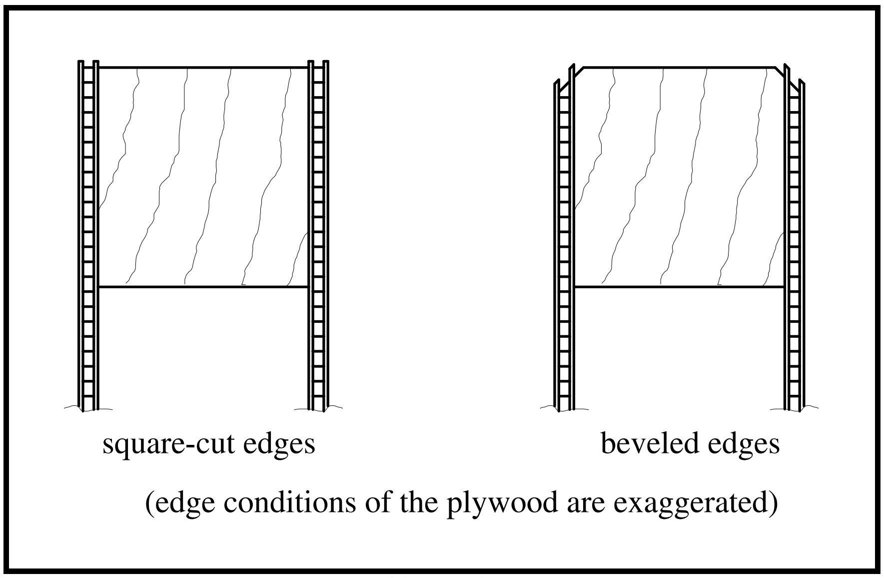


Figure 7

Whenever plywood butts up against anything, the plywood should be beveled so that only a slight edge is left at the joint. The function of the plywood gussets on the wing ribs is to tie the spruce pieces together. The edge of the plywood contributes almost nothing to the strength of the joint. The gluing surface on the spruce is all that is needed for the required strength. Be on the watch for this phenomenon. Whenever you are preparing to glue something together, be sure to check to see if you have any plywood that should be beveled.

Staples & Nails

There are times, particularly when gluing on plywood skins, that the only way that you can clamp the wood in place is with nails or staples. The nails or staples should be small enough so that they do not split the wood.

Nail diameters are expressed in wire gauge sizes, and lengths are expressed in inches. Slender 20-gauge nails are best. 18-gauge nails are heavier and more likely to cause splitting in the wood. The nails should be long enough to penetrate into the underlying structure to a minimum depth of about 3 times the thickness of the surface plywood, but the nails should not be so long as to pass completely through the underlying structure.

The same guidelines would apply to staples. We have already suggested in the chapter on tools the two recommended staplers. Nails are difficult to handle and slow to install.

Staples and nails are used to hold the wood in place during gluing and to provide the necessary clamping pressure. Many texts suggest that the best procedure is to leave the nails in the airplane. We have found that Falco builders are reluctant to do this. For one thing, they worry about the weight! Many go so far as to keep all of their old staples in a can. They can add up to a big pile. For your information, the wing rib staples add up to nine ounces.

Because of the use of internal antennas, it is best to have as little metal in the wings as possible. So if you ever needed an excuse to take out the staples or nails, there is your excuse! We think most builders are just offended by the looks of the things.

If you remove the staples or nails, you have to be careful not to bruise the wood. This risk of crushing the wood is the principal reason that the standard practice was to leave the things in the airplane. You may be more careful than factory labor, but be careful. Many builders use diagonal side cutting pliers to pull out staples. Others have fashioned custom homemade tools to remove the staples.

When you install the skins, it is a standard practice to use nailing strips. These are thin strips of wood through which you nail or staple. These become badly chewed up from repeated stapling and removing the staples, and they protect the wood from bruising. They also help to distribute the load from the staples or nails.

With wood production aircraft, it was the practice to use cotton tape under nails and staples. This permitted the quick removal of the things. You should avoid, wherever possible, the use of permanently installed nails on the exterior of the airplane.

When you remove staples and nails, it leaves a small hole. You should be careful to make sure that the hole is filled with filler or sealer before you apply varnish. You cannot always depend on varnish to fill such holes.

You may use either steel or brass nails. The steel nails are either plated, galvanized or cement-coated to prevent rust, but they seem to rust with age anyway. Most builders prefer brass nails, but it's not really an important consideration.

In *The Sportplane Builder*, Tony Bingelis suggests the following nails and spacings. For 1/16" plywood use 1/4" 20-gauge nails spaced 1/2" apart. For 3/32" plywood use 3/8" 20-gauge nails spaced 3/4" apart. For 1/8" plywood use 1/2" 20-gauge nails spaced 3/4" apart. For 1/4" plywood use 1" 18-gauge nails spaced 1" apart.

Staples are much easier to install if you have a pneumatic staple gun (see Chapter 4 "Tools"). You will have to experiment to determine the best spacing for the staples. This will change depending on the glue that you use. Resorcinol requires quite a bit of clamping pressure, while epoxy requires very light clamping pressure.

Bending Spruce and Birch Plywood

There are a number of places in the Falco where you will have to bend spruce and birch plywood. If the bend has a large radius in relation to the thickness of the wood, the wood can be easily bent, clamped and glued in place. If the bend has a tight bend radius, then you must soak and pre-bend the wood. The rib capstrips must be soaked overnight in water, then put into a bending jig until dry. It is not necessary to bend the wood precisely as there is still plenty of "flex" left in wood.

The birch plywood is bent in a similar fashion. The amount of curvature that can be introduced into a flat piece of plywood depends on numerous variables, a few of which are moisture content, direction of grain, thickness and number of plies, species and quality of veneer, and the technique applied in producing the bend. Figure 8 shows the approximate relationship between thickness and breaking radius of plywood. The minimum radius beyond which it is impossible to bend a piece of plywood without fracture decreases when any of the following conditions prevail:

1. Thickness is decreased.
2. Face plies are laid more nearly parallel to the axis of the bend.
3. Moisture content of the plywood is raised.
4. Temperature of the bending form is raised.
5. Quality of the veneer is increased (particulary by minimizing cross grain).
6. Technique of bending is improved.

It should be noted that no constant ratio of radius to thickness can be set for all thicknesses. In Figure 8, "hot soaked" means that the plywood is thoroughly soaked in hot or boiling water until the plywood sinks, after which it is bent over a mandrell heated to approximately 300°F; "10% moisture content" means plywood of this moisture content bent over a cold mandrel.

Said another way, thin plywood is easier to bend than thick plywood. It is easier to bend plywood with the face grain parallel to the axis of the bend. It is easier to bend plywood if it is wet, and it is much easier to bend plywood if it has been heated—plywood (and all other woods) become very plastic if heated to around 212°F. Note from Figure 8 that 2mm (.08") plywood has a breaking radius of about 1.5" if bent across the grain at a normal moisture content of 10%, while the breaking radius decreased to about 1.0" if bent with the face grain parallel to the axis of the bend. If heated, the breaking radius is reduced to about .03" if bent parallel to the face grain and heated.

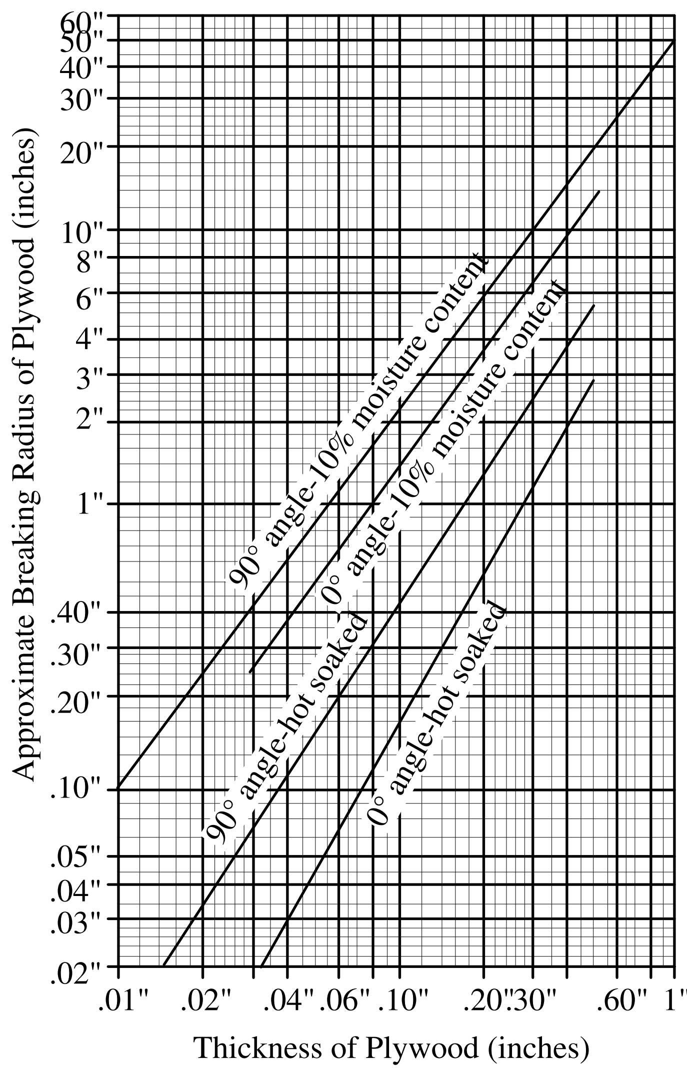


Figure 8

The first lesson to learn is that all plywood should be cut so that the grain is parallel (or roughly parallel) to the axis of the bend.

The next thing to understand is that the plywood must be soaked in water. Birch plywood takes longer to become thoroughly soaked, so you will have to soak it for a couple of days. The moderate bends of the elevator and rudder leading edges can be easily made by soaking the plywood and clamping it in place. The leading edges of the fin, stabilizer and wing are much tighter. These can be bent by soaking and clamping, but many builders have found that using a steam iron on the plywood will allow them to bend a tightest radius easily and quickly. The steam from the iron quickly heats the plywood to the temperatures needed for easy bending.

This method of hot-bending plywood should not be overlooked by a Falco builder. You can do truly amazing things with wood once it is heated. Bentwood rockers are made this way, as are the molded plywood chairs you see so frequently in cafeterias.

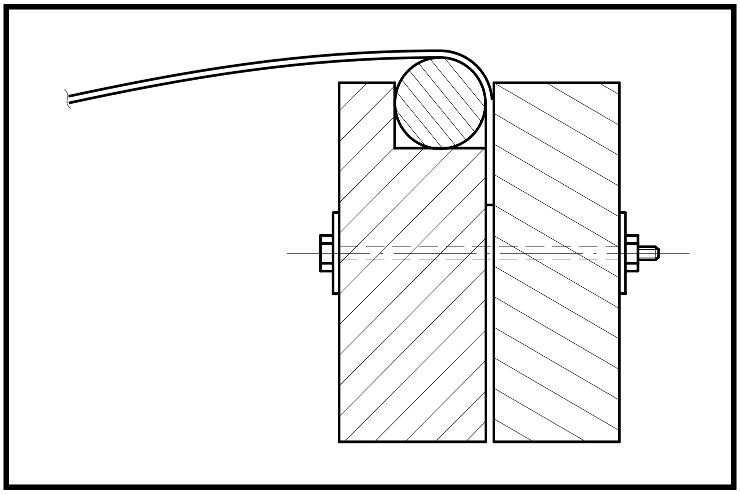


Figure 9

The leading edges of the wing, tail and control surfaces are the most common plywood bending exercise in the Falco. There are several methods that may be used. One of these is to pre-bend the plywood over a mandrel as shown in Figure 9. This is a method employed by a Falco builder to pre-bend his wing skins. A large broom stick was used as the mandrel, and it was clamped between two boards. One of the boards was cut to receive the broom stick. In most cases, the weight of the plywood is sufficient to bend the plywood, but weights may be added as well.

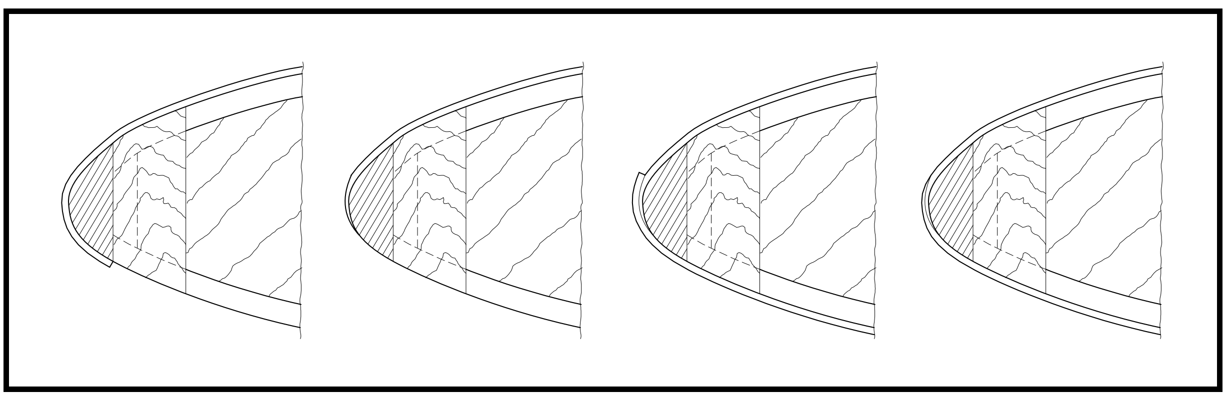


Figure 10

After the skin is bent for the leading edge radius, the skin is glued in place as shown in Figure 10. Next the skin is scarfed. Unlike most scarfs, this is not a straight cut. Instead, you must sand a smooth, radiused scarf on the plywood. This is not as difficult as it may seem, since the layers of wood and glue lines reveal any irregularities. Next the skin for the other side is glued in place. After the glue is dry, they plywood is feathered to a smooth radius.

Most Falco builders do not pre-bend their skins off the airplane. Instead, they prefer to bend the plywood over the leading edge strip using nails or clamps to hold the plywood in place. One method developed by a Falco builder is to use large rubber bands to bend the leading edge skin. This method is shown in Figure 11. The skin is cut so that it is a couple of inches longer than needed at the leading edge. To this extra plywood, you glue a scrap piece of wood, say 20x20 pine. Before gluing the pine in place, drive a nail into it every 4 inches or so. Another piece of 20x20 pine-with-nails is used as well, and it is clamped to the rib. Cut an automobile inner tube into long strips about 1” wide. If you cut the inner tube with a spiral cut, the rubber band will be quite long, and this is desirable. To bend the plywood, lace the rubber bands back and forth over the nails of the two 20x20 pine pieces. The first couple of lacings will do little to bend the plywood, but as you work your way down the leading edge, the cumulative pressure of the bands will bring the plywood down into place. If a single pass is not enough, then lace back over the nails again and again until the plywood bends into place. Ordinarily, soaking the leading edge of the plywood in water is all that is required, but the use of a steam iron in this situation would greatly speed things up.

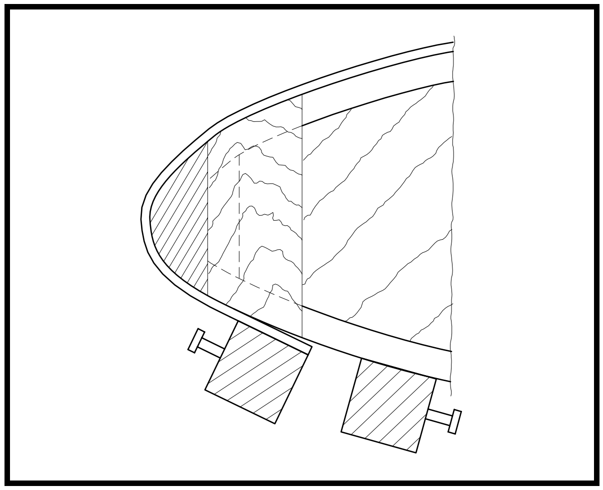


Figure 11

After the leading edge plywood is bent, it is kept clamped in place for a couple of days until dry. The plywood is then removed from the airplane and allowed to completely dry. When the skin is glued to the airplane, the same method with the rubber bands may be used to clamp the skin in place. After the glue is dry, the extra plywood and the 20x20 pine is cut away. The same method is used for the skin on the other side of the wing, or tail.

A few builders complain that these methods are not completely to their liking, since the plywood tends to lift from the rib while the leading edge radius is being bent. Another method—and the one used on the production Falcos—is to glue the first skin in place without bending the leading edge radius or getting any glue on the leading edge strip. After the glue is dry, the leading edge of the plywood is bent by wetting the wood with hot water and using a steam iron. Pull the plywood over and nail to the leading edge strip. After a couple of days, remove the nails and allow the entire assemblage to dry completely. Then, stuff glue under the leading edge of the plywood and nail down. Then proceed as shown in Figure 10.

The fuselage has slight compound bends on the side skins around the cockpit. In this case the plywood is clamped to the fuselage frames. As an alternative method, you may make a simple form to bend the skin over. Don't worry about this now, instructions for bending this plywood be covered in the appropriate chapter.

Clamping Methods

Figure 12 shows the most common method of clamping a rib to a spar. A block of wood is inserted into the gusset pocket of the rib, then two pieces of wood are screwed together as shown and a clamp is used to hold things in place.

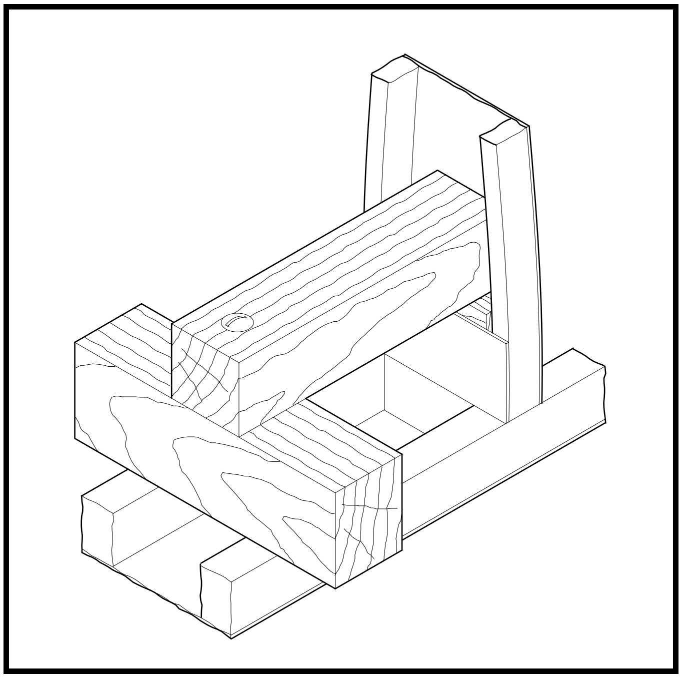


Figure 12

For many of the wing ribs you can use the rubber bands to clamp the ribs in place. These are the "open" ribs; that is, they do not have plywood glued to the face of the rib.

To clamp a corner block in place, the method shown in Figure 13 is most often used. The clamping blocks will try to slip, so you can clamp a couple of blocks in place to keep them from moving, or you can drive a couple of small nails through the clamping blocks so that the ends of the nails will stick out slightly and bite into the wood.

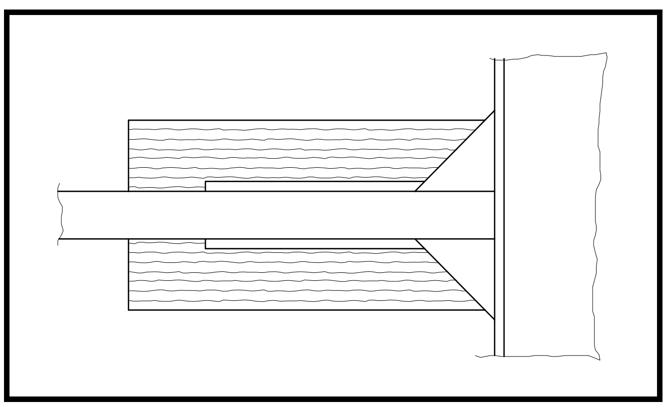


Figure 13

Figure 14 shows a method for clamping a trailing edge strip in place. The nails are for rubber bands. If this type of clamping block is positioned right over the rib, you will end up gluing it as well, so you can use some wax paper to keep this from happening.

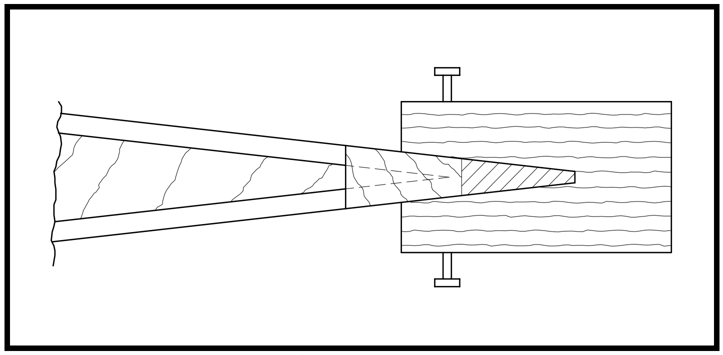


Figure 14

When you glue the leading edge skins on the elevator or rudder, you can use the method shown in Figure 15. These custom band clamps are made of aluminum and a bolt is used as a jack-screw to apply the pressure. The nut may be epoxied in place and you may tap the wood if you wish. These clamps work very well, but they have a couple of disadvantages. They will not work well with fast setting glues such as Aerolite unless you can devise some way of quickly putting the clamps in place. The clamps are also some trouble to make.

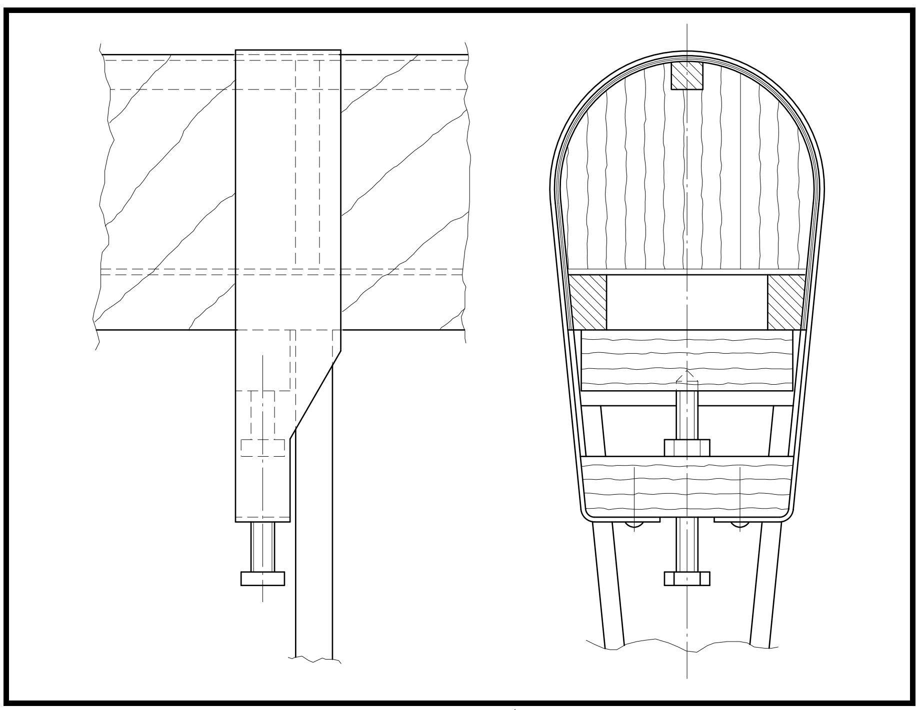


Figure 15

For the ailerons you can use a variation shown in Figure 16. In this case a 3/4"Ø dowel is used and a hole drilled in the assembly jig for the dowel.

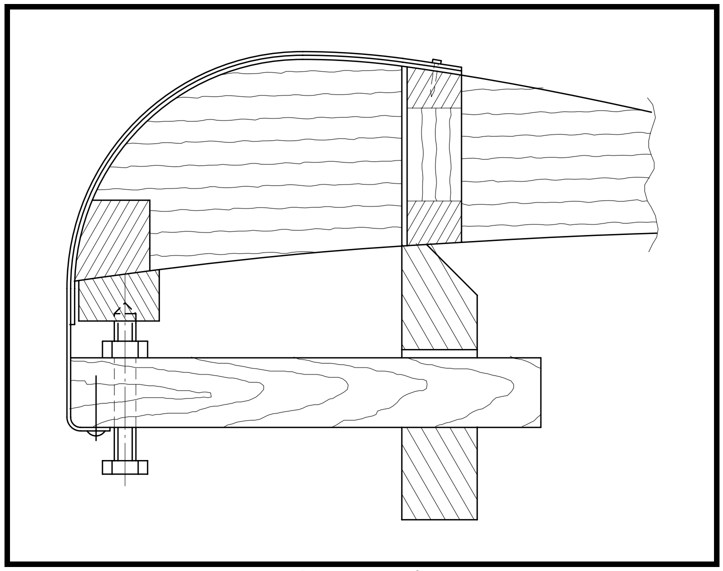


Figure 16

A simpler method is to use the large rubber bands to clamp the skins in place. For the upper leading edge skin of the aileron, you may use the same type of method shown in Figure 11.

Drilling Holes

Most of the fittings (supplied in our kits) already have the required mounting holes drilled in them. To install the fittings, clamp the fittings in place and drill through the wood. It is always best to drill the holes on a drill press. This way you can be assured that the holes are straight. You should also use brad point drills. These drills do a beautiful job of drilling holes in wood, unlike ordinary twist drills which tend to tear their way through the wood. Brad point drills leave an exceptionally clean hole—the inside of the hole is nearly a polished surface. You should always use a piece of scrap wood on the far side of the spruce to keep the drill from splintering the wood when it appears on the other side.

When you drill a hole in metal, you typically drill the hole undersized and then ream up with the final size drill. You do not do this with wood. With wood you use the proper size drill the first time.

There are a few places in the Falco where you will have to drill through wood and a steel plate. This requires a special procedure. If you attempt to drill the steel plate in the airplane, you are in for a very rude surprise! When the drill hits the steel, it will tend to wander. This will end up ruining the fitting and the steel plate, and the hole in the wood will be a genuine mess. The proper procedure is to drill the wood first, using only the normal backup block. After the holes are drilled in the wood, the steel plate is clamped in position. The steel part is then marked using a “transfer punch”. A transfer punch is just like a center punch except that the shaft of the punch is to a specific diameter to fit inside a drilled hole. Unlike a center punch, it is not free to move around in the hole. The transfer punch is hit with a hammer, which center-punches the steel plate dead on center. After all holes are marked like this, the steel plate is removed from the airplane and drilled on a drill press.

There will be a few instances when you will find that you have really botched a hole. In this case, you may use a wood dowel to plug the hole. Glue a short dowel in place, and after the glue is dry, drill the hole again.

Bolt Torques

With a metal airplane, all bolts are expected to be torqued to a specific value. This is not true of a wood airplane. The bolts are expected to be tight but not so tight that the wood is crushed. You will notice that the more important fittings have wide plates on the reverse side to distribute the load into the wood. The larger the backing plate, the more the bolts may be tightened without damaging the wood. Other fittings use channel-nuts or wide washers. If you overtighten the bolts, you will notice that the large washers will start to cone. If this happens, you have gone too far, and you are crushing the wood. By the same token, you do not want any of the bolts loose.

Drain and Vent Holes

When an airplane climbs to altitude, the air becomes thinner. Any air trapped within a closed compartment will try to force its way out due to the lower outside air pressure. For this reason, you should not build any such closed compartments in the airplane. Because of the nature of the Falco design, this will require that holes be drilled in the tail ribs and at other places to allow air to move about the airplane.

These holes should be positioned so that they will drain any water that may enter the airplane or condense within it. The bottom of the wing, tail and fuselage should have drain holes drilled in the lower skins to allow any water that may be in the airplane to escape.

The vent holes should be positioned so that it also makes it difficult for moisture to enter the airplane. For example, the leading edge of the rudder is a closed compartment without any vent holes drilled. At the upper leading edge, it is best to route any vent holes through the spar instead of “daylighting” out at the upper hinge opening. The escape path for the air should lead to the bottom of the rudder.

Drain holes are normally 1/4”Ø. For vent holes, all you need is a 1/8”Ø hole. With many of the drawings, we drew all of the vent and drain holes as 1/8”Ø. Many builders blanch at the thought of 1/4”Ø holes in the airplane, and you may use any size hole you like. The only important thing is that the holes be open so that water will drain out. This is a maintenance item, and the larger holes are less likely to become clogged with dirt.

Chapter 11
Making Ribs

This chapter is devoted entirely to making the wing and tail ribs. If you are purchasing the ribs, you may skip this chapter. If you are going to make all of your wood components you should start with the ribs. It is always best to start with the simplest things first and work up to the more complex parts as you gain experience.

The tail group ribs are simpler than the wing ribs, so you should make the tail group ribs first. If you have never done this sort of thing before, the best approach is to complete a single rib before attempting to make the other ribs. It is a mistake to lay out all of the ribs at once, make up the jigs and start a little production line going for all of the ribs in the airplane. That would be a dandy idea if you are experienced, but you should not do this if you are inexperienced. Follow the steps all the way through for a single rib. When the rib is complete, you may then evaluate your method. If you have made a mistake, you only have to build one new rib. You will also find that you will find some problems with your original way of producing the ribs. Imagine the chagrin of the overly ambitious builder who discovers too late that all of his carefully-made ribs are permanently glued to the jig boards! This is perhaps a little far-fetched, but problems have a way of sneaking up on you. Build one rib. Build one more rib using any improvements to your technique. Once you are comfortable that you have the construction of the ribs down pat, go ahead and make all of the rest at any pace you like.

Watch Those Dimensions

All of the ribs are drawn full size. It is important that the ribs be made to the correct dimensions. The paper on which the drawings are printed will expand and contract with changes in the humidity. The changes in the size of the paper can be startling. It is quite possible to have dimensional errors of 10mm or more on the wing ribs as a result. If you use the drawings as patterns, be careful to check the dimensions for accuracy.

It is also important to keep in mind that when you assemble the Falco, you will need to maintain control of your dimensions and reference lines. The primary reference lines for the tail group will be the centerlines of the ribs and spars. If you have these lines drawn on the ribs and spars, the assembly is much quicker.

You should also be aware of the classic problem of tolerance build-up. You should always work from one point when laying out the locations for the various parts of the airplane. The drafting convention is to show the dimensions between the various parts, but this will not do when you are building something. The wing ribs, for example, are spaced 250mm apart. There are 14 ribs, so if you measured from one rib to the next, any error would be passed on the the next rib. The proper method is to measure from the first rib to the second, then measure from the first rib to the third, and so on.

The tolerance build-up problem can result in disastrous situations. We recall a professional boat builder who measured from one bulkhead station to the next. When the boat was finished it was 12” too long. Unfortunately, the deck of the boat was being built separately, and the hull and deck did not match.

Note that the drawings for all of the ribs show the spars for the wing or tail as well as the rib. This is so that you can see how everything will fit together when the rib is installed in the airplane.

The drawings for the rudder ribs are badly out of scale. As noted in the revisions, the lightening holes in the nose ribs are to be omitted.

Jigs

Ribs require some type of jig during their construction to insure accurate contours and dimensions. The jigs for the vertical tail will only be used once, while the jigs for the wing and horizontal tail will be used twice. Any experienced Falco builder will tell you that the jigging is the most time-consuming part of building a Falco. The jigs do not need to be elaborate, but they should be accurate.

Many of the ribs in the Falco are two and three piece ribs. In the wing there are even a couple of four piece ribs at stations 1 and 2. Even though these ribs will be separate pieces when they are glued in the airplane, they should be made as a single assembly to assure more accurate contours. The ribs are cut apart for the spars after they are made. This way the rib capstrips take a continuous bend. If each rib is made separately, the capstrips do not take the correct bend.

Draw the rib shape on a piece of 3/4" plywood and then overlay it with a sheet of wax paper or polyethylene to prevent the glue from sticking to the jig board. Headless nails or small wood blocks are used to outline the rib shape and to locate the positions of the uprights and diagonal braces. The blocks should be shorter than the rib stock so that you can clamp and sand the rib pieces only. Also, be sure to keep the blocks away from corners where they might be glued to the rib, and they should allow for any corner blocking to be installed. It is best to use a single block to locate the position of the spars. The corners of these blocks should be cut on the diagonal to stay away from the glue. You do not have to be too elaborate with the jig, just locate the blocks wherever necessary to hold the rib pieces in place and to the exact curvature required.

There are several methods for drawing the curved lines for the airfoil contours. The most accurate method is to use a computer aided drafting (CAD) system. These systems are *extremely* expensive, but if you have access to one, you may have the entire rib drawn on mylar. The rest of us will have to use a flexible spline.

Keuffel & Esser Company sells a drafting spline, and this is what we use for doing the drawings (K&E P/N 57-2849-36). This is a 36" long piece of clear plastic, about 3/16" by 5/16" in cross-section. There are grooves at the top and bottom for "spline weights" which hold the spline in position for drawing. The spline is aligned with the dimensioned points. The spline takes the curve of the airfoil. You can sight down the spline and spot any irregularity before drawing. We have found that French curves and flexible rulers are nearly useless for this type of work.

You do not have to purchase a drafting spline to do the same thing. A piece of wood will do as nicely. You will find that model airplane stores sell strips of basswood, which may be used. If the wood is of a consistent thickness and of clear grain, it will serve to make a smooth curve. You may also be able to get a piece of plastic sheet from a local supplier. They are bound to have thin pieces that they have cut off from larger sheets. A piece of 1/8" or 3/16" thick Plexiglas cut to a width of 5/16", 1/2" or more.

The gussets may be nailed, stapled or clamped in place when they are glued to the rib. If you plan to use clamps, you should modify the jig slightly. First, cut the jig board to the approximate shape of the rib, reducing its overall size as much as possible. Nail several blocks across the bottom of the jig board so that it is elevated above the work table. This will permit you to place clamps on each gusset. The glue and clamp method will require that you leave the rib in the jig until the glue is dry. This usually means overnight, and you will have to repeat the process for the gussets on the opposite side.

One method of making rib jigs is to drill large holes at each joint intersection. The purpose of this is that the rib cannot be glued to the jig. Wax paper or plastic sheet is not required on such a jig.

The curvature of the rib at the forward end requires that the capstrips first be pre-formed by soaking and bending. The spruce may be soaked for about 30 minutes in hot water and then placed in a bending jig. The capstrips should be bent to a curvature slightly greater than the rib shape at the forward end. This bending jig may be used for most of the ribs since the wood will maintain a degree of flexibility.

The bending jig may be cut from a single block of 4” by 4” wood. Bandsaw through the block to the desired curvature. The capstrips are placed between the two blocks and clamps are used to maintain the required pressure.

A variation of this type of jig is made from a single “two by four”. The jig is open on the convex side of the capstrip. At one end, the jig is made with a slot for the capstrip. This permits the capstrip to be clamped at one end only.

Before putting the capstrips in the bending jig, flex each to see which way it bends easiest. The capstrips should be allowed to dry thoroughly before removing them from the jig and gluing them. Unless the humidity is high, 24 hours is normally enough.

Making the Ribs

The normal procedure is to glue in all of the rib capstrips and braces at one time. Corner blocks, if required, are also glued in at the same time. Remember, all birch plywood should be scuff-sanded lightly before gluing.

The rib should be sanded smooth before the gussets are glued in place. It is important that all glue joints be leveled before applying skin or gussets. This may be done with a mill bastard file or with a large sanding block. A hand plane should not be used since it will chip the braces. The same would also apply to a jointer or planer. If you have access to a thickness sander, you might want to use it. If you do, it would be a good idea to make all of the pieces a little wider than the final dimensions. A thickness sander works just like a planer, but the wood is sanded with a wide belt or drum sander. Kuster Woodworkers makes a thickness sander kit, but unless you need such a sander for other things, it is not worth the time.

Before you remove the rib from the jig, carefully mark the rib centerline at each end and where it will be glued to the spars. You should check the rib against the profile drawings to see how accurate your contours are. If the contours are a little low, you may glue on a strip of spruce. There is no point in sanding the rib to the exact contour at this point. The rib will be sanded for the skin after it is glued to the spars, so why do it twice?

After removing the rib from the jig, the ribs need to be trimmed and the spar openings and gussets cleaned up of glue runs. The best tool for this is a 10-inch mill bastard file. The file will have a film of oil on it, and the oil will contaminate your glue joints. It is best to clean one file with MEK or lacquer thinner and set it aside for woodwork only. If you prefer to use sandpaper, be sure to use a sanding block so that you don’t round the areas that should be square.

One method that you can use to speed up the construction of the ribs is to make two ribs at one time. You will need to make the rib slightly more than twice the normal width. Use a band saw to resaw the ribs in two pieces. You will have to sand the ribs flat. The builders that have tried this report that they were able to plane the ribs with an electric planer. The planer would try to "clip" the first and last part of the rib. To keep this from happening, a scrap piece of wood was used in front of and behind the rib.

Wing Ribs

The wing ribs are built in the same manner as the tail group ribs. Because of the twist of the wing, there is no centerline to use as the primary reference. Instead you use the horizontal reference line.

The chord line is a straight line which connects the leading edge with the trailing edge. This chord line should be drawn on the wing ribs as it will be a critical and highly-useful reference for installing the wing ribs.

Remember that the faces of the spars are all perpendicular to the horizontal reference line, and *not* perpendicular to the chord line of the rib.

Like the tail group ribs, the wing rib capstrips should be soaked and bent in a bending jig. At least one fastidious builder laminated the capstrips from two pieces of spruce. This makes for a nice looking job, and it is perfectly acceptable. This technique is very slow, and we doubt that it is needed except to appease a personal sense of perfection.

Chapter 12
Making the Fuselage Frames

This chapter is devoted entirely to making the fuselage frames. If you are purchasing these frames, you may skip this chapter.

As with the ribs, it is best to start with the simplest of the fuselage frames. Make one frame all the way to completion to check out your method of construction.

Fuselage Frame Jigs

There are two types of jigs which may be used for the fuselage frames, male molds and female molds. A male mold fits inside the lamination. This will require that holes be cut in the mold so that you can use clamps. It is not a good idea to use band clamps since these exert uneven pressure on the laminations. Since the curve is not a true radius, the clamping pressure will be greater at the sharper corners. Also, all of the fuselage frames have some internal structure. These pieces are normally installed on a jig similar to the ribs, using headless nails or blocks of wood to hold the members in place.

Before you rush off and start making jigs, start by considering exactly what you will need. You will need a mold for laminating the rings, and you will need a jig board for installing the additional bracing. For all practical purposes, this means that you will have to lay out each frame twice.

Making a Lamination

Start by making the simplest lamination. This is frame No. 2 “diagonal”. Because of the dimensions given, you will find it easier to make this in a female mold. Most builders find that chipboard (“particle board” or “underlayment”) is the cheapest thing to use for laminating molds. Lay out the dimensions and draw the curve. You want to always maintain your dimensions, so you need to draw the centerline and horizontal reference line on the chipboard. Later you will transfer this to your part.

Note that the lamination is 20mm thick. Ordinarily you should use strips of spruce which are at least 22mm wide. This will allow you to sand the lamination to the correct thickness after gluing. You will find that the lamination will be an unholy mess of glue squeezeout when you first remove the lamination from the mold.

Cut the chipboard so that the mold is about 4 inches wide, assuming that you have clamps which will reach far enough to clamp the laminations in place. The exact shape of this frame is not particularly critical since much of the outside will be sanded away when it is installed. For this reason you do not have to be overly concerned about the laminations distorting the mold. You want to be more careful with the other frames, so you may find that it is easier to screw the mold down to a piece of plywood to give it stability while you are laminating. To keep the glue from sticking to the mold you will need to use wax paper or plastic sheets. Lay in the strips of spruce and clamp until the glue is dry. Laminations are nice because it is easy to inspect the thickness of the glue line.

When the lamination is complete, sand it down to the final thickness and mark the horizontal reference line and the aircraft centerline. There are a number of ways to get the lamination down to the final thickness. The best way is with a thickness sander, but this is a professional tool that only the largest woodworking shops would have. The sanding belts for these sanders are very expensive, and most shops are very fussy about what they will let go through their sander. Epoxy glue, for example, will gum up a sanding belt very quickly. When the lamination is removed from the mold, the lower side is usually flat. Some builders put a fence on a band saw and carefully saw the extra wood off. Others put a router bit in a drill press and carefully move the lamination around under the bit. This is slow going, but it does a nice job—providing you do not slip! When one side is done this way, the surface is smoothed out with a sanding block and then the other side is done the same way.

There is a nice trick to sand down a lamination like this. If you use a sanding block you will probably not get a flat surface. Instead of using a sanding block, take a smooth board and glue a piece of sandpaper to the face of one end. The board should be long enough to reach across the widest frame. When you sand, allow the "tail" of the sanding board to rest on the far side of the lamination.

Open vs Closed Laminations

Any lamination that can be made in an "open" lamination is much easier than when you have to laminate completely around to make a closed loop. There are a number of open laminations—more than you might think if you look for them. Frame No. 3 consists of two open laminations glued together. Frame No. 1 is an open lamination, as is frame No. 2. These open laminations make for easier work, but you should be warned that with frame No. 2 you will want to be able to clamp a block of wood in the nose gear bay to hold it in place when you put it in the fuselage frame. Since it is open on the bottom, it will be quite flimsy if not restrained.

There is a further trick. If you use a male mold for the closed laminations you can make life easier for yourself by strategically locating the ends of the outer laminations at the longeron cutout points. With this method, you would do the inner laminations one at a time with a scarf joint at each end. Aerolite is good for this since it sets up so quickly. Lay in the innermost two laminations. When the glue is hard, glue in one lamination at a time until you are out to the area of the longeron cutouts. At this point, all of the remaining laminations may be done at once if the ends are terminated in a longeron cutout.

A Few More Tips

Speaking of longeron cutouts, we would advise against using any of these except the ones at the aircraft centerline or at W.L. 0. We think it is a mistake to measure for each longeron cutout on the jig board. It is best to use one single board on which you have drawn the aircraft centerline, Water Line 0 and all of the longeron elevations. This way, all of the longeron cuts will be determined by a single template. This is the best way to assure yourself that they will all be the same.

Remember, in all laminations, the nearest tips of scarf joints in adjacent laminations may not be less than ten time the thickness of the lamination.

Because open laminations are much quicker to do than closed laminations, the normal way of making closed laminations is to make two parts, each in the shape of a "C", and these are joined with a scarf joint. The scarf joint may be in either direction. If the scarf is cut so that you see the slope from the side, the scarf will be shorter. If the scarf is cut so that you see the slope from the front, then the scarf is quite long and the scarf joint becomes a curved line. Either method is acceptable. Again, you can use the longeron cutouts to good advantage by having the scarf "daylight" into the cutout—a clever trick to make a shorter scarf joint.

You will note on the fuselage assembly drawing that the fuselage stations are located on either the forward surface or the aft surface of the frame. Unfortunately, the dimensions for the frames are not always given at the face with the larger overall dimensions. For most of the fuselage frames in the tail section, this is inconsequential, but if you wish, you may work out the larger dimensions using trigonometry and a calculator. There are two frames where this discrepancy cannot be ignored. Frame No. 8 is actually two frames, and the forward frame is the larger of the two. It is best to make both in a female mold to the dimensions shown and then add an extra lamination to the outside of the forward frame. It would be ideal if you could get the outside shape of frame No. 1 right on the money. This will make for a better fit with the cowling, and it will make the already-tight front fuel tank installation no tighter.

The Fuselage Curve

The fuselage frames are curved. The curve is very similar to an ellipse, but it is *not* a true ellipse. The curve has no name that we know of. The curve is sometimes called a "faired curve" since it is frequently used in wing fairings, wing tips, etc. The curve is developed as shown on drawing No. 301. Each side of the "box" is divided into a number of equal divisions. It does not matter how many divisions you use except that for a given "box" you *must* use the same number of divisions on the horizontal side as you do on the vertical side. Failure to use the same number of divisions will give you an incorrect curve. For most drawings, we find it easiest to use divisions of ten or twenty. If there are more divisions it is easier to draw the curve with a flexible spline.

When all divisions have been marked off, connect the points with straight lines. The method of connecting the points is also important. Refer to drawing No. 301. For the upper left quadrant, you can label the marks on the horizontal line as "1", "2", "3", "4" etc. from the inboard out. Next, repeat the process on the side working down from the top.

> *Note:* The centerline of the airplane and Water Line 0 are *not* used in connecting the lines. It is possible to draw a curve using those points, but the curve will *not* be correct. One builder has made this mistake, and he had to add wood to frame No. 1.

Next, connect point "1" on the top side with point "1" on the side, "2" with "2" and so on until all of the points are connected. Use a spline and draw the curved line. The line should be tangent to the segmented "curve" formed by the straight lines you have just drawn.

There is one additional method of drawing the curve. This method requires a programmable calculator or a computer. To calculate the curve, three variables must be known. These variables are shown in Figure 1.

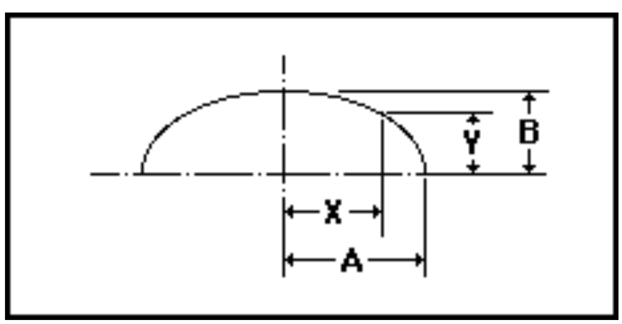


Figure 1

The formula for this curve is:

$$\sqrt{1-\frac{x}{A}}+\sqrt{1-\frac{y}{B}}=1$$

This same formula can be solved for either **X** or **Y**. These two formulas are:

$$x = A\left[1 - \left(1 - \sqrt{1 - \frac{y}{B}}\right)^2\right]$$

$$y = B\left[1 - \left(1 - \sqrt{1 - \frac{x}{A}}\right)^2\right]$$

If you have a Hewlett-Packard HP-11C programmable calculator you may use the program shown in Figure 2.

```
f LBL A
STO 1
g RTN
f LBL B
STO 2
g RTN
f LBL C
STO 3
1
ENTER
ENTER
RCL 3
RCL 1
÷
−
√x
−
g x²
−
RCL 2
x
g RTN
f LBL D
STO 4
1
ENTER
ENTER
RCL 4
RCL 2
÷
−
√x
−
g x²
−
RCL1
x
g RTN
```

Figure 2

The program does the following:

Program A:	Stores **A**
Program B:	Stores **B**
Program C:	Stores **X** (B.L.), Solves for **Y** (W.L.)
Program D:	Stores **Y** (W.L.), Solves for **X** (B.L.)

Storage registers used:

R1:	**A**
R2:	**B**
R3:	**X** (B.L.)
R4:	**Y** (W.L.)

Chapter 13
Making the Spars

This chapter is devoted entirely to making the spars. If you are purchasing the spars, you may skip this chapter. As always, it is best to start with the simplest parts and work your way up to the most difficult pieces.

Spar Jigs

Spars are made on jig boards just like ribs and fuselage frames. Use wood blocks to hold the parts in position while gluing. The simplest spars are those which do not have any taper to the thickness of the spar caps (or "booms", as they are sometimes called).

The rudder beam is probably the first part that you should make. When this is complete, you can build the forward fin beam. The laminated portion is made in the same way as the fuselage frame laminations. Because of the tight bend radius, you will find that you will have to soak and pre-bend the spruce laminating strips.

The elevator beam and forward stabilizer beam should be the next to be built. These are simple and like the others you have made.

At some point you are going to have to contend with the tapered spars. These are more difficult. In most cases, you will find that the spar caps are tapered both ways. Most builders are able to saw the spruce to the required taper on a bandsaw and then sand the spruce smooth. It is ideal if you can make the spars so that the tapering occurs on the inner face of the caps. This way, you have the grain of the wood next to the skin parallel to the skin.

You may also taper the spars by making the spars with non-tapered stock and then taper the finished spar. The risk of this method is that you might end up ruining the spar on the final tapering operation.

Plywood Grain Direction

Note that all of the spars specify that the plywood is at 45°. The plywood that you should use will be normal plywood with each layer at 90° to each other. The face grain of this 90° plywood is installed so that it is at 45° to the centerline of the spar.

A debate can always be started on the subject of the direction of the face grain of the plywood on spars—should it be "up and in" or "up and out"? For the wing spars, the grain should be "up and in" according to Mr. Frati and ANC-18. The theory of this method is that the plywood resists buckling better this way, but others insist that it is equally acceptable to have it run the other way where you have the greater strength of the wood running in the direction of the greater load in tension. The manuals of Fairchild and other aircraft companies frequently had wing spars with one method on the front and the other method on the aft face. Do it any way that you like, but the airplane was engineered with "up and in" in the calculations, and that is the way that the production aircraft were built.

For the horizontal stabilizer, the spars take a download, so the grain direction of the spars should be "up and out".

Plywood Scarf Joints

Some of the spars have several thicknesses of plywood on the faces of the spars. The plywood joints are scarf joints, of course, but they are drawn in an exaggerated manner for clarity. On the faces of the spars, the plywood should be joined with a 15 to 1 scarf.

The scarf may be either a diagonal scarf or perpendicular to the centerline of the spar. The diagonal scarf is considered slightly stronger, but it is not essential. The diagonal scarf joint must be done before the plywood is glued to the spar, unless some means can be worked out to get a clamping block in place.

Note also that the diagonal direction of the plywood will require that there be a scarf joint at the centerline of the aircraft.

Spar Cap Joints

The spar caps should have 15 to 1 scarf joints wherever there are any joints. The 15 to 1 scarfs are required in the outer eighth of the lamination. Steeper scarf joints (12 to 1) may be used on the inner laminations, but we suggest that the stronger 15 to 1 scarf be used for all of the spar caps.

Remember, in laminated members the longitudinal distance between the nearest tips of the scarf in adjacent laminations may not be less than 10 times the thickness of the thicker of the laminations.

The Ends of the Spars

The plans show the spars with a considerable amount of curvature to the ends. These can be made in two ways. One way is to bend the spruce by soaking the end and bending it. This can be done before the spar is assembled or later. The other method is to make the end of solid spruce, and then sand the outside of the spar to the required profile.

Doubling Up

Some of the spars may be made as one assembly and resawed into the two spars required. The aileron, flap and aft wing spars may be made this way. An allowance must be made for the sawcut needed to split the double-thickness spar into two spars.

The Aileron and Flap Spars

For simpler assembly, you will find it easier to make the aileron and flap spars as one piece end-to-end. This will allow for easier alignment of the flap and aileron to the wing, and the spars are cut apart after the aileron and flap are complete.

The Forward Wing Spar

The lower spar cap of the forward wing spar is bent. The plans show this as a single piece of spruce. You will find that if the lower spar cap is made from a single piece of spruce, the spar will have a certain amount of “spring back” after it is removed from the jig. For this reason, it is much better to make this piece as a lamination of two pieces of spruce. This eliminates the problem of “spring back”.

The Main Wing Spar

This is the big one! The main wing spar can be (and has been) made on a shop floor. Most builders will find the job easier if it is done on a long jig table which places the work at a more comfortable level.

Start by laying out the dimensions of the spar on the jig table. As always, work carefully. This is one part of the airplane that you do not want to make twice, so measure everything three times.

The upper and lower spar booms will be laminated in the jig and then the final assembly will also take place in the jig. It is best to elevate the work off the table slightly to keep glue squeeze-out from creating a rough surface. You may use pieces of nylon or some other material for this purpose.

You will need to build a fence to hold the laminations on the top and bottom. These are normally made of boards, say "two by six" lumber. These fences are held in place with screws and wood "knees", which are a wood version of a normal shelf bracket.

The spar cap laminations should be made with the grain parallel to the skin for greater strength. This means that all of the tapering will be on the inside of the spar. The upper lamination is made by laminating the first two outer layers. After the glue is dry, you may laminate the next layer. Note that the inner layers may be shorter, due to the taper of the spar caps. When all of the laminations are done, the spar cap is removed from the jig and the inner surface is tapered to the required thickness. You may also find it easier to laminate all of the laminations at one time. If the glue that you are using has a long working time, this would be no problem, but you will find this difficult to do with Aerolite.

The bottom lamination is glued up in the same way, but this time you work from the bottom lamination in.

If you wish, you may taper the rough spar caps in their fore-and-aft thickness at this time. You should not do more than the rough taper, since the parts may not be exactly aligned in the jig when you assemble the spar.

Put the spar caps back in the jig and glue in the blocking.

When the glue is dry, remove the spar from the jig and sand the forward and aft faces. Note that the aft face is a straight line. Sanding this precisely is very difficult. We like to make the analogy that it is like trying to hand sand a bowling alley, but builders have proved that with patience it can be done.

How to sand the spar? With the kit spars, Trimcraft has constructed a special sanding table. The table has a flat surface and a traveling drum sander is used. The sanding drum moves back and forth from one end of the spar to the other. This gives the spar a perfectly smooth surface.

The homebuilder will not be able to afford such an elaborate tool. Some builders have used an electric plane. Others have used electric routers supported by two straight boards. The straight boards are placed on either side of the spar, and the router is moved back and forth. The router is supported in a "carriage" consisting of two pieces of steel angles. The angles are bolted to a piece of wood at each end to hold them in position. The router is mounted in a third piece of wood, which sits in the angles and which is allowed to slide in the angles. This process is extremely slow, but it will work. Finish off the spar by sanding with a piece of sandpaper glued to a flat board. You will find that a sanding belt cut to make a single strip will work better than individual pieces of sandpaper.

Fit the plywood skins to the spars. Use a couple of small nails as alignment pins. Mark off and apply sealer to the inside surfaces of the plywood and to the inside of the spar. You will also want to draw the inside framework of the spar on the outside faces of the plywood. Glue on the plywood.

Chapter 14
Antenna Installation

The internal antenna system described in this chapter provides for the installation of antennas for dual VHF COM, dual VHF NAV (VOR-LOC-GS), DME, ADF, transponder, and marker beacon within the wooden structure of the Falco. This system was designed by Radio Systems Technology, which once offered kits for the Falco. RST stopped selling airplane-specific kits, so the complete kits are now available from Sequoia Aircraft, however RST still offers components. Builders who wish to order the antennas separately from RST may use the "materials required" list for each antenna, but we would strongly advise that all antennas be installed even though no immediate use of the antennas is planned, as it will be quite a problem to install them after the aircraft is complete. Radio Systems Technology is *not* available to custom engineer any modification of this system.

No. 1 Communications Antenna Installation

See Drawings No. 160 and 161. The primary VHF communications antenna consists of a ferrite-foil antenna located in the vertical fin. The foil antenna elements are sticky-back and may be temporarily attached to any clean, dry wooden surface. It is absolutely mandatory to cover the elements with varnish, epoxy or some other nonconductive coating to ensure that the elements are firmly and permanently attached to the airframe.

The antenna radiators consist of two pieces of copper tape arranged as a vertical dipole along the leading edge of the vertical fin. Each "ear" of the dipole element is 20.3" long, with a 5-10mm center gap. It is important that the antenna be placed as far forward on the vertical fin as is reasonably possible to get the antenna away from the metal hinges. There are several methods of installing the antenna. The antenna may be installed on the inside of one of the side skins between the skin and the ribs, or the antenna may be installed on the outside of the skin, with a small hole drilled in the skin for the lead to the coaxial cable and balun. The balun is the name for the assembly of ferrite toroids. Three toroids are all that are required. Sometimes four are used, but it doesn't make any difference. The toroids should be as near to the end of the cable within reason, but there is no critical distance—anything within about an inch is fine. The coaxial cable and ferrite balun assembly should be fastened firmly against the skin so that they will not vibrate loose during service. Epoxy resin with a small strip of fiberglass cloth should do the job nicely. In particular, the solder joints at the coaxial cable-to-elements must be coated with epoxy and fiberglass cloth so that years of airframe vibration will not break the joints. There is no critical length of coaxial cable or matching network required for this antenna.

Keep the coaxial cable and any other metal fittings as far away as possible from the antenna tips. (Metal near the center of the antenna—that is, near the coaxial cable attach points—has little effect on the proper operation, but the tips are rather sensitive.) The coaxial cable should run aft at right angles to the antenna elements and then down the main fin beam, along the upper right side longeron to frame No. 7, then to the center console area, then forward to frame No. 3 and up to the radio. The coaxial cable will require one UG88 (male) and one UG89 (female) BNC cable connector at frame No. 8. Do not run the coaxial cable along the bottom of the fuselage as it will interfere with the marker beacon antenna.

Because the length of the antenna is important for good reception, it is preferable that the antenna elements be laid straight on (or under) the skin, and if the elements are run "up and over" the rib cap strips, the reception of the system will suffer.

If only one communications antenna is installed, it should be this antenna since the radio waves from unicom radio antennas are vertically polarized to a greater extent than other communications (ATC, FSS, tower, ground, etc.).

Materials required:

1	RST Ferrite-foil Antenna Kit
1	UG88 (male) BNC Connector
1	UG89 (female) BNC Connector
25’	RG58 Coaxial Cable (includes 3’ extra)

No. 2 Communications Antenna Installation

See Drawings No. 160 and 161. The No. 2 VHF communications antenna is identical to the No. 1 COM antenna described above; however, this antenna is installed in the left wing and no cable connectors are required for the coaxial cable.

The center of the antenna should be installed 120mm outboard of wing station No. 10. The elements are run parallel to the spar to stations 9 and 12, and then the elements are run aft along the two ribs. The elements should run diagonally along the rib; that is, from the top of the wing at the aft face of the spar to the bottom of the wing at the aft end of the antenna elements. Details of the installation of this antenna are shown in Chapter 24 “Wing Assembly”.

The purpose of running the elements diagonally down-and-aft is to make the antenna as vertical as possible within the wing. VHF communications radio waves are vertically polarized, some more than others depending on the transmitter antenna. A similar antenna (designed by Radio Systems Technology) was used in the wing of the Bellanca Viking, and it was found that the communications antenna in the wing worked well when talking to everyone except unicom, and the range with unicom was limited to about 20 miles.

The coaxial cable should be run at right angles to the element down the spar aft face, then forward through the spar just under the upper spar cap to the wing leading edge strip (still at right angles to the antenna elements), and then along the leading edge strip to the cockpit and the radio. See “special considerations in wiring” if wing tip strobes are used.

Because a metal pitot tube line will interfere with the operation of the antenna, a nylon line should be used. The wiring for the wing tip lights should be run along the leading edge of the wing. The usual method of installation is to drill a small hole in the wing rib gusset just aft of the forwardmost vertical brace, and run the wiring through this hole.

As with the No. 1 COM antenna, the antenna elements, ferrite balun assembly, solder joints and coaxial cables must be firmly attached to the wooden structure with epoxy and fiberglass cloth to prevent airframe vibration from affecting the antenna.

Materials required.

1	RST Ferrite-Foil Antenna Kit
17’	RG58 Coaxial Cable (includes 3-1/2’ extra)

VHF Navigation Antenna Installation

See Drawings No. 160 and 161. The VHF navigation antenna is a nearly-identical mirror image of the No. 2 COM antenna, but in the right wing. The elements are run parallel to the wing spar to the ribs at stations No. 9 and 12, and instead of angling diagonally aft-and-down the elements are brought directly aft so that the entire antenna is horizontal. Navigation radio waves are horizontally polarized, so the ideal is to have the entire antenna exactly parallel with the fuselage W.L. 0. Details of the installation of this antenna are shown in Chapter 24 “Wing Assembly”.

Note on Drawing No. 161 that the length of the elements for the NAV antenna is 22.8” for each element.

The coaxial cable should be run at right angles to the elements forward to the wing leading edge strip and then along the leading edge strip to the cockpit and the instrument panel. See “special consideration in wiring” if wing tip strobes are used.

If one NAV radio is used, the coaxial cable may be run directly to the radio. If two NAV radios are used, the signal is split at the instrument panel into two equal parts with a RST-514 NAV splitter to feed two VHF VOR-LOC receivers, plus a separate glideslope output. If desired, a second glide slope output may be added later by splitting this glideslope output.

> *Note:* With all other things being equal, it is usually preferable to install two separate navigation antennas since the signal is weakened slightly by the splitter. The engineer who designed this system considered the possibility of installing two navigation antennas and concluded that the use of one antenna with a splitter was superior to the use of two antennas, since more signal was lost to the resistance of the extra length of the coaxial cable to the tail of the airplane than was lost to the splitter. Any builder determined to experiment with a second NAV antenna should purchase the materials for an extra antenna and install it in the stabilizer.

Materials required:

1	RST Ferrite-foil Antenna Kit
22’	RG58 Coaxial Cable (includes 3-1/2’ extra)
1	RST-514 Splitter
4	UG88 (male) BNC Connector

Marker Beacon Antenna Installation

See Drawings No. 160 and 161. The marker beacon antenna is a ferrite-foil antenna similar in construction to the NAV and COM antennas described above. This antenna also has two elements, each 34.3” long, installed in the bottom aft section of the fuselage. The center of the antenna is about 70mm forward of station No. 11. The elements of the antenna are installed on the bottom center longeron. Due to the nature of the marker beacon signal (blasting at the airplane from below at close range) it is completely acceptable to run the elements “up and over” the fuselage frames.

As with the other ferrite-foil antennas, the elements, ferrite balun assembly, solder joints and coaxial cable must be securely fastened with epoxy and fiberglass cloth.

The coaxial cable should be run at right angles to the antenna elements along the fuselage skin up to the right side longeron and then routed forward with the cable for the No. 1 COM antenna. The coaxial cable will require one UG88 and one UG89 BNC cable connector at frame No. 8.

Materials required:

1	RST Ferrite-foil Antenna Kit
1	UG88 (male) BNC Connector
1	UG89 (female) BNC Connector
20'	RG58 Coaxial Cable (includes 3' extra)

Since this system was designed, the location of the marker beacon receiver has been changed to the aft face of frame No. 6. Builders wishing to install the marker beacon receiver on the instrument panel may do so, but we now consider the standard installation location to be on the aft face of frame No. 6. This will mean that extra coaxial cable is supplied. This cable may be used for the DME since the DME is now installed on the aft face of frame No. 6.

Transponder Antenna Installation

See Drawings No. 160 and 162. The transponder antenna is a rod-ground plane device. The ground plane should be mounted horizontally (parallel with fuselage W.L. 0) with the radiating rod pointing straight down.

Install the transponder antenna in the right wing between stations 3 and 4. It is important that the the antenna be installed as low as possible and centered between the aileron cables. The fore-and-aft position in the wing is not critical, but it is best to locate the antenna in the forward part since this results in a shorter coaxial cable. The ground plane may be glued to a piece of 1mm birch plywood with epoxy glue. The plywood sheet should be supported by 10x10 spruce strips, and the whole affair may be installed between the ribs in any convenient manner. You may find that the most convenient location is to locate the radiating rod in the middle of one of the ribs. We would suggest that all nails and staples be removed from the ribs as well as any used in gluing on the wing skin.

Route the coaxial cable to the instrument panel as shown in Drawing No. 160.

Materials required:

1	RST Transponder/DME Antenna Kit
10'	RG58 Coaxial Cable (includes 3-1/2' extra)

A second transponder antenna, if required, may be installed in the right wing between stations 5 and 6. This requires 12' of coaxial cable, which includes 3-1/2' extra.

DME Antenna Installation

See Drawings No. 160 and 162. The DME antenna is identical to the transponder antenna except that it is installed in the left wing.

Materials required:

1	RST Transponder/DME Antenna Kit
10'	RG58 Coaxial Cable (includes 3-1/2' extra)

A second DME antenna, if required, may be installed in the left wing between stations 5 and 6. This requires 12' of coaxial cable, which includes 3-1/2' extra.

You should note that the DME receiver may be installed either in the instrument panel or remotely on the aft face of fuselage frame No. 6. If the DME receiver is installed remotely, the coaxial cable must be run to the receiver. It may be preferable to install the antenna in the alternate position for a shorter coaxial cable. Note also that the marker beacon receiver cable may be run to a remote receiver on the aft face of frame No. 6. This installation will provide the extra cable needed.

ADF Antenna Installation

No special antenna is offered by Radio Systems Technology since most new radios are supplied with a combined sense-loop antenna. This antenna should be installed inside the top of the fuselage around station No. 9. Because of the proximity of the antenna to frame No. 8, it may not be necessary to have cable connectors if the cable can be easily detached from the antenna, or if the antenna can be easily detached from the airframe.

Special Considerations in Wiring

Any of the antenna coaxial cables may be run beside any other antenna coaxial cables. Care must be exercised when installing some of the antenna cables near strobe light wires. Strobes are operated by high voltage, and these high voltage wires lead from the strobe power supply to the strobe light. It is permissible to run these high voltage wires with the cables for the DME and transponder antennas, but the VHF navigation and communications antenna cables should be spaced about 6” from the high voltage wires to eliminate the noise that will otherwise be created. The ADF antenna cable is ten times more sensitive to the strobe light wiring and should be kept as far away from it as possible. The strobe light wiring for the tail should be run down the upper left side longeron—on the opposite side of the fuselage from the ADF cable.

General Comments

Wood aircraft are customarily covered with a metalized paint over the fabric. This “silver” coat has no effect on the operation of the antennas, since the metal parts in the paint are in suspension and do not touch each other. This does not apply to metallic enamel final coatings, however. No tests have been done for such paints, and one Falco was painted with metallic Imron enamel, and the internal antennas (not RST design) did not work. While it may be that the failure of the antennas was a result of their design, it does cast doubts on the success of using internal antennas under metallic enamels. We suggest that metallic enamels *not* be used.

These assembly instructions were written without the actual installation of the antennas in a Falco. Accordingly, we suspect that there are some ways of installing the antennas which are easier than others, and that there are a number of better ways of installing the antennas which have not occurred to us. The placement of the antennas within the aircraft should not be changed, but we are free to admit that we do not have all of the answers about what is the best way of installing the antennas, fitting them to the structure and how this installation best meshes with the assembly of the aircraft. Please let us have your ideas if you come across some better way of doing things.

For additional information on these types of antenna system:
1. “The Plastic Plane $5 Antenna System”, *Sport Aviation*, Jim Weir, May 1979.
2. “Antennalets”, *Sport Aviation*, Jim Weir, January 1981.
3. “Economy Antennas”, *Sport Aviation*, Jim Weir, October 1976.

Loran Antenna Installation

At this time all of the details of the installation of a Loran antenna have not been worked out for the Falco. Radio Systems Technology has worked on the design of internal antennas for Loran navigation systems. For additional information, see “Loran Antennas for Plastic Airplanes”, *Sport Aviation*, Jim Weir, March 1984. The notes which follow are taken from that article and from discussions with Jim Weir on the specific Falco installation. This installation is not finalized yet and is subject to change.

Loran Antenna Design Requirements
Loran systems were originally developed for marine navigation. Ships and boats use a vertical whip antenna, usually 5 or 10 feet high. The antenna does not require a specific tuned length like the other antennas installed in the Falco. The length of the antenna does affect the range of the equipment. The antenna should be vertical and only the vertical height of the antenna counts toward long range reception. Therefore, it is desirable that the antenna be as tall as possible *vertically*.

The second requirement is that the antenna requires a ground plane. Boats have no problem with this since the water acts as a ground plane. Metal aircraft act as a ground plane. For these aircraft a short (24") vertical antenna above a metal ship that extends 5 or 10 times that length in most directions will perform very well, if not perfectly. With the Falco, we must take measures to provide a ground plane for the Loran antenna without interfering with the other antennas.

A third requirement is that all of the larger metal pieces must be grounded. It is absolutely essential that all major metal parts be bonded to each other and to one of the three negative buses in the Falco. Not only does this prevent noise, it also extends the ground plane.

Lastly, good reception with Loran requires that electrical noise ("hash") and other digital signals be suppressed as much as possible.

Apollo II Loran Receiver
There are a lot of Loran receivers on the market. Some are made for marine applications and some for aircraft. The aircraft versions are either certified for IFR or not. Those that are not certified for IFR may not be legally used as the primary source of navigation for flight in IFR conditions. This does not mean that the Loran may not be on during IFR flight. The IFR certified Loran receivers are substantially more expensive than the VFR units.

Because of the limited radio stack space in the Falco (8") it is best to select the most compact Loran receiver. This receiver is the II Morrow (pronounced "tomorrow") Apollo II, which is 2" high, 11" deep, and will fit in the standard width radio stack. Without regard to the features, the Apollo II would be the natural choice for the Falco.

When features are considered, the Apollo II still comes out on top. The receiver has only six buttons for data entry and a single dual-function knob. The Apollo II has all public-use airports in memory as well as all VOR's; all you have to do is to dial-up the three-letter identifier of your destination airport and watch the display tell you the heading to fly, distance, time to destination and ground speed. In addition, you can enter up to 100 waypoints or private airstrips in the permanent memory. The Apollo II may be purchased from Radio Systems Technology at substantial savings when compared to normal avionics shops. The Apollo II can be coupled to the autopilot. The connection is identical to that of the NAV radios.

The Loran Antenna
The Loran antenna on the Falco will be a length of wire running up the main fin spar. Any type of wire may be used. It may be a strip of copper tape, light gauge insulated wire, welding rod, bare wire, or even a coat hanger. The type of wire is *not* important.

It is important that the antenna be as tall as possible, measured from the bottom to the top. The antenna wire may be installed on either the forward face or the aft face of the fin spar. It should extend to the bottom of the tail cone.

You must install the antenna coupler. The antenna coupler is sold with the Loran and is optimized to work with the specific radio. You should *not* try to use a Loran coupler from another manufacturer or to use an ADF coupler. The Apollo II antenna coupler (see Figure 1) is a metal box with a male BNC connector on each end. Two .155” diameter holes are on the base for mounting, and these will accommodate No. 6x1/2” TRA screws.

RG58 coaxial cable is used to connect the receiver to the coupler. The Apollo II is supplied with the antenna coupler, the BNC connectors needed for the coupler and the receiver, two ring terminals and a very short piece of coaxial cable. You will need to purchase the receiver-to-coupler coaxial cable, and you will need to get some additional BNC connectors. You will need to install connectors on the coaxial cable at frame No. 8, and you may want to install connectors below the instrument panel for easier removal of the panel.

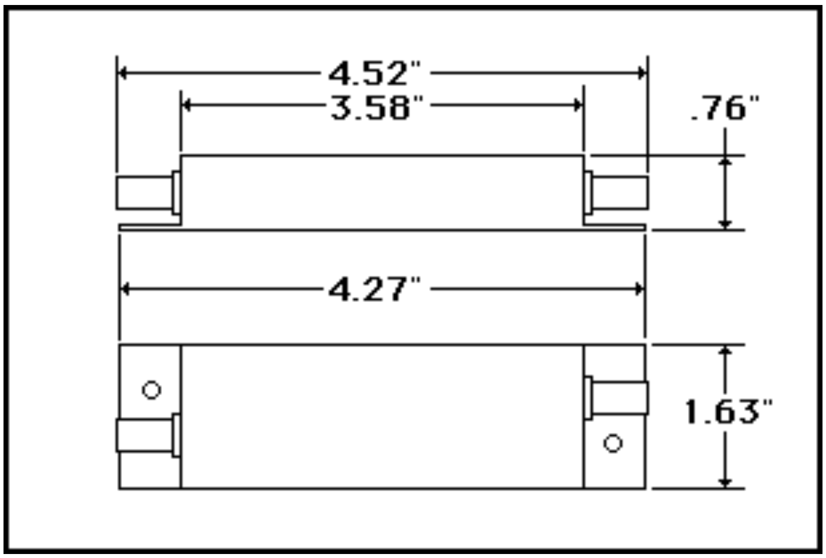


Figure 1

At the antenna end of the coupler, a *short* pigtail is made using a female BNC connector, coaxial cable and two ring terminals. The coaxial cable should be as short as possible. About 2” is normal, but certainly no more than 6”. The longer this pigtail of coaxial cable, the more your reception will suffer.

See Figure 2 to make the pigtail. Install a female BNC connector on a short piece of coaxial cable. Within about an inch of the connector, strip the outer insulation. As you have done with the NAV, COM, DME and transponder antennas, the outer braid of the coaxial cable is formed into a separate lead. To insulate this outer braid from the antenna wire, heat shrink tubing or electrical tape may be used over this lead. A solderless ring terminal is installed on this lead. This is the ground terminal to which all wires from the ground plane are attached, along with other ground wires.

The inner insulation is stripped so that the inner lead will be insulated from the outer ground shield. To insulate this inner lead, heat shrink tubing or electrical tape may be used. A solderless ring terminal is installed on this lead. This is for the antenna wire.

The antenna coupler may be installed either vertically or horizontally. The coupler may be installed in several places. The most convenient place is inside the access door for the rudder cable pulley.

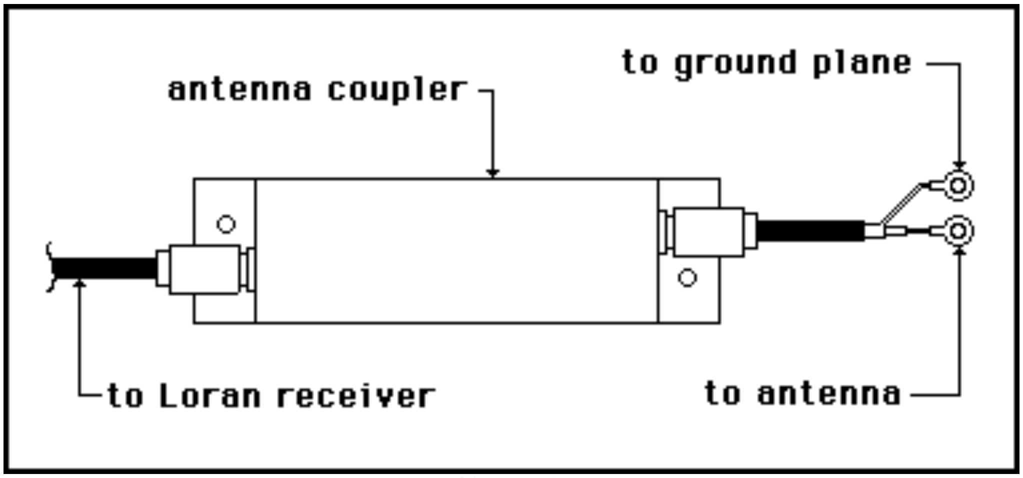


Figure 2

See Drawing No. 410, Section A-A, for the installation of the antenna coupler. To install the coupler at this location, it would be easiest to install it very early; however, the antenna coupler is not sold separately from the Loran receiver. Since the coupler can be installed through the access door, it can be installed after the airplane is completed, but you should run the antenna wire and the coaxial cable during the construction of the Falco.

As previously stated, the antenna wire should run up the forward or aft face of the main fin beam. Unlike the other antennas in the Falco the Loran antenna may be next to other pieces of metal, and this does not affect its reception. We did inquire if it might make sense to use the upper rudder hinges as part of the antenna by joining the antenna wire to the hinges. The answer was that it would probably not help, and might well detract from, the reception. It does not matter if the antenna wire is run around the hinges or up-and-over the ribs. You will find that you will have to snake the antenna wire around things, and this does not affect the reception.

The coaxial cable from the antenna coupler should be run along the upper right side longeron to frame No. 7, then to the center console area, then forward to frame No. 3 and up to the radio. You will have to install BNC connectors at frame No. 8. In addition, you may want to install BNC connectors below the instrument panel so that you can easily disconnect the antenna coaxial cable for removal of the instrument panel.

You will notice that the top of the Loran antenna is close to the upper tip of the No. 1 COM antenna. This is an unavoidable compromise, and it will cause an aft null in the COM antenna's pattern, but the null will be narrow (5 degrees or so) and so shallow (say, 15 dB) that it will not materially affect the communication transceiver's performance.

We did consider the possibility of installing the Loran antenna in the rudder, but this would put the coupler in the rudder. It might be possible to locate the coupler in the leading edge of the rudder, but we think this would be a difficult installation. Installing the coupler aft of the rudder hinge line would be an invitation to flutter.

The Ground Plane

In layman's terms, the object of the ground plane is to make the Loran antenna think it is installed on a metal airplane. The Loran antenna is easy to fool, so you will only need a few wires. The ground plane will consist of a number of wires running from the antenna coupler forward along the sides of the fuselage tail cone. If there were no other metal structure in the tail section, this would mean that you would need about eight wires—four per side. These wires should be connected to the ground lead of the antenna coupler. The forward ends of the wires should also be joined together. The forward ends of the wires *and* the ground lead of the antenna coupler should be connected to one of the three negative buses in the airplane. There are three negative buses in the Falco: the engine, the instrument panel and the negative bus bar installed on the bottom of the fuselage skin just aft of frame No. 6. These ground plane wires may be on the outside of the skin or on the inside—it doesn't matter. The ground plane wires may be any type of wire. Perhaps the simplest thing would be to use sticky-backed copper foil. This is the same type that we use for the NAV and COM antennas. It is commonly used for burglar alarm systems in store windows, and you should be able to get some locally.

As a practical matter you may not need to install any of these wires. There are already plenty of metal parts in the tail which can be used as ground planes. This includes the rudder cables, the elevator cables, the elevator trim tab push-pull cable, the tail position light ground wire, and the shielding of the strobe light wire. It is important that these things be grounded to the case of the coupler box in the most direct manner. With the other parts of the electrical system, the length of the wire to a ground bus is not important, but it is important in this situation. Grounding the elevator and rudder cables at the forward ends will *not* work. Try to keep the length of the ground wire to the antenna coupler box as short as possible. Anything within one to two feet is all right.

The antenna coupler should be grounded to the system of grounding buses in the Falco. This may be done by putting it in series with the tail position light ground wire. This wire would run from the tail position light to the ground lead of the antenna coupler and then to the negative bus bar.

If you wish, you may also run a ground plane wire out in the horizontal tail. This is probably not necessary, but it is not difficult and certainly will not hurt. Grounding to the elevator trim tab cable will not be easy, and you should not forget to also ground the aluminum tube in the horizontal stabilizer. Once you have run wires out in the horizontal tail, you might as well run them out to the tips of the horizontal tail. While you are out there, also ground the outboard elevator hinges.

The coaxial cable for the COM antenna does not have a shield, so it is not part of the ground plane wiring system.

Grounding Other Metal Parts

All large metal parts in the airplane must be grounded to one of the three negative bus bars. In his original article, Jim Weir stated that every piece of metal over one square inch should be grounded—but in his conversations with us he said that you only need to ground those pieces over 6 square inches. You can be your own judge and do as you see fit. Bear in mind that if a metal part is exposed to the air stream it will be subject to precipitation static (P-static), and it is more important to ground exterior parts like access panels than it is to ground internal parts of the same size.

The grounding of metal parts is primarily related to the installation of an ADF or Loran, and there is no special need to do this if these systems are not installed.

A partial list of things to be grounded: the firewall, all control cables, aileron pushrods, elevator pushrod, seat tracks, flap torque tube, firewall, landing gear retraction system, the engine mount, main landing gear, nose gear, all metal access doors and all metal fairings. Many parts of the Falco are already grounded as part of the electrical system design. These include the fuel tanks, the landing gear motor, the flap motor, the instrument panel and the engine. In addition to eliminating noise from the signal that the Loran receiver uses, this grounding also extends the ground plane for the antenna. The upper hinges for the rudder should *not* be grounded as this would put a ground plane in line with the antenna.

When grounding metal parts, literally any wire size or type will do.

Noise Suppression

The Loran depends on decoding a low-frequency noise-sensitive pulse in the midst of a lot of crackles and pops. These come from lightning and from the devices installed in the airframe. The Falco's electrical system is extremely quiet and generates no audible noise, but there could be some inaudible noise that the Loran will detect. We already use a solid-state voltage regulator, and we have a shielded ignition system, so those two requirements are met. Digital devices can generate some noise which will also affect the Loran. This is the big unknown for the Falco. Potential sources would be the digital clocks, digital fuel flow analyser and digital OAT. Until we know if we have a problem, we will not be able to offer any advice on this subject.

Materials required:

1	Apollo II Loran receiver (includes antenna coupler)
2	UG88 (male) BNC Connector
2	UG89 (female) BNC Connector
20'	RG58 Coaxial Cable (includes 3' extra)

BNC Assembly Instructions

In the process of installing the antenna system, you will have to assemble a number of BNC connectors. To assemble one of these connectors:

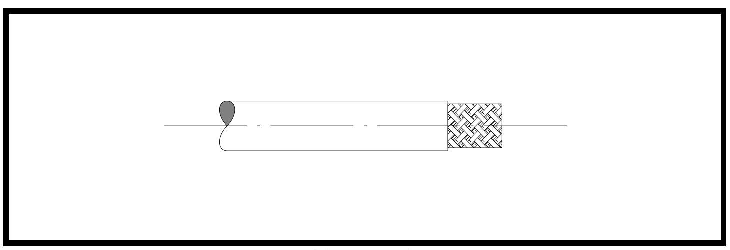


Figure 3

❏ Strip the outer cable insulation for a length of 9/32" (7.1 mm).

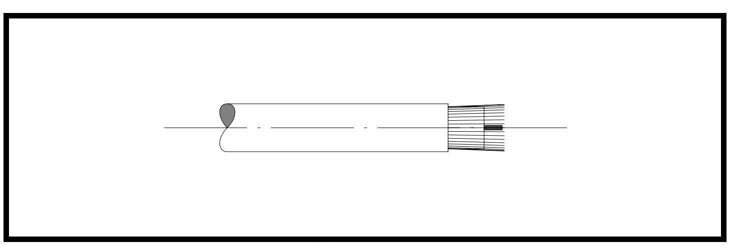


Figure 4

❏ Fray the shielding braid and strip the inner insulation 3/32” (2.4mm). Tin the center conductor; that is, coat the conductor with solder to make the delicate job of soldering the contact easier.

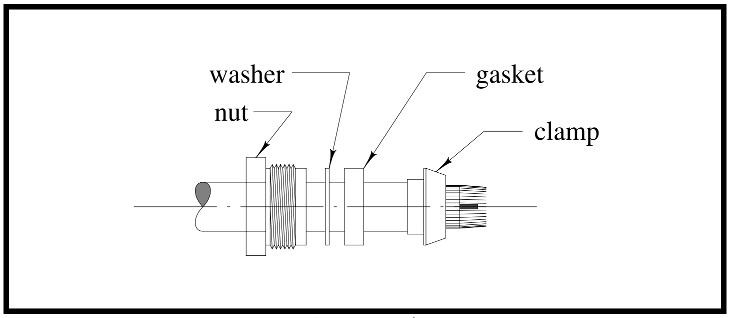


Figure 5

❏ Pinch the shielding tight around the wire and slide the nut, washer, gasket and clamp over the braid. The inner shoulder of the clamp should fit squarely against the end of the outer cable insulation.

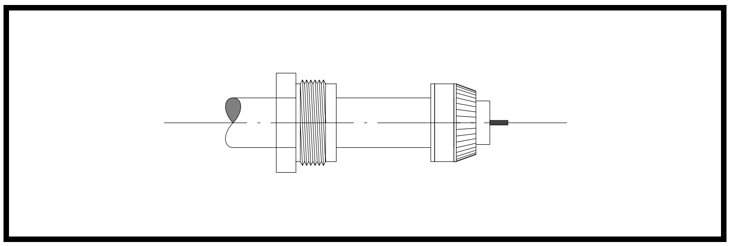


Figure 6

❏ Comb the shielding out and fold back smoothly over the clamp. Trim off any excess shielding that extends past the clamp.

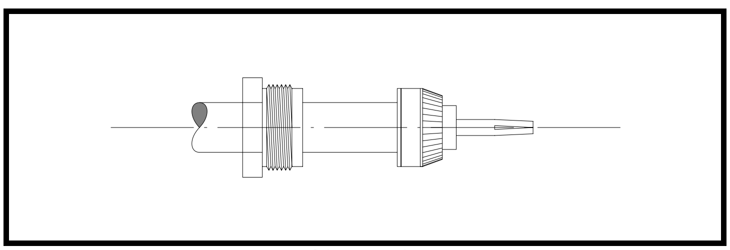


Figure 7

❏ Slip the (male or female) contact in place, butt against the inner insulation and solder. The contact has a tiny hole drilled in it for soldering. Turn the contact so that this hole is on the top, hold the soldering gun under the contact, and feed solder into the hole. Remove excess solder from the outside of the contact. Be sure the inner insulation is not heated excessively and swollen so as to prevent the insulation from entering into the connector body.

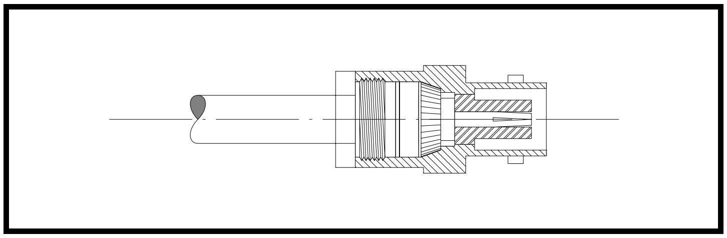


Figure 8

- ❑ Push the assembly into the body as far as it will go. Slide the nut into the body and screw in place with a wrench until tight. For this operation, hold the cable and shell rigid and rotate the nut.

Chapter 15
Electrical System

The electrical system is installed in accordance with the drawings and manual supplied with the electrical system kit. These drawings and the manual are not available separately. This chapter will provide you with the necessary preliminary information to proceed with the construction.

Navigation & Strobe Light System

If you wish to install a navigation and strobe light system, you will need to purchase the following:

Whelen A650-PR-14 (or A429-PR-14) Wing Tip Light
Whelen A650-PG-14 (or A429-PG-14) Wing Tip Light
Whelen A500-14 Tail Light
Whelen A413A, HDA-DF-14 Power Supply
Whelen HD, T3-90 Installation Package

The wing tip lights and tail lights are combination navigation position lights and anti-collision (strobe) lights.

These lights are widely available and may be purchased from many different suppliers. You will find, however, that the prices will vary widely. Wag-Aero and San-Val Discount Aircraft Parts have very competitive prices on the strobe systems.

You may also want to purchase the landing light (GE 4509) at the same time.

Equipment Installation

It may help to know the location of the electrical equipment installed in the Falco, so that you can understand the routing of the wires.

Engine Compartment:

Oil pressure transducer (on the engine mount)
Oil temperature sender (on the engine)
Cylinder head temperature sender (on the engine)
Fuelgard transducer (on the firewall or engine mount)
Electric fuel pump (on the firewall)
EGT thermocouples (on the exhaust pipes)
Landing gear down limit switch (on nose gear lower drag strut)
Landing gear up limit switch (on firewall)
Landing light (on the lower cowling)

Frame No. 1, aft face:

Alternator shunt
Fuse holder
Alternator analyzer transducer

Front Fuel Tank:

Fuel quantity sender

Glare Shield:

Four glare shield lights

Frame No. 3:
Compass (internally lighted)
OAT probe (on right fuselage skin, forward of the frame)

Center Console Panel:
Flap position switch
Throttle position switch
Landing gear warning horn

Control Sticks:
Microphone push-to-talk switches

Center Console Cover:
Alternator analyzer gauge (on P/N 833A)

Frame No. 4:
Autopilot roll servo (on right side of aircraft)

Frame No. 5:
Landing gear up relay (on forward face)
Landing gear down relay (on forward face)
Fuse holder (on forward face)
Terminal block (optional, on aft face)

Frame No. 6:
Master relay
Starter relay
Strobe power supply
Ammeter shunt
Fuse holder
Terminal block
Main negative bus bar (on bottom floor)
Voltage regulator
Starting vibrator (if required for engine)
DME or RNAV receiver
Carburetor ice detector (optional)
Marker beacon receiver
Altitude encoder

Aft Fuel Tank:
Fuel quantity sender

Battery Compartment:
Battery (Gill PS6-11 or Gel/Cell U-128)

Front Fin Spar
Loran antenna coupler
Terminal block (for tail light wires and Loran antenna)

Rudder:
Tail light

Wing:
Wing tip lights
Heated pitot

Wire Bundle Routing

The instrument panel has three large plugs which are installed on the forward face of the panel. The wires from these plugs go down and then split into two bundles. The forward bundle runs forward along the nose gear bay cover. The bundle splits up and runs outboard to each side of frame No. 1 and into the engine compartment through grommets on each side of the airplane. Wires for the OAT probe, front fuel tank sender, glare shield lights and compass light run up the aft face of frame No. 1, then aft along the top of the fuselage skin. The wires for the OAT probe, glare shield lights and compass light will run through a small hole in frame No. 2. It is important that the wiring not prevent the removal of the front fuel tank.

The aft bundle will be routed through the holes in the main wing spar to the aft face of frame No. 6. Wires will be split off from the bundle as required for the wing tip lights, heated pitot, microphone push-to-talk switches, autopilot roll servo, landing gear motor, flap motor, landing gear warning horn, flap position switch, throttle position switch, etc.

The main battery wires will exit the battery compartment (through the floor of the compartment) and will be routed to the master relay, starter relay, main negative bus bar and then to the engine compartment. Thus, they will pass through frame No. 6, just outboard of the flap motor, through the main wing spar, under the control stick torque tube, through the forward wing spar and frame No. 3, through frame No. 2 (under the flooring) and through frame No. 1 through two grommets installed in the firewall. This routing of the main battery wires will greatly ease the installation. On the original production Falcos, these wires were routed up and over the nose gear bay cover. This greatly complicates the installation.

Chapter 16
Tail Group Assembly Preparations

Kits on Hand

To assemble the tail group you should have the following kits:

Kit No. 801-1 Tail Group Equipment
Kit No. 806 Trim Tab Control Equipment
Kit No. 402 Tail Group
Kit No. 405 Tail Group Ribs
Kit No. 861 Antenna Components

You will need the following sheets of plywood (Kit 402 includes this plywood)

1.5mm birch plywood: 8 sheets (50”x50”)
2mm birch plywood: 1 sheet (50”x50”) or one small piece—see Figure 8.

The tail group assembly is covered by Chapters 16 through 20. This work should be done in sequence, that is, you should complete the work in each of these chapters before proceeding to the next chapter.

Basic Principals

First off, we should admit that there is no one correct way to assemble the Falco. There are an infinite number of ways that the airplane can be built and still conform to the plans. There is, however, a single quickest, easiest method for each builder. The method chosen by a particular builder may depend on the tools, space and finances available. For example, a builder who is able to purchase the canopy kit early in the construction will have an easier time of building the Falco than one who must wait until later. This is just one example, but it is to emphasize the diversity of correct procedures.

The assembly method presented in this and subsequent chapters is a method that is in constant revision. Every builder is urged to comment and offer suggestions for faster, simpler ways of building the Falco. As anyone who has built a Falco can tell you, *the order in which you do things is the single most important determinant of the airplane’s completion time*.

We will assume that all kits are purchased or that you have already made all of the parts required. Additionally, we will be stating what we see as the fastest method of building the airplane. In many cases this will require the purchase of some kits earlier than might have been otherwise planned. In those cases, you may defer the purchases and install the parts later, postponing the purchase and extending the building time.

The assembly order presented here may not be complete, and it will be refined and added to in the future. You should always be on guard against “painting yourself into a corner”.

Before we get into the actual assembly, we would like to point out that there are certain basic principals that should be understood. These principals are the basis of the assembly order given, and their understanding is *more* important, in many ways, than a literal following of the assembly order given.

First, *always install parts at the earliest possible stage of construction*. It is very easy to install fittings on the fuselage frames when you can place the parts on a drill press and drill the holes. If you wait until late in the construction, you will need “six fingers and an eyeball on a string” to get the parts in the airplane. In addition to fittings, there are a lot of little pieces of wood which are easily installed early in the game. The little pieces of wood which are required for the cockpit flooring and side walls are in this category.

Secondly, *always maintain control of your dimensions*. Marking fuselage frames with water lines and butt lines, drawing centerlines and chord lines on ribs and spars, and using your pencil to note the locations of installations to come will greatly simplify the construction of the airplane. If you have the dimensions marked, you will always know where you are. Without the dimensions, you will have to resort to guessing, and that is a very bad thing to have to do.

Background

To date, Falco builders have been evenly divided between two assembly methods for the tail group. Some use a flat table and wood blocks (of all the same length) to hold the centerline a certain distance above the table. The advantage of this method is that the “jig” is a minimum effort.

The other method is to build the tail surfaces on a table with the spars carefully leveled and with the leading edge up. The ribs are fitted and glued to the spar with the ribs plumbed with a plumb bob. All of the spars and ribs have the centerlines drawn on them, so it is a simple matter to line the ribs up. After the two end ribs are installed, strings may be used to align the ribs in between. The centerlines drawn on the forward fin spar, forward stabilizer spar or leading or trailing edge strips may be use to align these ribs as well.

We favor the vertical assembly method. For this you will need to make a jig table. The jig table should be long enough to assemble the vertical tail, the horizontal tail (about 10 feet long) and the flaps and ailerons end-to-end (about 10 feet long). Take care to make the top of the jig table as flat as possible. Ideally, the jig table should be 3 feet wide and 12 feet long. Some builders have used solid-core doors and formica counter tops.

When you work on the elevator or rudder, you will find it impossible to place the thing on the table with all of the ribs installed. The best thing to do is to screw a number of 20x20 pieces of scrap wood to the table with the ends projected out from the table’s edge. The spar for the control surface can now be placed on these pieces and the ribs will not hit the table. The reason for having the pieces of wood extending out from the table is to allow you to flip the elevator or rudder over and work on either the trailing edge or leading edge on the top. See Figure 1.

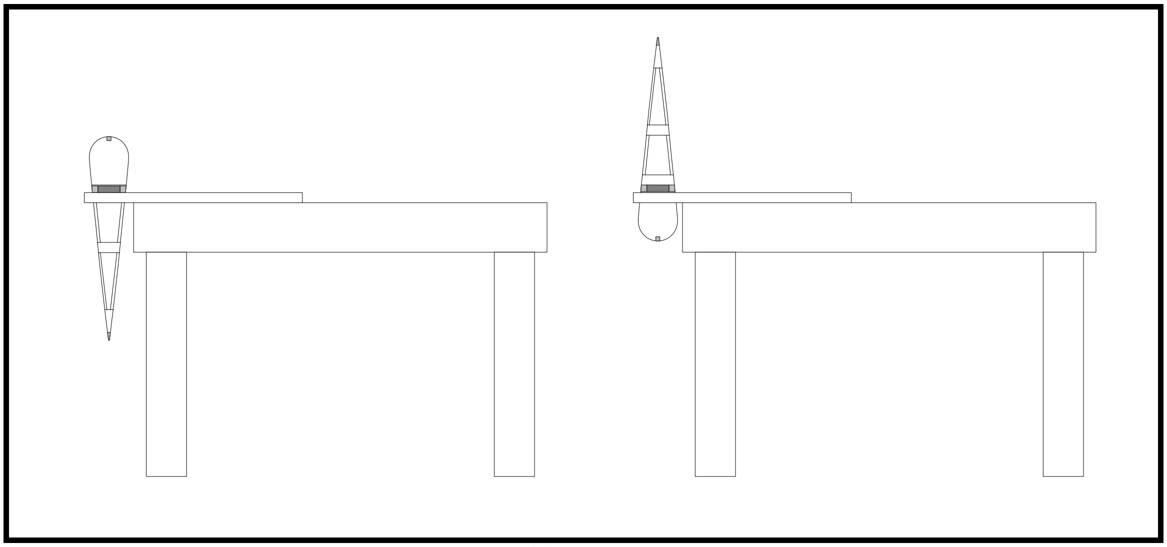


Figure 1

If you wish, you can make plywood plates for each end of the assembly at hand. A vertical line can be drawn on the plate and the plate used to support alignment strings for the leading edge, trailing edge, or any other part of the assembly. With the stabilizer or elevator, you will need a plate for the center of the aircraft as well. Most builders find this method too fussy and don't bother with it.

So far, all builders have built the horizontal tail with the methods described above. A few builders have built the vertical tail "on the airplane"; that is, they did not use a jig at all but put the vertical spars in the fuselage jig and fitted in the ribs. While this has worked, we don't think that this is really the best way. It is much easier to align the ribs to the vertical plane with plumb bobs or levels than it is when the tail is on the airplane.

The problem is that the spars of the vertical fin must be glued to the spars of the horizontal stabilizer. One builder solved this problem by building his vertical tail section first. When the horizontal tail was assembled, a block of wood was used as a spacer between the two stabilizer spars to make sure that they were the correct distance apart. The vertical tail was mated to the horizontal tail on the fuselage jig, and the forward fin spar is flexible enough to spring open for gluing.

Remember, you should always scuff-sand birch plywood before gluing. When birch plywood is made, the hot press leaves a hard shiny surface to the plywood, and the glue will adhere better if this sheen is removed by a light scuff sanding.

In this manual, we will be reminding you to varnish the many pieces. As a practical matter, most builders find it easier to do most of the varnishing in advance. It is much easier to varnish all of the nooks and crannies of the ribs if you can hold them in your hand. You should be very careful to avoid varnishing any area that will be used for gluing.

You will also find that it is necessary to mask the spars and ribs for varnishing. While it may seem possible to brush varnish only on the areas you intend, the reality is that the varnish inevitably gets on the surfaces that will later be used to glue on the skins. If you try to wipe up the varnish, you will find that you will only smear it into the wood.

Drawing Notes

This chapter describes the assembly of the tail group in accordance with the tail group drawings issued in June 1985. These drawings have a number of changes from the earlier drawings issued in 1979. Many of you may be working with parts made from the first drawings, so the purpose of these notes is to highlight the changes.

The drawings show the elevator and rudder skinned entirely with plywood. The original Falco had control surfaces that were fabric covered. Many builders suggested that the construction would be quicker and simpler if the control surfaces were skinned entirely with plywood. We agree, and since we feel that almost all builders will opt for the plywood skinning, this is the only method of construction that we are showing in these drawings. The drawings for the metal control surfaces have been eliminated, since no one was using them.

With the fabric covered control surfaces, the trailing edge strip had to provide sufficient stiffness to take the loads imposed by the fabric tautening process. With the plywood skinning, the trailing edge strip serves only to provide a gluing strip between the two skins. Since the plywood skins will add some weight to the control surface and throw the balance slightly aft, it is advisable to reduce the weight of the trailing edge strip as much as possible. The trailing edge strip is now 15mm wide—previously 30mm wide for the fabric covered elevator and rudder.

Similarly, the elevator tab has been lightened by building it of spar, ribs and trailing edge strip. The weight of the trim tab is probably cut in half. While the total weight saved is very small, this is significant since the balancing situation is improved.

With the reduced trailing edge strip, the skinning may become slightly more difficult since the 15mm trailing edge strip is considerably less stiff than the 30mm strip. For this reason, it is advisable to support the trailing edge strip during skinning.

The original drawings showed plywood pads under the hinges. The purpose of these pads was to protect the plywood spar web from being crushed when the bolts are tightened. These pads were shown in an inconsistent manner. When the bolts were selected, the plywood pads were used in the computation of the bolt lengths. Many builders have elected to leave off the pads, and then found that the bolts were too long. In these new drawings, we have eliminated the plywood pads. The hinge bases are reasonably large and much larger than that of the channel-nuts. It seems to us that it makes more sense to distribute the load of the channel-nut. In these new drawings, we show plywood pads under the channel-nuts. In many cases, an extra piece of plywood is installed to make the bolts come out to the correct length. Bolts are available in increments of 1/8" in length. It is rare that a bolt is precisely the correct length, and we always use the longer bolt so that the shank of the bolt (the unthreaded portion) is in bearing and not the threaded portion.

With the original drawings, the information was scattered among several drawings. With the ribs, for example, the builder had to refer to the rib drawing, the rudder contour drawing and the table of chord station dimensions in the construction manual. With these new drawings, all of the pertinent information is given on the same drawing. In the past, the hinge installation was shown in a separate drawing. In the process of overhauling these drawings, the drawing numbers have been changed and will be easier to follow. There are a few details which are now shown in two places in the Falco plans. The elevator controls are an example of this, and the elevator controls drawing is scheduled for rework.

The rib drawings are drawn very accurately and may be used as patterns for the ribs as long as dimensions are checked to make sure that the paper has not contracted or expanded due to the humidity. The rib drawings show a number of new details. There are now rib drawings for the Sta. 0 ribs for the stabilizer rib, for example.

The original drawings did not show the fairings for the tail group. These new drawings now show the fairings. Since the rudder fairings are installed with screws, the ribs to which they are screwed have been increased to a thickness of 10mm. To allow for the installation and removal of the outboard elevator hinge bolts and the upper rudder hinge bolt, the extra rib has been moved slightly to provide clearance.

Drain and vent holes are now shown in all appropriate locations. The vent holes are 1/8"Ø and are provided so that no closed compartment is created to trap the air. Drain holes are located in the bottom of the elevator, stabilizer and rudder. These drain holes are shown as 1/8"Ø, but if you wish, the drain holes may be 1/4"Ø as well.

The trim tab hinge is now shown as being installed with No. 6x1/2" TRA screws. Originally, this hinge was installed with flat head screws, but some builders complained that the hinge was difficult to countersink. Once countersunk, the material is so thin that only part of the head of the screw was engaging the hinge material, so some builders have gone to the trouble of dimpling and countersinking the screws in the hinges. By carefully locating the screws so that the screw heads are offset from the screws "across the way", ordinary truss head screws can be used for a simpler installation.

An aluminum tube is installed in the stabilizer for the trim tab control cable. This tube allows the cable to be removed. To hold the tube in place, the old drawings showed a hose clamp fastened by screw and nut to a spruce block on the Sta. 1 stabilizer rib. To simplify the construction, the drawings now show the tube epoxied to a block of spruce in the main stabilizer spar, but the screw and clamp method may still be used.

There are a lot of new details shown so that little will be left to your imagination. Whenever possible, the details incorporate details previously shown elsewhere. The elevator balance weight installation is now shown as part of a detail for the elevator hinge installation.

Many builders have experienced great difficulty in understanding how the tail section of the fuselage is skinned. In a word, the fuselage tail section is skinned all the way back to the main fin spar. This forms a continuous plywood tube which is very strong torsionally. In order to skin this, a number of gluing strips are required, and these are shown on the drawings. Because of the difficulty of sanding the angle on these strips, the gluing strips are drawn so that the angles can be sanded in advance.

Some of the more frustrating design details of the tail group are the installation of the tail light and the routing of the wiring to the light. The new drawings show the tail light installation and wires as well. The principal difficulty comes from the small amount of space available. In most aircraft, an electrical connector is used so that the rudder may be removed. As you can see from Drawing No. 402, Section B-B, there is not enough room for such a connector. Even if a connector were installed, an additional connector would be required on the aft face of the rudder spar to provide for the removal of the tail light. These new drawings show what we feel is the best solution to this problem. Since there is no room for a connector, we do not use one! Instead, the wires for the tail light are extended into a long "pigtail" and are connected at a terminal block on the forward face of the forward fin spar. The wires are pushed through a plastic tube which serves as a conduit.

The forward fin spar has been changed to include a triangular block of spruce to allow for the installation of the terminal block just mentioned. The opening at the bottom has been changed slightly (the *30R* dimensions) to provide clearance for the rudder cable. To allow for drilling through solid wood, the spruce block in the main fin spar has been extended down slightly. Also, the top of the slot in the main fin spar has been raised slightly to provide clearance for the elevator control arm.

The construction of the rudder has been changed slightly to simplify the installation of the upper channel-nut for P/N 751. The previously-shown construction was difficult, requiring that the doublers on the aft face of the spar be notched and boxed around the channel-nut. In these drawings, the diagonal rib is installed above the channel-nut.

A jacking/tie down installation is now shown. A number of alternative installations were studied, but all proved to be very difficult to install. This installation is similar to the installation for the wing. Since the center of gravity of the Falco is forward of the wing jack points, the tail must be held down during jacking, so an eyebolt is put in the fitting in the tail and used to keep the tail down during the jacking process.

The COM antenna is now shown in the drawings installed in the fin, and the Loran antenna coupler is shown installed on the forward fin spar.

All in all, we feel that the new tail group drawings are a big improvement and are about as good as drawings can be. We hope you agree.

Hinge Installation Notes

When you install the hinges in the tail group, you may think that some of the bolts are too long. In the Falco, we use MS21042 nuts. These nuts are shorter than the nylon stop nuts used on most production aircraft. The nuts that we use are lighter, and—while the difference is small—the way to keep weight down is to save on the ounces. Because the nuts are shorter, more threads are exposed than with nylon stop nuts. This is a normal installation for this type of nut.

Some of the hinge bolts (those that go through the bronze bushings) are a little too long. The bolts should have a washer installed under the bolt head and under the nut. Extra washers may be used if needed.

The hinges are installed with channel-nuts. These are strips of steel formed over the heads of bolts. They retain the bolts and allow the bolts to be permanently installed in the airplane. The advantage of these things is that you do not have to have an access panel. The channel-nuts are provided with a 1/8"Ø hole. This hole is provided for use on metal control surfaces, where a 1/8" rivet is used. For the wood control surfaces you will be using a No. 6x1/2" sheet metal screw. This screw is too large for the 1/8" hole, so you will need to ream the hole with a drill bit. It is not essential that the hole be a tight fit over the screw. (One builder did not understand this and went to the trouble to cut threads in the channel-nut. This is not necessary.)

By the way, the plans call out the screws as No. 6x1/2" TRA screws. For these sheet metal screws there is no AN, NAS or MS part number. The proper description of the screws is "Truss, recessed head, self-tapping sheet metal screw, type A". The "truss" means that it has a rounded head. The "recessed head" means that it uses a Phillips screwdriver. The "type A" means that the screw has a sharp point. We abbreviate this as "TRA". For flat head screws, we use the abbreviation of "FRA".

When you install sheet metal screws in the wood, drill a small pilot hole to keep the screw from splitting the wood.

Preparatory Work

Each of the steps listed has a box for you to check as you do the step.

Main Fin Spar

- ❏ Review Drawing No. 412. If your spar has been made to the older drawings, you should add a spruce block so that the 3/8"Ø hole for the tail light wiring conduit will be drilled through solid wood.

- ❏ If your spar has been made to the older drawings, you should add a block of spruce at Sta. 1 to allow for the raised top of the slot. Confused? See Drawing No. 402, Section B-B, for what happens to the slot when the aircraft is finally assembled.

- ❏ Varnish all interior surfaces in preparation for closing the spar.

  Note: We'll be telling you to 'varnish all interior surfaces' often. All we mean by this is to varnish any part of the spar or the plywood that you're going to glue in place that will be covered up once the plywood is glued on.

- ❏ Glue plywood on forward face of the spar and add plywood pad on the forward face at Sta. 4. Scuff-sand the plywood prior to gluing.

- ❏ Draw centerline on forward and aft face.

- ❏ Draw W.L. 0 on forward and aft face.

- ❏ Draw W.L. +70 on forward face and on the sides of the spar. This is to align the main horizontal stabilizer spar.

- ❏ Draw fuselage "elliptical" curve on forward face of the spar. See Drawing No. 410, Section C-C. This curve will position the gluing strip, P/N 410-12. The fuselage skin is continuous all the way back to the aft fin spar. The fin and stabilizer spars will pass through this skin. To support the skin while gluing, gluing strips will be glued to the various spars.

- ❏ Draw the cutouts for the bottom and side longerons. Do not cut out the longeron cutouts at this time. The side longeron cutouts will be slightly shorter due to the main stabilizer spar.

- ❏ Drill the 3/8"Ø hole just below W.L. O. This is for the conduit for the tail light.

- ❏ Any preliminary work for the installation of a Loran antenna coupler may be done at this time. See Chapter 14 for Loran antenna installation details.

- ❏ If necessary, trim the end of the spar as shown for P/N 415-1.

Forward Fin Spar

- ❑ Review Drawing No. 412. If your spar has been made to the older drawings, you should add the 25x25x13 spruce triangle to the right side.
- ❑ If your spar has been made to the older drawings, you should change the radius of the plywood to the 30R shown to provide room for the rudder control cables.
- ❑ If your spar has been made to the older drawings, install the spruce on each side of the top center longeron. This is to provide a gluing surface for the plywood covering, which becomes a gluing surface for the gluing strips (see Drawing No. 410, Section A-A and B-B).
- ❑ Varnish all interior surfaces in preparation for closing the spar.
- ❑ Close the spar by gluing on the plywood skin to the forward face. Scuff-sand the plywood prior to gluing.
- ❑ Draw centerline on forward and aft face of the spar.
- ❑ Draw W.L. 0 on the forward and aft face of the spar.
- ❑ Draw W.L. +70 on aft face and on the sides of the spar. This is to align the forward horizontal stabilizer spar.
- ❑ Draw the cutouts for the bottom and side longerons. Cut out the longeron cutouts.
- ❑ Check fit of top center longeron through spar.
- ❑ Install tapered pads for P/N 724. See Drawing No. 410, Section E-E. Scuff-sand the plywood prior to gluing.
- ❑ Install P/N 724 bracket, if available.

Rudder Spar

- ❑ Review Drawing No. 412. If your spar has been made to the older drawings, you will note that the spruce block at Sta. 4 is now 90mm long. This is because the Sta. 4-1/2 rib is now installed higher to provide room for the hinge bolt. If the spruce is not installed to the full 90mm, don't worry about it. This dimension is more for convenience than for strength.
- ❑ Varnish all interior surfaces in preparation for closing the spar.
- ❑ Close the spar by gluing on the plywood on the aft face at the lower end and at Sta. 4. Note that there are two pieces of plywood at Sta. 4. Scuff-sand the plywood prior to gluing.
- ❑ Draw centerline on forward and aft face of the spar.
- ❑ Draw Sta. 0 on the forward and aft face of the spar.

❏ Drill the 1/4"Ø hole for the tail light wires.

❏ If necessary, trim the end of the spar as shown for P/N 415-2.

Main Stabilizer Spar

❏ Review Drawing No. 406. If your spar has been made to the older drawings, you should add an extra block of spruce at Sta. 1 on the right side. This is so that you can epoxy the trim tab tube in place.

❏ Glue plywood on forward face of the spar at the center. Note that the plywood extends out to B.L. 90. The reason for this is that the Sta. 0 ribs will be glued to the forward face of the spar, and it seems to be neater to glue to a plywood surface. Scuff-sand the plywood prior to gluing.

❏ Glue plywood pads on the forward and aft face at Sta. 5. The plywood pad on the aft face is to create a "level" surface for the hinges. Because thinner plywood is used on the outboard ends of the spar, the hinges will be moved forward slightly. Probably this is academic, but since you will need to increase the thickness of the spar to match the grip length of the bolts, it seems to be a good idea. Scuff-sand the plywood prior to gluing.

❏ Draw spar centerline on forward and aft face of the spar.

❏ Draw aircraft centerline on forward and aft face of the spar.

❏ Drill the .62"Ø hole at Sta. 1 on the right side.

❏ The trim tab tube is flared at the aft end (so that it will not cut and chafe the trim table control cable) so you may now sand a "countersink" to match the tube.

❏ Epoxy the small piece of aluminum or stainless steel on the bottom of the spar at the centerline (this is the elevator stop, see Drawing No. 402, Section B-B). Any epoxy may be used, but if you can get it, 3M 2216B/A epoxy is one of the best glues for bonding metal to wood. You can get it in 2 oz. kits from your local 3M distributor—there's one in every major city.

❏ If necessary, trim the end of the spar as shown for P/N 403-1.

Forward Stabilizer Spar

❏ See Drawing No. 406. Draw spar centerline on forward and aft face of the spar.

❏ Draw aircraft centerline on forward and aft face of the spar.

❏ Install plywood disk at aircraft centerline and drill 3/8"Ø hole for the elevator control cable. Scuff-sand the plywood prior to gluing.

❏ Drill the .62"Ø hole at Sta. 1 on the right side only. This is for the trim tab cable tube.

Elevator Spar

- ❑ See Drawing No. 406. Install plywood pads on forward and aft face of the spar as shown. At the center of the aircraft, the 2mm plywood extends to B.L. 100. This is because ribs will be glued to the aft face of the spar and extending the plywood to this point will make for a neater installation. Scuff-sand the plywood prior to gluing.
- ❑ Draw spar centerline on forward and aft face of the spar.
- ❑ Draw aircraft centerline on forward and aft face of the spar.
- ❑ Drill the .62"Ø hole on the right side for the trim tab control cable. This hole will be opened slightly later on to accommodate the movement of the elevator (see Drawing No. 402, Section C-C).
- ❑ Drill the 1/8"Ø vent holes as shown.
- ❑ If necessary, trim the end of the spar as shown for P/N 403-2.

All Ribs

- ❑ Draw centerlines on all tail group ribs.
- ❑ Drill vent holes and antenna coaxial cable holes as shown.

Note: You may note that the rib drawings show the leading edge strip at some rather odd dimensions considering that the part is actually 15mm thick. Because the leading edge strip is installed at an angle, there is a change in the true fore-and-aft dimension. Also, the gap in the ribs at the fin Sta. 1 and stabilizer Sta. 0 does not match the thickness of the forward spars. These ribs are installed at an angle to the spars, and the extra material on the ribs allows for sanding to match the spars.

- ❑ Cut out all elevator and rudder leading edge ribs for the leading edge strip.

Note: To assure a snug fit, the slots should be cut slightly undersized and then sanded for the final fit. The normal practice is to glue the leading edge ribs to the spar, then sand the slots for the leading edge strip. This is done with a sanding stick.

An alternative that you might want to consider is to clamp all of the leading edge ribs for the elevator together with the centerlines of the ribs aligned, then sand out the 8x8 slot for all of the ribs at one time, then repeat the process for the rudder leading edge strips. While you have the ribs clamped together, you may be tempted to sand the contours of the ribs, but this should not be done since the ribs will not match the angle of the skin.

- ❑ If not already done, cut off all trailing edge ribs for the trailing edge strip.
- ❑ If not already done, install 20x10 spruce block on R.H. elevator rib Sta. 1. See Drawing No. 403. Scuff-sand the plywood prior to gluing.

- ❏ Install the 20x18 spruce block on the R.H. Sta. 1 elevator rib. See Drawing No. 402, Section C-C and G-G. Note that the plywood face of this rib is outboard. Scuff-sand the plywood prior to gluing.

- ❏ Install P/N 117-11 clamp on this rib, along with the channel-nut. You should check the installation of P/N 117-10 control cable.

- ❏ Prime the channel-nut for the elevator trim tab cable or paint with epoxy.

- ❏ If not already done, make trim tab ribs. See Drawing No. 403.

- ❏ If not already done, make elevator & stabilizer tip bow. See Drawing No. 403. These two parts may be made as one lamination of spruce and cut apart prior to installation. If you don't want to make a lamination, these parts may be made of solid spruce.

- ❏ If not already done, make fin and rudder tip bow. See Drawing No. 415. These two parts may be made as one lamination of spruce and cut apart prior to installation. If you don't want to make a lamination, these parts may be made of solid spruce.

- ❏ Cut openings in R.H. stabilizer ribs at Sta. 0 & 1 for the elevator trim tab cable tube. See Drawing No. 403.

The Skins

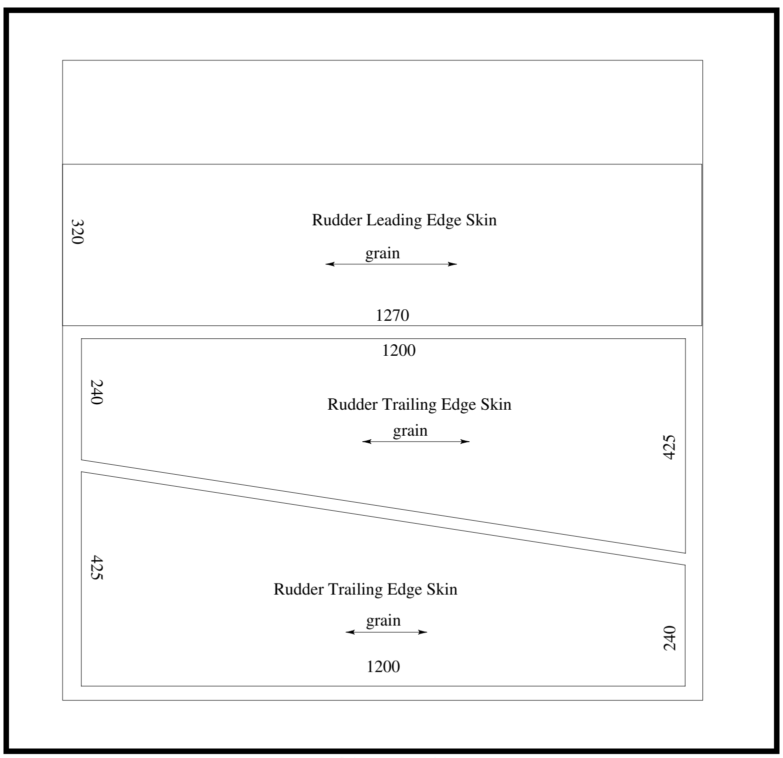


Figure 2

- ❏ Use one 50"x50"sheet of 1.2mm birch plywood and cut in accordance with Figure 2.

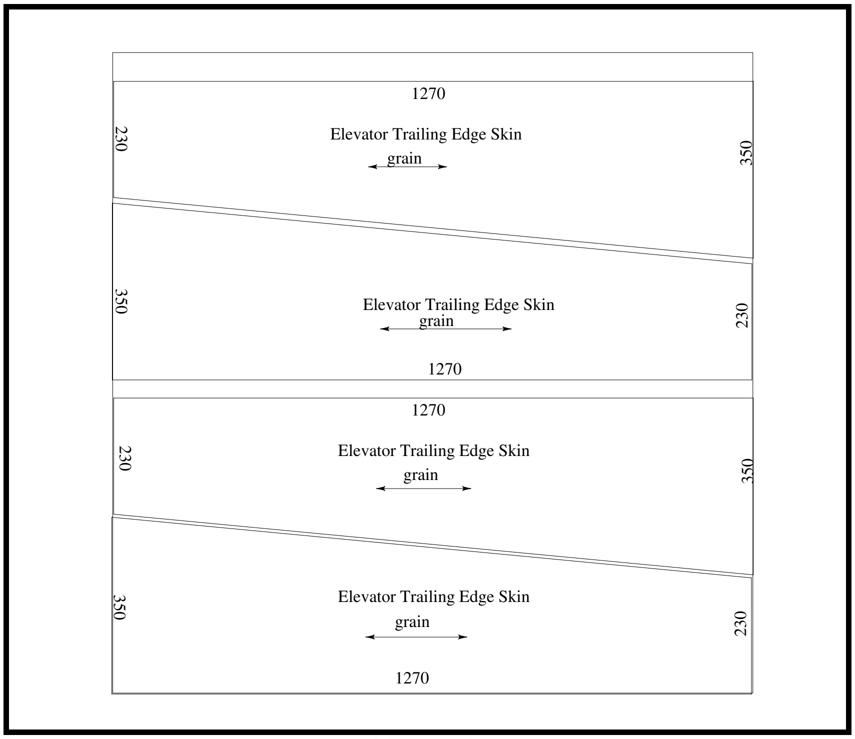


Figure 3

❏ Use one 50"x50"sheet of 1.2mm birch plywood and cut in accordance with Figure 3.

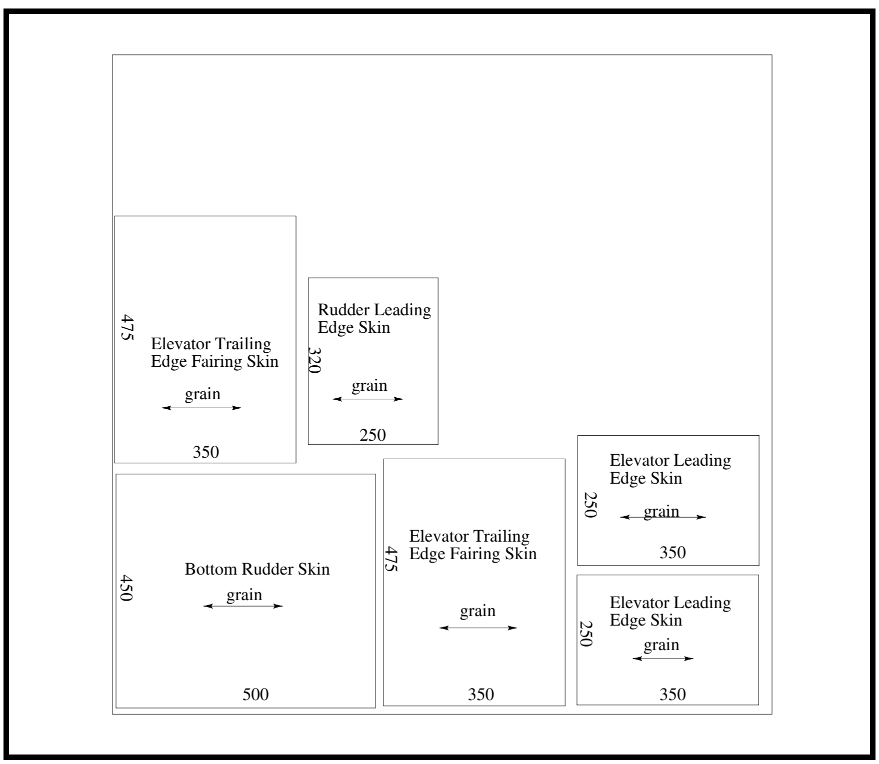


Figure 4

❏ Use one 50"x50"sheet of 1.2mm birch plywood and cut in accordance with Figure 4.

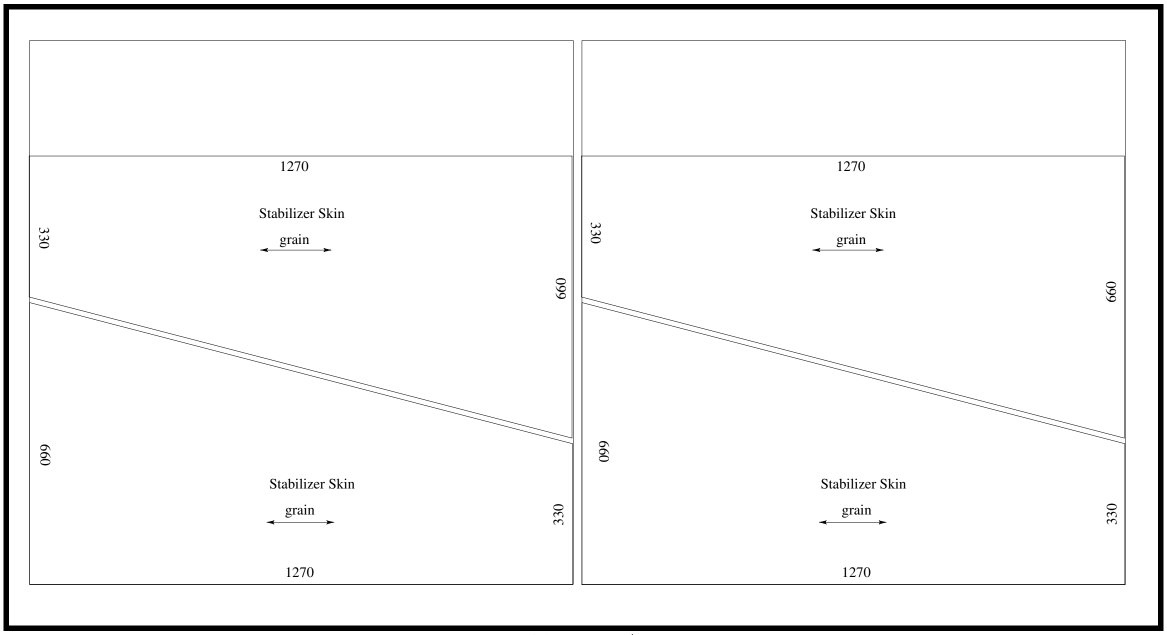


Figure 5

❏ Use two 50”x50”sheets of 1.5mm birch plywood and cut in accordance with Figure 5.

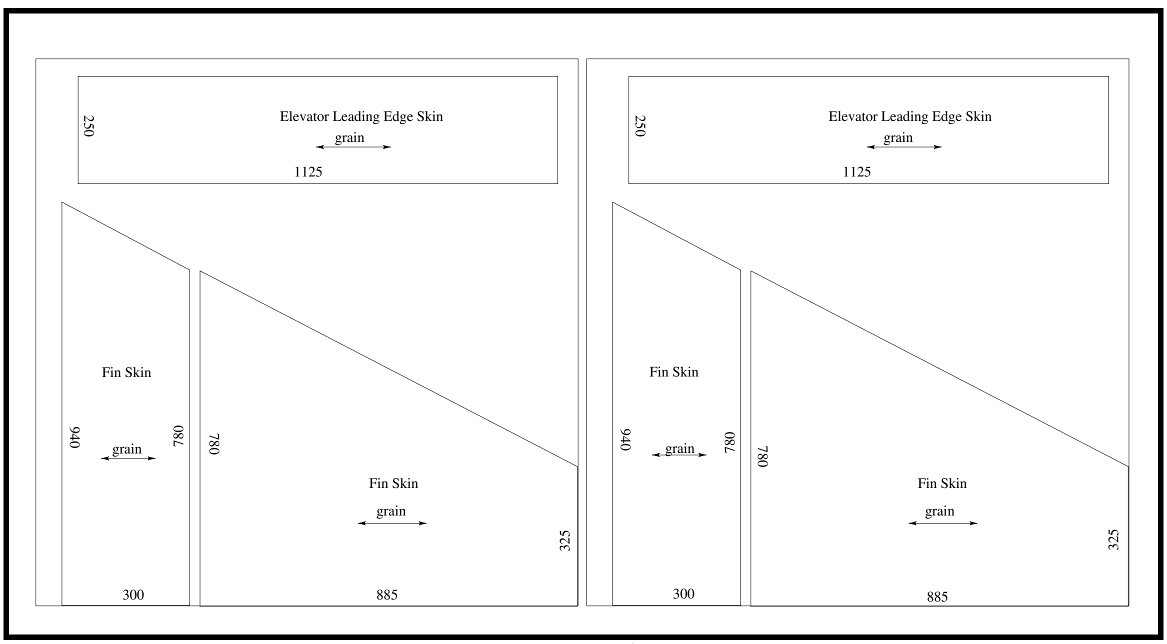


Figure 6

❏ Use two 50”x50”sheets of 1.5mm birch plywood and cut in accordance with Figure 6.

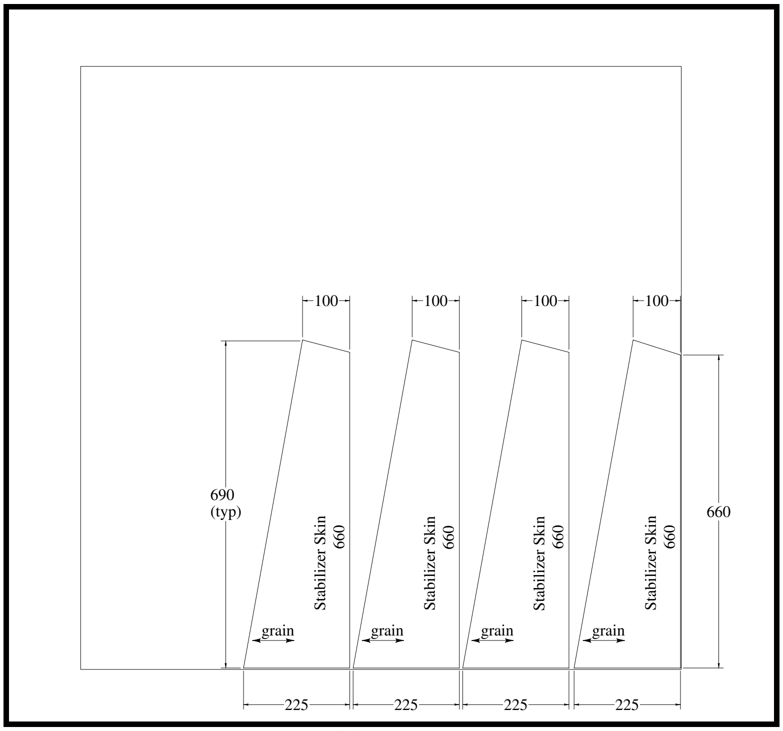


Figure 7

❏ Use one 50”x50”sheet of 1.5mm birch plywood and cut in accordance with Figure 7.

Figure 8

❏ Cut one piece of 2mm plywood for the elevator center trailing edge skin. See Figure 8.

Chapter 17
Tail Group Hinge Installation

Elevator Hinge Installation

For the control hinge installation, you will have to ream the bronze bushings with a 1/4"Ø reamer. Do this on a drill press. You can use a 1/4"Ø drill bit, but a reamer does a much nicer job.

You should also be aware that the aluminum hinge angles may not be made exactly at 90°. The tolerance for aluminum extrusions is ±1.5°. Most of the hinges are at the correct angle, but you may find one or two which are not. These may be sanded to the correct angle with a stationary belt sander, or you may taper a plywood pad to fit. We were told by one builder that P/N 755 is slightly off from 90°.

❏ Ream all 1/4"Ø hinge bolt holes with 1/4" reamer. This is only for the bronze bushings. Do not ream the 3/16"Ø holes in the hinge base.

❏ Clamp all elevator hinges to the elevator spar. See Drawings No. 402 and 401.

❏ Assemble all stabilizer hinges with the elevator hinges by installing the 1/4"Ø hinge bolts.

❏ Clamp the main fin spar to the main stabilizer spar. Be very careful to locate the main stabilizer spar at W.L. +70.

Note: You must be very careful to make sure that the stabilizer spar is perpendicular to the fin spar. This can be done with a square, but it is much better to check the alignment in other ways. If the fin spar is held in a vertical position, a plumb bob may be used on it while a water level is used on the stabilizer spar. Another method is to "trammel" the two spars. Under this method, a tape measure is used to check the distance from the tip of the fin spar with the tips of the stabilizer spar. It is not essential that the tips be used, as you can also use one of the stations. If the distance is the same for both sides, the fin is perpendicular to the stabilizer spar.

Be sure that the main stabilizer spar is installed with the hole for the trim tab control cable on the right side of the aircraft and with the stainless steel (or aluminum) elevator stop on the bottom.

❏ Mark the upper edge of the side longeron cutouts on the main fin spar.

❏ Trace the outline of the main fin spar on the aft face of the stabilizer spar, and trace the outline of the stabilizer spar on the forward face of the main fin spar. This will help remind you not to varnish these gluing surfaces.

❏ Clamp the stabilizer hinges to the main stabilizer spar. See Figure 1. Make sure the hinges are correctly aligned and that the hinges work smoothly. You must be able to move the elevator spar smoothly on the hinges without binding.

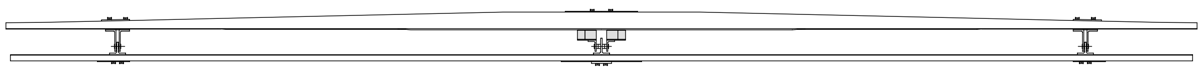


Figure 1

❑ When you have the hinges in the correct position, remove the 1/4”Ø hinge bolts and carefully drill the 3/16”Ø holes for P/N 750. Use a drill press for all hinge bolt holes through the spars.

❑ Install the channel-nuts for P/N 750. To keep from moving anything at this critical stage, the screws for the channel-nuts should not be installed at this time.

❑ Re-assemble the hinges with the hinge bolts. Check the alignment of all of the hinges.

❑ Remove the 1/4” hinge bolts and carefully drill the 3/16”Ø holes for P/N 756 on the right side.

❑ Install the channel-nuts for P/N 756. To keep from moving anything at this critical stage, the screws for the channel-nuts should not be installed at this time.

❑ Re-assemble the hinges with the hinge bolts. Check the alignment of all of the hinges.

❑ Remove the 1/4” hinge bolts and carefully drill the 3/16”Ø holes for P/N 756 on the left side.

❑ Install the channel-nuts for P/N 756. To keep from moving anything at this critical stage, the screws for the channel-nuts should not be installed at this time.

❑ Re-assemble the hinges with the hinge bolts. Check the alignment of all of the hinges.

❑ Remove the 1/4” hinge bolts and carefully drill the 3/16”Ø holes for the two P/N 752 hinges at the center of the aircraft. Note that these bolt holes go through the fin spar *and* the stabilizer spar. Before drilling these holes, you should double-check to insure that the fin and stabilizer spars are correctly aligned.

❑ Install the channel-nuts for P/N 752. To keep from moving anything at this critical stage, the screws for the channel-nuts should not be installed at this time.

❑ Re-assemble the hinges with the hinge bolts. Check the alignment of all of the hinges.

❑ Remove the 1/4” hinge bolts and carefully drill the 3/16”Ø holes for the two P/N 755 hinges on the right side.

❑ Install the channel-nuts for P/N 755. To keep from moving anything at this critical stage, the screws for the channel-nuts should not be installed at this time.

❑ Re-assemble the hinges with the hinge bolts. Check the alignment of all of the hinges.

- ❑ Remove the 1/4” hinge bolts and carefully drill the 3/16”Ø holes for the two P/N 755 hinges on the left side.

- ❑ Install the channel-nuts for P/N 755. To keep from moving anything at this critical stage, the screws for the channel-nuts should not be installed at this time.

Rudder Hinge Installation

- ❑ Ream all 1/4”Ø hinge bolt holes with 1/4” reamer. This is for the bronze bushings only. Do not ream the 3/16”Ø holes in the hinge base.

- ❑ Install P/N 857-9 rudder stop between P/N 754 and 774. See Drawing No. 411, Section D-D. To assure alignment of the hinges, temporarily install P/N 751 with the 1/4” hinge bolt.

- ❑ Clamp P/N 751 to the rudder spar. See Drawings No. 411 and 410.

- ❑ Clamp P/N 753 to the main fin spar.

- ❑ Assemble P/N 754 and P/N 774 with P/N 751 by installing the 1/4” hinge bolt. The rudder stop should be in place at this time.

- ❑ Assemble P/N 757 hinges to P/N 753 by installing the 1/4” hinge bolt.

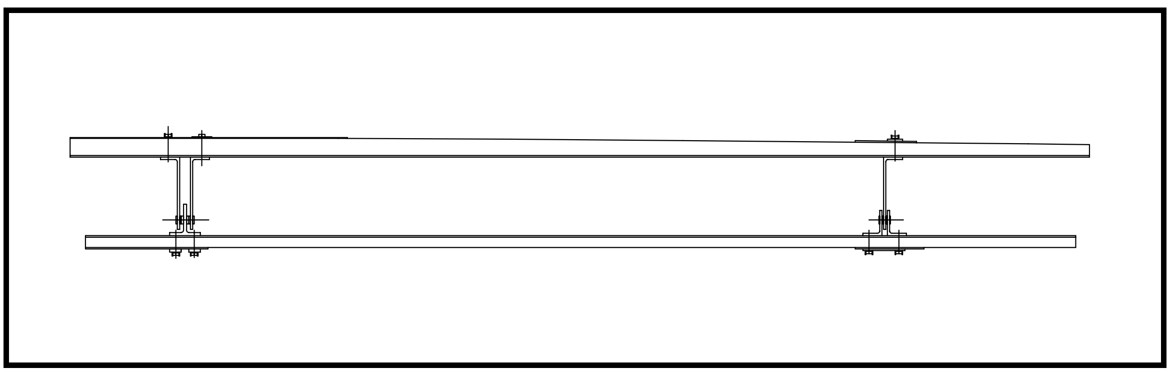


Figure 2

- ❑ Clamp these hinges to the fin and rudder spar. See Figure 2. Check for the correct location of the lower hinge assembly. Check that the lower P/N 757 on the rudder will clear the nose rib. If necessary, move the hinges up.

- ❑ Make sure the hinges work smoothly. You must be able to move the rudder spar smoothly on the hinges without binding.

- ❑ When you have the hinges in the correct position, remove the 1/4” hinge bolts and carefully drill the 3/16”Ø holes for P/N 751.

- ❑ Install the channel-nuts for P/N 751. As you can see from Drawing No. 411, two pieces of 4mm birch plywood will be installed under the channel-nuts. These can be made by gluing two pieces of 2mm birch plywood together. Since it is desirable that these pads be installed after the Sta. 0 trailing edge rib, you may use extra washers on the bolts or place a temporary shim under the channel-nut. The screws for the channel-nuts should not be installed at this time.

❏ Re-assemble the hinges with the hinge bolts. Check the alignment of all of the hinges.

❏ When you have the hinges in the correct position, remove the 1/4" hinge bolts and carefully drill the 3/16"Ø holes for P/N 753.

❏ Install the channel-nuts for P/N 753. To keep from moving anything at this critical stage, the screws for the channel-nuts should not be installed at this time.

❏ Re-assemble the hinges with the hinge bolts. Check the alignment of all of the hinges.

❏ When you have the hinges in the correct position, remove the 1/4" hinge bolts and carefully drill the 3/16"Ø holes for P/N 754 and P/N 774.

❏ Install the bolts and nuts for P/N 774 (a channel-nut is not used since it would interfere with the elevator balance weight and arm assembly). Install the channel-nuts for P/N 754. To keep from moving anything at this critical stage, the screw for the channel-nut should not be installed at this time.

❏ Re-assemble the hinges with the hinge bolts. Check the alignment of all of the hinges.

❏ When you have the hinges in the correct position, remove the 1/4" hinge bolts and carefully drill the 3/16"Ø holes for P/N 757 hinges.

❏ Install the channel-nuts for P/N 757. To keep from moving anything at this critical stage, the screws for the channel-nuts should not be installed at this time.

❏ Re-assemble the hinges with the hinge bolts. Check the alignment of all of the hinges.

❏ At this time the main fin spar and main stabilizer spar may be joined again. Check to make sure that all of the hinges work well. If you have made a mistake, you may plug the holes in the spars with wood dowels and re-drill the holes.

❏ The screws for the channel-nuts may be installed at this time. The screws for the channel-nuts for P/N 751 should not be installed at this time. Pilot drill the wood with a 3/32"Ø drill. Ream the 1/8"Ø holes in the channel-nuts with a 9/64"Ø or No. 27 (.1440"Ø) drill.

❏ Prime the channel-nuts with zinc chromate primer to prevent corrosion, or paint with epoxy.

Elevator Balance Weight Installation

See Drawing No. 402, Section B-B for the elevator balance weight assembly. Note that the elevator travel is 22° up and 16° down.

When the elevator is in the full-up position, the elevator balance weight arms will hit the bottom of the slot in the main stabilizer spar. If the upper elevator stop, P/N 857-8, is not installed, a stainless steel plate should be glued to the bottom of the slot with epoxy. As an alternative, you may use any hard thin material such as aluminum or Lexan.

You should understand that the elevator balance weight cannot be installed from the aft end of the airplane through the spar—it simply will not fit (you may be able to get the weight only through, but once the arms are riveted in position, it will not go). Since it must be installed from the forward end, it must be bolted to the elevator control arm. Spacers are required, and these are riveted to the arms so they they will not fall out during installation and removal.

To install the balance weight and arm assembly on the elevator, you will have to reach into the inside of the tail section of the fuselage through the access door. A number of builders have installed an extra access door for this purpose, but it is really not necessary. If the access door is increased to 165mm in length, you can easily reach into the tail section and install the balance weight assembly.

> *Note:* A few builders have attempted to omit the spacers, to their eternal regret. Don't do it! When the elevator is in the full up position, the lower elevator control cable must pass between the two balance weight support arms.
>
> As an alternative, the spacers may be riveted (or bonded with epoxy) to P/N 750. If riveted, you will need a longer rivet. Countersink at both ends of the rivet hole, then set the rivet and shave the "shop head" flush.

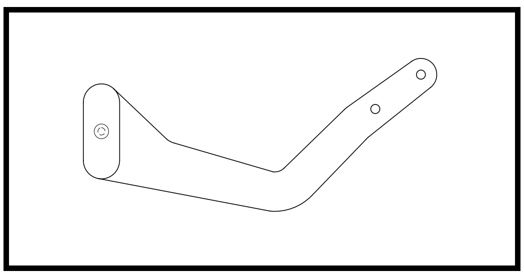


Figure 3

❏ Install the spacers on the elevator balance weight arms. See Figure 3. You will need to sand the aluminum to the finished profile—a vertical belt or disc sander is best for this. Drill the rivet hole with a 1/8"Ø drill. Ream the hole up with a No. 30 drill (.128"Ø). Countersink (100°) the spacer on the inboard face and install the rivet. It would be a good idea to paint the spacer with zinc chromate primer, and we prefer to install such parts with wet primer between the parts while riveting to exclude moisture. As an alternative, you could epoxy the spacers to the arms.

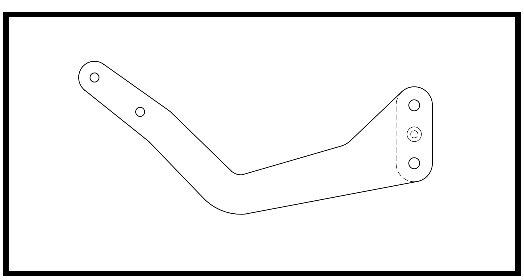


Figure 4

❏ Drill the spacers with a 5/32"Ø drill using the holes in the arms as a guide. Do this on a drill press to make sure that the holes are drilled straight. See Figure 4.

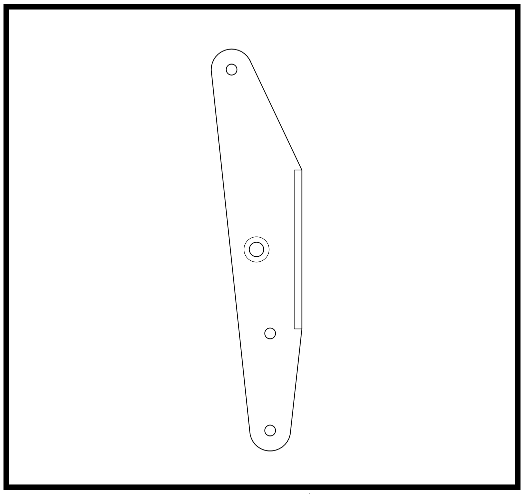


Figure 5

❏ Drill P/N 750 with a 5/32"Ø drill at 37mm below the hinge line. See Figure 5. Drill only one hole at this time. Insure that this hole is 14mm from the base of the hinge (see Drawing No. 750). The holes for the attachment of the arm should be parallel to the base of the hinge and in line with the lower control cable hole.

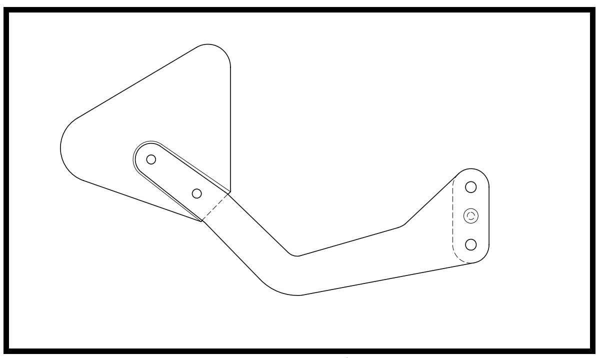


Figure 6

❏ Place one P/N 825A arm on the elevator balance weight and drill the two 5/32"Ø holes through the balance weight. See Figure 6.

Note: In the following steps, you will be installing the balance weight arms on the balance weight. A few builders have reported that they found this operation difficult since the lead weight is so soft. For this reason, you might want to install the weight with AN525-832R16 screws and MS21042-08 nuts. If so, the holes for the screws should be reamed with a No. 19 drill (.166"Ø).

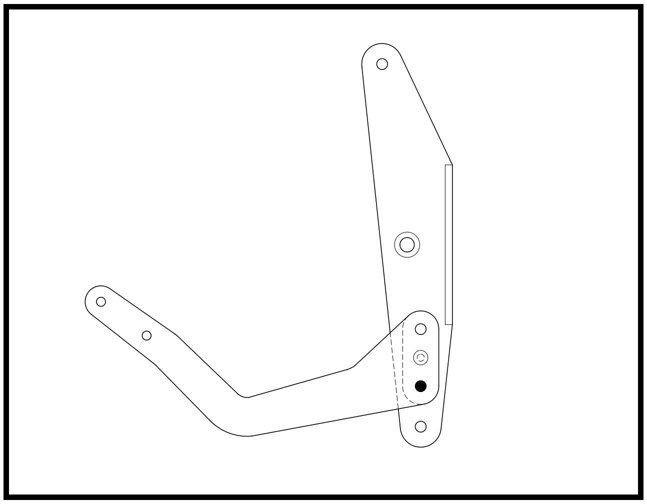


Figure 7

- ❏ Install both balance weight arms (with spacers) on P/N 750. See Figure 7. Use a 5/32"Ø drill bit to align the one hole already drilled. You may also use a No. 8 machine screw or one of the MS20470AD5-16 rivets. If a rivet is used, you will have to ream up the hole with a No. 21 drill (.159"Ø). Use a clamp to hold these control arms in place.

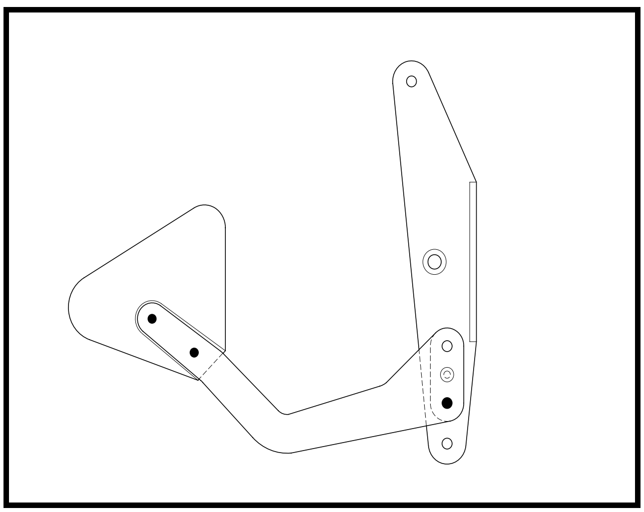


Figure 8

- ❏ Clamp the balance weight in place. See Figure 8. Use a 5/32"Ø drill bit to align the rivet holes. Make sure that the two arms are aligned with each other. Ream up the rivet holes through the balance weight and arms with a No. 21 drill (.159"Ø). After you have reamed one of the holes, place a rivet in the hole before drilling the other hole.

- ❏ You may need to bend the arms slightly to allow for the slight difference in thickness at each end.

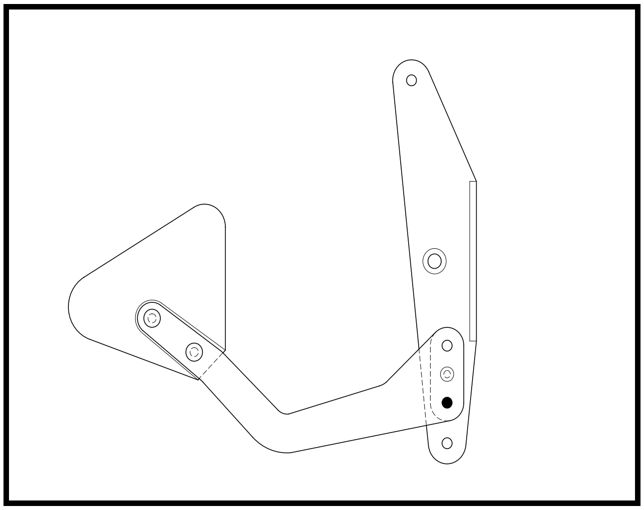


Figure 9

- ❏ Rivet the balance weight in place. See Figure 9. To prevent any corrosion, you should bed the arms down in wet zinc chromate primer or bond with epoxy.

Note: In the next few steps you will install the balance weight and arms to P/N 750. The alignment is very important. The assembly should be compared to Drawing No. 402, Section B-B (which is to scale) and also fitted to the aircraft to check. The arms should be adjusted as needed so that they fit under the bottom of the stabilizer spar with the elevator in the full down position. This 16° deflection can be checked with a combination square. Since only one hole is presently drilled in P/N 750, there is still some adjustment that can be made. The holes should be reamed up to 3/16"Ø. Some slight adjustment can be made prior to each reaming operation. We would prefer to see the upper hole finished, and the bolt installed. This bolt can be tightened to hold the arm in place. When this is done, the bottom hole can be drilled through with a 5/32"Ø drill. Check this alignment and ream up in small increments to the final 3/16"Ø.

Reaming holes in metal is usually done in increments of 1/32" in diameter. Ordinary twist drills should be used for all of the reaming, but a reamer should be used for the final hole. It is normal to have the hole 1/32" undersized before the final reaming operation.

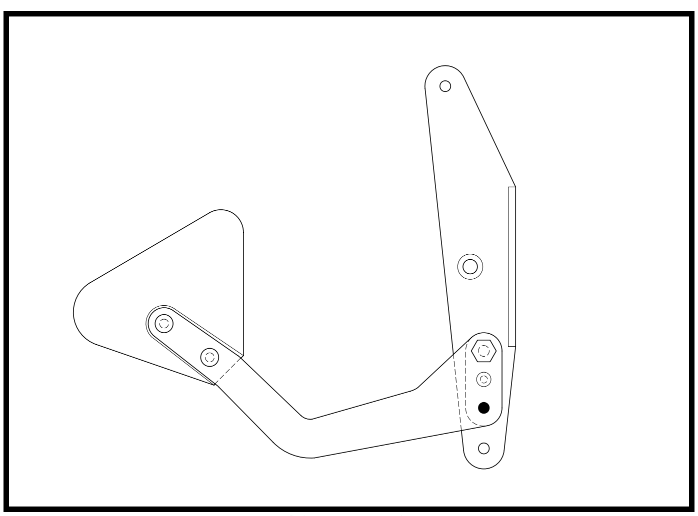


Figure 10

❏ As stated above, ream the upper 3/16”Ø bolt hole through P/N 750 and install the bolt. See Figure 10.

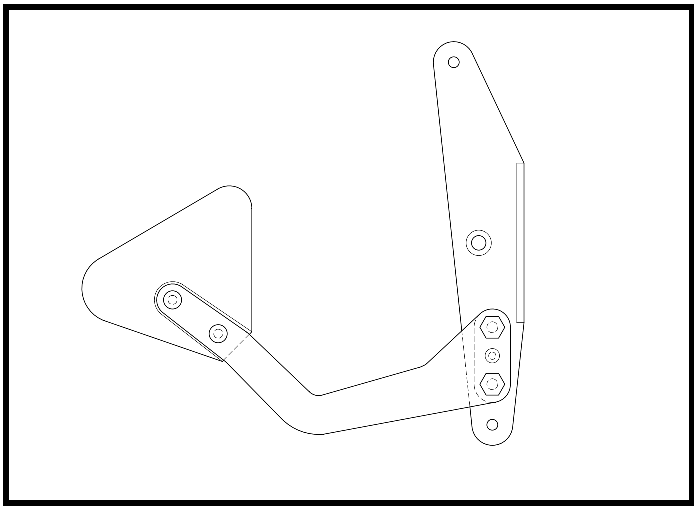


Figure 11

❏ As stated above, drill the lower hole through P/N 750 with a 5/32”Ø drill, ream up to 3/16”Ø and install the bolt. See Figure 11.

As you can see from Drawing No. 402, Section B-B, the bottom of the slot of the fin spar must be sanded for clearance with the elevator balance weight arms. At the top of the slot, the upper center fuselage longeron must also be sanded to provide clearance with P/N 750. You may have to carve small recesses into the aft face of the main fin spar to provide clearance for the bolts fastening the elevator balance weight arms to P/N 750. You should also be aware that one or two metal plates, and P/N 857-8 are installed as elevator stops. See Drawing No. 857 for alternative construction of P/N 857-8.

Chapter 18
Elevator Assembly

❏ If not already done, cut the elevator leading edge ribs for the 8x8 leading edge strip.

Note: In the following steps, the leading edge ribs and the leading edge strip will be installed on the elevator. The leading edge strip may be fitted to the ribs before gluing on the ribs. Some builders prefer to glue the leading edge strip to the ribs first and then glue the entire assembly to the elevator spar.

❏ Install all leading edge ribs. Scuff sand the plywood prior to gluing. See Figure 1.

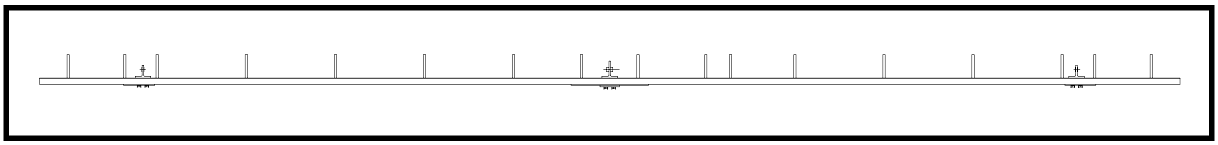


Figure 1

❏ Install the leading edge strip. See Figure 2. We recommend that the leading edge strip be continuous from B.L. 70 to the tip for extra strength during the skinning process. This will be cut out for the trim tab cable and hinge openings after the elevator is skinned.

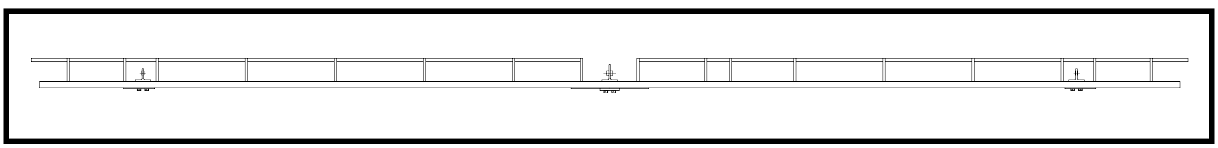


Figure 2

In the following steps, the trailing edge ribs will be installed on the spar. It will be important that you maintain the alignment of the trailing edge. You will find that once things are glued in place, there is relatively little opportunity to make an adjustment, so it is best to get things aligned correctly from the beginning. This is complicated by the fact that the trailing edge strip is a constantly-tapering triangular strip of spruce.

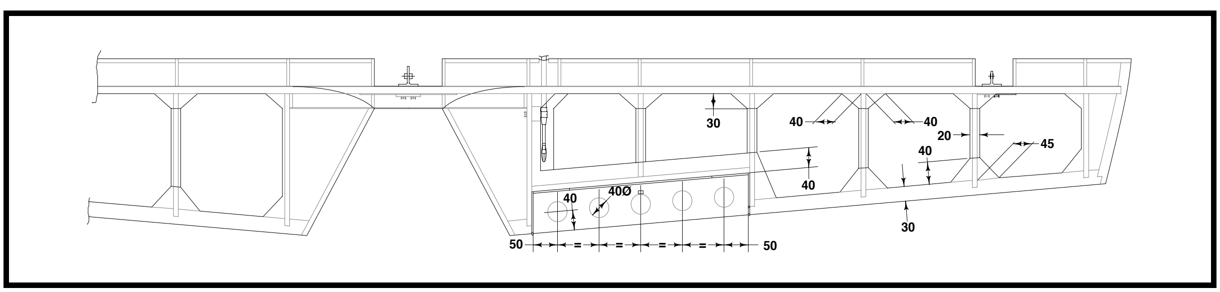


Figure 3

The original drawings showed the trim tab of solid spruce construction. The present drawings show the trim tab of spar and rib construction for lighter weight. Also, we believe that the new method of construction is simpler. If you wish to construct the trim tab of solid spruce, see Figure 3 and use the contours of P/N 403-3 and P/N 403-6. Because this solid spruce construction requires a break in the trailing edge, it is easier (although slightly wasteful) to make the trailing edge strip as a continuous strip of spruce on the right side of the aircraft and cut it out later. This makes the alignment of the trailing edge strip inboard of the trim tab much easier.

The ribs should be aligned with a string. The usual practice is to install the rib at Sta. 1 and Sta. 6, then loop a string across the trailing edge of these ribs to align the ribs in between. Boards may be clamped to the sides of the ribs to stabilize them. You may also use straightedges against the trailing edge of the ribs to determine if the right and left side are in alignment—the two straightedges must meet in the center.

If you plan to skin the elevator in plywood, the trailing edge strip is 15mm wide. If you plan to use the fabric covered elevator, the trailing edge strip should be 30mm wide. In this method the ribs are joined to the trailing edge with a 15mm deep notch in the trailing edge. See Figure 3 for details regarding the construction of the fabric covered elevator.

On the right side of the aircraft, the trailing edge ribs at Sta. 1 and 3 should be installed with the plywood toward the trim tab.

❏ Draw the forward face of the elevator trim tab closing spar on the trailing edge ribs for Sta. 1 and 3 for the right side of the aircraft. As you can see from Drawing No. 403, the forward face of the closing spar is located 90mm forward of the trailing edge. The ribs at Sta. 1 and 3 should be installed with the plywood toward the trim tab.

> ⚠ **Caution** During the following steps, the elevator ribs will be very delicate and may be easily broken from the spar. Many builder have reported that curious visitors have done the dirty deed, and a few builders have done it themselves, particularly while sanding the ribs. To prevent such events, treat the assembly with great care, and brace the ribs with a thin board or scrap piece of paneling or plywood.
>
> If a rib breaks off, you may despair at how easily it broke and that little failure can be observed in the wood. First, the glue joints are intended to take shear loads, and they are quite strong in shear. When you knock a rib off, the lever action of the rib causes to glue joint to fail in tension. To make matters worse, the joint will be either a side grain or edge grain tension failure—two of the weakest modes of failure for wood. In all probability, you will find on close examination that a single layer of wood cells are still stuck to the glue, so what appears to be a glue failure is actually a failure of the wood. ⚠

❏ Install P/N 403-4 trailing edge ribs at Sta. 1. The plywood should be on the outboard face of these ribs. (If you wish, you may also glue P/N 404-7 ribs in place at the same time, per the following step.) See Figure 4.

❏ Install P/N 404-7 ribs. See Figure 4.

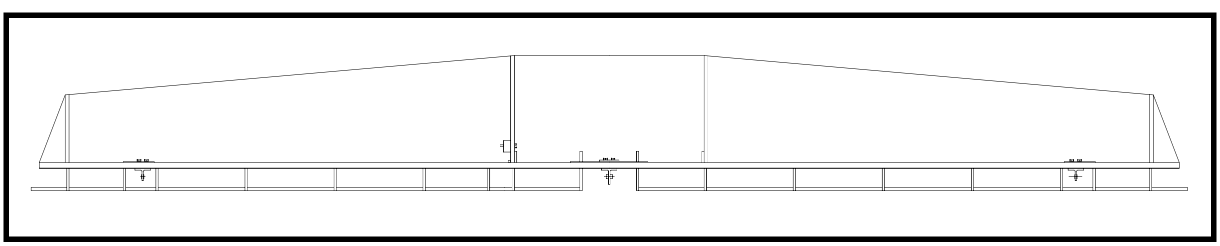


Figure 4

- ❏ Drill the 1/8”Ø vent hole through P/N 404-7 and P/N 403-4 ribs on the left side of the aircraft. We do not suggest drilling this hole on the right side due to the increased possibility of moisture entering around the elevator trim tab cable.

- ❏ Install P/N 404-4 ribs. Scuff sand the plywood prior to gluing.

- ❏ Install P/N 405-13 ribs at Sta. 6.

- ❏ Loop an alignment string along the trailing edge of the trailing edge ribs at Sta. 1 and Sta. 6. See Figure 4. You will need to clamp a brace against the ribs to steady them from the tension of the string.

- ❏ Using this string to align the ribs, fit all of the remaining trailing edge ribs in place, but do not glue at this time. See Figure 5.

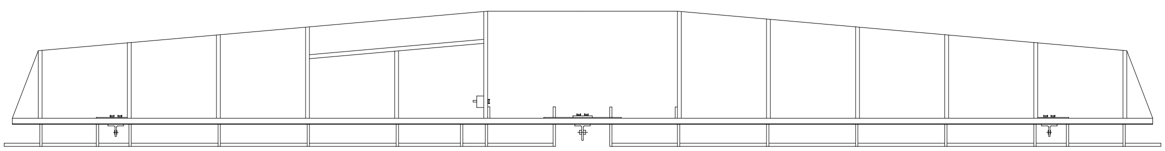


Figure 5

- ❏ Fit the trim tab closing spar, P/N 406-5, in place. This will require that you sand the aft end of P/N 403-9 rib. See Figure 5.

- ❏ Glue all of the remaining trailing edge ribs in place. The trim tab closing spar should be glued in place at the same time. Scuff sand the plywood prior to gluing. The ribs may be glued one at a time or all at once if the alignment is correct.

Note: In the following steps, the elevator trim tab spar and ribs will be installed, followed by the trailing edge strip. It would seem to be best to install the hinges and then install the ribs, trailing edge strip and finally the skin.

To keep the trim tab spar rigid during this construction, wedges of scrap wood should be cut to the required 22° angle and glued in place with Elmer’s carpenters glue. The trim tab hinges, P/N 857-6 (formerly P/N 113-2), must be compared to the wedges to assure that the wedges are properly sized.

(The trim tab hinge should be installed so that the upper surface of the hinge is in line with the contour of the ribs before the skin is installed. This is best shown on Drawing No. 403. See Drawing No. 402, Detail A, for the location of the screw holes. See Drawing No. 402, Section C-C, for the screws installation.)

If the hinges are installed at this point in the construction of the elevator, they will make it difficult to skin. In the method described here, you will skin the trim tab with the elevator with one piece of plywood. Since the wedges are glued in place, the skin and wedges must be sawn to separate the trim tab from the elevator. This appears to be impossible to do if the hinges are in place, and the glue could get into the hinges—not an appealing idea if you are using epoxy.

Some builders have built the trim tab completely separately. After the trailing edge strip and the 10x15 spruce pieces from the trailing edge strip to B.L. 70 are glued in place, the trailing edge for the trim tab is cut out of the elevator, and the trim tab is assembled separately. We prefer the method described here, but there is certainly no harm done in this alternate method—if it feels good, do it!

❏ Install the elevator trim tab spar, P/N 406-4, on the elevator trim tab closing spar, using 22° wedges of scrap wood as described above. See Figure 6.

❏ Install the three trim tab ribs. The outboard ribs may be clamped to the elevator ribs using a 3mm shim, or temporarily glued, to be separated later. See Figure 6.

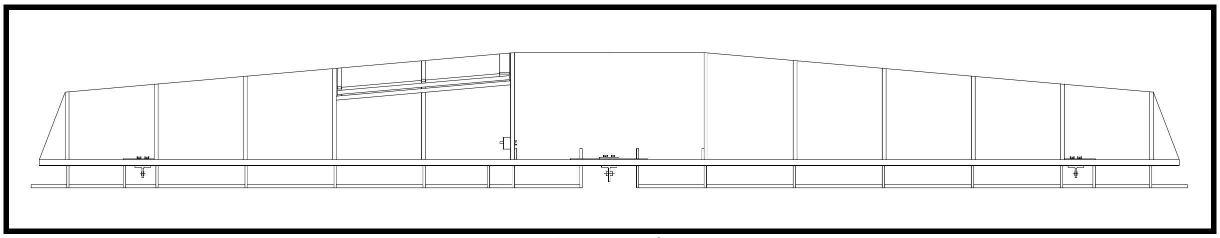


Figure 6

❏ Install the elevator trailing edge strip. See Figure 7.

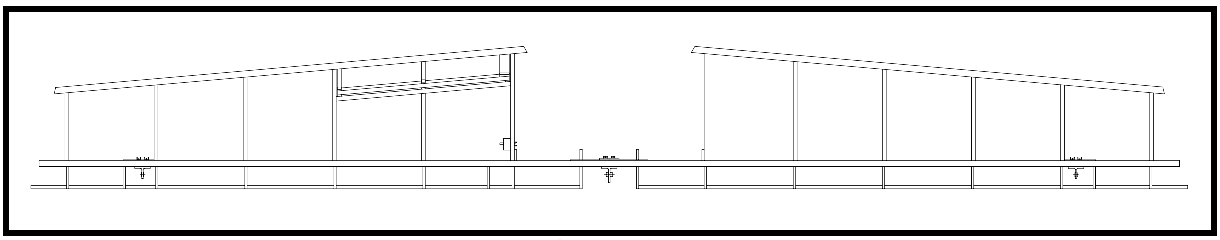


Figure 7

❏ Install the elevator tip bows, P/N 403-2. See Figure 8.

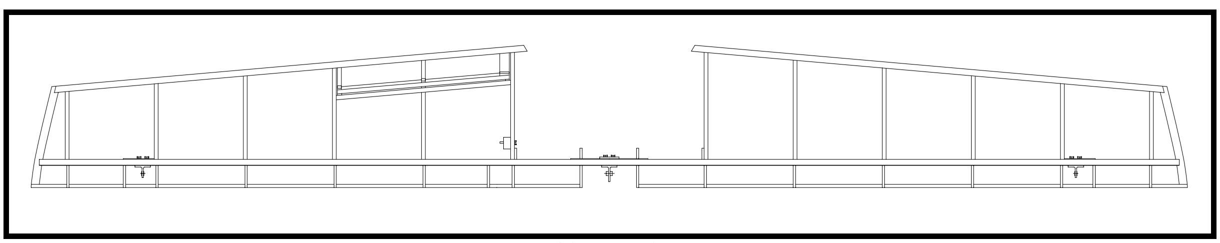


Figure 8

❏ Float sand the entire elevator to prepare for the skin.

Note: Float sanding is the process of sanding the ribs and spars to a smooth surface before skinning. The normal practice is to glue a piece of sandpaper to a smooth board. A planed board is best, and the best sandpaper to use is a sanding belt used for a stationary belt sander. These are 6" wide and 48" long. As the paper is supplied in a continuous belt, you must cut the belt. Glue the sandpaper to the board with contact cement. You will be able to purchase a contact cement made for gluing sandpaper discs to disc sanders at the same hardware store that sells the sanding belts. Auto body shops and auto paint stores also sell a variety of sanding strips intended for use with special sanding blocks, and you might try these as well.

Initial sanding should be done with a rough grit, such as 80 grit, and the final sanding may be done with a finer paper, such as 120 or 180 grit. It is a mistake to attempt to use a fine sandpaper for the initial sanding, since it will remove the material very slowly.

❏ Fit the leading edge skin. This skin will extend from B.L. 70 to Sta. 5. The plywood must be soaked and bent. See Figure 9.

Note: Plywood is most easily bent across the grain. Thus, the face grain of this skin should be parallel to the elevator hinge line.

Do not attempt to cut the scarf on the plywood until it is installed on the elevator.

To bend the plywood, you should soak the plywood 24 hours in water, and then clamp it over the ribs until dry. Some builders have used plastic pipe over which they bent the plywood. Other builders have found that they are able to bend the plywood by wetting the wood and heating it with a steam iron. Wood becomes very plastic at the boiling point of water and bends very easily. The steam iron method is capable of making a sharper bend than is possible with other methods.

If you wish, you may glue a piece of plywood on the spar at the center. This will make the installation of the center trailing edge skin easier since you will have an uninterrupted scarf joint. The problem may be seen in Figure 11, which shows the interrupted scarf joint.

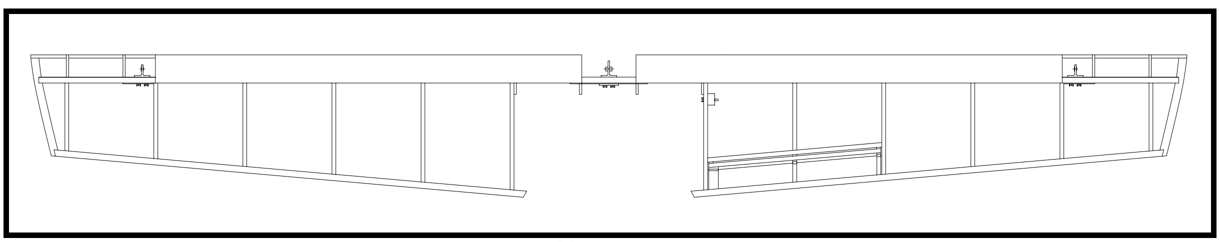


Figure 9

❏ Mask off the inside of the leading edge skin for varnishing. The internal structure may be drawn on the outside of the skin for stapling or nailing on the installation of the skin. (Builders using epoxy glue will be able to eliminate the masking required by other glues.)

Note: There are several methods for masking the inside of the skin. The most common method is to locate the skin with two small nails at the leading edge strip at each end. These nails will serve as alignment pins and will allow you to place the skin very accurately. Because the skin will have a certain amount of springback, you will be able to reach in with a pencil and mark the inside of the skin. Once you have made a few marks, you will be able to remove the skin and mask to the lines drawn.

A more complex method might also be tried. Wrap a piece of masking tape around each rib, sticky side out and tape to the trailing edge ribs with a separate piece of tape. Then, lay a piece of masking tape along the spar, sticky side out and tape to the spar inboard board of Sta. 1. and outboard of Sta. 5. Lay a piece of masking tape along the leading edge strip, sticky side out. These pieces will also stick to the tape on the ribs. Place the skin in position and push it down so that the masking tape adheres to the inside of the skin. Remove all extra pieces of masking tape used to adhere the sticky-side-up tapes to the railing edge ribs. This will allow the tapes to be removed with the skin. Remove the skin and rub the masking tapes down.

- ❑ Remove all channel-nuts and varnish the entire elevator, except for those areas which will be glued to the skin. The inboard end of the trailing edge strip should not be varnished at this time, since the 10x15 spruce piece will be glued to it.

- ❑ Varnish the inside surfaces of the leading edge skin.

- ❑ When the varnish on the elevator is dry, install all of the channel-nuts. Since wood rot most often occurs under metal fittings, you should bed the channel-nuts in epoxy or wet zinc chromate primer.

- ❑ Glue on the leading edge skin. Scuff sand the plywood prior to gluing.

Note: Builders differ greatly in their preferred method of skinning. It is important that the spar not be bowed or twisted during this skinning process. If the spar is bowed, the hinges will not be in a straight line, which can usually be cured by shimming the hinges or forcing the elevator into place. If the elevator is twisted, the trailing edges of the left side will not be aligned with the right side. A slight twist is probably not noticeable either to the eye or in the way the aircraft will fly, but it's always nice to do a pretty job.

Most builders support the spar off the edge of the jig table with the 20x20 extensions. This keeps the spar nice and straight. It also requires greater planning in the clamping method to be used. If you are using a fast-setting glue like Aerolite, you should have all clamps ready and be prepared to install them in a hurry. This will be your first excerise in skinning, and it is a good idea to develop the techniques that you will use later on when you skin larger areas. Skinning is the one time when an extra helper is most needed. Run through the procedure a couple of times, then after you apply the glue, it's "asses and elbows" until the job is done.

Custom aluminum band clamps do an excellent job of holding the skin to the ribs, but they are slow to install and work best with slow-setting glues like epoxy. For the faster-setting glues, you might want to try 1" strips of rubber cut from inner tubes. These can be quickly laced in place, and then you can use wood blocks and clamps to press the skin against the spar.

There are other builders who tackle the elevator with all of the grace of a professional wrestler, usually muttering that "The good Lord looks after fools and cripples". These tend to be the more experienced woodworkers, and they somehow come up with a straight elevator in the process.

- ❑ Install the trim tab cable on Sta. 1 rib. See Drawing No. 402, Section C-C. As you can see in the drawing, the clamp (P/N 117-11) is installed with the pressed-down part in the slot on the cable assembly. This may require that you enlarge the hole in the elevator spar, and you must cut the elevator leading edge skin and leading edge strip (see Drawing No. 402). The cable should then be removed for the rest of the skinning operation. See Figure 10.

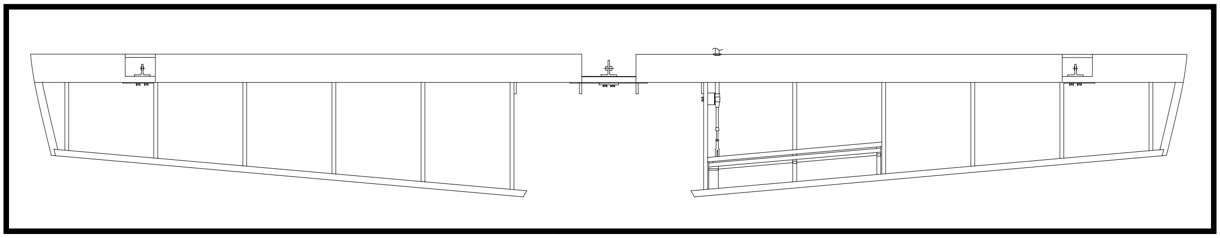


Figure 10

❏ Fit and bend the leading edge skin outboard of Sta. 5. See Figure 10.

Note: This skin is a little tricky. If you attempt to skin this area with a single piece of plywood wrapped around the leading edge, you will find that the skin will pucker out away from the leading edge near the tip when you bend the plywood down to match the curvature of the end of the spar.

Cut the leading edge skin along the leading edge at this "pucker zone". Bend the skin around the leading edge radius, and pull the skin down at the tips. This can be done by using pinch clamps, stapling into the tip bow, or by pulling the plywood down with pliers while you use a steam iron to make the plywood see it your way. Don't worry about the looks of the leading edge at the "pucker zone" at this time. It is not necessary that the plywood wrap around the tip bow, which can be sanded to a blunt wedge. After the plywood is glued in place, the tip is sanded to the final radius.

After the leading edge skin is glued in place, the ugly leading edge at the tip may be sanded at a shallow angle, and a piece of plywood may be glued on as a patch over this sanded area. After the glue is dry, the plywood may be sanded to a smooth shape.

Just so things look nice and tidy, it is best to extend this skin along the spar to join the skin at Sta. 5. This will make the scarf joint for the trailing edge skin easier, as you can see in Figure 11.

❏ After you have bent and fitted the skins for the outboard leading edges, mask the skins on the inside, and varnish.

❏ Glue the outboard leading edge skins in place. Scuff sand the plywood prior to gluing.

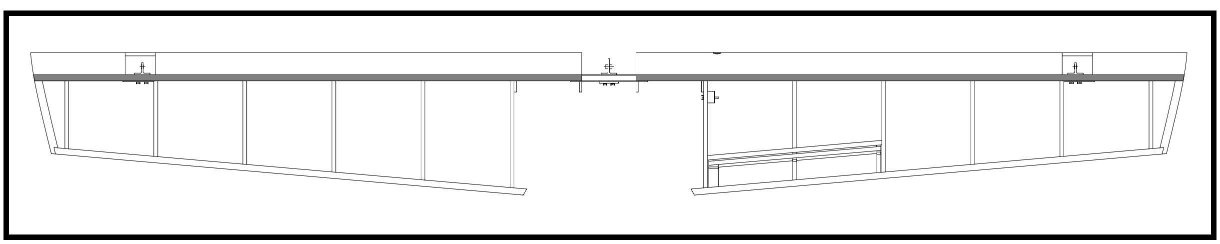


Figure 11

❏ Scarf the leading edge skin along the spar to prepare for the trailing edge skins. See Figure 11.

Note: Draw a line to mark the end of the scarf. If you are using a 12/1 scarf, then the scarf will be 18mm wide with 1.5mm plywood (12 x 1.5 = 18) and 14.4mm wide with 1.2mm plywood. This can be sanded with a drum sander in an electric drill (work very carefully!) and finished off with a sanding block.

❏ Turn the elevator over, and fit the 2mm skin over the trailing edge inboard of Sta. 1. The plywood must be soaked in water and bent. Do not attempt to cut the scarf on the plywood until it is bent. See Figure 12.

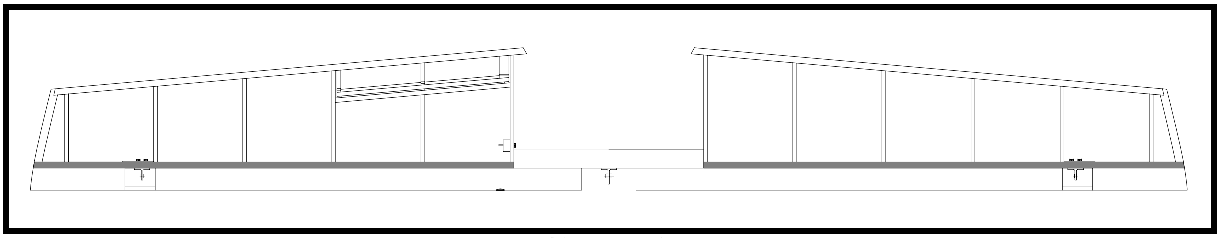


Figure 12

❏ After the plywood is bent, scarf the plywood on the inside to match the scarf on the leading edge skins. This is most easily done with a drum sander in an electric drill and finished off with a sanding block. If you have put a piece of plywood on the top and bottom of the spar for an uninterrupted scarf joint, then you may omit the inside scarf on the 2mm skin, and feather the plywood after it is glued in place.

❏ Mask the interior of the skin for varnishing. You should also draw the internal structure on the outside of the skin for stapling or nailing at installation.

❏ Glue this 2mm skin in place. Scuff sand the plywood prior to gluing.

❏ Glue the 10x15 spruce strips that go from B.L. 70 to the trailing edge strip. Scuff sand the plywood prior to gluing.

❏ Cut and fit the four trailing edge skins for the elevator. These will go from Sta. 1 to the tip of the elevator. Leave extra material on the tip for bending. See Figure 13.

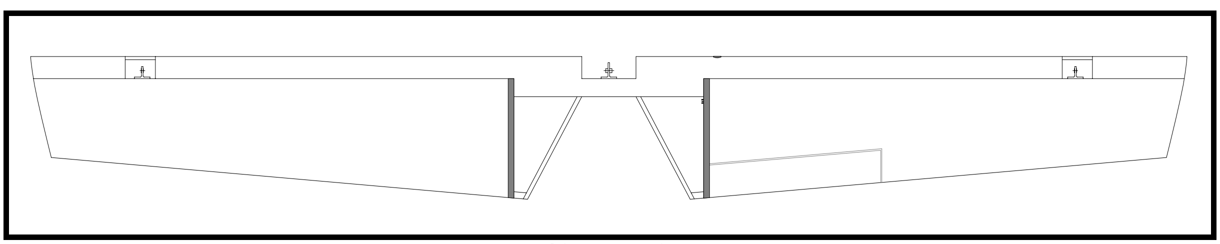


Figure 13

❏ Scarf the skins along the forward edge to match the scarf of the leading edge skin on the spar. Scarf the outside of the skin along the rib at Sta. 1.

❏ Soak the outboard ends of the skins in water, then clamp a skin in position and bend the tip down over the tip bow. Use a steam iron and the same method used on the leading edge tip skins. Repeat this process for all four trailing edge skins.

❏ Use alignment pins for the upper skins and mask the inside for varnishing. Draw the internal structure on the outside of the skin for stapling or nailing during the skinning process.

- ❏ Fit the lower skins and draw the outline of the ribs and spars for gluing. It will not be necessary to varnish the inside of these skins before gluing. Draw the internal structure on the skin for stapling or nailing during the skinning process.

- ❏ Locate and cut openings for the trim tab cable. See Drawing No. 402, Section C-C, which is accurate enough to locate the hole where the cable exits the bottom of the elevator. This hole may be opened up later if too small. A small opening is also required to get a wrench on the nut for P/N 117-11 clamp.

  Note: To remove the elevator from the aircraft, it is first necessary to loosen P/N 117-11 clamp so that the control cable is released. In the design of this installation, it was our intention that the lower nut only be loosened, and the clamp pried up to allow the cable to be removed. Before you commit yourself, practice the installation and removal of the cable several times.

  If you are successful with this method, the access opening will be very small. In that case, the cover for the opening can be simply a piece of white plastic tape, applied after the airplane is painted. If you have a larger opening or don't care for the tape idea (you won't beat it for weight or simplicity!), then you can use a small piece of aluminum or Lexan, held in place with a couple of screws. One builder used a couple of Tinnerman A1776-4Z-1 nuts with No. 4x1/2" type B sheet metal screws (the Tinnerman nuts are designed to work only with the blunt type B screws). The nuts were glued in place with epoxy, then a small rectangular piece of plywood (with a rectangular hole) fitted around it, and covered with another piece of birch plywood to trap the nut in place.

  There are other variations of this theme: Tinnerman A6195-6Z-3 anchor nuts epoxied and riveted in place with soft aluminum rivets (MS20426A3-4), or you can bond a piece of aluminum in place that you have drilled and tapped. The simplest screw installation is to build up a little pad of birch plywood and use a No. 4 sheet metal screw.

- ❏ Glue the bottom skin to the elevator. Scuff sand the plywood prior to gluing.

  Note: This will be your first experience with skinning a large flat area. You will find that there is no substitute for a pneumatic staple gun. Use extra strips of plywood for "nailing strips" to protect the skin from being damaged.

  To remove the nailing strips quickly, you might try putting a piece of fiberglass reinforced strapping tape down first. This tape is quite strong. Some builders have found that you can quickly zip the nailing strip off when the glue is dry.

  The trailing edge is a bit tricky. The trailing edge strip is not stiff enough to keep itself straight during the skinning. Most builders use long straight boards and clamp them on either side of the elevator. An alternative is to staple through the trailing edge into a long straight board.

- ❏ Drill the 1/8"Ø drain holes as shown on Drawing No. 402. If you wish, these holes may be 3/16"Ø or 1/4"Ø. It is only important that they be kept open and drain water. You will also be able to install seaplane grommets later on. These are streamlined covers which keep water from being blown into the holes.

❑ Cut away the plywood on the bottom between the elevator and the trim tab. It is not essential that you cut all of the plywood away at this time, but you should cut enough out so that you can drill up through the top skin to locate the cut for the upper skin.

❑ After you have done your thing to the access opening for the trim tab cable clamp, varnish the inside of the bottom skins.

❑ Varnish the inside of the upper trailing edge skins.

❑ Glue the upper trailing edge skins in place. Scuff sand the plywood prior to gluing.

❑ Cut out the leading edge strips at the two outboard hinge openings as shown in Figure 14.

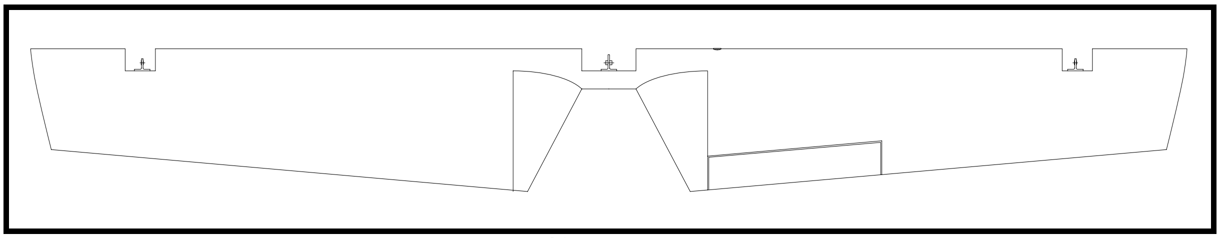


Figure 14

❑ Fit the inboard fairing skins. See Figure 14. These skins are aft of the elevator the elevator spar and inboard of Sta. 1.

Note: These skins will require a very tight radius toward the trailing edge of the spar. While they can be made in an upper and lower piece, they look better if made in one piece.

Start by making a pattern of cardboard and then cut the plywood roughly to size. Draw a line down the center of the piece to mark the bend.

Because the bend is so tight, it is a good idea to sand away the first layer of veneer on the inside of the bend for a couple of inches at the aft end. Wet the wood and then bend. Use a steam iron. If you are unable to get the bend, then sand the first layer of veneer away on the outside. This will make the plywood much easier to bend as you will now be bending only a single layer of veneer.

❑ Locate these fairing skins with a couple of alignment pins, and trim the skins for a good fit. Fitting these skins to the rounded inboard trailing edge skins may be easier if you wrap the inboard trailing edge skins with a piece of sandpaper. The sandpaper should have the abrasive surface on the outside. The sandpaper may be "shoe-shined" over the skin while the fairing skin is pushed against it. (This fairing skin is not important structurally, and you may find that it is most easily installed with epoxy since it will eliminate the masking and varnishing.)

❑ Scarf these fairing skins to match the scarf at the Sta. 1 rib.

❑ Mark the fairings skins for varnishing.

❑ Drill 1/8"Ø drain holes in the bottom of the fairing skins as shown on Drawing No. 402.

- ❑ Trace the outline of the fairing skins on the 2mm skin of the elevator, then varnish the inside of the fairing skins and that area of the 2mm skin which will be enclosed by the fairing skins.

- ❑ Glue the fairing skins in place. Scuff sand the plywood prior to gluing.

- ❑ Sand the tip of the elevator to a smooth radius. Any irregularities in the skin shape may be filled with epoxy and microballoons. Try to do this only forward of the spar so that you don't throw the elevator out of balance. (You should always refrain from doing a lot of filling aft of the thickest part of the wing or tail—it's all for cosmetic purposes and does nothing for the speed of the airplane.)

- ❑ Install P/N 775 on the trim tab. See Drawing No. 402, Section C-C.

- ❑ Cut the trim tab from the elevator. Drill up from the bottom to locate the slot to cut in the top skin. Use a straightedge to locate the cut lines. The best tool to cut this upper skin is a veneer saw held against a straightedge. You could also use a Dremel Moto-Tool with the router base resting against a straight board to guide it. Hacksaw blades, keyhole saws, etc. could also be used.

- ❑ Install the trim tab hinges, P/N 857-6 (formerly P/N 113-2) on the elevator and trim tab. The trim tab hinges should be installed so that the upper surface of the hinge is in line with the contour of the ribs before the skin is installed. This is best shown on Drawing No. 403. See Drawing No. 402, Detail A, for the location of the screw holes. See Drawing No. 402, Section C-C, for the screws installation.

Chapter 19
Stabilizer Assembly

Stabilizer Assembly

Many builders inquire if the ribs should be installed with the plywood web inboard or outboard. It doesn't matter, and you may install the ribs either way; however, we prefer to see the plywood web installed on the inboard side. This way, when you sand the ribs to the final contour, you will have less sanding to do on the plywood.

Remember, the stabilizer spars are glued to the fin spars, and gluing strips are installed on the forward and aft faces of the fin spars. These gluing surfaces should not be varnished.

You should be aware that when the tail group is installed in the airplane, the side longerons must be notched for the stabilizer spars. Failure to do this will cause the horizontal tail to be installed too high in the airplane. At the forward fin spar the longeron will be full-depth. The longeron will be notched for the forward stabilizer spar and the main stabilizer spar. At the main fin spar, the longeron will be the same as it is under the main stabilizer spar.

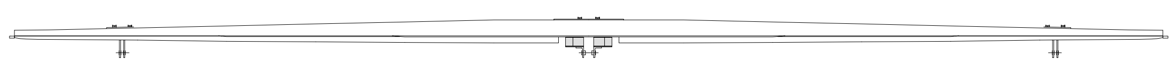


Figure 1

- ❏ Install the triangular strips on the aft face of the stabilizer spar. See Figure 1. Scuff sand the plywood prior to gluing.

  Note: These strips must end at the outline of the fin spar drawn on the aft face of the stabilizer spar. Because the stabilizer spar and fin spar must be fitted together several times, it will probably be necessary to end the triangular strips slightly outboard of the fin spar so that they will clear the widest part of the spar. These “missing teeth” may be filled in later with small blocks of spruce.

  The triangular strips must be notched to fit around P/N 755 hinges.

  Some builders have gone to great difficulty to taper the triangular strips prior to gluing them in place. We feel that the easiest method is to use 15x15 triangular strips and glue them in place and then cut off the excess. These strips are shown on Drawings No. 404 and 405, which are very accurately drawn. Thus, we suggest that you take the necessary measurements from these drawings. See Figure 2.

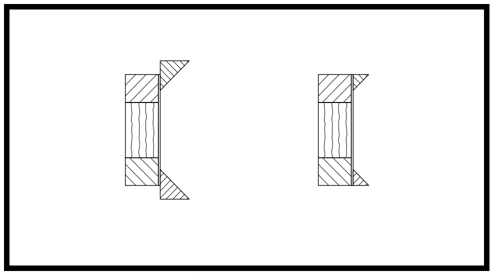


Figure 2

- ❑ Place the main stabilizer spar in the jig table, forward face up, and level the spar. It is imperative that the spar remain straight during the assembly process to insure that the hinges on the stabilizer will remain aligned with the elevator hinges. Since you will be clamping the ribs to the spar, it will be best if you place the spar near the edge of the jig table, or use 20x20 extensions from the table.

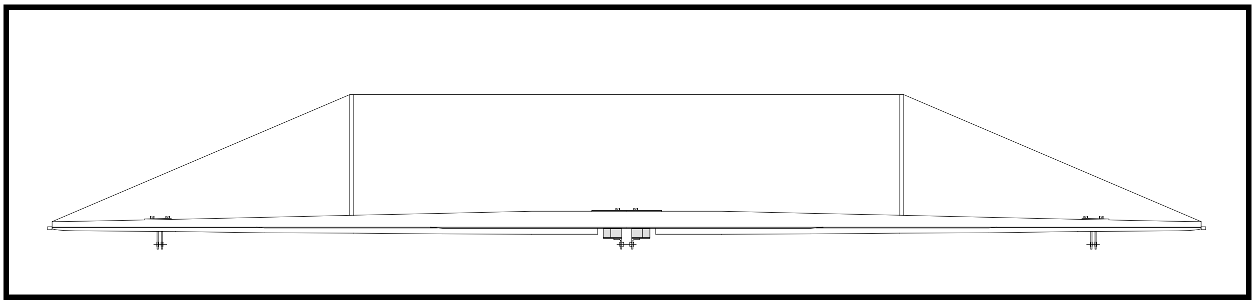


Figure 3

- ❑ Fit the intermediate ribs for Sta. 3, P/N 405-2, to the main spar. See Figure 3. Clamp in place.

Note: In the following steps, you will be looping a string over these ribs to align the inboard ribs as shown in Figure 5 and 7. Since the tension of the string will pull the ribs over, we suggest you make a wood brace to hold the rib at the proper vertical position.

Since the forward face of the main stabilizer spar is tapered, you cannot use a carpenter's square against the forward face to align the ribs since this would result in the ribs tilting outboard. A combination square could be set to the correct angle. A plumb bob or carpenter's level might be used for the vertical alignment of the ribs.

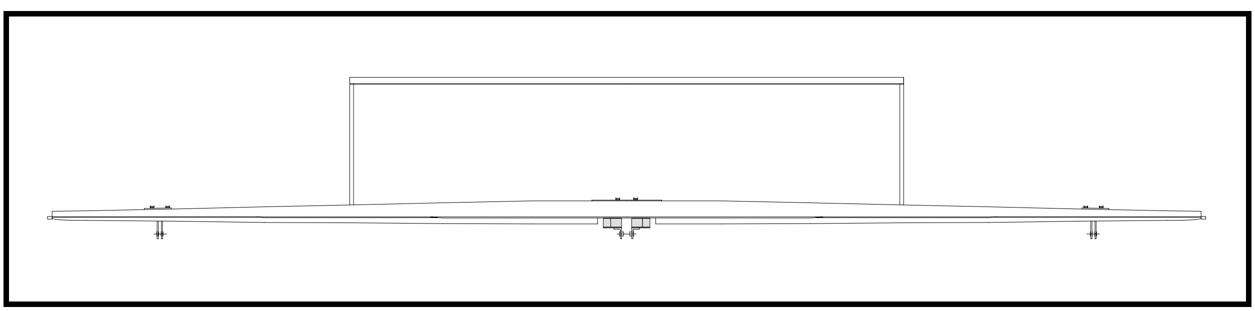


Figure 4

- ❑ Trial fit the forward stabilizer spar. See Figure 4. Check to make sure that the forward face of the forward stabilizer spar is 350mm from the aft face of the main stabilizer spar.

Since the plywood on the aft face of the main stabilizer spar is stepped, the 350mm dimension would only apply to the center of the aircraft. For Sta. 3, you must make allowance for the thinner plywood, so the proper dimension is 349mm to the actual aft face of the main stabilizer spar. Make sure the forward ends of the ribs are sanded as needed before the ribs are glued to the main stabilizer spar.

Note: Be careful to install the forward stabilizer spar so that the hole for the elevator control cable is on the upper side. (By "upper side" we are referring to its installed position in the airplane. If confused, see Drawing No. 410, Section B-B.)

❏ Glue the intermediate ribs for Sta. 3 in place.

❏ Loop a string over the ribs to locate the centerline of the inboard ribs. The ribs should be braced for the tension of this string. See Figure 3.

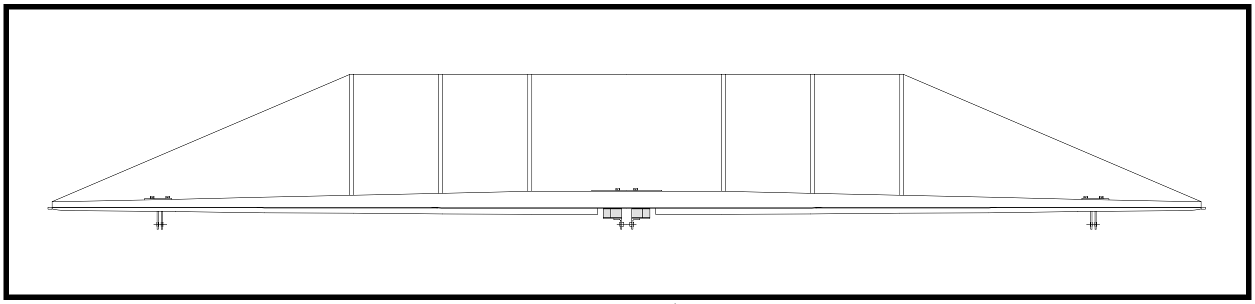


Figure 5

❏ Fit the intermediate ribs for Sta. 1 and 2 (P/N 404-6 and 404-9). See Figure 5.

❏ Trial fit the forward stabilizer spar to the ribs. This will require that the string be removed temporarily. Sand the forward ends of the ribs for the forward stabilizer spar. See Figure 6.

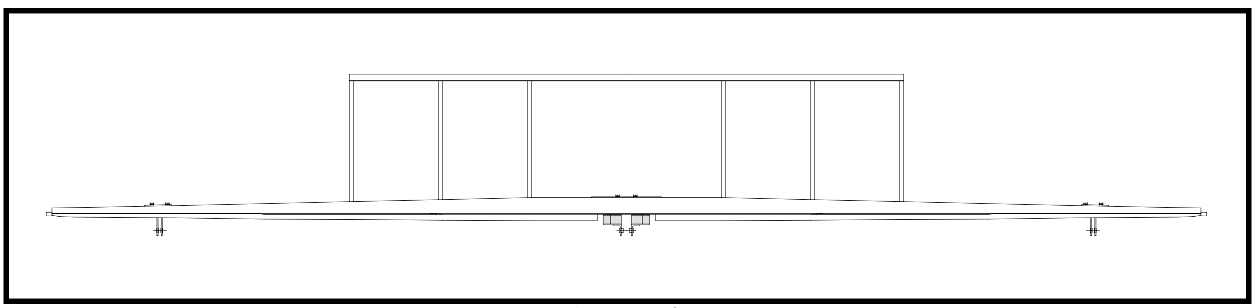


Figure 6

❏ Glue intermediate ribs for Sta. 1 and 2 to the main stabilizer spar.

❏ Glue the forward stabilizer spar to these ribs. Scuff sand the plywood before gluing.

❏ Fit the leading edge rib for Sta. 1 and 6 (P/N 404-5 and 405-11) in place. These ribs must be placed very accurately, since they will be used to align all of the ribs in between. See Figure 7.

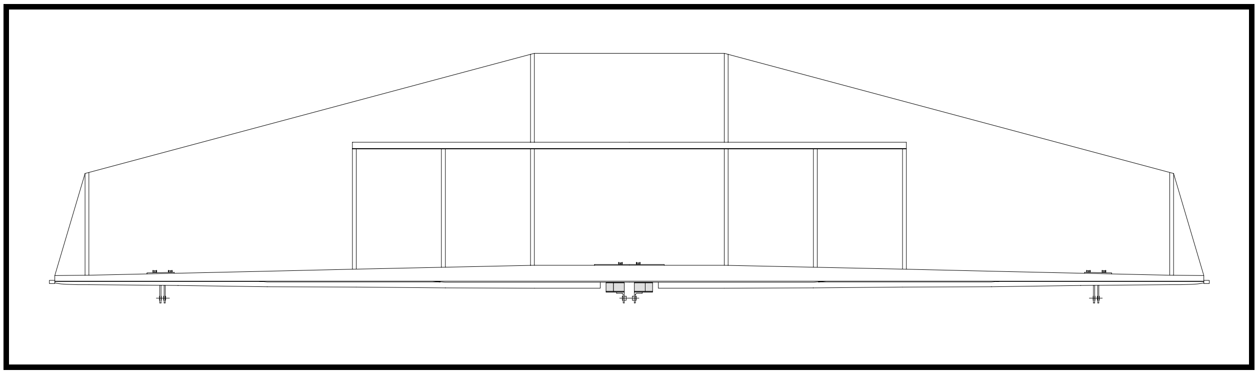


Figure 7

- ❏ Sand the ribs to the correct angle for the leading edge strip.
- ❏ Glue the leading edge ribs for Sta. 1 and 6 in place.
- ❏ Stretch a string across the ribs at Sta. 1 and 6. This is to align the remaining ribs. See Figure 7.

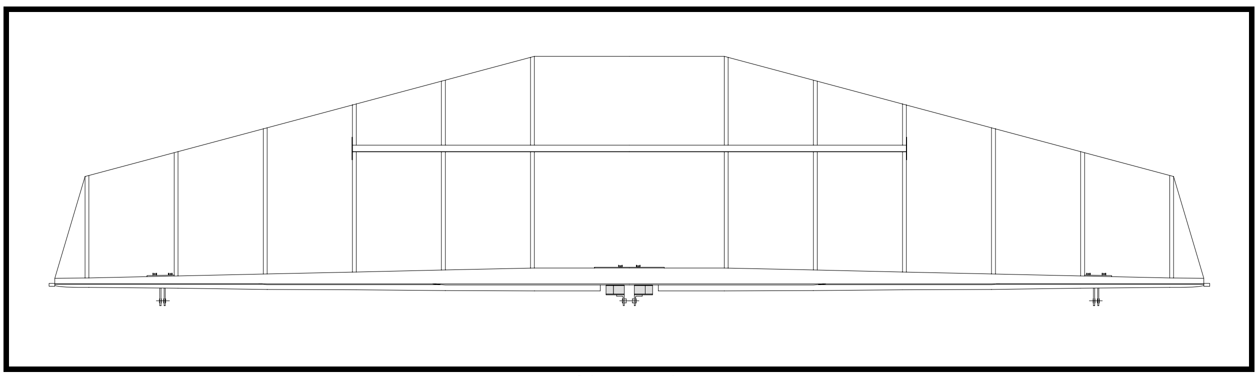


Figure 8

- ❏ Fit the remaining ribs. See Figure 8. If you wish, you may fit the Sta. 0 ribs (see Drawing No. 401), but these ribs are not installed until after the fuselage skin is installed.

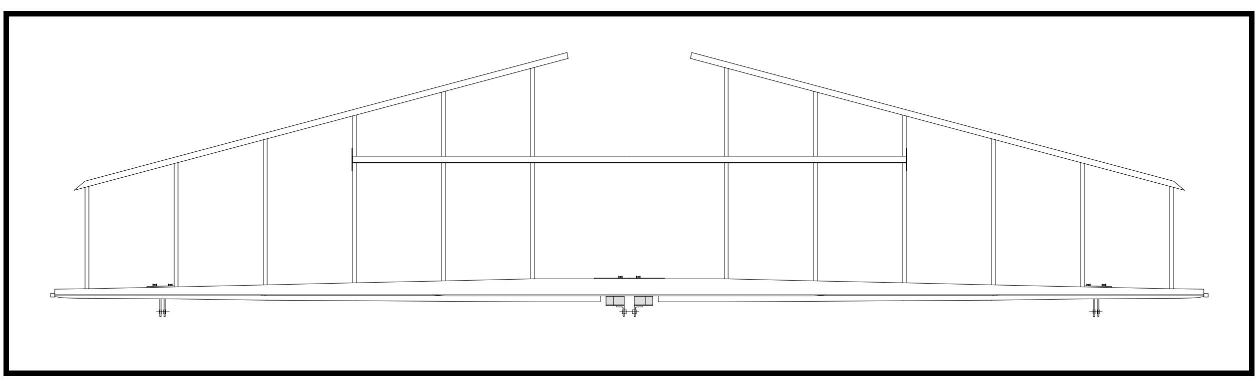


Figure 9

- ❏ Fit the leading edge strip to the ribs and clamp in place. See Figure 9. Check the stabilizer for alignment. See Drawing No. 402 for the dimensions for the leading edge strip.

Note: When the leading edge strip is finally installed, it will be somewhat difficult to clamp. Because of the angle between the ribs and leading edge strip, the ribs will tend to “squirt” inboard. To keep this from happening, it is best to tack small blocks of spruce to the aft face of the leading edge strip to prevent the ribs from shifting laterally under the gluing pressure. See Figure 10.

To make it easier to clamp the ribs to the leading edge strip, triangular blocks may be tacked to the leading edge strip to provide a square clamping surface.

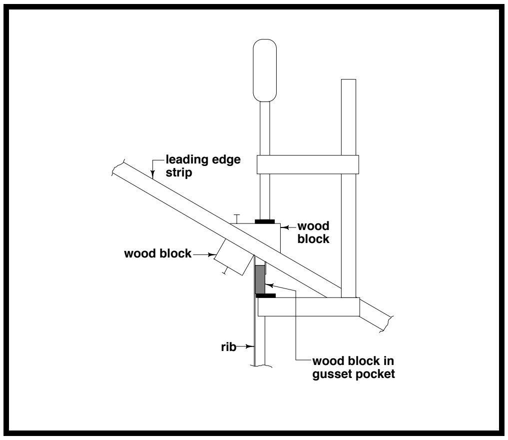


Figure 10

- ❏ Glue the ribs to the main stabilizer spar and to the forward stabilizer spar. Do not glue the Sta. 0 ribs in place at this time. Scuff sand the plywood before gluing.

- ❏ Glue the optional 1mm birch plywood pieces to the ends of the forward stabilizer spar. This is to cover the end grain of the spar and to protect it. Scuff sand the plywood before gluing.

- ❏ Glue the leading edge strip to the ribs.

- ❏ Fit and glue the stabilizer tip bows, P/N 403-1, at the ends of the stabilizer to the spar and to the leading edge strip. This piece may be of solid spruce or a lamination. See Figure 11.

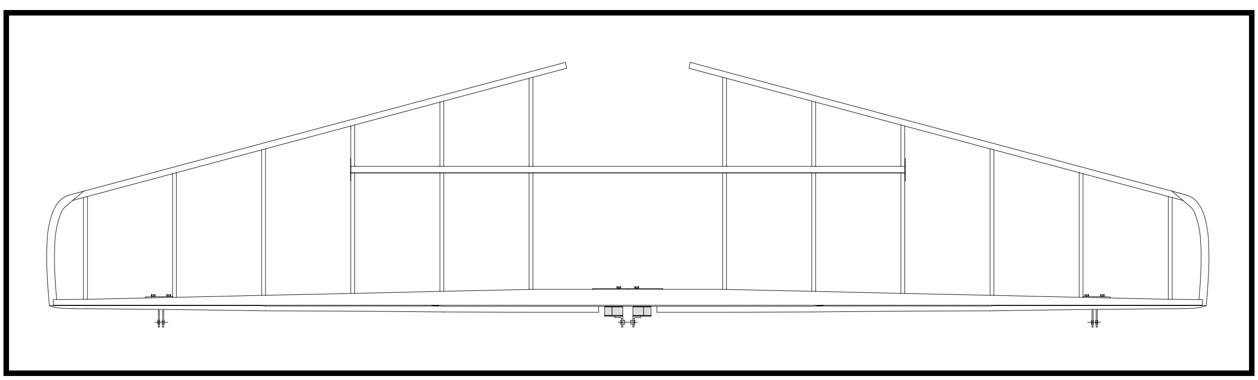


Figure 11

Note: At this time you should review your plans for your Falco. If you plan to install a Loran antenna, you may want to install a ground plane wire in the stabilizer.

❑ The stabilizer may now be removed from the jig.

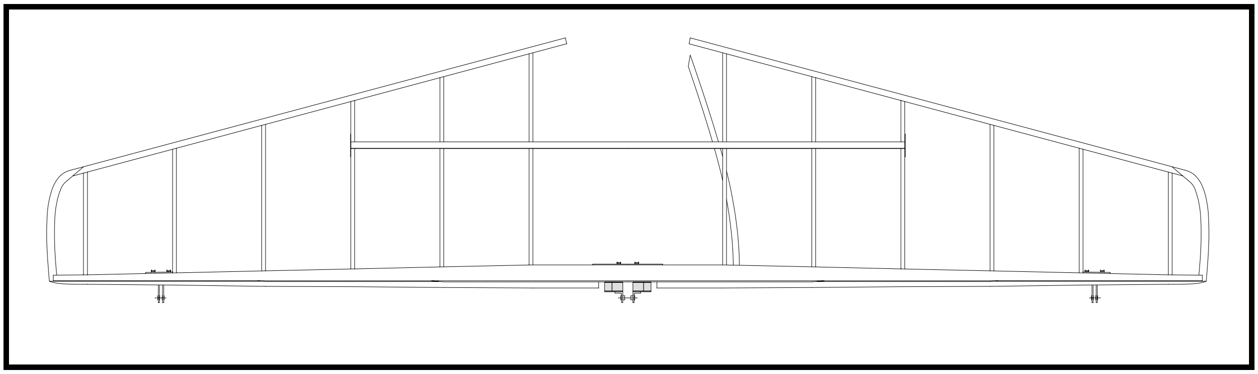


Figure 12

❑ Install the trim tab control cable tube in the horizontal stabilizer. See Figure 12. Bend the tube as required to fit in the intermediate rib and forward stabilizer spar. The aft end of the tube is flared to keep the tube from chafing the control cable. 3M 2216B/A epoxy is recommended. The "dry flox" is a mixture of flocked cotton with epoxy. First mix the epoxy. Brush the wet epoxy resin on all surfaces to be glued, and then mix the flocked cotton into the remaining resin until it becomes stiff. Putty around the trim tab control cable tube with a fillet of the dry flox. When hard, this material is quite strong.

Note: At the forward end of the tube, the tube will be cut off at an angle to match the Sta. 0 rib (see Drawing No. 401). This will allow you to skin the fuselage without having to contend with the interference of the tube. If you wish, you may cut the tube close to the final length and angle, for easier trimming with a portable disk sander.

The original drawings showed the trim tab cable tube attached to the Sta. 1 intermediate rib with a clamp. If you wish to do this, install a 10x20 spruce brace in the rib, and then install a spruce block on the outboard face. The clamp is a MS21919-DG10, and is installed with an 8-32x1-1/4" socket head cap screw, AN960-8L washer and MS21042-08 nut. Drill the hole for the screw with a No. 19 (.1660"Ø) drill.

❑ Float sand the entire stabilizer. The leading edge strip must be sanded to a smooth radius. The stabilizer tip bows do not need to be sanded to an exact radius. They should be tapered for the skin to make a blunt wedge shape in cross-section. After the skin is glued down, the ends will be sanded to a smooth radius.

❑ Fit the skins to the stabilizer. See Figure 13. These skins will extend from the ends of the stabilizer to the ribs at Sta. 1. Leave extra material at the tip for bending the compound bend. Use small nails as alignment pins.

❑ Scarf the skins at Sta. 1 for the inboard stabilizer skin that will be installed after the stabilizer is installed on the fuselage (see Drawing No. 401).

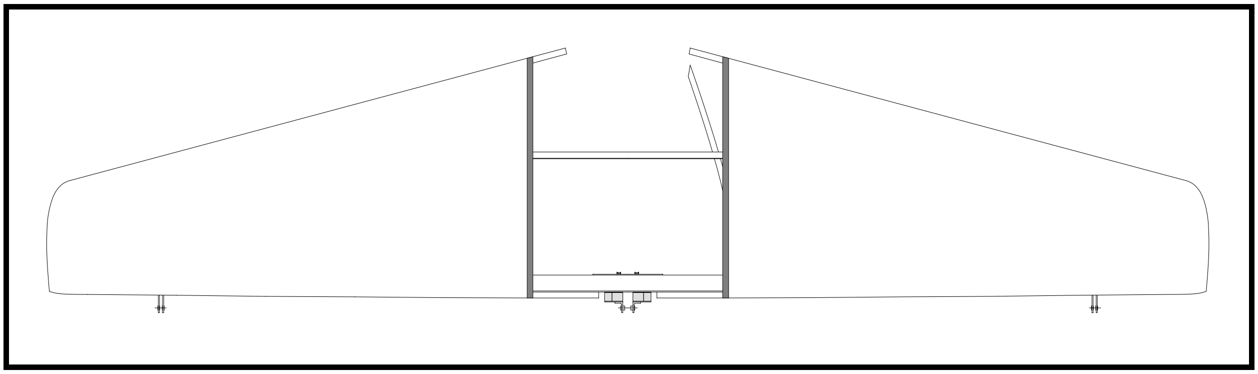


Figure 13

❏ Soak the skins in water and bend around the leading edge strip. Do this for the top and bottom skins. At the tip, you should use a steam iron and pull the plywood down around the stabilizer tip bow to get the compound bend

Note: You should be aware of the moisture content (M.C.) of the plywood installed as skins on your Falco. In most parts of the U.S., wood stabilizes at about 12% M.C. Plywood is made in high temperature presses and is usually quite dry at the time of shipment. In addition, the plywood is very slow to stabilize to the local conditions. You will find that the plywood you receive will be probably about 6 to 7% M.C. If the plywood is installed in this condition, it will pick up moisture with time and swell. This will give your airplane a wavy skin. It is ideal to have the M.C. of the plywood from 1.25% to 1.5% greater than the M.C. of the underlying structure. This way, the plywood pulls tighter with time. The only way to know the exact M.C. is to use a wood moisture meter. In any event, it is a good idea to soak the entire skin for a couple of days prior to bending the leading edges. Remember the plywood has waterproof glue between the layers, and this prevents the plywood from soaking up water as quickly as spruce.

❏ Mask off the top skins for varnishing. You should also draw the internal structure of the stabilizer on the outside of the skins. This will make it easier to use nails or staples when you glue on the skin.

❏ Varnish the entire internal structure of the stabilizer except for the surfaces to be glued when the skin is installed. Varnish the inside of the top skins. Varnish under the channel-nuts and under hinges.

Note: If you wish, this varnishing may be postponed until later. You will be varnishing the inside of the bottom skin before you close the stabilizer; however, you will find it easier to reach all of the nooks and crannies with everything open.

You will need to hold the stabilizer in alignment while you are gluing on the skins. The simplest way to do this is on a flat table. You may use a number of short wood blocks clamped to the ribs and spars. Pick any handy dimension, say 100mm. These blocks will rest on the flat surface of the table and keep the stabilizer from moving when the skin is being glued in place. Also, it would be an excellent idea to install the elevator on the hinges at this time so that you will know if you are bowing the stabilizer spar.

❏ Install the channel-nuts for the outboard stabilizer hinges. To prevent moisture from getting under the channel-nuts, they should be bedded down with wet zinc chromate primer or epoxy.

❏ Glue on the bottom stabilizer skin. This skin will extend from the tip of the stabilizer to Sta. 1. Scuff sand the plywood before gluing.

❏ Drill drain holes in the bottom skin. These are normally 1/4"Ø holes, although 1/8"Ø may also be used.

❏ Varnish the inside of the bottom skin. Check to make sure that all internal surfaces are varnished.

❏ Feather the bottom skin at the leading edge.

❏ Glue on the top stabilizer skin. This skin will extend from the tip of the stabilizer to Sta. 1. Scuff sand the plywood before gluing.

❏ Feather top skin at leading edge. Sand ends of the stabilizer to a smooth radius.

Chapter 20
Rudder Assembly

Fin and Rudder Assembly Notes

See Chapter 14 for the installation of the Loran antenna. In particular, the Loran antenna coupler, the installation of the antenna coaxial cable and the installation of the ground plane should be understood and planned. Chapter 14 also covers the installation of the COM antenna in the fin.

Many builders inquire about whether the ribs should be installed with the plywood web on the bottom or the top. It makes absolutely no difference which way you install the ribs, although you will find it easier if you install the plywood web on the bottom. This way, when you sand the ribs to the final contour, you will have less sanding to do on the plywood.

You should be aware that when the tail group is installed in the airplane, the side longerons must be notched for the stabilizer spars. Failure to do so will cause the horizontal tail to be installed too high in the airplane. At the forward fin beam the longeron will be full-depth. The longeron will be notched for the forward stabilizer spar and the main stabilizer spar. At the main fin spar, the longeron will be the same as it is under the main stabilizer spar.

You may want to be aware that builders have approached the dorsal fin in a number of different ways. The dorsal fin is not detailed in cross-section on the drawings except for a section shown on Drawing No. 306. Note on this drawing that top of the dorsal fin is a strip of spruce similar to the leading edge strips of the wing and tail. At the base of the dorsal fin, you will need some 10x10 gluing strips glued to the top of the fuselage skin. As these strips approach the fin, these strips bend outboard so that the bottom of the dorsal fin blends with the fin.

With the original production Falcos, the dorsal fin was added after the fin was completely skinned, and the outline of the dorsal fin skin is indicated on Drawing No. 410. Some builders have changed the "leading edge strip" of the dorsal so that it is a straight piece of spruce running aft to the fin leading edge, and a separate curved piece of spruce is used to make the radius. We have no objection to this technique. It may be easier to build, but it will add a small amount of weight and will make for a more complicated masking job for varnishing.

Some builders have widened the leading edge strip of the fin at the bottom so that it is the same width as the dorsal fin. This way, the dorsal and the bottom of the fin share the same piece of plywood for the skin. This may or may not be a good idea. Our principal worry is that the plywood may not take the sort of bend that you might desire, and it may end up having a poor appearance. Only time and the experience of builders who are doing this will tell the tale.

You should be aware of the fact that the height of the dorsal fin is important. This positions the roller for the canopy.

You should remember that the fin spars are glued to the stabilizer spars and that gluing strips are installed on the forward and aft faces of the fin and stabilizer spars. The surfaces that are to be glued should not be varnished.

Rudder Assembly

In the following steps, the leading edge ribs and the leading edge strip will be installed on the rudder. The leading edge strip may be fitted to the ribs before gluing on the ribs. Some builders prefer to glue the leading edge strip to the ribs first and then glue the entire assembly to the rudder spar.

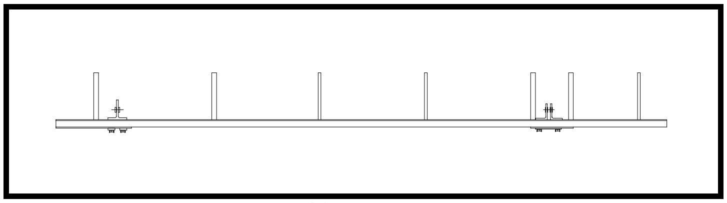


Figure 1

❏ Install all leading edge ribs. On the rib above the upper hinges, be sure to observe the 80mm dimension so that you have sufficient room to remove the hinge bolt. See Drawing No. 411. See Figure 1. Scuff-sand the plywood before gluing.

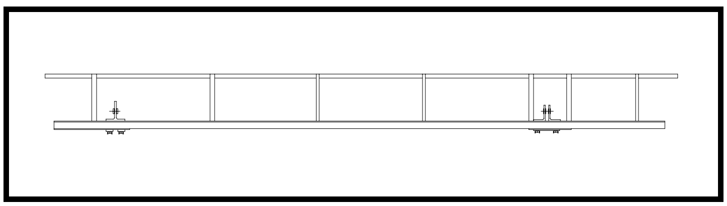


Figure 2

❏ Install the leading edge strip. For the simplest construction and stiffness during assembly, the leading edge strip should be continuous to the bottom of the rudder. See Figure 2.

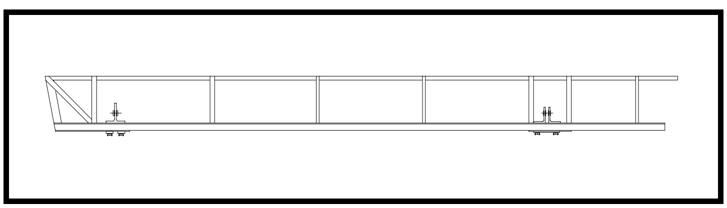


Figure 3

❏ At the bottom of the rudder, install the diagonal leading edge rib, P/N 414-3, and the piece of spruce along the bottom of the rudder. See Figure 3. Scuff-sand the plywood before gluing.

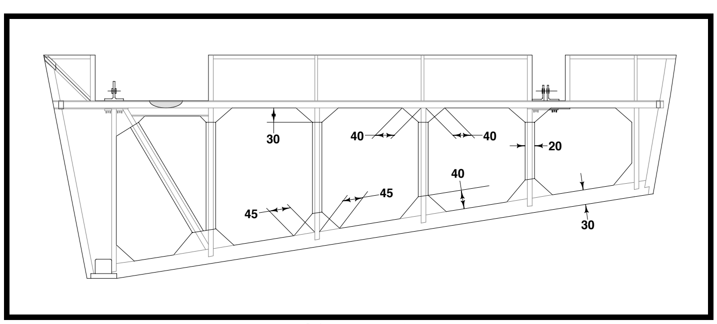


Figure 4

Trailing Edge Rib Installation

In the following steps, the trailing edge ribs will be installed on the spar. It will be important that you maintain the alignment of the trailing edge. You will find that once things are glued in place, there is relatively little opportunity to make an adjustment, so it is best to get things aligned from the beginning. This is complicated by the fact that the trailing edge strip is a constantly-tapering triangular strip of spruce.

The ribs should be aligned with a string. In addition, boards may be clamped to the sides of the ribs to stabilize them.
If you want to cover the rudder with fabric, see Figure 4. Note that the trailing edge strip is 30mm wide and each rib is joined to it by a 15mm deep notch in the trailing edge strip.

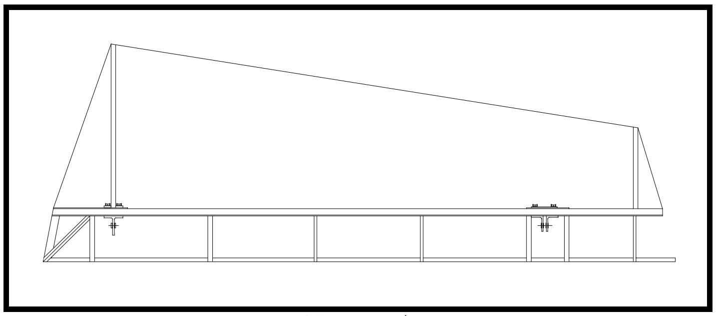


Figure 5

- ❏ Fit the trailing edge ribs for Sta. 0 and 5. See Figure 5. The Sta. 0 rib must be centered between the channel-nuts for the control arm. Since a string will be used for aligning the ribs, a brace should be made of wood to support these two ribs to keep them from "leaning" due to the tension of the string.

- ❏ Sand these two trailing edge ribs to the angle required for the trailing edge strip.

- ❏ Glue the trailing edge ribs for Sta. 0 and 5 in place. Scuff-sand the plywood before gluing.

- ❏ Loop a string over the ends of these two ribs to align the other rudder trailing edge ribs. See Figure 5.

- ❏ Fit the trailing edge ribs for Sta. 1, 2, 3 and 4. Do not fit the Sta. 0 diagonal rib at this time. See Figure 6.

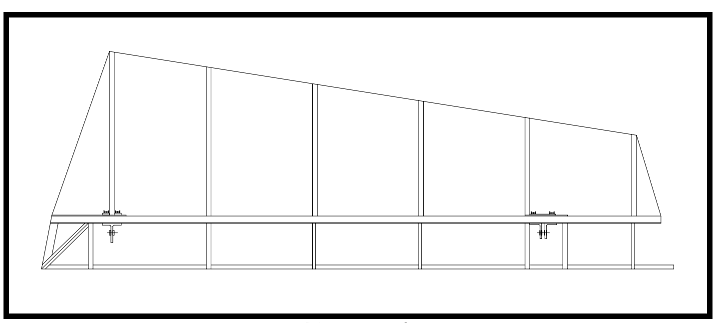


Figure 6

- ❏ Sand these trailing edge ribs to the angle required for the trailing edge strip.

❏ Glue the trailing edge ribs for Sta. 1, 2, 3 and 4 in place. Scuff-sand the plywood before gluing.

❏ Fit the two spar doublers to the aft face of the spar. These are shown on Drawing No. 411, Section B-B.

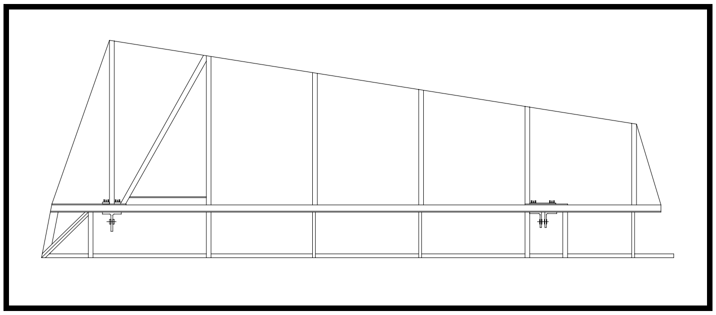


Figure 7

❏ Fit the Sta. 0 diagonal rib. This will require that you also cut the two spar doublers to an angle to match that of the diagonal rib. Note that this angle is also the same as is used in the following step. See Figure 7.

❏ Fit the two 4mm birch plywood doublers installed under the channel-nuts at Sta. 0. Two pieces of 2mm birch plywood may be glued together to make these pads. Drill through these pads for the channel-nuts.

❏ Glue the spar doublers in place.

❏ Hold the diagonal rib in place and trace the inside surface of the spar doublers on the upper face of the rib. This is for varnishing.

❏ Fit the 1.5mm plywood skin on the aft face of the spar doublers. Note on Drawing No. 411, Section B-B, that a 1/8"Ø vent hole is drilled in this skin.

❏ Varnish the interior surfaces of the spar between Sta. 0 and 1, the forward face of the 1.5mm plywood skin and the upper forward face of the diagonal rib. The gluing surfaces should be masked off, and you only want to varnish those areas which will not be glued.

❏ Glue the 1.5mm plywood skin on the aft face of the spar doublers. Scuff-sand the plywood before gluing.

❏ Glue the Sta. 0 diagonal rib in place. Scuff-sand the plywood before gluing. If you wish, the following step may be done at the same time.

❏ Glue the two 4mm birch plywood doublers in place. These are most easily clamped by using the channel-nuts and the hinge. If you are using epoxy glue, the channel-nuts may be bedded down in epoxy and installed. If you do this, first ream the screw holes for the channel-nuts with a No. 27 (.1440"Ø) drill. Scuff-sand the plywood before gluing.

❏ Glue the trailing edge strip in place. See Figure 8.

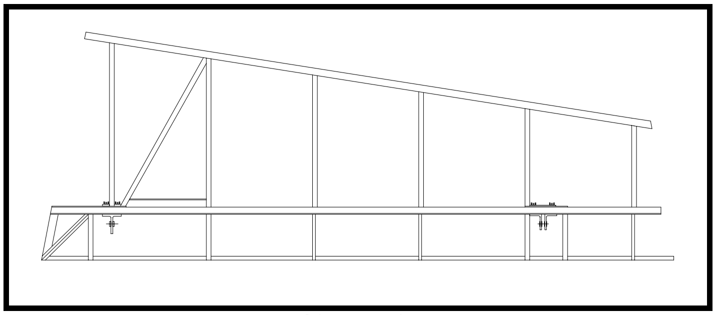


Figure 8

❏ Fit and glue the rudder tip bow, P/N 415-2, in place at the top of the rudder. See Figure 9.

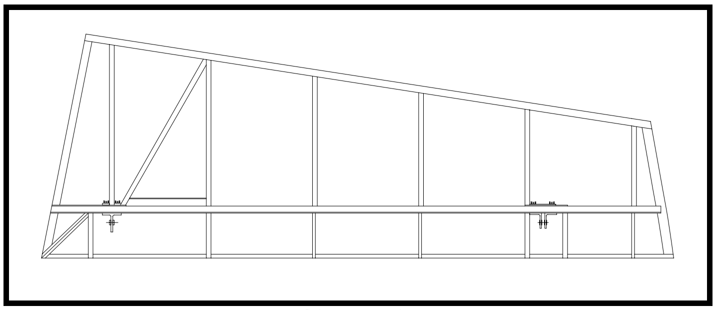


Figure 9

❏ Install the strip of spruce at the bottom of the rudder, between the rudder spar and the trailing edge strip. See Figure 9.

Skinning the Rudder

❏ Float sand the entire rudder to prepare for the skin. Do not attempt to sand the shape for the bottom skin at this time.

Note: In the following steps, you will be skinning the leading edge of the rudder. The leading edge is divided into three areas. The top skin should be skinned with a piece on each side of the rudder to facilitate the compound bend at the upper "corner". If each separate area is skinned with a separate piece of plywood, you will use less plywood, but it will be desirable to glue on little pieces at the two hinge openings so that the trailing edge skin will have a continuous scarf joint.

To reduce the number of steps involved, we suggest skinning the leading edge in one operation from the bottom to Sta. 4-1/2. There is an additional advantage which will outweigh the expense of the wasted plywood: the fiberglass rudder fairings may be made in an easy, cheap operation.

❏ Fit the leading edge skin. This will extend from the very bottom of the rudder to the upper face of the rib at Sta. 4-1/2. Do not bend the plywood at this time. See Figure 10.

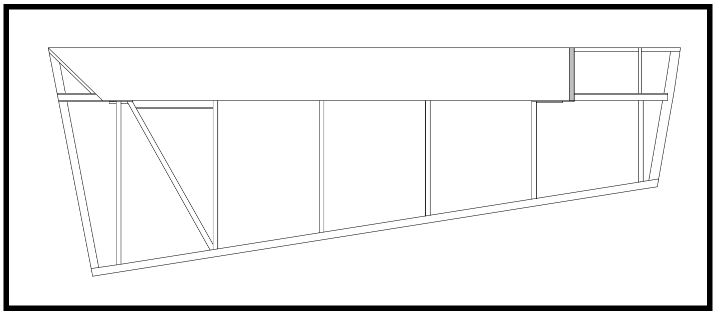


Figure 10

❏ Scarf the plywood for the joint that will occur with the leading edge skin above Sta. 4-1/2. (If you wish, you may skip this step and install the skin so that it extends just to the lower surface of the Sta. 4-1/2 rib, then the fiberglass fairing can be made from the skin. The risk is that the plywood will bell out at the open end.)

❏ Soak and bend this skin to fit the leading edge of the rudder.

❏ Mask the inside of the leading edge skin. Draw the internal structure on the outside of the skin for stapling or nailing at the installation of the skin.

❏ Remove all channel-nuts and varnish the entire rudder except where gluing will take place.

❏ Glue the leading edge skin in place. Scuff-sand the plywood prior to gluing.

❏ Fit and bend the leading edge skin above Sta. 4-1/2. Scarf the plywood to match the scarf at Sta. 4-1/2. See Figure 11.

Note: This skin is a little tricky. If you attempt to skin this area with a single piece of plywood wrapped around the leading edge, you will find that the skin will pucker out away from the leading edge near the tip when you bend the plywood down to match the curvature of the end of the spar.

Cut the leading edge skin along the leading edge at this "pucker zone". Bend the skin around the leading edge radius, and pull the skin down at the tips. This can be done by using pinch clamps, stapling into the tip bow, or by pulling the plywood down with pliers while you use a steam iron to make the plywood see it your way. Don't worry about the looks of the leading edge at the "pucker zone" at this time. It is not necessary that the plywood wrap around the tip bow, which can be sanded to a blunt wedge. After the plywood is glued in place, the tip is sanded to the final radius.

After the leading edge skin is glued in place, the ugly leading edge at the tip may be sanded at a shallow angle, and a piece of plywood may be glued on as a patch over this sanded area. After the glue is dry, the plywood may be sanded to a smooth shape.

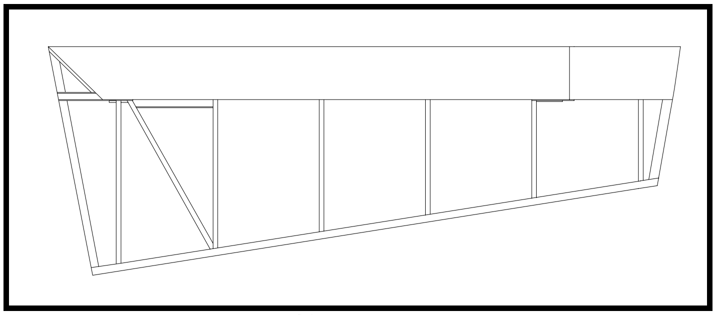


Figure 11

❏ After you have bent and fitted the skin for the upper leading edge, mask the skin on the inside and varnish.

❏ Glue the upper leading edge skin in place. Scuff-sand the plywood prior to gluing.

❏ Cover the two hinge "openings" with plastic food wrap and lay up two layers of 9 oz. fiberglass cloth and epoxy resin to make the two fairings. These are P/N 857-1 and 857-2. See Drawing No. 857 and 410. Make the fairing oversized for trimming at the final installation. See Figure 12.

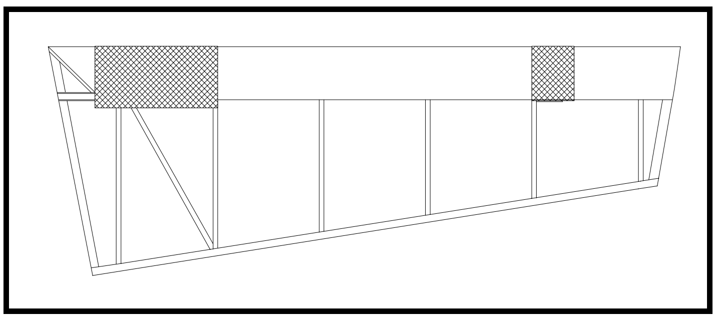


Figure 12

❏ Scarf the leading edge skin along the spar to prepare for the trailing edge skin. See Figure 13.

Note: Draw a line to mark the end of the scarf. If you are using a 12/1 scarf, then the scarf will be 14.4mm wide with 1.2mm plywood (12 x 1.2 = 14.4). This can be sanded with a drum sander in an electric drill (work very carefully!) and finished off with a sanding block.

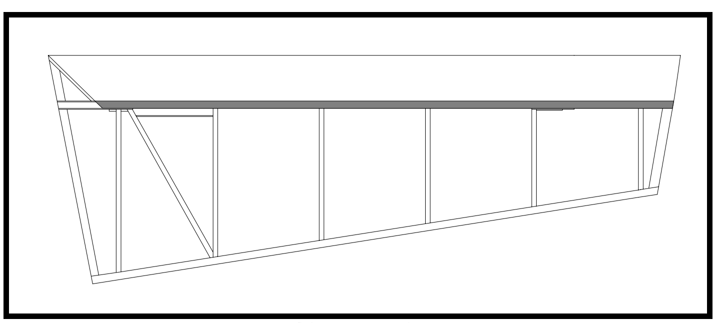


Figure 13

❑ Cut out the two hinge openings in the leading edge skin. See Figure 14.

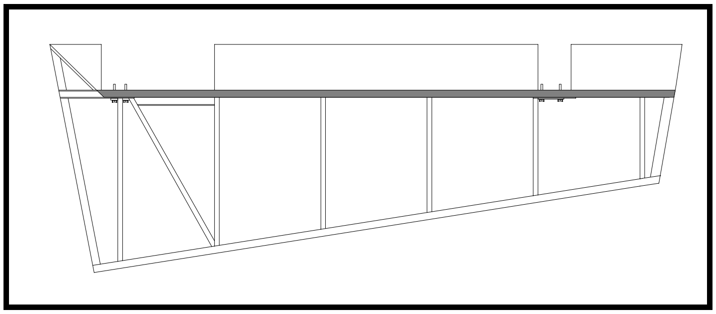


Figure 14

❑ Install all of the channel-nuts. Since wood rot most often occurs under metal fittings, you should bed the channel-nuts in epoxy or wet zinc chromate primer.

❑ Fit the trailing edge skins for the right and left side. See Figure 15. Leave extra material at the upper end for bending.

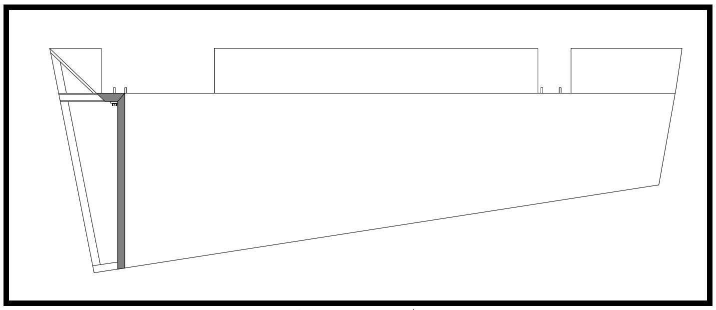


Figure 15

❑ Scarf the trailing edge skins along the forward edge to match the scarf of the leading edge skin on the spar. Scarf the outside of the skin along the rib at Sta. 0.

❑ Soak the upper end of the skins in water, then clamp a skin in position and bend the tip down over the tip bow. Use a steam iron and the same method used on the leading edge tip skins.

❑ Use alignment pins for the left trailing edge skin, and mask the inside for varnishing. Draw the internal structure on the skin for stapling or nailing during the skinning process.

❑ Fit the right trailing edge skin and draw the outline of the ribs and spars for gluing. It will not be necessary to varnish the inside of these skins before gluing. Draw the internal structure on the outside of the skin for stapling or nailing during the skinning process.

❑ Glue the right trailing edge skin on the rudder. Use long straight boards and clamp them on either side of the rudder to support the thin trailing edge strip, or staple through the trailing edge into a long straight board. Scuff-sand the plywood before gluing.

❑ Varnish the inside of the right trailing edge skin, and all other internal surfaces that will not be glued.

❏ Glue the left trailing edge skin on the rudder. Use long straight boards and clamp them on either side of the rudder to support the thin trailing edge strip, or staple through the trailing edge into a long straight board. Scuff-sand the plywood before gluing.

❏ Sand the bottom of the rudder to receive the bottom skin.

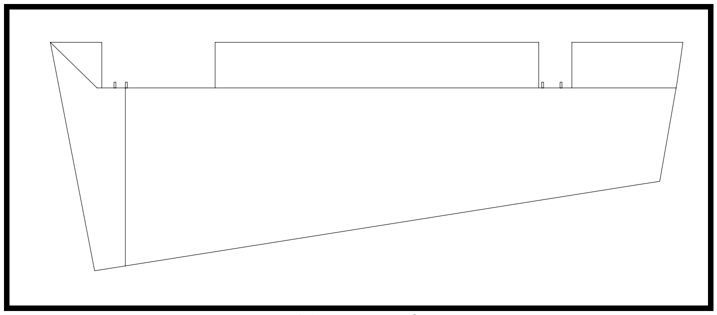


Figure 16

❏ Fit the skin below Sta. 0. See Figure 16. This skin wraps around the bottom of the rudder. At the spar, it will have the same curvature as the spar, and at the trailing edge it will have a very sharp radius. For this reason, you will have to soak the plywood to bend it to the required shape.

Note: This skin will require a very tight radius toward the trailing edge of the spar. While it can be made in a left and right piece, it looks better if made in one piece.

Start by making a pattern of cardboard and then cut the plywood roughly to size. Draw a line down the center of the piece to mark the bend.

Because the bend is so tight, it is a good idea to sand away the first layer of veneer on the inside of the bend for a couple of inches at the aft end. Wet the wood and then bend. Use a steam iron. If you are unable to get the bend, then sand the first layer of veneer away on the outside. This will make the plywood much easier to bend as you will now be bending only a single layer of veneer.

❏ Scarf this skin to match the scarf in the trailing edge skins at Sta. 0.

❏ Mask and varnish this skin. Drill the four drain holes shown (on the left and right sides of the bottom spruce strip).

❏ Glue this skin on the rudder. Scuff-sand the plywood before gluing.

❏ Cut out the opening required for the tail light. See Drawing No. 411, Detail A.

❏ Install the two spruce blocks required for the tail light. Scuff-sand the plywood before gluing. See Figure 17.

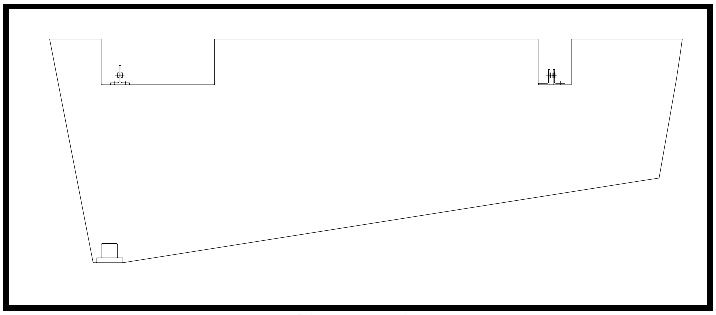


Figure 17

❏ Install the tail light.

Note: The tail light is installed with two small machine screws (with 4-40 screw threads, we understand). The simplest installation is to epoxy the nuts in the wood. As an alternative, you could drill and tap a short piece of 3/16"Ø aluminum and epoxy this in place. One other possibility, hardware stores sell something known as a Tric-Nut. This is intended to be expanded into a piece of sheet metal—you could just epoxy one of these into the spruce and then tap out the threads to clean out any excess resin.

Chapter 21
Fin Assembly

The fin is assembled just like the stabilizer, elevator and rudder. You have to make sure that the fin spars will match the stabilizer spars. This can be accomplished in three ways:

One way is to glue the main stabilizer spar to the main fin spar, glue the intermediate fin ribs in place, then glue the forward fin spar to both the fin ribs and the forward stabilizer spar and complete the assembly of the fin. This method will insure that the fin spar spacing will match that of the stabilizer spars. The primary disadvantage is that the skinning of the fin will be difficult with the stabilizer in place. The skinning is normally done on a flat jig table. The length of the stabilizer (roughly ten feet) will require that the table be at least five feet from the floor. In addition, the ceiling height must also accommodate the elevator, and not every shop will do this.

The second way is to use a block of wood to hold the fin spars the required 350mm apart. This block can be clamped in place, and it will assure the proper spacing. This is a compact method of assuring that the fin will mate with the elevator. Since the block is not as wide as the stabilizer, there will be plenty of working space around the fin while you are assembling it.

The third way is to build the fin with the stabilizer clamped in place. This method is the same as the first method, except in this case the stabilizer is not glued to the fin. We think this method is the best choice, and it will allow you to check the position of the forward fin spar with the forward stabilizer spar as you assemble the fin. This method also allows you to skin the fin without having the stabilizer in place. The only disadvantage is that the stabilizer will require that you work around it while you assemble the fin.

We will describe this third method; however, you may use one of the other methods if you prefer.

❏ Cut the longeron cutouts in the main fin spar. There are three: two side longeron and the bottom center longeron. Be careful to cut the tops of the side longerons to match the lower profile of the main stabilizer spar.

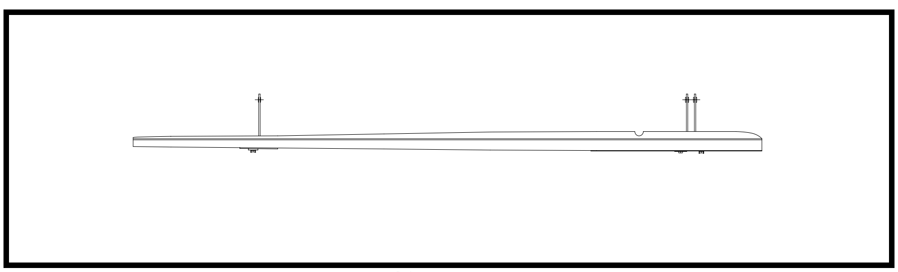


Figure 1

❏ Install the triangular strips on the aft face of the fin spar. See Figure 1. Scuff-sand the plywood before gluing.

Note: You will have to cut a small clearance radius in these strips for the hinge bolt of the center elevator hinge, and you will have to notch the strips around the upper fin hinges.

Some builders have gone to great difficulty to taper the triangular strips prior to gluing them in place. We feel that the easiest method is to use 15x15 triangular strips and glue them in place and then cut off the excess. These strips are shown on Drawings No. 413 and 415, which are very accurately drawn. Thus, we suggest that you take the necessary measurements from these drawings. See Figure 2, Chapter 19.

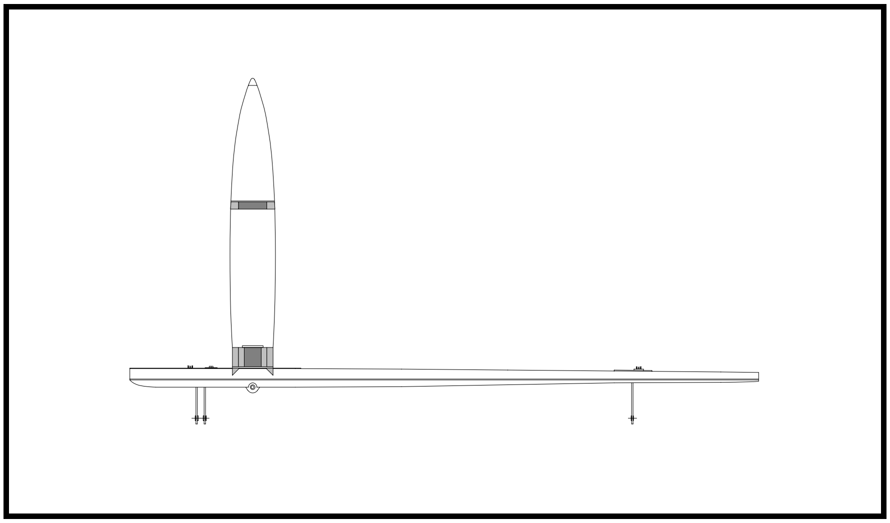


Figure 2

- ❏ Join the main fin spar to the main stabilizer spar, but do not glue at this time. See Figure 2. The bolts for the stabilizer hinges will hold things in place.

Note: Remember to install the stabilizer with the trim tab cable tube on the right side of the aircraft and with the hole in the forward stabilizer spar on the upper side. (By "upper side" we are referring to its installed location in the airplane. If confused, see Drawing No. 410, Section B-B.)

- ❏ Place the main fin spar, forward face up, on the edge of the jig table with the stabilizer across the jig table. Since you will be clamping the ribs to the spar, it will be best if you place the spar near the edge of the jig table, or use 20x20 extensions from the table. Use a water level to level the main fin spar. Use a water level to make sure that the stabilizer is level, block and clamp in place. Make sure that the stabilizer chord line is exactly vertical. For this you can use a plumb bob to check the centerlines of the stabilizer Sta. 1 ribs. You can use two wood blocks clamped to the forward and main stabilizers, say 100mm long, to make an offset of the rib centerline, and hang a plumb bob from the upper block. As with the stabilizer ribs, you have to be careful not to use a carpenter's square to set the vertical alignment of the ribs due to the taper of the spar. Use a plumb bob, carpenter's level or combination square.

- ❏ If not already done, drill holes required in the intermediate ribs at Sta. 2 and 3 for the COM antenna coaxial cable (see Drawing No. 411 and 413). If you are going to install a Loran antenna on the forward face of the main fin spar, you should run this wire now. You may drill some holes in the ribs for this wire, but if the wire is small, a small groove may be cut in the braces of the spar.

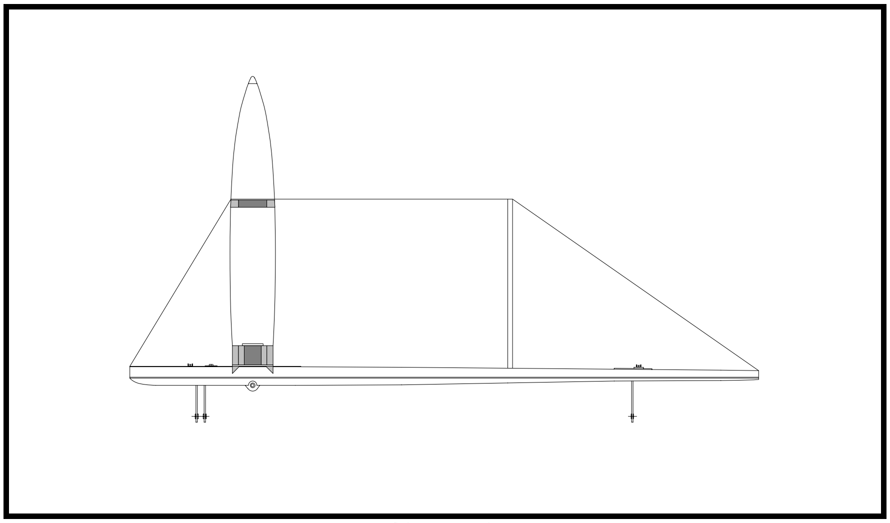


Figure 3

- ❏ Fit the intermediate rib for Sta. 3, P/N 413-4, to the main fin spar. Clamp in place. See Drawing No. 411 and Figure 3.

  Note: In the following steps, you will be looping a string over this rib to align the Sta. 2 rib. Since the tension of the string will pull the ribs over, we suggest you make a wood brace to hold the rib at the proper vertical position.

  Since the forward face of the main fin spar is tapered, you cannot use a carpenter's square against the forward face to align the rib since this would result in the rib tilting. A combination square could be set to the correct angle, and a plumb bob or carpenter's level might be used for the vertical alignment of the rib.

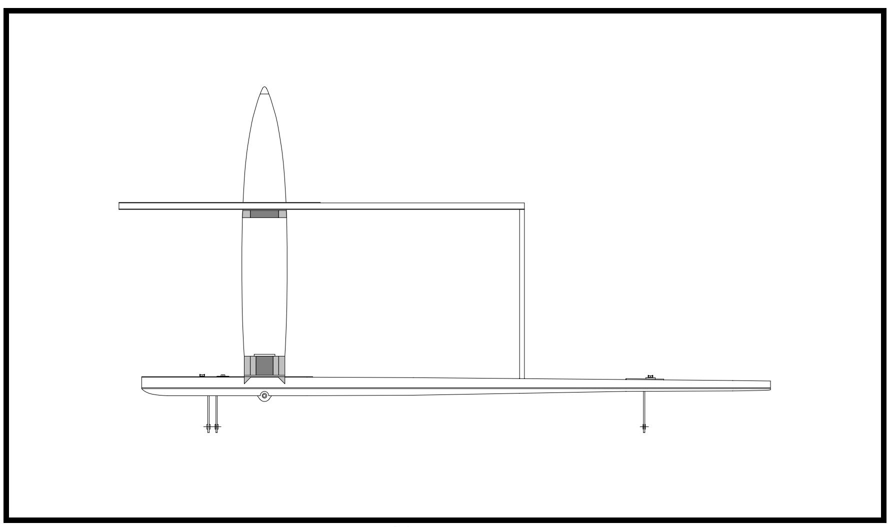


Figure 4

- ❏ Trial fit the forward fin spar. See Figure 4. The line for W.L. 70 on the forward fin spar should be aligned with the centerline of the forward stabilizer spar. Use a water level to check that the forward fin spar is parallel to the main fin spar. The distance from the aft face of the main fin spar to the aft face of the forward fin spar should be 375mm, but with the stabilizer already made, it is too late to change anything now. If you are off this dimension, you will have to adjust the lengths of the intermediate fin ribs.

❑ Glue the intermediate rib for Sta. 3 to the main fin spar

❑ Loop a string over this rib and over the forward stabilizer spar to locate the centerline of the rib at Sta. 2. See Figure 3. You should brace the rib and stabilizer for the tension of this string.

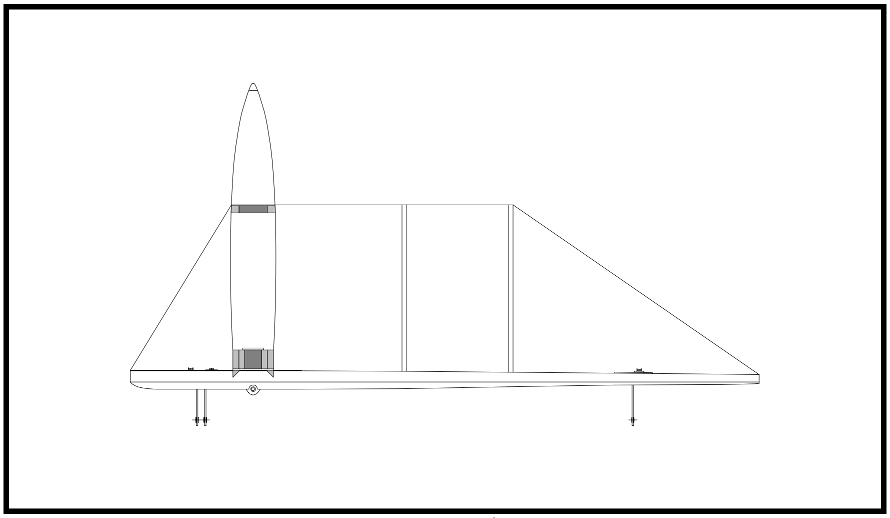


Figure 5

❑ Fit the intermediate rib for Sta. 2 in place. See Figure 5.

❑ Trial fit the forward fin spar to the ribs. This will require that the alignment string be removed temporarily. Sand the forward end of the rib for the forward fin spar.

❑ Glue the intermediate rib for Sta. 2 to the main fin spar. While the glue is drying, it would be a good idea to clamp the forward fin spar in place to make sure that everything is aligned. See Figure 6.

❑ Glue the forward fin spar to these ribs, but do not glue the forward fin spar to the forward stabilizer spar. Clamp to the forward stabilizer spar during this gluing operation. See Figure 6. Scuff-sand the plywood before gluing.

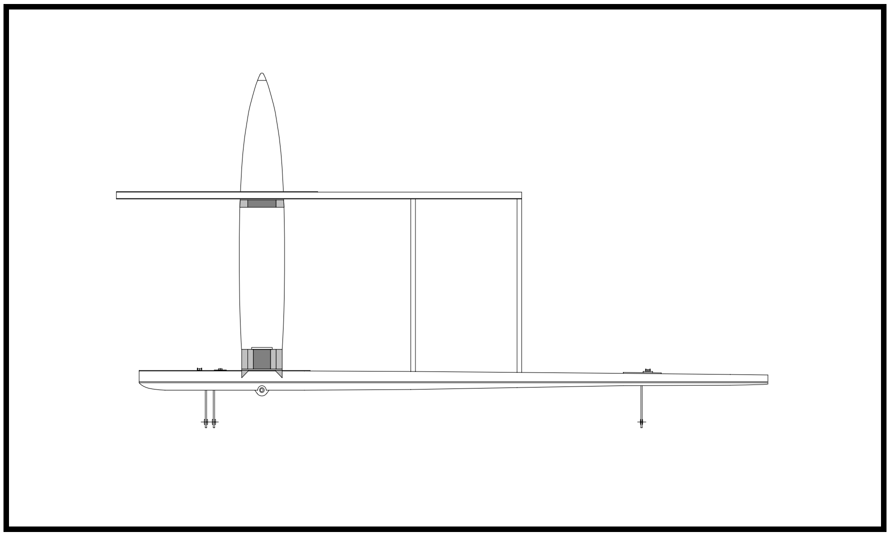


Figure 6

- ❏ Fit the leading edge ribs for Sta. 2 and 5 (P/N 413-3 and 415-6) in place. These ribs must be placed very accurately, since they will be used to align all of the ribs in between. See Figure 7.

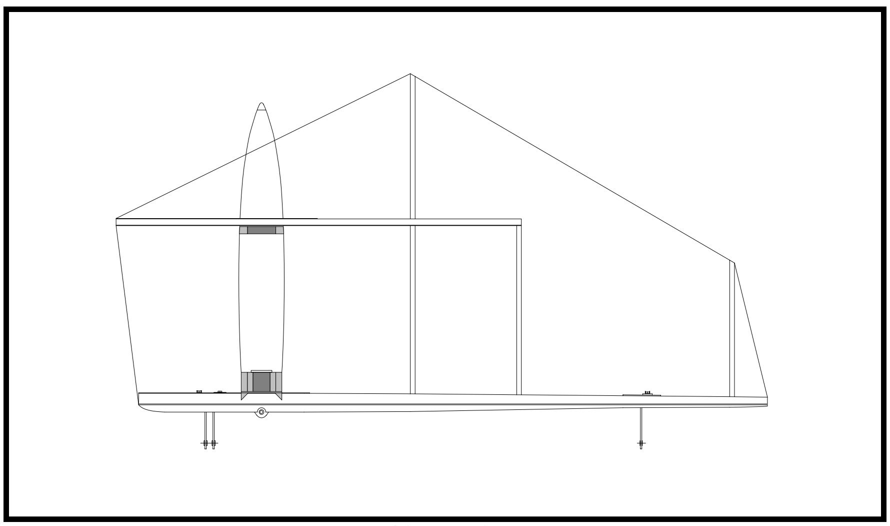


Figure 7

- ❏ Sand the ribs to the correct angle for the leading edge strip.

- ❏ Glue the leading edge ribs for Sta. 2 and 5 in place.

- ❏ Stretch a string across the ribs at Sta. 2 and 5. See Figure 7. This is to align the remaining ribs.

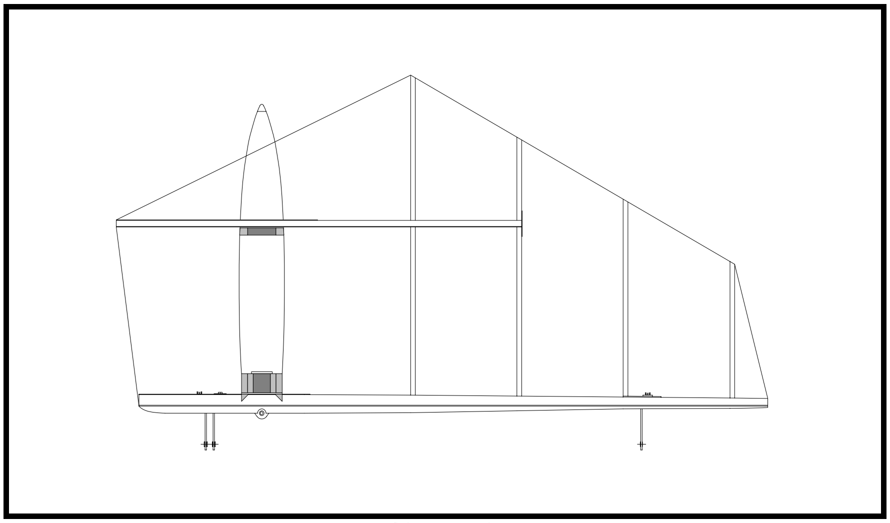


Figure 8

❑ Fit the remaining ribs. See Figure 8. If you wish, you may fit the Sta. 1 ribs (see Drawing No. 410), but these ribs are not installed until after the fuselage skin is installed.

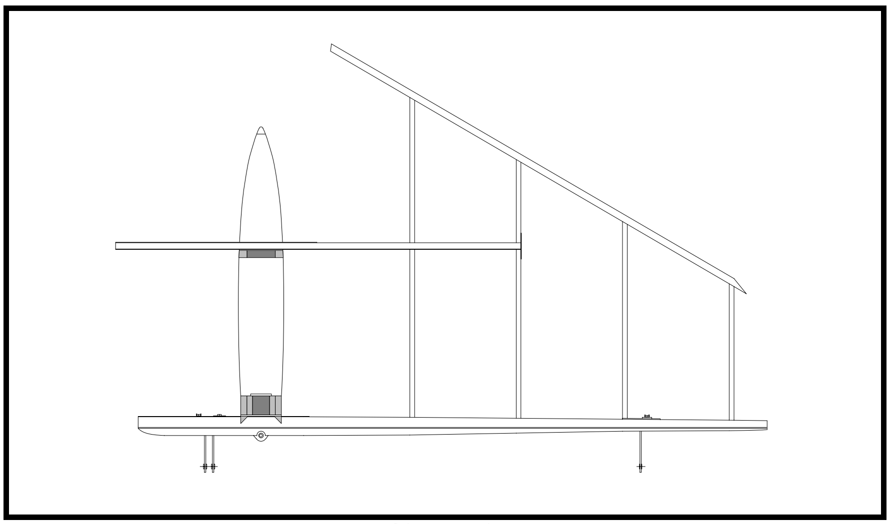


Figure 9

❑ Fit the leading edge strip to the ribs and clamp in place. See Figure 9. Check the fin for alignment. See Drawing No. 415 for the dimensions for the leading edge strip.

Note: When the leading edge strip is finally installed, it will be somewhat difficult to clamp. Because of the angle between the ribs and leading edge strip, the ribs will tend to "squirt" inboard. To keep this from happening, it is best to tack small blocks of spruce to the aft face of the leading edge strip to prevent the ribs from shifting laterally under the gluing pressure.

To make it easier to clamp the ribs to the leading edge strip, triangular blocks may be tacked to the leading edge strip to provide a square clamping surface. See Chapter 19, Figure 10. A small block of wood is inserted into the gusset pocket for clamping.

- ❏ Glue the remaining ribs in place on the forward fin spar and the main fin spar. Do not glue the ribs for Sta. 1 at this time. Scuff-sand the plywood before gluing.

- ❏ Glue the optional piece of 1mm birch plywood to the upper end of the forward fin spar. This is to cover the end grain of the wood to protect it. Scuff-sand the plywood before gluing.

- ❏ Glue the leading edge strip to the ribs (but not to the Sta. 1 rib).

- ❏ Fit and glue the fin tip bow, P/N 415-1, at the end of the fin to the spar and to the leading edge strip. This piece may be of solid spruce or a lamination. See Figure 10.

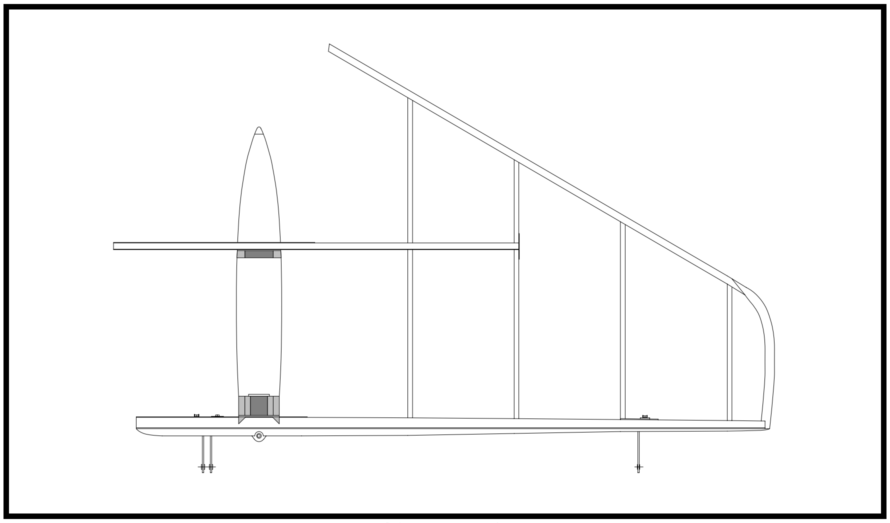


Figure 10

- ❏ The fin may now be removed from the jig.

- ❏ Float sand the entire fin. The leading edge strip must be sanded to a smooth radius. The fin tip bow does not need to be sanded to an exact radius. It should be tapered for the skin to make a blunt wedge shape in cross-section. After the skin is glued down, the ends may be sanded to a smooth radius.

- ❏ Fit the skins to the fin. The skins will extend from the top of the fin to the rib at Sta. 2. See Figure 12. Leave extra material at the tip of the fin for bending. Use small nails as alignment pins.

- ❏ Scarf the skins at Sta. 2 for the lower fin skins that will be installed after the fin is installed on the fuselage (see Drawing No. 410).

- ❏ Soak the skins in water and bend around the leading edge strip. Use a steam iron and pull the plywood down at the fin tip bow to get a smooth compound bend in the plywood. Do this for both the left and right skins.

Note: Remember the importance of the moisture content of the skins. See the note in the section on skinning the stabilizer.

❑ Use small nails as alignment pins and mask off the left skin for varnishing. You should also draw the internal structure of the fin on the outside of the skins. This will make it easier to use nails or staples when you glue on the skin.

❑ It is now time to begin work on the installation of the COM antenna. See Figure 11. See Chapter 14 for the antenna installation for specific details relating to the COM antenna. Lay out the COM antenna on the right skin in pencil. Mark the routing of the coaxial cable along the skin.

❑ Put the right skin on the fin and mark the locations of the ribs on the inside of the skin.

❑ Mask the right skin for the ribs, and varnish locally those areas that will be covered by the antenna, the ferrite balun assembly and the coaxial cable. At the ribs, you may varnish those areas directly under the antenna tape.

❑ Mask the left skin and varnish all areas that will not be glued.

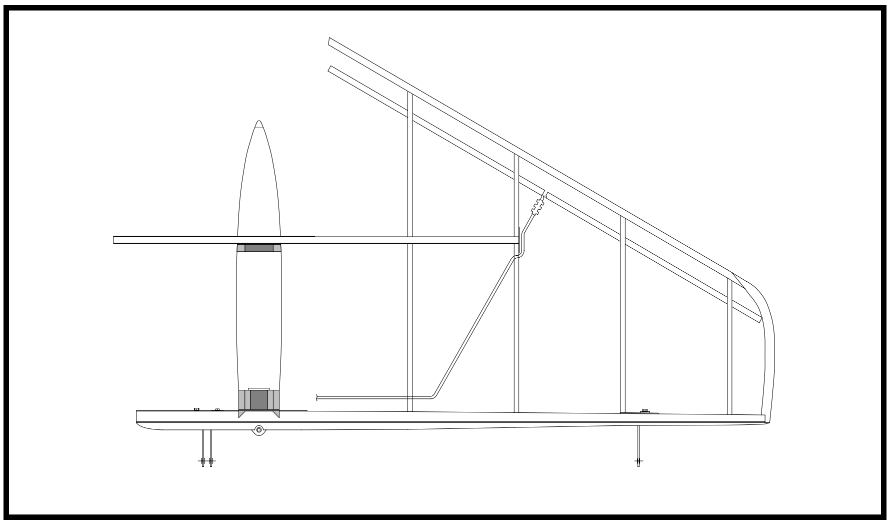


Figure 11

❑ Varnish the entire structure of the fin except for the surfaces to be glued when the skin is installed. Varnish under the channel-nuts and under hinges.

Note: If you wish, this varnishing of the fin structure may be postponed until later. You will be varnishing the inside of the right skin before you close the fin; however, you will find it easier to reach all of the nooks and crannies with everything open.

Skinning the Fin

❑ Install the channel-nuts for the upper fin hinges. To prevent moisture from getting under the channel-nuts, they should be bedded down with wet zinc chromate primer or epoxy.

❑ Install the COM antenna on the right skin. The ferrite balun assembly and coaxial cable do not have to be installed at this time. Note that the bottom part of the antenna will be hanging loose until the lower skin is installed. This copper tape is easily broken, so roll the tape into a tight coil and tape to the bottom of rib No. 2 with masking tape.

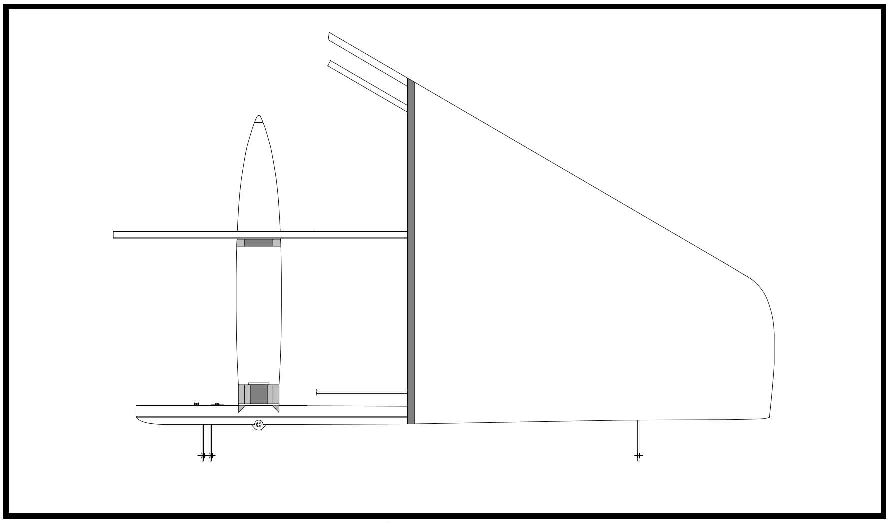


Figure 12

- ❏ Glue on the right skin. See Figure 12. This skin will extend from the top of the fin to the rib at Sta. 2. Scuff-sand the plywood before gluing.
- ❏ Install the ferrite balun assembly and the coaxial cable for the COM antenna on the inside of the right skin.
- ❏ Varnish the inside of the right skin. The next step will be to close the fin, so you must check to make sure that all internal surfaces are varnished.
- ❏ Feather the right skin at the leading edge to receive the left skin.
- ❏ Glue on the left skin. This skin will extend from the top of the fin to the rib at Sta. 2. Scuff-sand the plywood before gluing.
- ❏ Feather the left skin at the leading edge.
- ❏ Sand a smooth radius on the top of the fin.

Chapter 22
Aileron/Flap Assembly

This chapter will cover the assembly of the aileron and flaps and the installation of their hinges. If you wish, you may do this work simultaneously with the work covered in Chapter 23 “Wing, Preliminary Assembly” and Chapter 25 “Fuselage, Preliminary Assembly”.

Kits on Hand

To assemble the ailerons and flaps you should have the following kits:

Kit No. 201 Wing Spars
Kit No. 205 Wing Ribs
Kit No. 803-1 Wing Equipment

If not included in the kits, you will need the following sheets of plywood

1mm birch plywood: 3 sheets (48”x48” or 50”x50”)
2mm birch plywood: 2 sheets (48”x48” or 50”x50”)

We also suggest that you review the kit requirements of Chapter 25 “Wing, Preliminary Assembly”, Chapter 24 “Wing Assembly” and Chapter 25 “Fuselage, Preliminary Assembly” for possible ordering at this time.

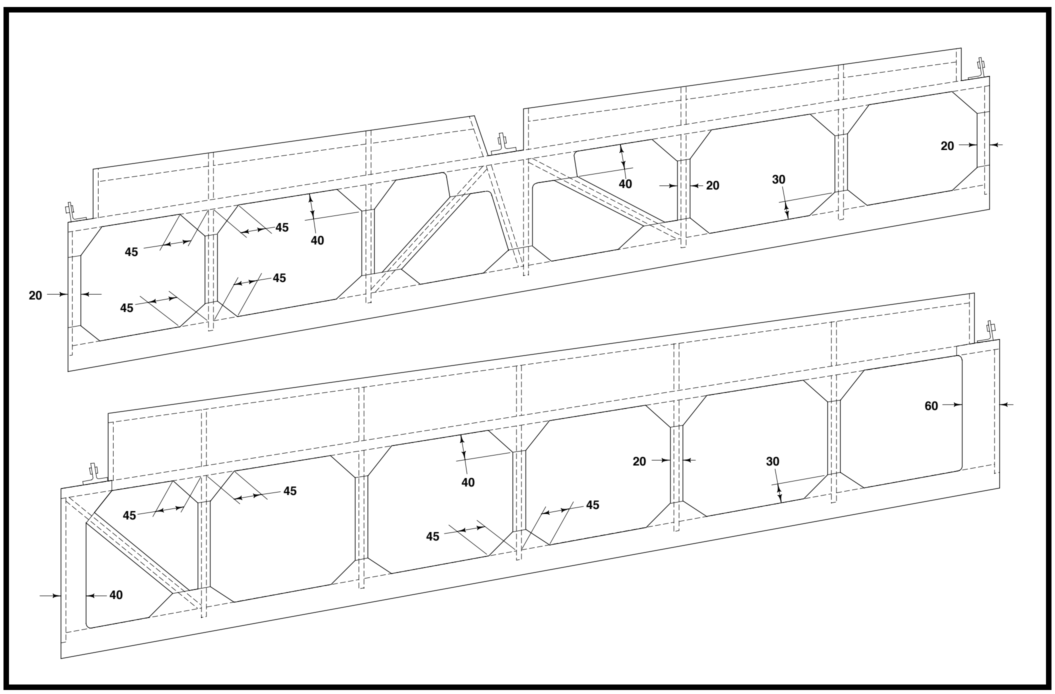


Figure 1

The drawings show the ailerons and flaps completely skinned with plywood, which is slightly heavier than the wood-and-fabric versions but much simpler to build and will give smoother surfaces. Figure 1 shows details for fabric covered ailerons and flaps. The spruce trailing edge strip may not be reduced in dimension since the full width is needed to carry the fabric tension.

Aileron/Flap Hinge Installation

- ❑ Draw the chord lines on the forward and aft face of the aft wing spars.

- ❑ Draw the wing stations on the aft face of the aft wing spar. See Drawing No. 206.

- ❑ Draw the wing stations on the forward face of the aileron/flap spar. See Drawing No. 206.

- ❑ Lay out the locations of the "hinge opening" leading edge ribs on the front face of the aileron/flap spar. These ribs do not fall directly on a wing station and should be laid out prior to the installation of the hinges. See Drawing No. 203. As you can see from Drawing No. 206, the stations on the aileron/flap spar are actually 253mm per 250mm wing station, thus the growth of horizontal dimensions is very small. You can see all of the interference/clearance problems for these leading edge ribs on Drawing No. 204

- ❑ Ream all 1/4" hinge bolt bushings with 1/4" reamer. (See Drawing No. 204 for the following steps.)

- ❑ Install all tapered plywood hinge pads on the aft face of the aft wing spar.

- ❑ Install all 1/4" hinge bolts in the hinges and assemble the hinges together.

  Note: To align the aileron and flap hinges, a number of builders have found it helpful to use a long 1/4"Ø steel rod. Others have used threaded steel rods or wooden dowels for the same purpose.

- ❑ Clamp all hinges in position on the aileron, flap and aft wing spars. Check to make sure that the hinges are working smoothly and that all hinges are correctly located.

  Note: The drawings show P/N 746 installed with the bolts inboard. Some early builders reported that there wasn't enough solid wood in the spar for this, so they switched the L.H. and R.H. hinges and installed the hinges with the bolts on the outboard end. There is really nothing wrong with doing this, but it will make the two 3/16" nuts difficult to reach.

- ❑ Remove the hinge bolts and drill the 3/16" bolt holes for P/N 743.

  Note: It is always best to drill such bolt holes with a drill press; however, you will find it easiest if you use a hand-held drill to start the hole, then remove the hinge and complete drilling the hole with a drill press.

- ❑ Install the channel-nuts for P/N 743. Do not install the screws for the channel-nuts at this time.

- ❑ Re-assemble the hinges with the hinge bolts and check for smooth operation of the hinges.

- ❑ Remove the hinge bolts and drill the 3/16" bolt holes for P/N 748.

  Note: Plywood pads are installed under the channel-nuts to make the bolt lengths come out right. These will be installed after all of the hinge bolt holes are drilled.

- ❑ Install the channel-nuts for P/N 748. Do not install the screws for the channel-nuts at this time.

- ❏ Re-assemble the hinges with the hinge bolts and check for smooth operation of the hinges.
- ❏ Remove the hinge bolts and drill the 3/16” bolt holes for P/N 747.
- ❏ Install the channel-nuts for P/N 747. Do not install the screws for the channel-nuts at this time.
- ❏ Re-assemble the hinges with the hinge bolts and check for smooth operation of the hinges.
- ❏ Remove the hinge bolts and drill the 3/16” bolt holes for P/N 749.
- ❏ Install the channel-nut for P/N 749. Do not install the screws for the channel-nut at this time.
- ❏ Re-assemble the hinges with the hinge bolts and check for smooth operation of the hinges.
- ❏ Remove the hinge bolts and drill the 3/16” bolt holes for P/N 742.
- ❏ Install the channel-nuts for P/N 742. Do not install the screws for the channel-nuts at this time.
- ❏ Re-assemble the hinges with the hinge bolts and check for smooth operation of the hinges.
- ❏ Remove the hinge bolts and drill the 3/16” bolt holes for P/N 744.
- ❏ Install the channel-nuts for P/N 744. Do not install the screws for the channel-nuts at this time.
- ❏ Re-assemble the hinges with the hinge bolts and check for smooth operation of the hinges.
- ❏ Remove the hinge bolts and drill the 3/16” bolt holes for P/N 745.
- ❏ Install the channel-nuts for P/N 745. Do not install the screws for the channel-nuts at this time.
- ❏ Re-assemble the hinges with the hinge bolts and check for smooth operation of the hinges.
- ❏ Remove the hinge bolts and drill the 3/16” bolt holes for P/N 746.
- ❏ Install the channel-nut for P/N 746. Do not install the screw for the channel-nut at this time.
- ❏ Install P/N 818 aileron control stops on P/N 745.
- ❏ Mark cutouts in the aft wing spar for aileron pushrod. See Drawing No. 206.
- ❏ Mark cutouts in the aft wing spar for the flap pushrod. See Drawing No. 206.
- ❏ Cut out the holes for the aileron and flap pushrods as noted above.

❏ Drill four 1/8"Ø vent holes in the aileron/flap spar as shown on Drawing No. 206.

❏ Install the plywood pads under the channel-nuts as shown on Drawing No. 204. You can glue on the pads and then re-drill the bolt holes through the plywood pads, or you can clamp the pads in position, drill through them and then use the channel-nuts to clamp the pads in position while gluing.

❏ Trace the outline of all hinges and channel-nuts for varnishing, then remove and varnish the wood under these hinges and channel-nuts. Be careful not to get varnish on the spars where the ribs will be glued.

❏ When the varnish is dry, re-install all channel-nuts. The screws for the channel-nuts should be installed at this time. Pilot drill the wood with a 3/32"Ø drill. Ream the 1/8"Ø holes in the channel-nuts with a 9/64"Ø or No. 27 (.1440"Ø) drill.

Note: You may be tempted to skip the installation of the channel-nuts—don't do it! After the diagonal trailing edge ribs are installed, they are difficult or impossible to install.

The hinges are not installed during skinning since they will interfere with float sanding and the jigging method.

❏ Cover the threaded ends of the channel-nut bolts with masking tape to protect them from glue during assembly.

❏ Prime the channel-nuts with zinc chromate primer to prevent corrosion, or paint with epoxy.

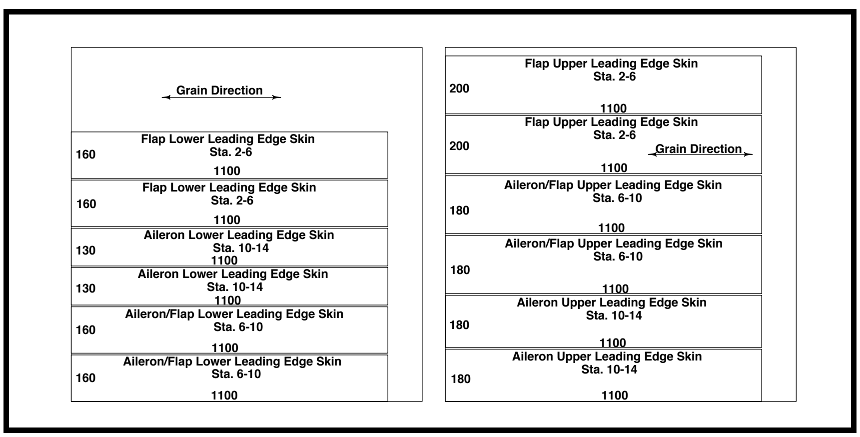


Figure 2

Aileron/Flap Assembly

❏ Use two 48"x48" or larger sheets of 2mm birch plywood and cut in accordance with Figure 2. These dimensions allow about 25mm of extra material. You may want to increase the widths of the upper leading edge skins by 20mm (to 220 and 200) for extra material required by the 20x20-glued-to-an-overhang method of bending the plywood.

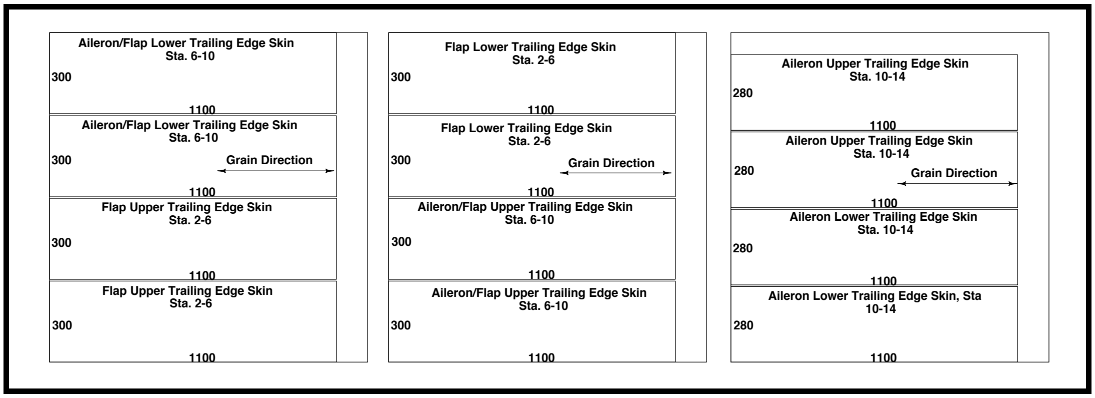


Figure 3

❑ Use three 48"x48" or larger sheets of 1mm birch plywood and cut in accordance with Figure 3.

The aileron and flap are assembled as a single unit and will remain as a single unit until after the wing is assembled. The trailing edge of the aileron/flap assembly will include enough extra length for the wing. This will simplify the alignment of the trailing edge and insure that the wing, aileron and flap will be aligned.

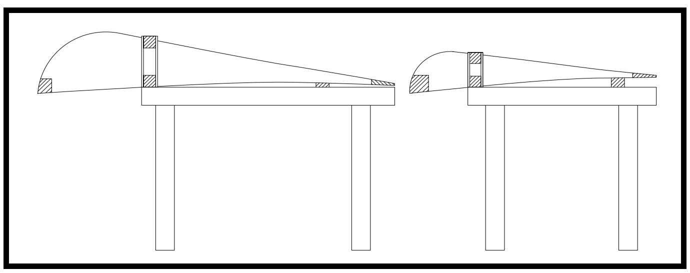
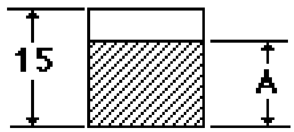


Figure 4

The aileron/flap assembly will require a number of simple jigs. As shown in Figure 4, the aileron/flap spar will be placed on the edge of a flat table—this will allow the leading edge ribs to clear the table. The aileron/flap spar is clamped in place so that it is exactly perpendicular to the jig table. The trailing edge ribs are installed on the aft face of the spar. To assure proper alignment, a long notched strip of wood is used to support the trailing edge ribs at the 95% chord station. Figure 4 shows a section through Station 2 and Station 14, as do most of the other illustrations in this chapter.

At the 95% chord station, the ribs are 253.5mm between stations when measured on the diagonal. The thickness of the notched strip of wood is the difference between the altitude of the bottom of the spar and the altitude of the bottom of the rib. (The bottom of the aileron/flap spar is calculated from 69.0 at station 1—a theoretical point—and 71.0 at station 14.)



	A
Sta 2	3.6
Sta 3	4.2
Sta 4	4.7
Sta 5	5.2
Sta 6	5.8
Sta 7	6.3
Sta 8	6.8
Sta 9	7.3
Sta 10	7.9
Sta 11	8.4
Sta 12	8.9
Sta 13	9.5
Sta 14	10.0

Figure 5

- ❑ Make the notched wooden strip for the 95% chord station. Use a piece of 15x15 pine about 3400mm or 11-1/2' long—it isn't structural so you *can* piece it together from shorter scrap pieces. It is important that the strip of wood be no higher than 15mm so that it will not interfere with float sanding for the upper skin. At the 95% chord station, the wing stations are 253.5mm apart. Cut a notch into the strip at each station to the dimension shown as "A" in Figure 5.

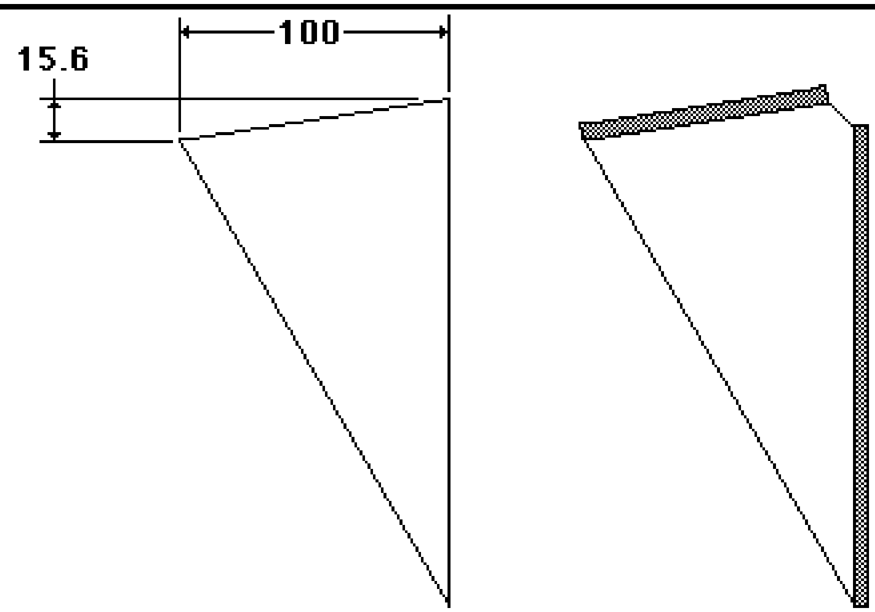


Figure 6

- ❑ Make a number of angle guides for the ribs by cutting some scrap pieces of wood to 81.1°—use the method shown in Figure 6 if you do not have a protractor. These will be used to align the ribs with the spar as shown in Figure 7. Glue some scrap pieces of plywood to each face as shown on the right side of Figure 6. The short face will be clamped to the forward or aft face of the spar. The ribs will be clamped to the long face of the angle guide. The length of the long face not terribly important—150mm will be fine. Cut the corner away so that glue squeeze-out will not glue the angle guide to the ribs and spar. You might as well make a lot of these angle guides so that you will not be slowed down by a lack of them—12 would be ideal. You should also make two angle guides with an angle of 98.9° to clamp against the outboard face of the Sta. 2 flap trailing edge rib. Use the same method shown in Figure 6 and extend the angled line to the right. The angle guides will also be used to brace the leading edge ribs when sanding for the leading edge strip. You will need to modify these slightly to clear the channel-nuts.

Note: For technically minded builders, the aileron/flap spar is installed so that at Sta. 14 it is 509.1mm forward of its theoretical position at Sta. 1. Thus the angle of the ribs is determined by the slope of 509.1:3250, 39.16:250 or 15.66:100.

❏ Drill vent holes in the leading edge and trailing edge ribs as shown on the drawings. Note that not every rib has a vent hole. The position of the vent holes in the ribs and spar is intended to make it difficult for water to find its way into the leading edge section and to provide drainage for any moisture that gets into the trailing edge section. The drain holes along the trailing edge of the ailerons are very important since water or ice in the aileron trailing edge would increase the risk of aileron flutter—and *that* can lead to inflight airframe breakup and fatalities.

❏ Mark the 95% chord station on each trailing edge rib as shown on the drawings. These marks will be used to position the notched strip shown in Figure 5.

❏ Cut the trailing ribs for the trailing edge strip as shown on the drawings.

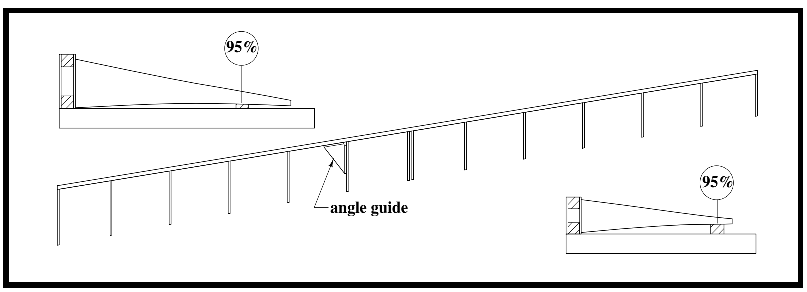


Figure 7

❏ Install the trailing edge ribs on the aileron/flap spar. See Figure 7. Clamp an angle guide to the spar and each rib to hold the rib at the correct angle. Use the angle guide to set the angle of the table on a stationary disc/belt sander when you sand the ribs to match the spar.

Note: While installing these trailing edge ribs, you may consider using the trailing edge strip to help align the ribs. For those who care to work to super-precision, Drawing No. 206 provides you with all of the dimensions needed for notching the trailing edge strip. Once notched, the trailing edge strip will assist in holding the ribs in place.

If you plan to notch the trailing edge strip to match the ribs as installed—rather than using the dimensions on Drawing No. 206—then it would be best if you work on one rib at a time. Clamp the rib in position, then fit the trailing edge strip and mark it for notching, notch it and then go to the next rib. If you install all of the ribs and then work on marking and notching the trailing edge strip you will have a more difficult time since all 14 ribs will fit into the notches or the trailing edge strip will not fit into place since one rib can prevent it from mating.

The notched strip of wood will correctly position the trailing edge rib at the 95% chord station, but at the aft face of the spar you should refer to the rib drawings to note the correct position. This is not as simple as it sounds since the spar will end up with some curve sanded into it. At each end, the ribs will appear to be installed too low when they are installed correctly. The rib drawings show the aileron/flap spar in its rectangular as-built-in-the-jig shape, and you must measure from this rectangular shape to correctly position the trailing edge ribs on the aft face of the spar.

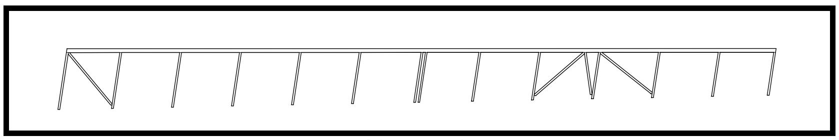


Figure 8

- ❏ Temporarily clamp the trailing edge strip in place. Fit and install the diagonal flap and aileron ribs. See Figure 8. The channel-nuts for the aileron and flap hinges should be permanently installed. After the diagonal trailing edge ribs are installed, most of the channel-nuts are difficult to remove and the channel-nut for the inboard flap hinge is probably impossible to remove.

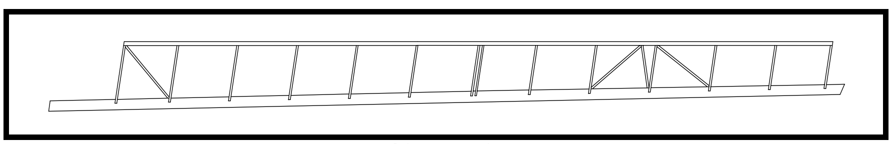


Figure 9

- ❏ Install the trailing edge strip. See Figure 9. Notch the trailing edge strip for the wing ribs at Sta. 1, 2, and 14 as shown on Drawing No. 206.

- ❏ Fit the leading edge ribs and notch them for the leading edge strip. As with the trailing edge ribs, refer to the rib drawings to locate the vertical positions of the ribs on the spar.

- ❏ Cut the leading edge ribs for the leading edge strip.

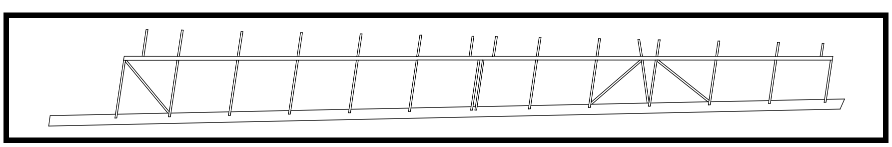


Figure 10

- ❏ Install the leading edge ribs. Use the angle guides to hold these ribs in place while gluing. See Figure 10. Check to make sure the leading edge ribs at the hinge openings will clear the hinge bases of the hinges installed on the aft wing spar—see Drawing No. 204.

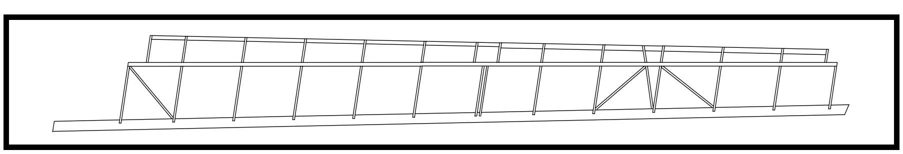


Figure 11

❏ Fit and install the leading edge strips into the flap and aileron leading edge ribs. See Figure 11. The notching already done in the leading edge ribs may be all that is required, although you may have to sand or shim in a few places. Because of the method that will be used to bend the upper leading edge skins, it is best to make the leading edge strips continuous across the hinge openings.

Note: The aileron uses a hardwood leading edge strip as an aileron balance weight. 15x15 beech was specified on the original plans, but our experience is that the use of 20x20 beech, walnut or oak will bring the balance point of the aileron into the middle of the acceptable balancing range, and is particularly important for an aileron skinned entirely with plywood.

To sand the notches, use a sanding stick to get the final fit for the leading edge strip. The sanding stick should be long enough so that the non-sandpapered end will rest on the adjacent rib while you sand the notch. (A good size of sanding stick to make is 20x20x480 and glue a 20mm wide by 11" long strip of sandpaper to one side—sandpaper comes in 9"x11" sheets in the U.S.)

Before installing the leading edge strip, it is best to sand it to the airfoil contour. This way you run less risk of breaking off the leading edge ribs while sanding.

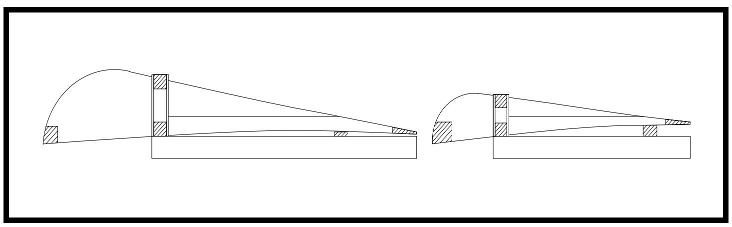


Figure 12

❏ Use an 18 to 20mm wide ruler—or some other parallel-edge device—to draw a horizontal line on the outboard face of Sta. 14 rib and on the inboard face of Sta. 2 rib as shown in Figure 12. This line is parallel to the top of the jig table, thus it is also parallel to the horizontal reference line for each rib. This line will be used as a cross-check to assure alignment while skinning. As you will see in the following steps, the line must be above the trailing edge strip to use a plumb line—you can't hang a plumb line *through* the trailing edge strip.

❏ Screw blocks to the jig table to keep the assembly from sliding around while you float sand. These should fit against the spars and ribs.

❏ Float sand the top of the ailerons and flaps to prepare for skinning.

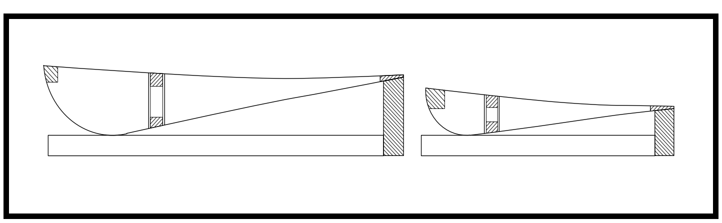


Figure 13

❑ Turn the aileron/flap assembly over and support the trailing edge with a long straight board as shown in Figure 13. The trailing edge strip can be closer to the table than shown and the long straight board need only keep the trailing edge is rough alignment. You don't have to hold the aileron/flap assembly in absolute precise alignment during the float sanding of the bottom. (Another method is to use a one-by-two board supported by shims. The advantage of this method is that the trailing edge is easily clamped to the board, which can be screwed to the shims which can be screwed in place as well. This will help to keep the aileron/flap assembly from sliding around during float sanding, but the clamps must be removed during the sanding of the trailing edge—but you can work on a short section at a time and leave the rest in clamps.)

❑ Screw a few blocks to the table—against the spars and ribs—to keep the assembly from sliding around while you float sand.

❑ Float sand the bottom of the aileron/flap assembly to prepare for skinning.

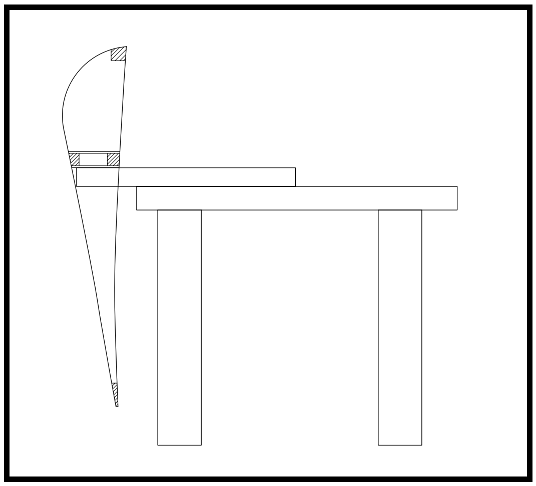


Figure 14

❑ Screw a number of 20x20 pieces of scrap wood to the jig table and clamp the aileron/flap assembly to them as shown in Figure 14. Make sure the spar is straight. Hang plumb lines from each end rib to check for alignment. The plumb line is compared with the line drawn in Figure 12. (Because of the angle of the ribs, the plumb line at Sta. 2 must be offset slightly from the rib.) The 20x20 pieces must be long enough for you to get a clamp between the jig table and the spar so that you can clamp the spar to the 20x20s.

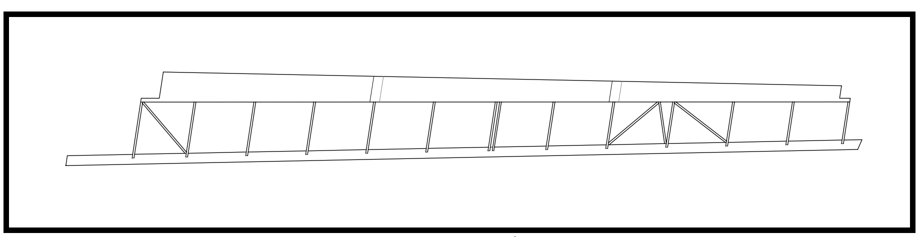


Figure 15

❑ Fit the upper leading edge skins. Soak the plywood in water for 24 hours, clamp in place to bend. See Figure 15. This will be done with 3 pieces of plywood—Sta. 2-6, 6-10 and 10-14.

❑ Trace the outline of the spar, ribs and leading edge strip on the under surface of the upper leading edge skins in preparation for varnishing. Locate each skin with a couple of "alignment pins"—little nails driven through the skin and just barely into a couple of ribs. This will insure that the skin will be glued in the same place.

❑ Mark the spar and make a small sawcut at the trailing edge to mark where the two control surfaces will be cut apart. The skinning will completely cover the joint between the aileron and flap. You do not want to lose track of where to cut.

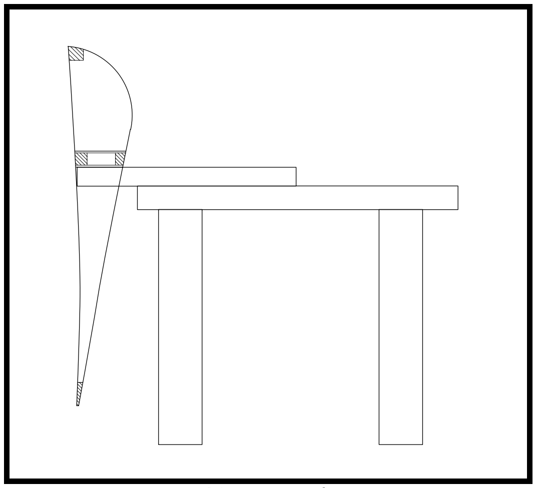


Figure 16

❑ Turn the aileron/flap assembly around so that its lower surface faces away from the jig table. See Figure 16. Clamp in place and check the alignment. It is particularly important that you make sure that the spar is not bowed—lower or higher in the middle—since the next step will stiffen the assembly in that direction.

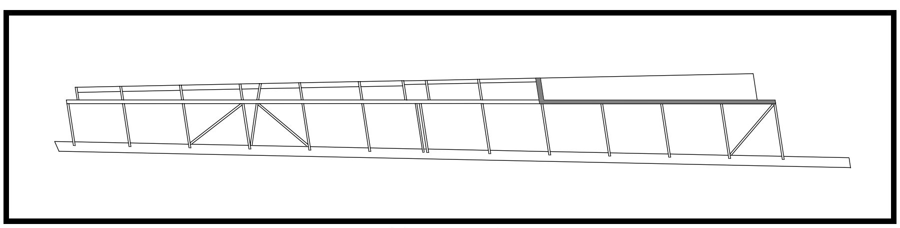


Figure 17

❑ Fit and install the lower leading edge skin between Sta. 2 and 6. See Figure 17. The skin should extend all the way to the inboard end of the flap spar. Before installation, scarf for the joint for the trailing edge skin and the next outboard skin.

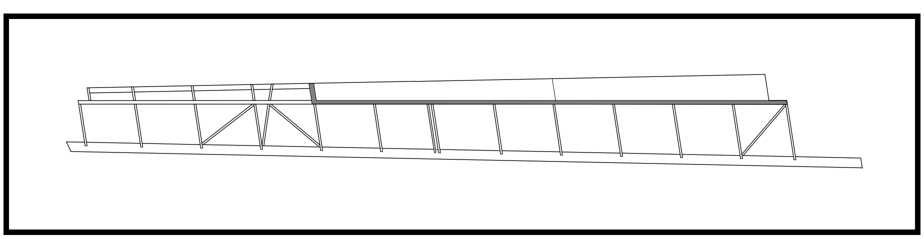


Figure 18

❑ Fit and install the lower leading edge skin between Sta. 6 and 10. See Figure 18. Before installation, scarf for the joint for the trailing edge skin and the next outboard skin.

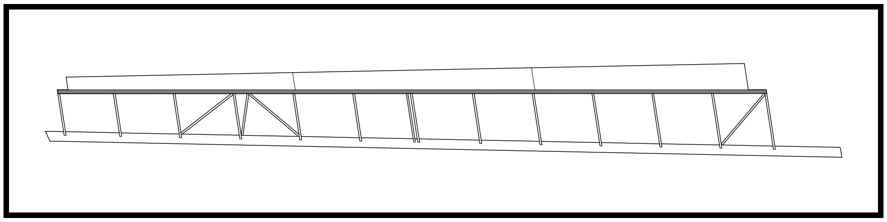


Figure 19

❑ Fit and install the lower leading edge skin between Sta. 10 and 14. See Figure 19. This skin should extend to the outboard end of the aileron spar. Before installation, scarf for the joint for the trailing edge skin.

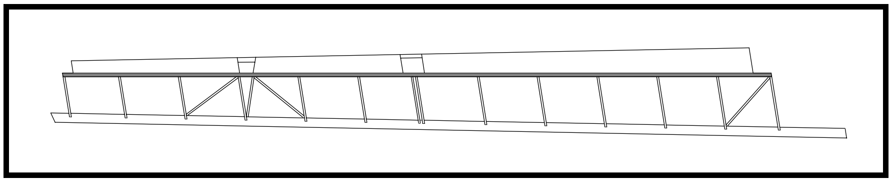


Figure 20

❑ Trim the lower leading edge skin for the hinge openings. See Figure 20. The leading edge strip should not be cut at this time. All you want to do is expose the spar for clamping to the 20x20 jig supports for the next skinning operation.

❑ Trim the lower leading edge skin at the forward end in preparation for installing the upper leading edge skin.

❑ Varnish the inside of the aileron/flap assembly in preparation for skinning. Mask off the gluing surfaces of the ribs, spar, leading edge strip and trailing edge strip to prevent varnish from getting on those surfaces. At this time, you do not have to do any varnishing of the aft ribs or aft face of the spar.

❑ Mask off the gluing surfaces of the upper leading edge skins and varnish in preparation for skinning.

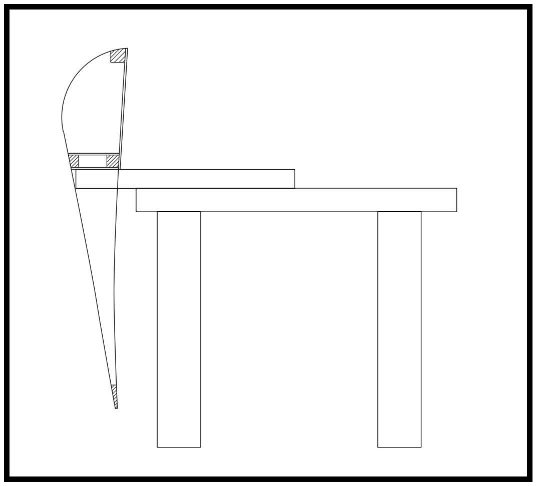


Figure 21

❑ Turn the aileron/flap assembly around so that its lower surface faces toward the jig table as shown in Figure 21. Clamp in place and check the alignment. It is particularly important that you make sure that the aileron/flap assembly is not twisted since in the next few steps you will install the upper leading edge skins.

Note: Up to this stage, the assembly has been rather limber, but when the upper skin is glued in place, nothing short of structural failure is going to change the twist of the ailerons and flaps. There are occasional builders who skin the ailerons and flaps free of any jigs, but very few have been successful at maintaining the alignment. Trust to luck if you will, but it seems to us to make more sense to hold the ailerons and flaps in alignment.

While skinning the leading edge, keep an eye on the trailing edge. If the end ribs stay in alignment and the trailing edge is not bowed then all is well with the alignment.

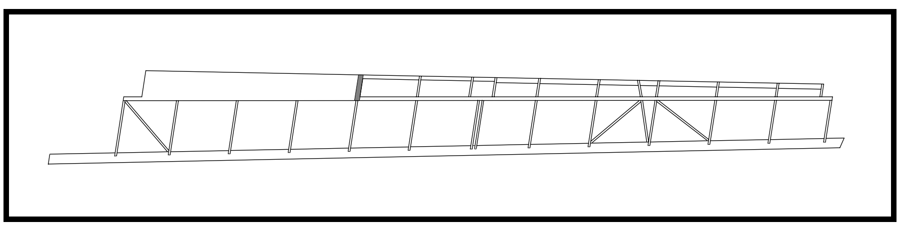


Figure 22

❑ Install the upper leading edge skin between Sta. 2 and 6. See Figure 22. This skin should extend all the way to the inboard end of the flap spar. Scarf for the joint for the next outboard skin, but do not scarf for the trailing edge skin, since you will need the full thickness of the plywood for secure clamping of the skin to the spar.

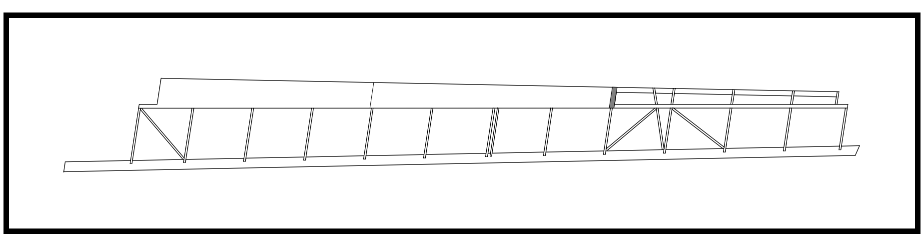


Figure 23

❑ Install the upper leading edge skin between Sta. 6 and 10. See Figure 23. Scarf for the joint for the next outboard skin, but do not scarf for the trailing edge skin.

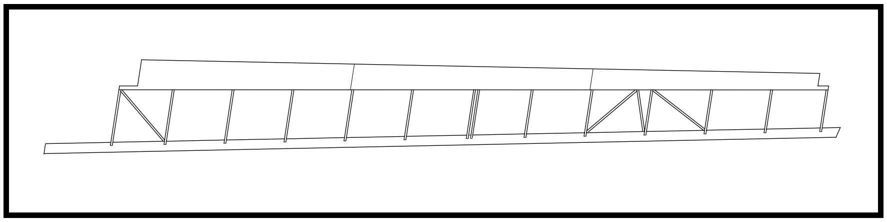


Figure 24

❑ Fit and install the upper leading edge skin between Sta. 10 and 14. See Figure 24. This skin should extend to the outboard end of the aileron spar. Do not scarf for the trailing edge skin.

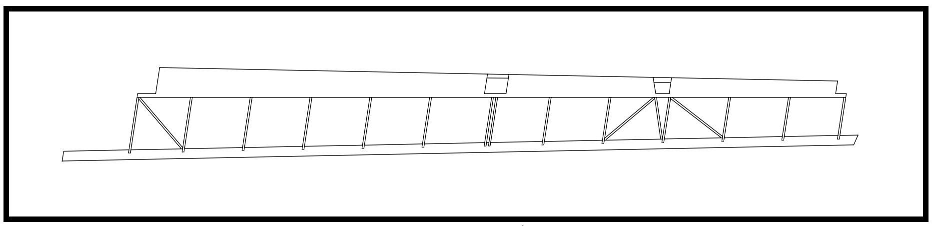


Figure 25

❑ Trim the upper leading edge skin for the hinge openings. See Figure 25. The leading edge skin should not be cut at this time since it will continue to stiffen the assembly during the skinning of the trailing edge. All you want to do is expose the spar for clamping to the 20x20 jig supports for the next skinning operation.

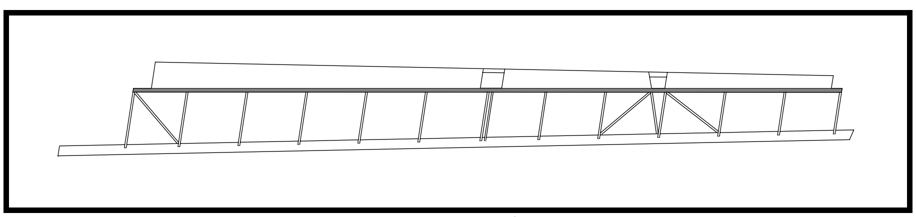


Figure 26

❑ Scarf the upper leading edge skin for the trailing edge skin. See Figure 26.

❑ Because the aileron/flap assembly is now torsionally rigid, you may just lay the assembly on the jig table and do the rest of the skinning without using the jig supports.

❑ Fit the upper trailing edge skins. These skins will be in 3 pieces—Sta. 2-6, 6-10, 10-14. As before, use a couple of tiny nails to assure alignment of each skin. Scarf each skin to fit the scarf at the spar, and each skin should be scarfed to fit the adjacent trailing edge skin.

❑ Trace the outline of the spar, ribs and trailing edge strip on the under surface of the upper trailing edge skins in preparation for varnishing.

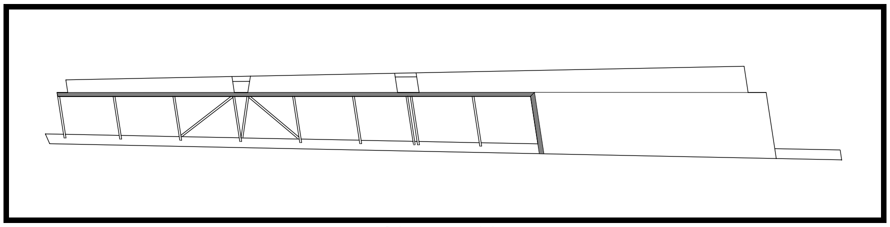


Figure 27

❏ Fit and install the lower trailing edge skin between Sta. 2 and 6. See Figure 27. Although the aileron/flap assembly is torsionally rigid at this stage of construction, the trailing edge can still be bowed and made into a wavy affair by poor clamping technique. It is best to clamp the skin to the trailing edge by sandwiching the trailing edge between two straight boards. Some builders use heavy gauge aluminum angles—find something that is straight and use it.

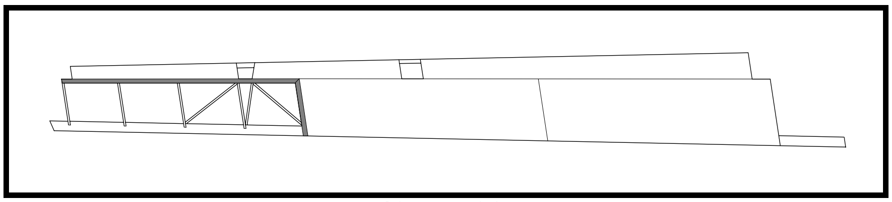


Figure 28

❏ Fit and install the lower trailing edge skin between Sta. 6 and 10. See Figure 28.

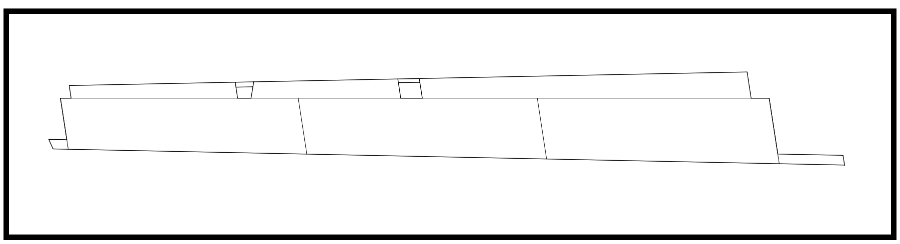


Figure 29

❏ Fit and install the lower trailing edge skin between Sta. 10 and 14. See Figure 29.

❏ Drill all drain holes in the lower trailing edge skin. See Drawing No. 203.

❏ Varnish the inside of the aileron/flap assembly in preparation for skinning. Mask off the gluing surfaces of the ribs, spar and trailing edge strip to prevent varnish from getting on those surfaces.

❏ Mask off the gluing surfaces of the upper trailing edge skins and varnish in preparation for skinning.

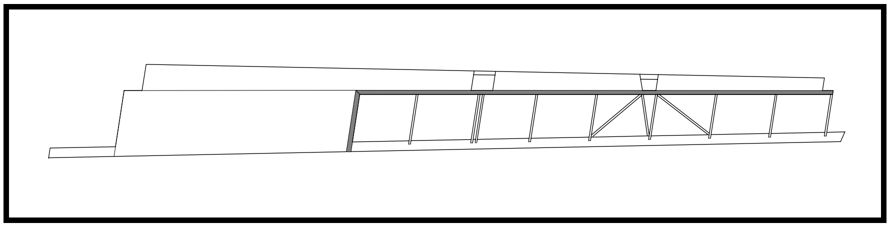


Figure 30

❏ Install the upper trailing edge skin between Sta. 2 and 6. See Figure 30.

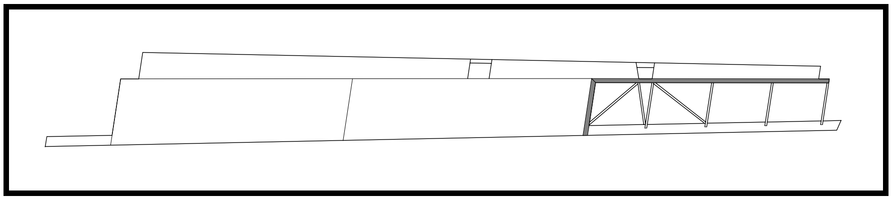


Figure 31

❏ Install the upper trailing edge skin between Sta. 6 and 10. See Figure 31.

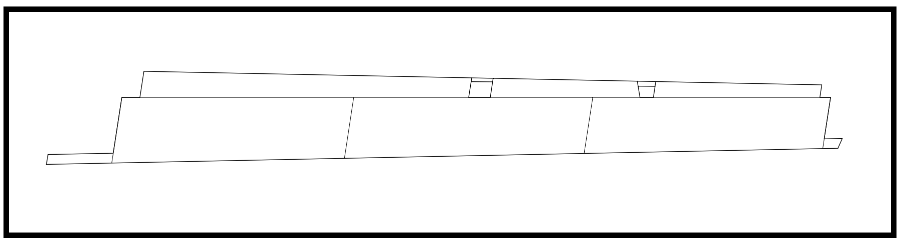


Figure 32

❏ Install the upper trailing edge skin between Sta. 10 and 14. See Figure 32.

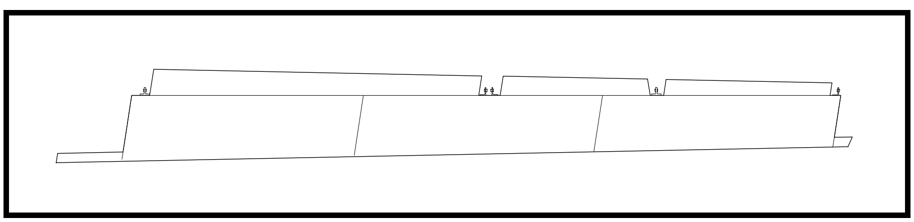


Figure 33

❏ Cut out the hinge openings. See Figure 33.

❏ Trim the trailing edge skins at the trailing edge. Trim the skins off flush with the trailing edge strip and then sand to a radius.

❏ Sand a small radius on the lower leading edge, where the two leading edge skins meet.

❏ Re-install the aileron and flap hinges.

Do not cut aileron/flap assembly in two at this time. The assembly should be in one piece when the wing is assembled.

Chapter 23
Wing, Preliminary Assembly

This chapter will cover the preliminary assembly of the wing. If you wish, you may do this work simultaneously with the work covered in Chapter 22 “Aileron/Flap Assembly” and Chapter 25 “Fuselage, Preliminary Assembly”.

Kits on Hand

To do the work covered in this chapter, you should have the following kits:

Kit No. 302 Fuselage Frames
Kit No. 802 Fuselage Equipment
Kit No. 805-1 Control System Equipment
Kit No. 810-1 or -2 Main Landing Gear & Equipment
Kit No. 812 Landing Gear Retraction Equipment
Kit No. 816 Electrical System

If not included in the kits, you will need the following sheets of plywood

2.5mm birch plywood: 4 sheets (50”x50”—48”x48” sheets are too small)
2mm birch plywood: 7 sheets (50”x50”—48”x48” sheets are too small)
1.5mm birch plywood: 4 sheets (50”x50”—48”x48” sheets are too small)

If not included in the kits, you will need the following spruce pieces:

Seat supports
Wheel well rings
Wing tip bow
20x20x820 spruce stringers (2)
Additional spruce for wing walk, access panel, corner blocking and other minor framing.

We also suggest that you review the kit requirement of Chapters 24 “Wing Assembly” and Chapter 25 “Fuselage, Preliminary Assembly” for possible ordering at this time.

Other Materials

To do the work in this chapter, you should have the following:

Main landing gear tires and tubes
Brown & Sharpe No. 1 tapered reamer.

The tapered reamer may be purchased from a local machine tool supply company or from Travers Tool Company (see F.8L Falco kit price list).

The 5.00x5 tires and tubes may be purchased from a local FBO or from one of the many catalogue companies listed in the Appendix A “Sources”. The 5.30x6 tire and tube may be purchased from Aircraft Spruce and Specialty or from your local Goodyear truck tire center. See “Which Landing Gear” in Chapter 5 “Planning Ahead”.

Spar Fittings Installation

- ❏ On the front and aft faces of the main wing spar, drill the holes shown on Drawing No. 205. The two 3/8”Ø holes at each side of the centerline are for the rudder cables. Due to the angled installation of the cables, the holes are drilled in different locations on the aft face than on the forward face. Beneath these two holes are 25x50 racetrack-shaped holes that will be used for the electrical wiring, fuel line, brake lines, antenna cables, etc. These holes were originally 20x40 but that size proved to be too small. These holes should be positioned so that they are just above the lower spar cap. Obviously, you do not want to drill into the spar cap. The 30x50 hole in the center is for the elevator control pushrod.

- ❏ Cut the openings in the main wing spar for the aileron pushrods. See Drawing No. 206.
- ❏ Drill the vent holes in the forward face of the main wing spar as shown on Drawing No. 205.
- ❏ Mask off and varnish all internal surfaces that will not be glued.
- ❏ Close the main wing spar by gluing on the open-sided plywood web.
- ❏ Review Drawing No. 206 and check to make sure your front wing spar is constructed with solid wood between B.L. 78 and B.L. 225.
- ❏ Drill 1/8"Ø vent holes through the plywood for the forward and aft faces of the front wing spar at each compartment. This will relieve pressure build-ups in the front part of the wing as well as in the spar itself.
- ❏ Mask off and varnish all internal surfaces that will not be glued on the front wing spar.
- ❏ Close the front wing spar.
- ❏ Mark the wing rib chord line on the aft face of the spar for Station No. 1. See Drawing No. 207. Your spar may not be exactly 200mm tall as designed, thus you may have to find the best compromise position for this wing rib chord line. Measure the height of the spar at Sta. 1 and split the difference if the spar is too tall. Mark the final trim line at the bottom and the top for the final 200mm height. Then measure from the bottom of the spar (where marked on the spar) to the chord line on the aft face of the spar as shown on the drawing. (Don't forget that whatever you do on the left side must also be done on the right side.)
- ❏ Mark the wing rib chord line on the aft face of the spar for Sta. 14. See Drawing No. 216. Proceed as before but this time you will see that the forward lower face and upper aft face are the tallest parts of the spar after it is trimmed to the final shape. Locate and mark the chord line. Also locate and mark the upper and lower final trim lines on the aft face of the spar.

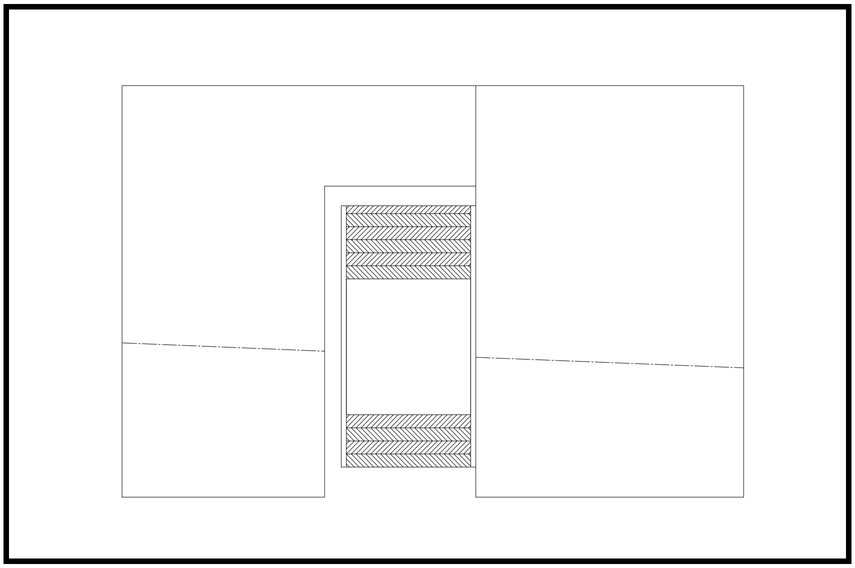


Figure 1

- ❏ Locate and mark the wing rib chord line on the forward face of the spar at Sta. 14. This point should be relative to the chord line on the aft face of the spar. The best way to do this is shown in Figure 1. Use a piece of plywood. Draw the aft face of the wing spar as a vertical line. Draw the chord line at the proper angle for the wing station. Cut out an area so that you can fit this over the spar. Locate the chord line on the aft face of the spar and align the template with it. Use a straightedge against the chord line to locate the chord line on the forward face of the spar. Remember, at each station the chord line is at a different angle.

- ❏ Locate and mark the wing rib chord line on the forward face of the spar at Sta. 1.

- ❏ Draw a straight line connecting the chord line at Sta. 1 and 14 on the aft face of the spar.

- ❏ Draw a straight line connecting the chord line at Sta. 1 and 14 on the forward face of the spar.

- ❏ Locate and mark the final trim lines for each station. Mark these on the forward and aft faces of the spar. Work from the chord lines and see the wing rib drawings for the trim lines.

- ❏ Use a straightedge and draw the trim lines by connecting these marks.

In the following steps you will be installing the landing gear fittings on the main wing spar. These fittings should be installed precisely. There are ample opportunities for tolerance build-up and dimensional errors. Since there can be two centerlines drawn on the spar—one on the front and one on the aft face—you should make every effort to see that all of the lines are accurately drawn.

There are a number of important water lines. W.L. O is the principal horizontal reference plane in the aircraft. W.L. –355 is the top of the main wing spar at the center. The top of the horizontal member of frame No. 4 is also W.L. –355. Thus the spar and frame No. 4 are glued together so that the top of the spar matches the top of frame No. 4.

W.L. –420 is the top of the center portion of the forward wing spar, and this matches the top of the center section of frame No. 3, to which it is glued.

The landing gear is installed as shown on Drawing No. 102. With the spar made to perfection, the landing gear will be located at W.L. –406.5, but this dimension is shown in reference since the 85mm from-top-of-spar takes precedence. With earlier drawings, there was some dimensional ambiguity for the wing spar, so don't be upset if the landing gear is located at some other water line. In the following steps, we will refer to this waterline—whatever it is—as the "landing gear water line", and we will use W.L. –420 as the primary reference line.

You must make sure the landing gear will be correctly positioned relative to the upper spar cap. When the landing gear is installed, it should clear the upper spar cap. It is *not* permissible to cut away the upper spar cap to clear the landing gear.

❑ Draw W.L. –420 on the aft face of the main wing spar. This line should continue to just outboard of Sta. 4.

❑ Draw B.L. 927.5 on the aft face of the main wing spar. It is very important that the B.L. 927.5 be used or the screwjacks will not come out right.

❑ Measure down 85mm from the top of the spar to locate the center of the hole for the landing gear fittings (see Drawings No. 102 and 205).

❑ Draw a horizontal line (parallel to W.L. –420) through the center of the hole for the landing gear fittings. This is the landing gear water line. To avoid confusion, the landing gear water line should *not* be drawn outboard of Sta. 3.

❑ Draw W.L. –420 on the aft face of the front wing spar. This line should continue to the end of the spar. On the end of the spar, draw W.L. –420 (use a square). This will be used to align the front wing spar with the main wing spar.

❑ Draw B.L. 927.5 on the aft face of the front wing spar.

❑ On the main wing spar, measure the distance between W.L. –420 and the landing gear water line. Using this dimension, draw the landing gear water line on the aft face of the front wing spar (between Sta. 2 and 3). To avoid confusion, the landing gear water line should *not* be drawn outboard of Sta. 3.

In the following steps, you will install the landing gear fittings on the main wing spar and the front wing spar. This method is based on the happy circumstance that the inside diameter of P/N 766 is the same as the outside diameter of P/N 768—a remarkable bit of serendipity that makes for an easy, precise alignment of the landing gear fittings.

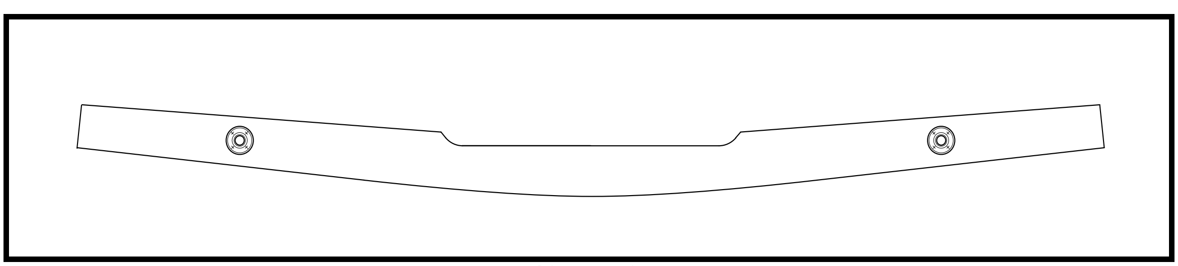


Figure 2

❏ Using the dimensions drawn on the spar—B.L. 927.5 and the landing gear water line—install P/N 767 on the front wing spar. See Drawing No. 102 and Figure 2. Drill the holes with a drill press. Be sure to install the fittings with the grease fitting hole on the bottom.

❏ Install P/N 768 on the aft face of the spar with the bolts specified on Drawing No. 102. This fitting has grooves for the heads of the bolts.

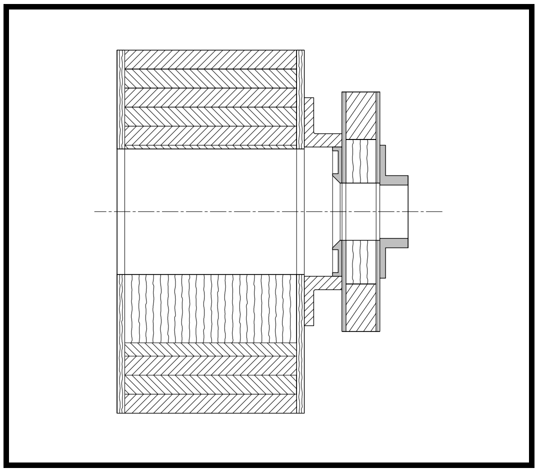


Figure 3

In the following steps, you will install P/N 766 on the aft face of the main wing spar. Because there might be some minor differences in the vertical position of the landing gear fittings on the forward wing spar, you may temporarily install P/N 768 on the forward face and P/N 767 on the aft face. This will keep the left side of the front spar with the left side of the main wing spar.

❏ Fit P/N 766 over P/N 768 as shown in Figure 3.

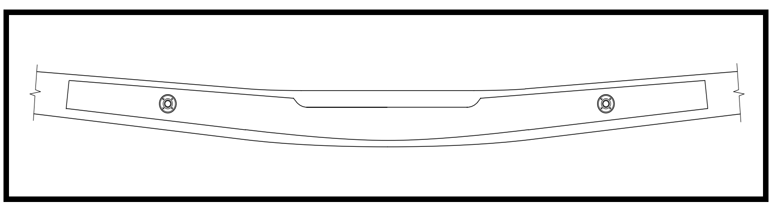


Figure 4

❏ Clamp this assembly to the aft face of the main wing spar as shown in Figure 3 and 4. Previously, you have drawn W.L. –420 on the aft face of the main wing spar and on the ends of the forward wing spar. Use these lines to locate the spars relative to each other.

❏ Use three small dabs of epoxy and glue P/N 766 to the wing spar. This will hold the fitting in place for drilling, and then the fitting can be knocked loose.

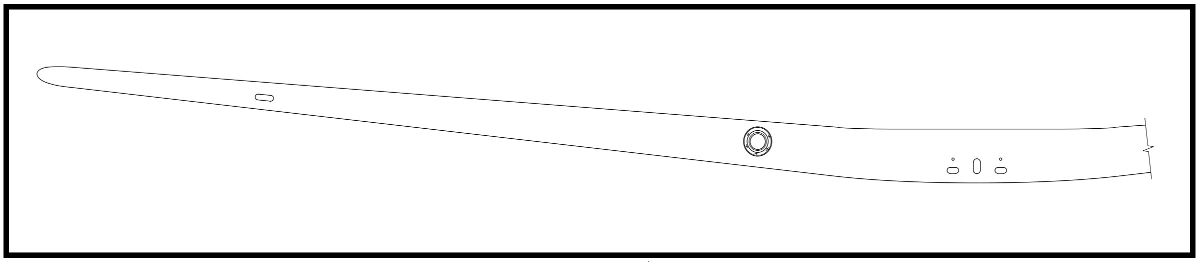


Figure 5

❑ When the epoxy has set, remove the front wing spar and drill the holes for P/N 766 through the main wing spar as shown in Figure 5.

Note: The best way to drill these holes is with a vertical milling machine or with a radial arm drill. Most machine shops have a vertical milling machine. Only the largest machine shops have a radial arm drill.

A Shopsmith is capable of being set up as a horizontal boring machine, and this would work very well. Some radial arm saws can be set up for horizontal boring

Most builders will be able to drill these holes with a drill press. You should note that the forward face of the main wing spar is tapered, so you must be careful to level the aft face. The method that is used is that you carefully level the spar (using the aft face), drill one hole, move the spar, level the spar and drill another hole, etc. It is quite easy to level the spar with a water level on each end of the spar. Leveling the spar in the other direction is more difficult. If the forward face of the spar is smooth and flat, the table of the drill press will take care of this, but it is safer to use a water level to be sure. Due to the short height of the spar, a water level will not give you an accurate method of leveling the spar. The simplest way to accomplish this is to clamp a board to the forward face of the spar and use this as the reference for the water level.

❑ When the holes are drilled, install P/N 771 on the forward face of the main wing spar. Note that this fitting has grooves for the heads of the bolts.

The bushings for these landing gear fittings will not be installed at this time since the same P/N 768-in-P/N 766 jigging method will be used again.

In the following steps you will locate and install the landing gear side load fittings. These fittings are located relative to B.L. 927.5 and the landing gear water line.

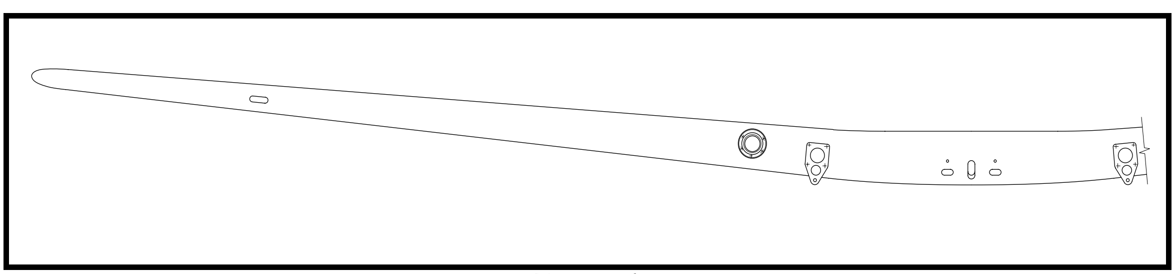


Figure 6

❑ Lay out the position of P/N 772-1 as shown in Figure 6. See Drawing No. 102. The centerline of P/N 772-1 should be perpendicular to the chord line drawn on the aft face of the spar.

Note: Remember that the spar is tapered. P/N 773 spacer is designed for P/N 772-2 to be installed directly on the forward face of the spar without any tapered shims.

P/N 772-1 and -2 are supplied with 9/64"Ø holes which are to be reamed to 5/16"Ø. The best procedure is to ream the holes of the part to be used as the drill guide, then ream the opposite part in place.

❑ Drill the holes for P/N 772-1 through the main wing spar. Use the same method that you used to drill the fittings for the main landing gear.

❑ Install P/N 772-2 with the bolts through the spar. To provide clearance for the screwjack, the bolts for P/N 772-1 and 772-2 must be installed with the bolt heads on the aft face. The Sta. 1 wing rib will be very close to this fitting so you should not varnish under the fitting until the rib is installed.

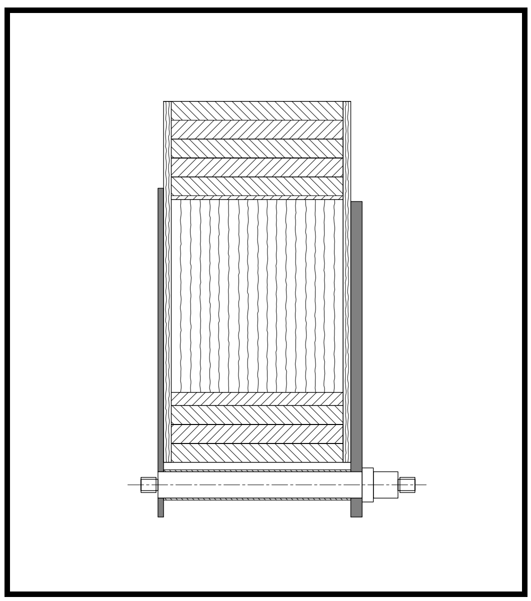


Figure 7

❑ Install P/N 706 and 773 as shown in Figure 7. See Drawing No. 102.

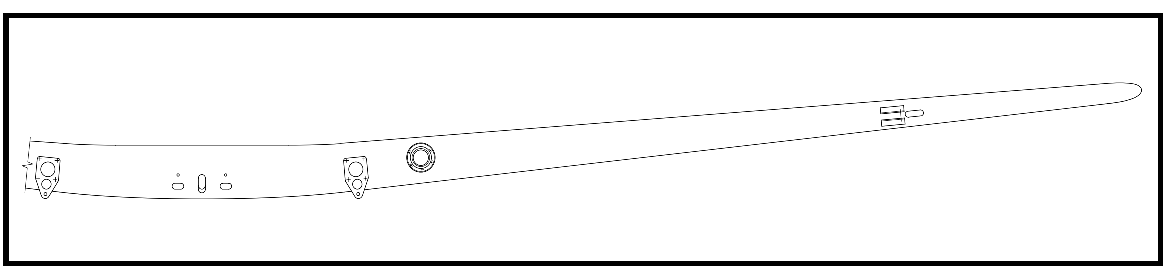


Figure 8

- ❏ Clamp P/N 759A and 759B on the forward face of the main wing spar. See Drawing No. 201 Sheet 4. Install the aileron bellcranks to make sure that the spacing between the support brackets is correct.

- ❏ Drill the holes through the main wing spar for P/N 759A and 759B.

- ❏ Install the channel-nuts for P/N 759A and 759B.

- ❏ Drill a 3/16"Ø hole through the spar just outboard of P/N 759B and just below the upper spar cap. These two holes—one on the left side of the aircraft and one on the right side—are for the antenna coaxial cable.

Main Wing Spar/Fuselage Frame No. 4

- ❏ Draw the aircraft centerline and W.L. 0 on the forward and aft face of fuselage frame No. 4.

- ❏ Drill the holes in fuselage frame No. 4 as shown on Drawing No. 305. Due to the routing of the rudder cables, the 3/8"Ø holes are drilled in different locations than on the main wing spar. The 25x50 holes should match the location of the holes on the main wing spar.

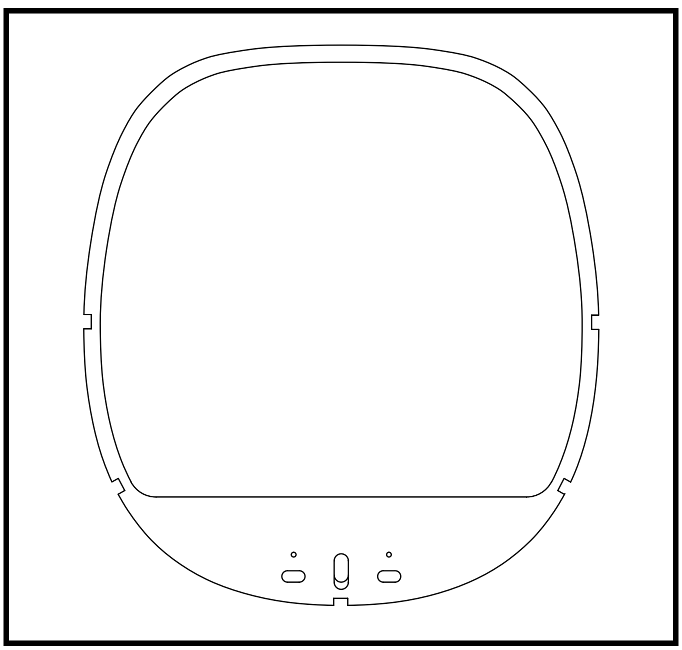


Figure 9

- ❏ Cut longeron cutouts in frame No. 4. The two upper side longeron cutouts and the bottom center longeron cutout should be cut full size and full depth. The two lower side longeron cutouts should be cut slightly undersized so that you can get a tight fit with the longeron at its installation.

Note: When you lay out the longeron cutouts for the fuselage frames, you should *always* use a master template. Draw the aircraft centerline and W.L. 0 on a piece of plywood and draw in the locations of the other longerons. Lay the fuselage frames on this template. When all of your dimensions are taken from the same template you can be assured that they will all be the same.

❏ Place frame No. 4 on the forward face of the wing spar. The top of the inside of the fuselage frame and the top of the main wing spar should line up. Line up the centerline of the fuselage frame and the main wing spar.

❏ Trace the outline of the lower center longeron cutout on the forward face of the main wing spar. Trace the outline of frame No. 4 on the forward face of the main wing spar. Remove the fuselage frame from the spar.

❏ Compare the mark for the bottom center longeron to the trim lines shown in Section B-B, Drawing No. 205. If everything is perfect, these dimensions should agree, and you can mark the trim lines on the spar to match fuselage frame No. 4. The bottom of the wing spar must be sanded to contour so that it will fit on top of the bottom center longeron and the dimensions in Section B-B will give you the correct angle to the bottom of the spar.

❏ Sand the bottom of the spar at the center of the airplane to the required contour. (The resulting cross-sectional area will be equal to or greater than the cross-sectional area at wing Sta. 1, so don't worry about this.)

❏ From Sta. 1 to Sta. 14, sand the top and bottom of the spar as shown by the trim lines and to the contour shown on the wing rib drawings—use templates made from these drawings. It is not essential to profile the spar exactly to the final shape, but it is a good idea to do most of the planing and sanding now. The final sanding will be done after the ribs are glued on.

❏ Sand the bottom of the spar inboard of Sta. 1. The contour transitions smoothly from the shape at Sta. 1 to the shape at the center of the spar. Keep the curves as smooth as possible. Don't get too worried about this—when the bottom of the fuselage and wing are skinned, you will be adding a few shims to this area.

❏ Mask off all gluing surfaces and varnish all surfaces on the front face of the main wing spar which will become internal surfaces when fuselage frame No. 4 is glued in place.

❏ Mask off all gluing surfaces and varnish all internal surfaces of fuselage frame No. 4.

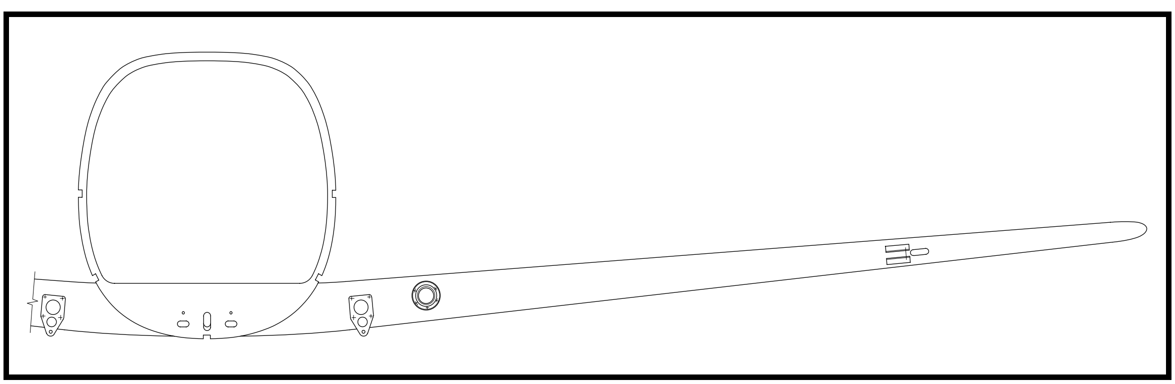


Figure 10

❏ Glue frame No. 4 to the main wing spar. Make sure that the frame is correctly positioned on the main wing spar. This is an important glue joint, so you should exercise great care in using the proper gluing technique.

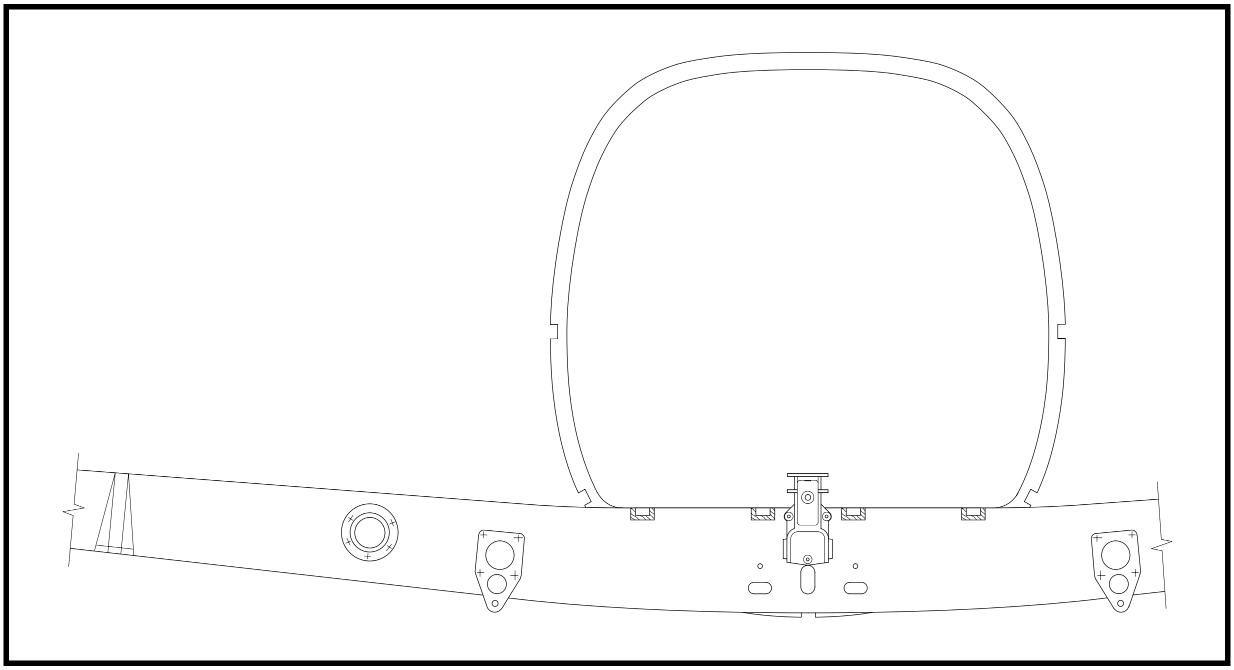


Figure 11

- ❏ Install P/N 520-2 on the aft face of the main wing spar at the aircraft centerline. See Drawing No. 102. Note that the upper bolt holes are located 18mm below the top of the spar. This will require that the spar be sanded slightly for the bearing housing on the forward face of P/N 520-2.

  Note: Many builders worry about drilling the two upper holes through the upper spar cap. These holes were taken into consideration when the Falco was designed. Spruce is much stronger in tension than in compression, and this is the reason that the upper spar cap is so much larger in cross-section than the lower spar cap. The steel bolts will take the compression loads in the upper spar just as well as the wood.

  These three holes should be drilled on a drill press. If the bolts are parallel, P/N 520-2 will be easy to remove from the bolts. If the bolts are skewed slightly, the gearbox housing will be difficult to remove, requiring the bolts be pushed forward in the airplane. This is quite difficult when all floor boards are installed.

- ❏ Install the blocks of spruce for the jack pad/tie down fitting on the aft face of the main wing spar as shown in Detail C of Drawing No. 201.

- ❏ For "open air" wheel well installation—install the four saddle gussets for the 30x15 seat track supports on the aft face of the main wing spar. See Figure 11. The locations for the seat track supports are shown at fuselage frame No. 5 on Drawing No. 310, and these same dimensions are used for the aft face of the main wing spar. The exact dimensions for these saddle gussets are not shown—make them 60x30 from solid spruce or 6mm thick plywood and glue several pieces of plywood together to get the desired thickness. Drawing No. 102 also shows a good view of these gussets.

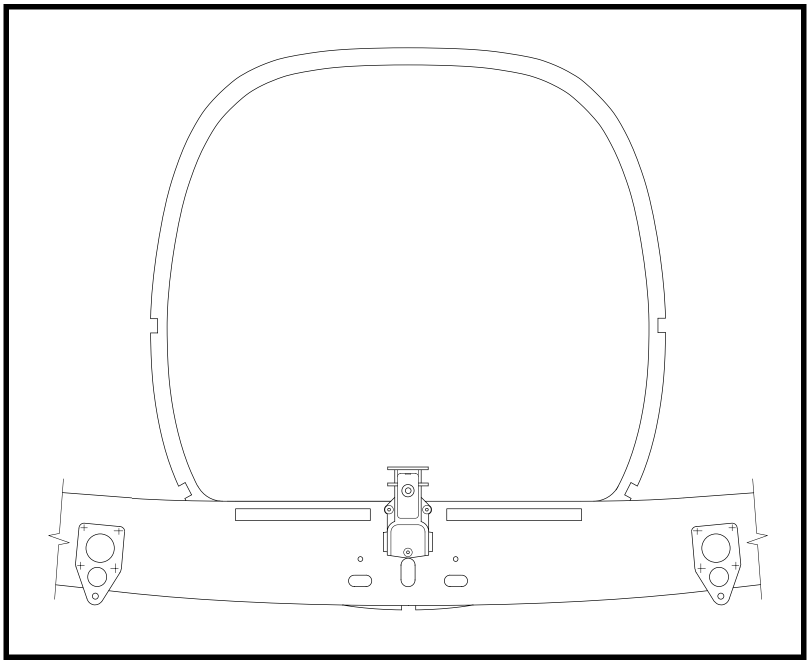


Figure 12

❏ For the wheel well door installation—install the 25x25 spruce triangle for the 30x15 and 60x15 seat track supports on the aft face of the main wing spar. See Figure 12. The locations for the seat track supports are shown at fuselage frame No. 5 on Drawing No. 310, and these same dimensions are used for the aft face of the main wing spar. Drawing No. 102 also shows a good view of this triangular strip.

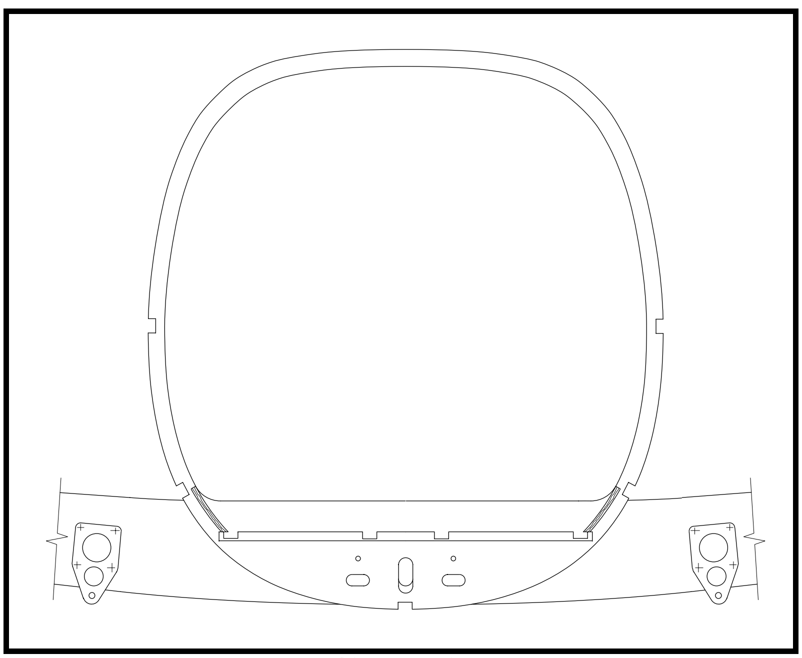


Figure 13

❏ Install the 20x20 spruce piece on the forward face of frame No. 4 as shown on Drawing No. 315. See Figure 13. This should be notched at four places for the 30x15 flooring supports. The top of this piece is located at W.L. –420. A good view of this piece is shown on Drawing No. 202.

❑ Install the 10x10 spruce triangles for the inside side walls on the forward face of frame No. 4. See Figure 13. These are shown on Drawing No. 315. If you wish, these may be 10x10 rectangular spruce strips. A good view of these gluing strips is shown on Drawing No. 202.

Autopilot mounting blocks are not installed at this time since they would interfere with the skinning of the bottom of the fuselage between frames No. 3 and 4.

Forward Wing Spar/Fuselage Frame No. 3

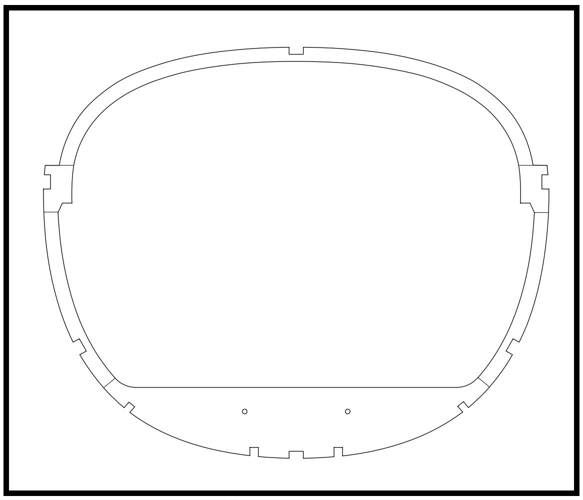


Figure 14

❑ If not already done, install solid wood between B.L. 80 and B.L. 225 on fuselage frame No. 3 as shown on Drawing No. 304.

❑ Cut the six longeron cutouts in fuselage frame No. 3. As with frame No. 4, a master template should be used to locate the longeron cutouts. See Figure 14.

❑ Cut the two 20x18 cutouts for the nose gear bay framing.

Note: If you are going to use 2mm plywood for the nose gear bay wall, then you must allow for its thickness so that the nose gear bay will be 160mm wide on the inside, so the spacing would be 164mm. If you are going to use 1mm plywood, the spacing would be 162mm.

❑ Cut the two 15x15 cutouts for the exhaust port framing.

❑ Because fuselage frame No. 3 does not have any plywood on the aft face, the forward face of the front wing spar will become an interior surface of frame No. 3. Mask off these soon-to-be-interior surfaces and varnish.

❑ Varnish all interior surfaces of frame No. 3 which will not be glued when this frame is glued to the forward wing spar.

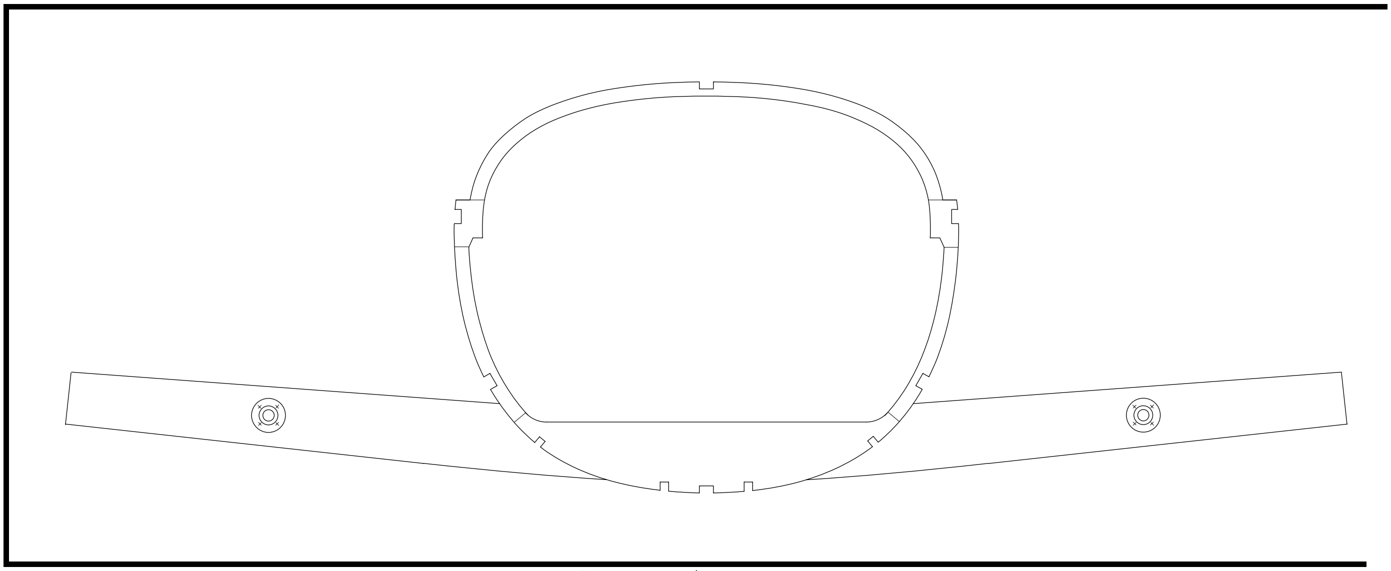


Figure 15

- ❑ Glue fuselage frame No. 3 to the forward wing spar. See Figure 15. It is very important that the fuselage frame be properly located on the wing spar. For this gluing operation, we suggest that the landing gear fittings be assembled as shown in Figure 3. This will allow the spars to be correctly positioned relative to each other. The aircraft centerline on fuselage frame No. 3 can be aligned with the aircraft centerline on fuselage frame No. 4.

- ❑ Trim the front wing spar so that it matches the inside contour of frame No. 3.

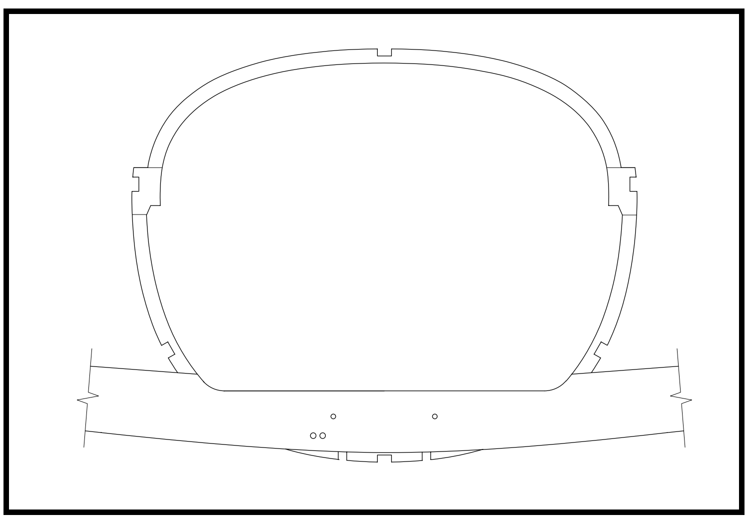


Figure 16

- ❑ Drill the 3/8"Ø holes for the rudder cables in fuselage frame No. 3. See Figure 16. Locate the holes as shown on Drawing No. 206. The hole should be angled up and forward at 11° from horizontal. You can see the angle of the cable on Drawing No. 122.

- ❑ Per Revision A28b, drill the two holes for the battery cables. These holes are on the left side only and should be drilled through the front wing spar and then through frame No. 3.

- ❑ Ream the bushings of P/N 764 with a 1/4" reamer.

❑ Assemble P/N 701 with four P/N 764 as shown on Drawing No. 126.

❑ Make the two spruce blocks that are used as mounting pads for P/N 764 as shown on Drawing No. 126.

❑ Install these two blocks on the aft face of the front wing spar. These blocks may also be seen in Drawing No. 120 and 155.

❑ Install the four P/N 764 brackets on the aft face of the front wing spar. Use a drill press to drill these holes. To assure alignment, P/N 701 should be in place during this drilling. See Figure 17.

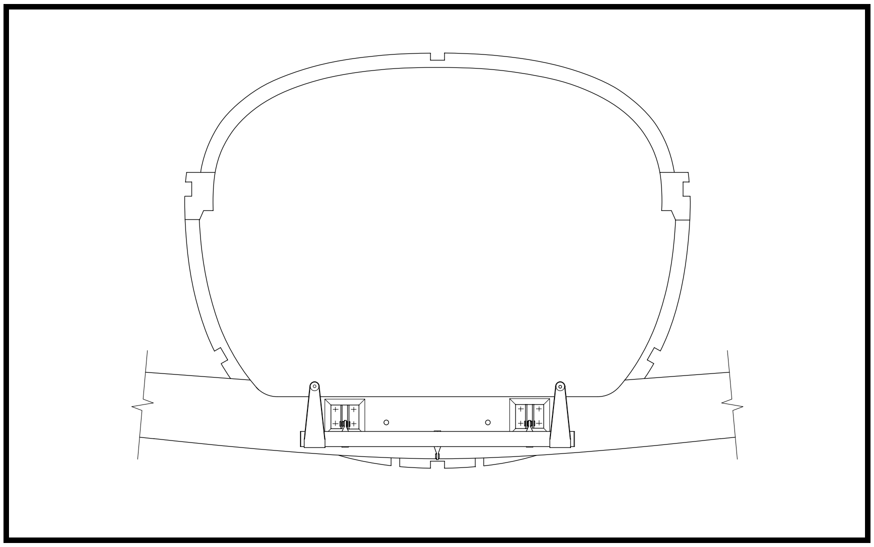


Figure 17

❑ Install the rudder cable pulleys on the aft face of the forward wing spar. See Drawing No. 126. Drill the holes for the brackets on the drill press.

Note: The bracket should be installed on the *outboard* side of the pulley. The drawings have not yet been changed to reflect this.

Drawing No. 725-1 has been eliminated. For the installation of the pulley on the bracket, see Detail R Drawing No. 201 Sheet 4.

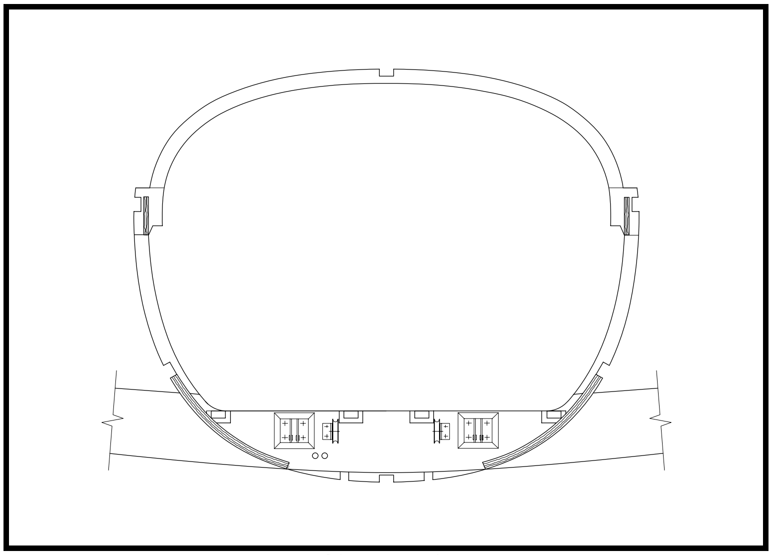


Figure 18

- ❏ Install the saddle gussets for the four 30x15 floor supports that are installed between frame No. 3 and 4. See Figure 7. These gussets are shown on Drawing No. 315 and 155. The overall dimensions of the gussets should be 25x50 and the gussets should be made from solid spruce or 6mm birch plywood—glue three pieces of 2mm plywood together.

- ❏ Make the two curved gluing strips of spruce which are glued on the aft face of the front wing spar for the bottom fuselage skin. This skin will wrap from lower side longeron to lower side longeron across the bottom of the fuselage. A gluing strip is needed on the aft face of the forward wing spar. This strip can be seen on Drawing No. 155.

Note: The dimensions for frame No. 4 are slightly greater than for frame No. 3. This means that the gluing strip on the aft face of the front wing spar will be slightly larger than the contour for frame No. 3. This is a very minor point, but it does merit some thought and planning.

Also, note that there will be a piece of wood installed on the aft face of frame No. 3 above the forward wing spar and below the lower side longerons. This is to provide a flat surface for the installation of the gluing strip.

We are not sure when this gluing strip should be installed. Our best guess is that it should be installed just prior to the installation of the fuselage skin. This way the fuselage frames can be float sanded to the precise shape, then the gluing strips may be made and sanded to match. This will eliminate the difficult job of sanding the gluing strips while they are installed in the airplane.

Builders using epoxy glue may have one other alternative. Composite aircraft builders use a substance known as “flox”. This is a mixture of flocked cotton fibers and epoxy resin. The fibers give the epoxy some strength when it is used in a gap-filling situation. We do not have any idea how strong this mixture is. Some tests might be in order to see if it is as strong as spruce. If the flox has sufficient strength, then the gluing strips may be installed early, and flox used during the skinning.

❏ If you wish, you may install the gluing strips and other wood pieces discussed in the note above.

❏ Install two 10x10 spruce strips on the aft face of fuselage frame No. 3 as shown in Figure 19. These strips will pick up the inside cockpit skin and carry it up to the cockpit coaming.

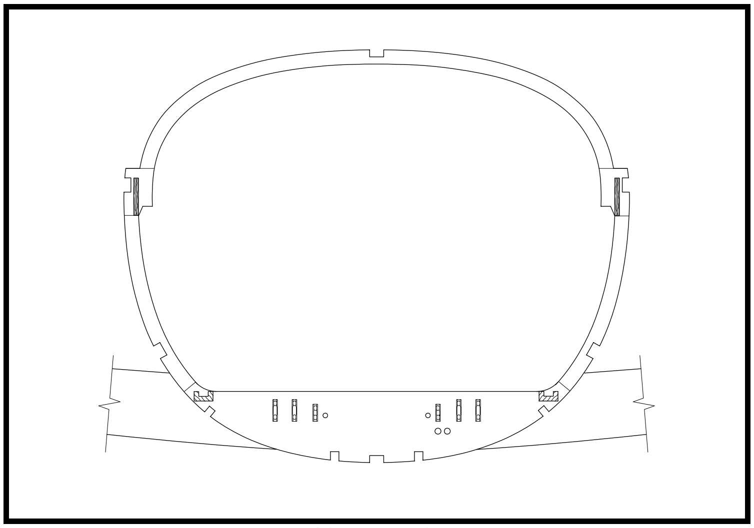


Figure 19

❏ Install two 10x10 spruce strips on the forward face of fuselage frame No. 3 as shown in Figure 18 (which shows the aft face). These are gluing strips to pick up the inside fuselage skin. View A-A of Drawing No. 157 shows the area where these strips will be installed although the strips are not shown. The top of these strips should be 10mm below the top of the upper side longeron.

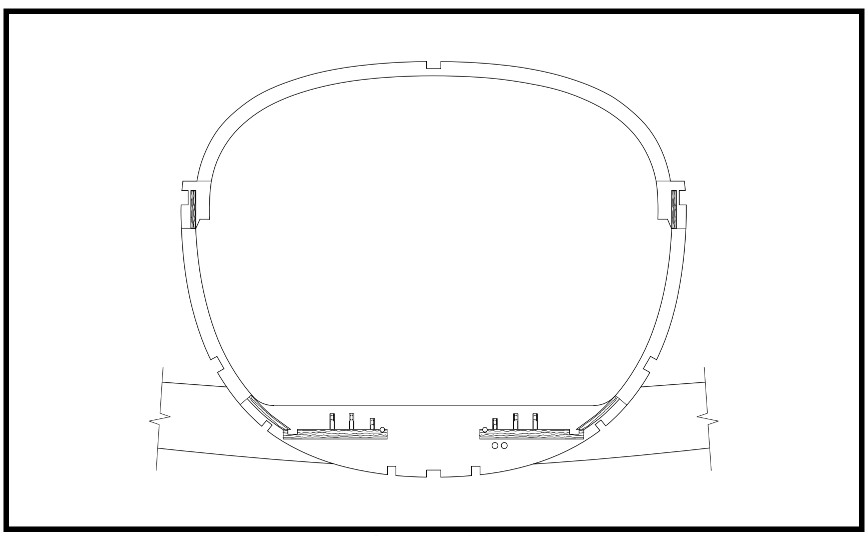


Figure 20

❏ If you wish, you may install the wood pieces necessary for the installation of the lower cockpit floor between fuselage Sta. 2 and 3. This can be seen on Drawing No. 315. The installation of this lower floor is optional and will put your feet in a more comfortable position, particularly if you have very large feet. (Builder comment: Says either channel-nut or spruce flooring support on the aircraft's right side interferes with drilling P/N 717.)

Fuselage Frame No. 5

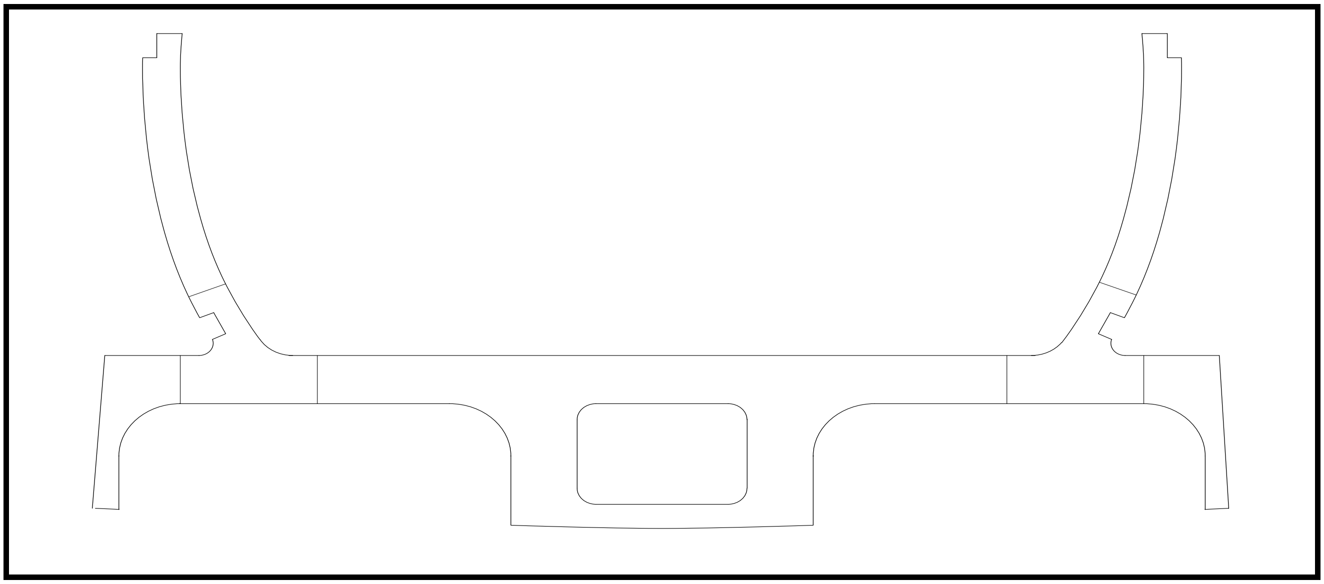


Figure 21

❑ Glue plywood on the forward and aft faces of fuselage frame No. 5.

❑ Cut the five longeron cutouts in fuselage frame No. 5 as shown in Figure 21. As with all other fuselage frames, a master template should be used to locate the longeron cutouts. See Drawing No. 310.

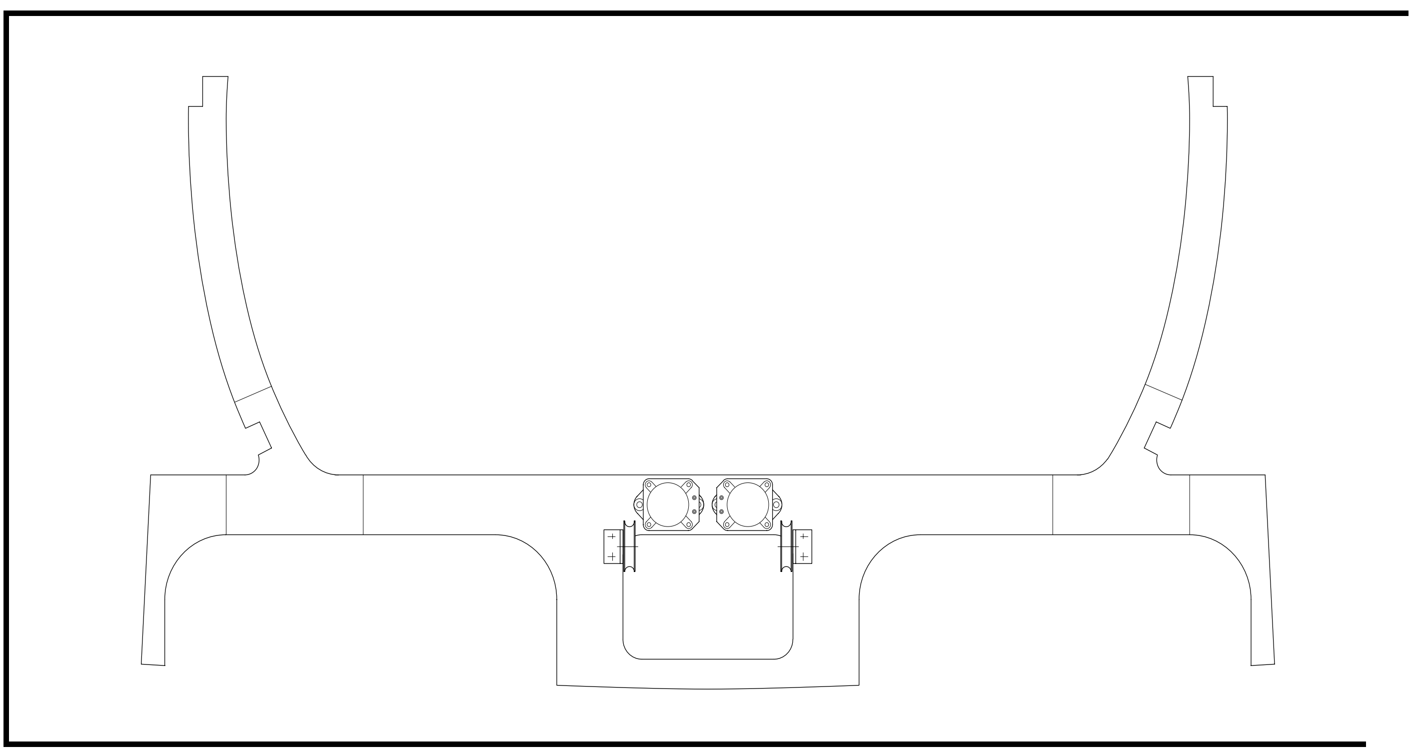


Figure 22

- ❏ Install the rudder cable pulleys on the front face of fuselage frame No. 5 as shown in Figure 22. See Detail A, Drawing No. 310. You will find Detail A on the right side of the sheet. We forgot to put a "see Detail A" on the drawing—sorree!

- ❏ Drill the two 3/16”Ø holes for the K3 gear-up relay and K4 gear-down relay on the forward face of fuselage frame No. 5 as shown in Figure 22. The relays should be installed so that the small field terminals are on the inboard side, and the gear-up relay should be on the right side of the aircraft. With the relays installed like this, the wires to the landing gear motor can be attached directly to the relays and there is no need for the TB4 terminal block; however, if you choose to install the terminal block, you may install it on the top of the frame at the centerline of the airplane.

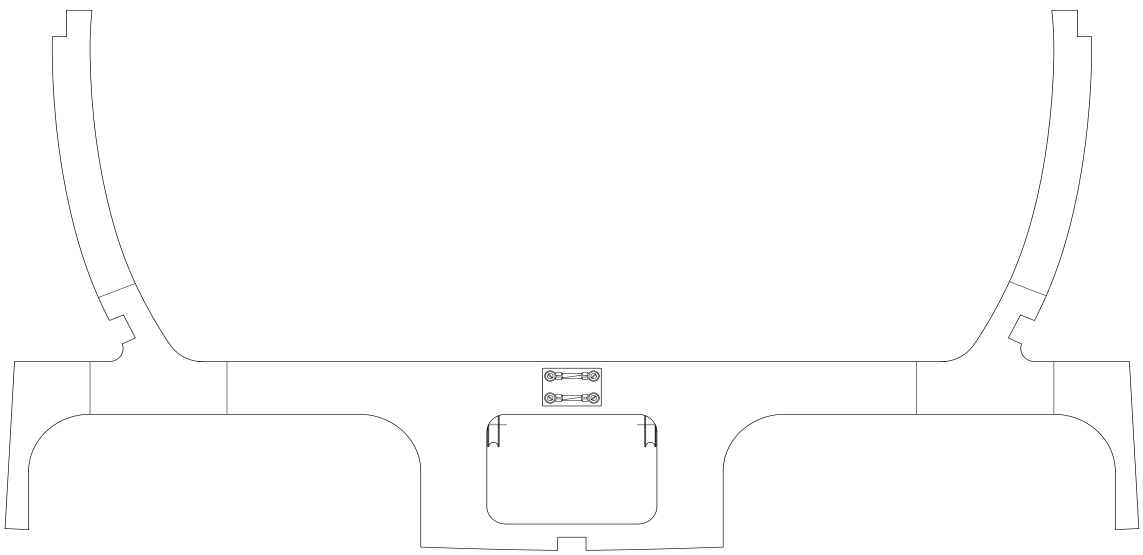


Figure 23

- ❏ Install the fuse holder for F5 and F6 fuses on the aft face of fuselage frame No. 5 as shown in Figure 23.

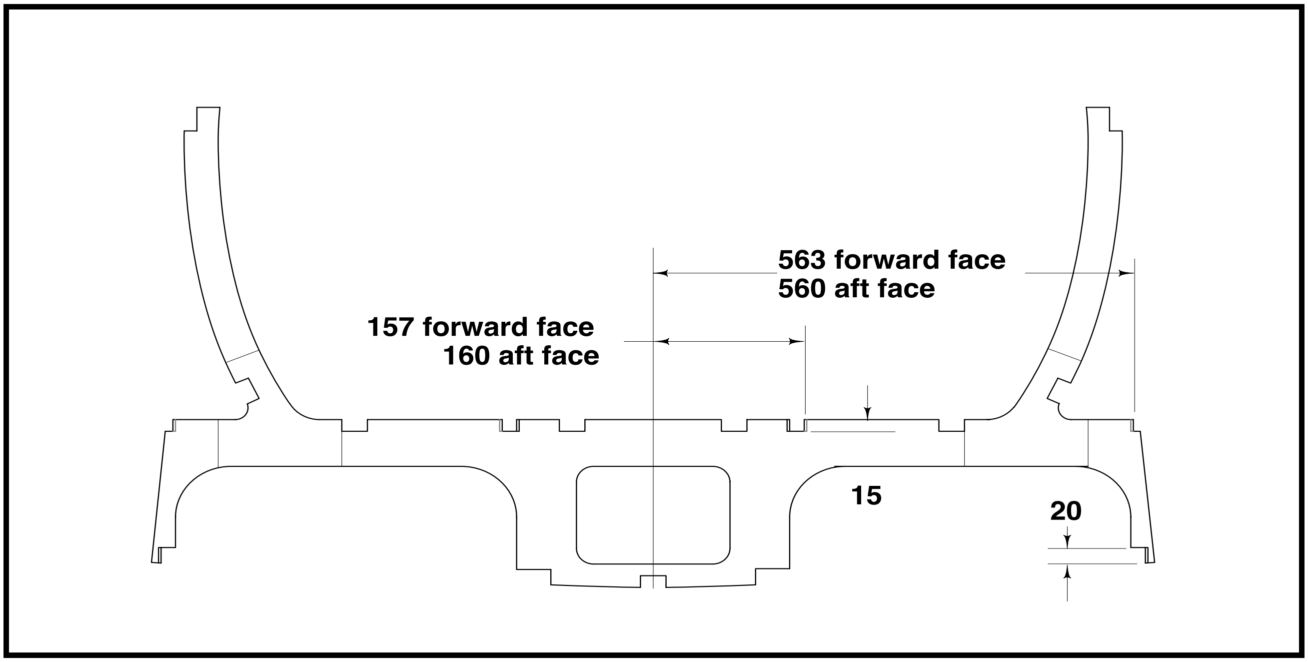


Figure 24

❏ For “open air” wheel well installation—cut out for four 30x15 seat track supports as shown in Figure 24. See Drawing No. 310.

❏ For “open air” wheel well installation—cut out for the two 20x20 spruce strips to each side of the bottom center longeron as shown in Figure 24. See Drawing No. 310. Because these cutouts are also for the wheel well rings, they are wider than the 20x20 spruce strips.

❏ For “open air” wheel well installation—cut the frame for the wheel well rings as shown in Figure 24. Because the rings are installed with the center of the axle—and therefore the center of these rings—forward of the frame, the slots for the rings are at an angle. The slots for the upper rings should be 15mm.

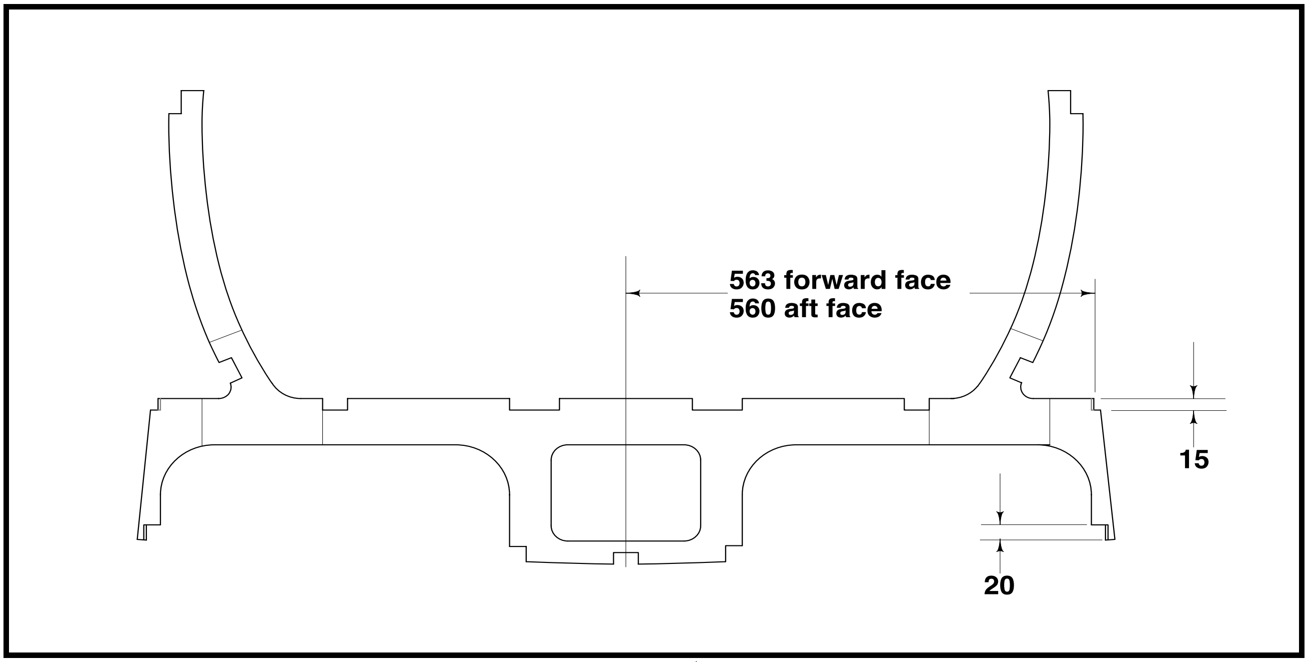


Figure 25

- ❏ For the wheel well door installation—cut out for 30x15 and 60x15 seat track supports as shown in Figure 25. See Drawing No. 310.

- ❏ For the wheel well door installation—cut out for the two 20x20 spruce strips to each side of the bottom center longeron as shown in Figure 25. See Drawing No. 310.

- ❏ For the wheel well door installation—cut the bottom center of the frame to a width of 280mm as shown in Figure 25. See Drawing No. 310.

- ❏ For the wheel well door installation—cut the frame for the wheel well rings as shown in Figure 25. Because the rings are installed with the center of the axle—and therefore the center of these rings—forward of the frame, the slots for the rings are at an angle. The slots for the upper rings should be 15mm.

Fuselage Frame No. 6

- ❏ Review Drawing No. 311 to check to make sure fuselage frame No. 6 is constructed with the spruce blocks shown for mounting the master relay, starter relay and altitude encoder.

- ❏ Drill the two 1.25"Ø holes for the plumbing and wiring.

- ❏ Drill the two rudder cable holes as shown on Drawing No. 311.

- ❏ Drill vent holes on the aft face of fuselage frame No. 6 to prevent any closed compartments.

- ❏ Draw W.L. –440 on the forward and aft face of the frame.

- ❏ Draw the interior structure of the frame on the outside of the plywood. This is particularly important for this frame since many electrical devices will be installed on the aft face.

- ❏ Mask off the inside of the closing plywood for varnishing.
- ❏ Varnish the inside of the frame and the inner face of the closing plywood.
- ❏ Glue on the plywood to close the frame.

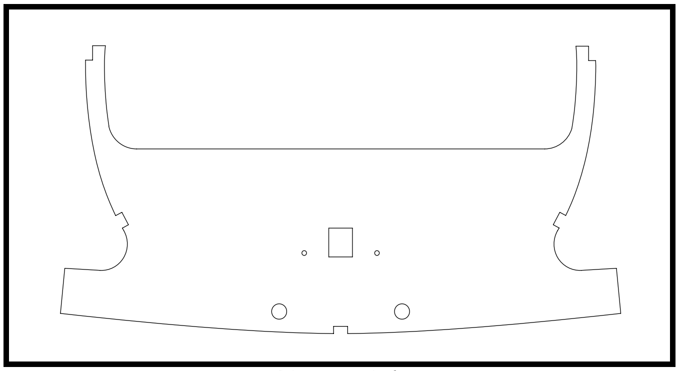


Figure 26

- ❏ Cut the five longeron cutouts in fuselage frame No. 6 as shown in Figure 26. As with the other fuselage frames, a master template should be used to locate the longeron cutouts. See Drawing No. 311.
- ❏ Use a 1/4" reamer to ream the bushing of P/N 760.
- ❏ Drill an extra 3/16"Ø hole in the base of each P/N 762 as shown on Drawing No. 120. To have both parts the same, you may match-drill the parts by first drilling one part, then backing the other part up to it and drilling through the second part.
- ❏ Assemble P/N 760 between two P/N 762 as shown on Drawing No. 120.

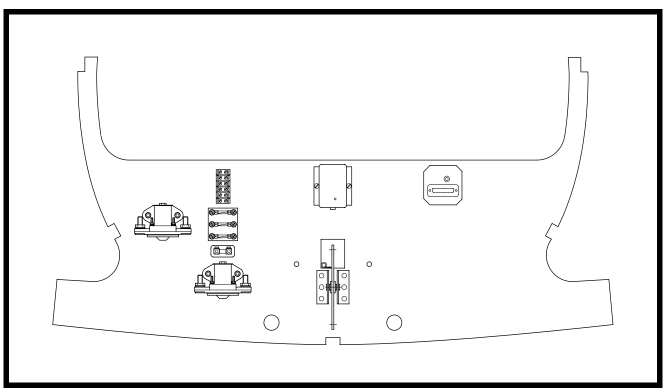


Figure 27

- ❏ Locate the two P/N 762, with P/N 760 in place, on the aft face of frame No. 6 and drill the six 3/16"Ø holes through frame No. 6. Do *not* drill through P/N 805. See Figure 27.
- ❏ Clamp P/N 805 in place and use a 3/16"Ø transfer punch to locate the six 3/16"Ø holes.
- ❏ Drill the six 3/16"Ø holes in P/N 805 using a drill press.

- ❏ Since the holes in P/N 762 are not likely to be exactly the same, you should mark them so that you can install them in the correct position. One method is to use a center punch and mark the upper outside of the part.

- ❏ Drill the two 1/4"Ø holes required for the K1 master relay. The master relay is installed on the left side of the aircraft at B.L. 360 and the bolt holes are 140mm above W.L. –440. If you do not have the relay, the holes are 2.44" between centers. This and all other electrical equipment installed on fuselage frame No. 6 are installed on the aft face of the frame.

- ❏ Drill the two 1/4"Ø holes required for the K2 starter relay. The starter relay is installed on the left side of the aircraft at B.L. 233 and the bolt holes are 18mm above W.L. –440. If you do not have the relay, the holes are 2.44" between centers.

- ❏ Drill screw pilot holes for the voltage regulator, install the screws and then remove. The voltage regulator is installed on the aircraft centerline with the screw holes 200mm above W.L. –440.

- ❏ Drill screw pilot holes for the ammeter shunt, install the screws and then remove. The ammeter shunt is installed on the left side of the aircraft at B.L. 233, centered 68mm above W.L. –440.

- ❏ Drill screw pilot holes for the fuse holder for F1, F2 and F7 fuses, install the screws and then remove. The fuse holder is installed on the left side of the aircraft at B.L. 233, centered 128mm above W.L. –440.

- ❏ Drill screw pilot holes for the TB1 terminal block, install the screws and then remove. The terminal block is installed on the left side of the aircraft at B.L. 233, with its top 234mm above W.L. –440.

- ❏ If available, install the altitude encoder and then remove for final installation later. The encoder is installed on the right side of the aircraft at B.L. 233. The Narco AR-850 encoder is installed with four screws with a 2.00" by 2.00" square pattern.

- ❏ Install an MS21919-DG5 clamp for the elevator trim tab cable. A typical installation is shown on Drawing No. 117, Detail A. The clamp should be installed in the rectangular opening for the elevator pushrod with the cable as far to the left side of the aircraft as possible.

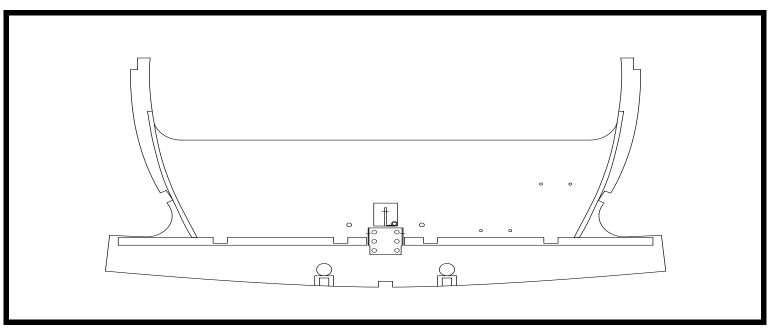


Figure 28

❑ On the forward face, install the 10x10 rectangular (or triangular) spruce strips for the inside fuselage side walls as shown on Figure 28. See Drawing No. 315.

Note: It is important that the inside fuselage side wall be as wide as possible at the bottom of this frame. This strip should just touch the edge of the longeron cutout. There are three reasons for this: the extra room is needed by the seat when it slides back, the skin will clear the outboard seat belt mount (see Drawing No. 123), and the inside skin is easier to install since it has less curvature.

❑ Make the two 20x20 spruce pieces that are installed on the forward face of frame No. 6, and notch for the 30x15—and 60x15 as appropriate to the wheel well framing—seat supports. This part can be seen on Drawing No. 315 and 123. The upper surface and the notches should be cut to an angle of 11° from the horizontal to match the angle of the seat supports—see Drawing No. 206. These pieces should not be installed until after the aft wing spars are glued in place. You should, however, mark the forward face of frame No. 6 for its installation. Note from Drawing No. 123 (Section B-B) that the upper aft surface of this part is installed at W.L. –440, the same vertical position as the 20x15 member of frame No. 6.

❑ On the forward face of fuselage frame No. 6, install saddle gussets for the aft ends of the 20x20 spruce stringers at the bottom of the fuselage. The outer faces of each stringer is located at B.L. 140. Because the flap actuator and torque tube support are installed on a spruce block on the left side of the aircraft, the saddle gusset on the left side may be "open" on the right side so as not to interfere with that block.

❑ Make a cardboard template of the forward face of frame No. 6 (below the luggage compartment floor) as a pattern for the upholstery.

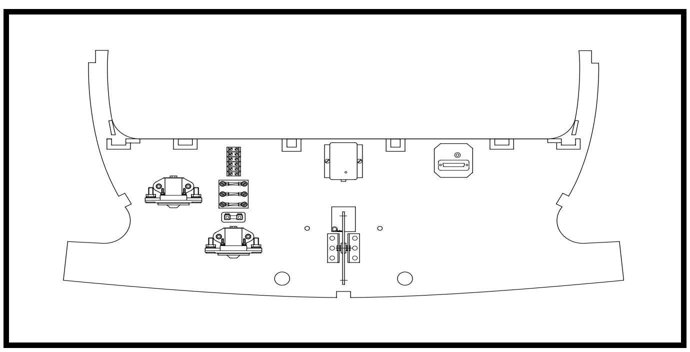


Figure 29

❑ On the aft face of the frame, install the six saddle gussets for the luggage compartment floor supports as shown in Figure 29. The location of the floor supports is shown on Drawing No. 315. The two inboard supports are 15x20 spruce and the four outboard supports are 30x15 spruce.

❑ On the aft face of the frame, install 10x10 spruce gluing strips for the inside cockpit skin. These gluing strips are installed just inboard and just above the outboard saddle gussets installed in the previous step. The gluing strip above the gusset should begin at a point about 10mm above the luggage compartment floor, thus making room for a 10mm strip which will be installed fore-and-aft along the base of the inside side wall.

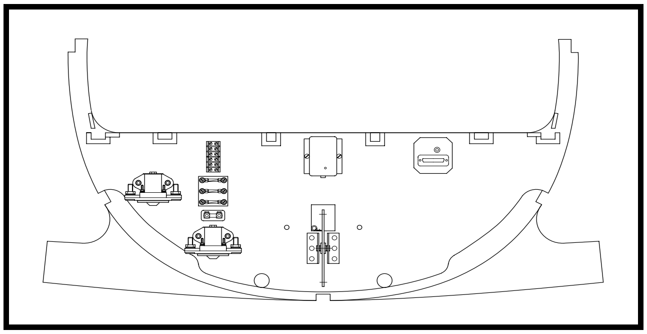


Figure 30

❏ Clamp the gluing strip in place on the aft face of frame No. 6 and trace its outline on frame No. 6. See Figure 30. The strip should not be installed until it is sanded to the angle required for the fuselage skin. This gluing strip, shown on Drawing No. 311, is for the aft fuselage skin and to carry the extra loads required by the outboard seat belt mounts.

At this time, you may continue with the work on the fuselage frames by doing the work in Chapter 25 "Fuselage, Preliminary Assembly".

Control Stick Assembly

❏ Cut off the top of the control sticks to match the rubber grips supplied. See Figure 31. The bottom of the rubber grips should be at the top of the bend. (At the time that the control sticks were designed, we had not yet selected the grips, therefore the extra length.) Do not install the rubber grips on the sticks at this time since they must be loose at the time that the microphone push-to-talk wiring is installed, and the grips are very difficult to remove once installed.

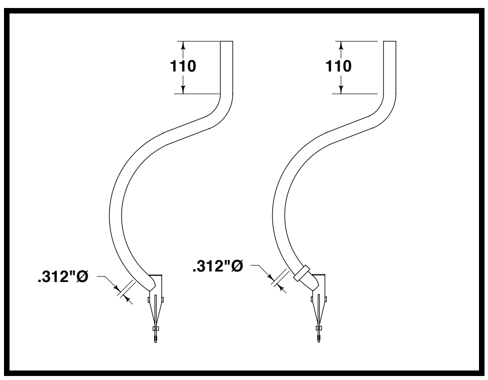


Figure 31

❏ Drill 5/16"Ø holes in the bottom forward face of the control sticks and install the MS35489-4 grommets for the wiring in these holes. These grommets are supplied as part of the electrical kit. See Figure 31.

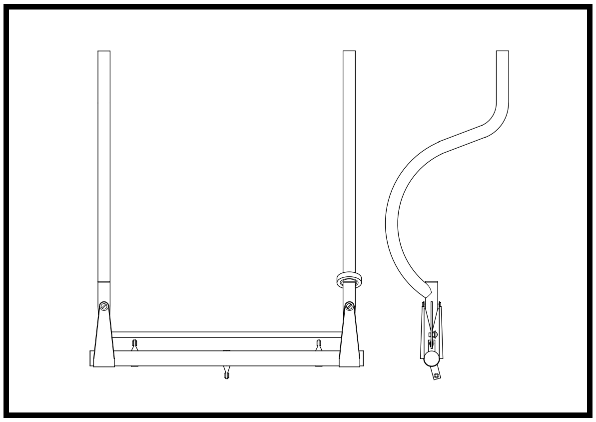


Figure 32

- ❏ Install the two control sticks on P/N 701 as shown in Figure 32. See Drawing No. 126.

- ❏ Install P/N 718 on the two control sticks. See Drawing No. 126 and 718. Note on Drawing No. 718 that the ends of the control stick connecting rod are not symmetrical. One side is shown as 3mm from the outside of the tube. This is the forward end.

Landing Gear Retraction Gearbox Assembly

In the following sequence, you will assembly the landing gear retraction gearbox. The alignment of the gears is important and you should make every effort to see to it that the gears run smoothly. One of the difficulties that you will encounter is holding a gear in position on a shaft while you drill the hole for the roll pin. One technique that you might want to consider is to use Loctite to bond the gear to the shaft after it is correctly aligned. In a few hours, the Loctite will harden and the hole can be drilled. To use Loctite, the mating metal surfaces should be clean and free from any oil. While it is unlikely that you would ever need to, the principal disadvantage of this method is that Loctite is so strong that it will be extremely difficult to disassemble the gearbox.

- ❏ If desired, P/N 520-2 gearbox may be primed with zinc chromate primer. Mask off the bearings to prevent paint-induced friction. The bearings in the P/N 520-2 gearbox are intentionally installed with a fit that is not tight so that the shafts will turn with a minimum amount of friction.

- ❏ For easier assembly, install P/N 623 bushing in each end of each MS20271-B14 universal joint with Loctite. See Drawing No. 102. Allow it to harden for several hours.

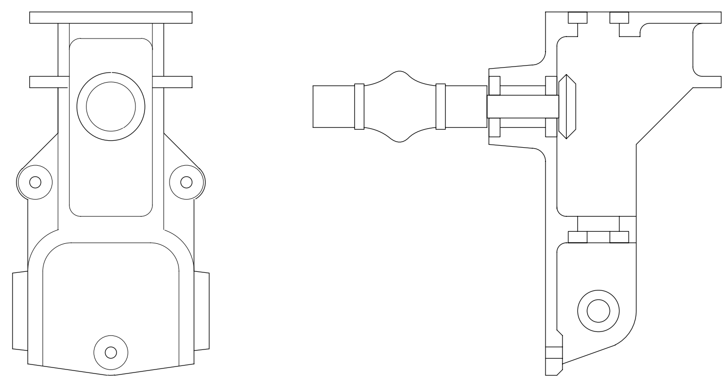


Figure 33

- ❏ Install the miter gear and shaft, P/N 520-4, in P/N 520-2 housing as shown in Figure 33. See Drawing No. 102 for all details for the assembly of this gearbox.

- ❏ Install MS20271-B14 universal joint on P/N 520-4. P/N 520-4 and the universal joint must be snug against the inner race of the bearing.

Note: The hole must first be drilled with a 3/16"Ø drill, then reamed with a Brown & Sharpe No. 1 tapered reamer. The small end of the tapered shank shall not extend more than 1/16" above the surface of the universal joint.

⚠ **Caution** It is very easy to over-ream with the tapered reamer. This is particularly true when an electric drill is used. Use a very slow speed and proceed very cautiously. For best results, use a variable-speed drill or a rechargable electric drill, which turns very slowly.

One method of reaming that works well is to use a drill press, but remove the belts and turn the drill by hand. ⚠

- ❏ Install the nut and washer. The reason for the MS21042-3 nut is because of the reduced clearance. Cut off the threads above the nut.

- ❏ Install P/N 520-6 vertical drive shaft and P/N 520-7 miter gear in the housing as shown in Figure 34. Line up hole in miter gear with the hole in the shaft and drill through with a 11/64"Ø drill, then ream with a 3/16"Ø reamer. Use a drill press, or the drill will "wander". Install the roll pin.

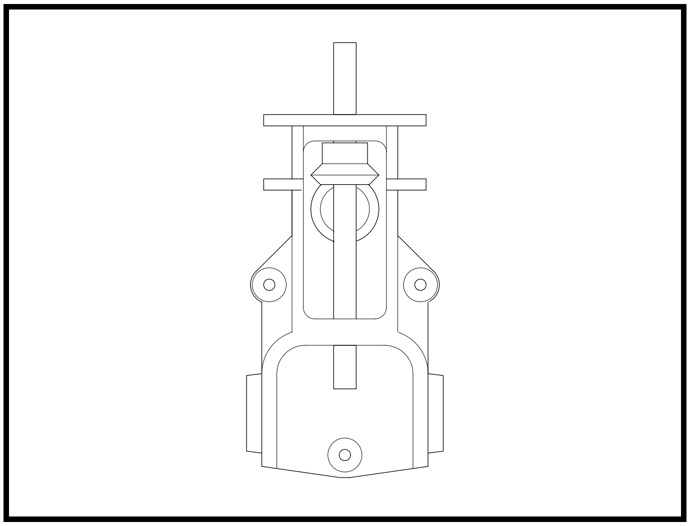


Figure 34

❑ Slip the lower P/N 520-7 miter gear and P/N 520-3 spur gear on 520-6A vertical shaft as shown in Figure 35 These two gears must have a snug fit against the inner race of the bearings, since this is what holds the gears in proper alignment. Do not drill for the roll pins.

Note: The best way to align miter gears with each other is with a single thickness of kraft paper. You literally cut a strip of paper from an ordinary grocery bag and press it between the teeth of the two gears. This strip of paper will insure that the gears are properly positioned and will run smoothly. You may find it hard to believe, but this is the industry-standard method of installing gears.

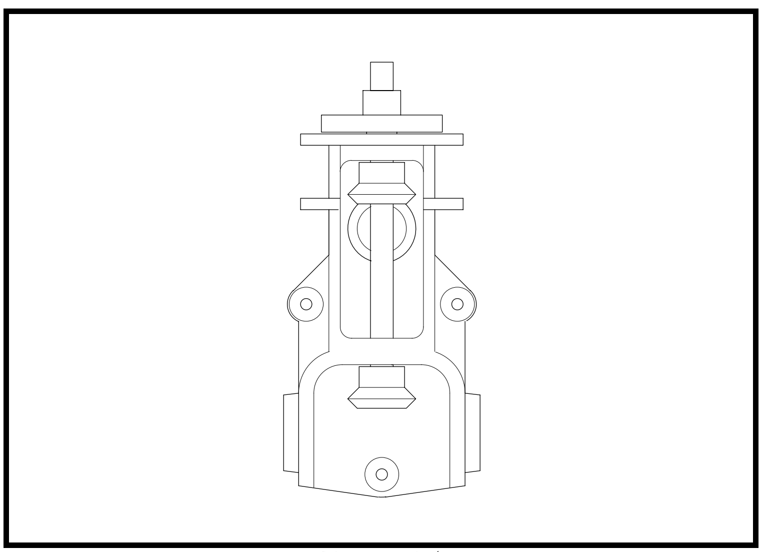


Figure 35

❑ Align the shaft so that the miter gear runs nicely with P/N 520-4. Use the kraft paper method described above.

- ❑ Trial fit the horizontal shaft and miter gear as shown in Figure 41. If it is necessary to achieve a proper meshing of the gear teeth, grind/sand the hub of the miter gear on the vertical shaft—a number of builders have reported that this was required.

- ❑ When you have everything firmly in place, drill 11/64" and then ream with a 3/16" reamer for P/N 520-3 spur gear.

  Note: All drilling should be done in a drill press, or the drill will "wander". This operation is best done with two people.

  It is *very* easy for the shaft to move after the drilling has begun, so any method that can be used to hold the parts in position should be used. Use a marking pen to mark the shaft so that you can detect any movement. Use wood wedges to hold things in position. P/N 520-5 shaft may be put in place and a wood wedge placed between it and the miter gear. A shim may be used above the middle miter gear to prevent it from moving. A small piece of angle-iron may be clamped to the inner side of the housing to prevent the gear from moving. Always use some mechanical means of preventing the shafts from moving.

  One method that has been used with great success by Falco builders is to drill and tap the gear hub for a setscrew. Put this hole (10-32 is fine) at 90° to the existing hole, then lock the gear in place with a setscrew while you drill the hole for the roll pin. Discard the setscrew after the roll pin is installed.

- ❑ Put a 3/16" drill in the hole for the roll pin and check the gears for smooth running. If things have shifted, you may make a slight adjustment by putting a shim between the spur gear and the bearing, or you may sand the bottom of the spur gear slightly.

- ❑ Install the roll pin for the spur gear.

- ❑ Clamp the shaft in position and prepare for drilling the lower miter gear. The spur gear may be clamped, or you may use a shim between the upper miter gear and the housing. The lower miter gear may be clamped in place with a wood wedge forced between it and P/N 520-5 shaft, but you must be very careful to make sure that the wedge does not push on P/N 520-6A shaft.

- ❑ When you have everything firmly in place, drill 11/64" and then ream with a 3/16" reamer for the lower miter gear. Install the roll pin for the miter gear.

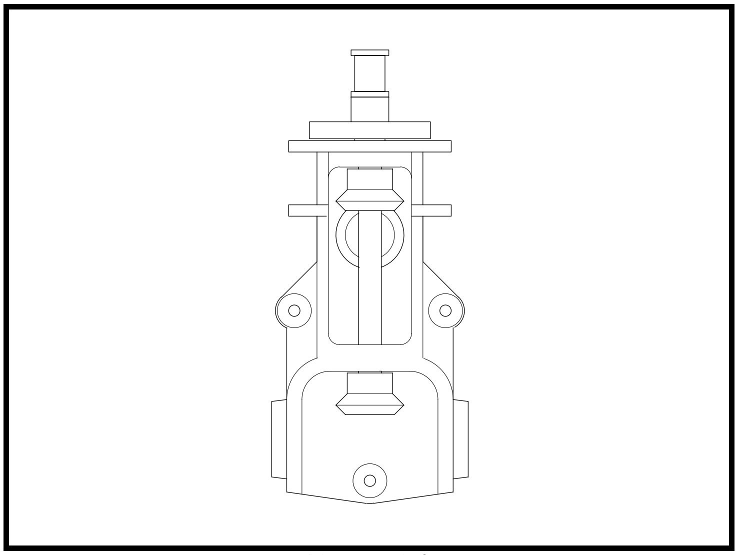


Figure 36

- ❑ Install P/N 821-2 spindle on P/N 520-6A shaft, drill and ream for the roll pin and install the roll pin as shown in Figure 36.

Note: It is important for all of the screwjacks to be synchronized exactly. The springs on the end of the screwjack sleeves will allow for some lack of precision in this respect, but they will do nothing to help you when the gear is fully up.

The ideal situation is to have all of the screwjacks arrive at the full “gear up” position at the same time. The only way to insure this is to install the screwjack sleeves and run them all the way up until they bottom out against the universal joint. The screwjack on the left side of the airplane is turned so that the gearbox’s shaft and gear is turned until the slotted end of the screwjack sleeve is exactly vertical. Then the screwjack on the right side of the airplane is turned to the same position (again with the screwjack bottomed out against the universal joint) so that the slotted end of the screwjack is exactly vertical. (The same procedure will be used for the screwjack for the nose gear to synchronize all three screwjacks.) This is the reason for all of the following procedures.

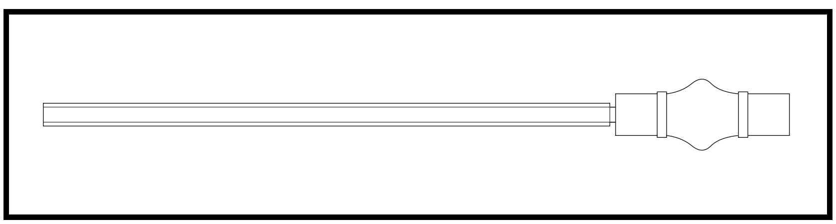


Figure 37

- ❑ Install P/N 513-2 screwjack on the universal joint for the left side of the aircraft. See Figure 37. This part has right hand threads. If you are unable to tell right hand threads from left hand threads, just remember that this screwjack has the same threads as the nose gear screwjack. The end of the screwjack has a short end to the shaft, shorter than the end of the universal joint.

Note: The hole must first be drilled with a 3/16”Ø drill, then reamed with a Brown & Sharpe No. 1 tapered reamer. The small end of the tapered shank shall not extend more than 1/16” above the surface of the universal joint.

⚠ **Caution** It is very easy to over-ream with the tapered reamer. This is particularly true when an electric drill is used. Use a very slow speed and proceed very cautiously. For best results, use a variable-speed drill or a rechargable electric drill, which turns very slowly.

One method of reaming that works well is to use a drill press, but remove the belts and turn the drill by hand. ⚠

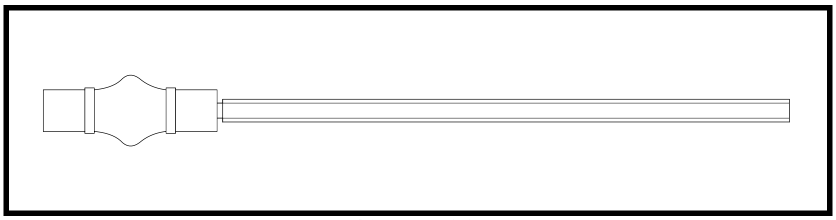


Figure 38

❏ Install P/N 513-1 on the universal joint for the right side of the airplane. See Figure 38. This screwjack has left hand threads. The end of the screwjack has a short end to the shaft, shorter than the end of the universal joint. Observe the note and warning above for the installation of taper pins.

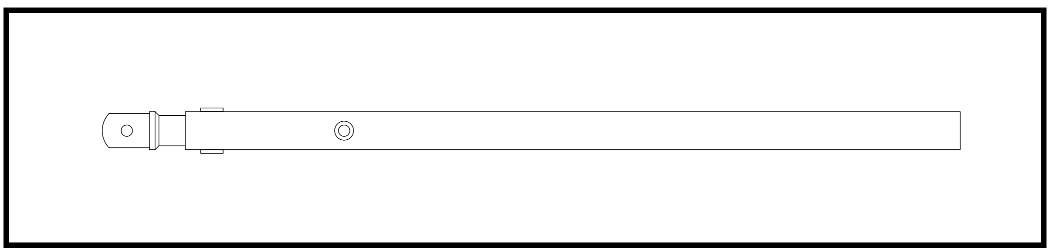


Figure 39

❏ Install P/N 602-3 retainer in P/N 512-1 and 512-2 screwjack sleeves as shown in Detail E of Drawing No. 102.

❏ Install P/N 602-1 spring in P/N 512-1 and 512-2 screwjack sleeves as shown in Detail E of Drawing No. 102.

❏ Install P/N 602-2 spacer in P/N 512-1 and 512-2 screwjack sleeves as shown in Detail E of Drawing No. 102.

❏ Install P/N 603 screwjack ends in P/N 512-1 and 512-2 screwjack sleeves as shown in Detail E of Drawing No. 102. See Figure 39. The nut must be finger tight only.

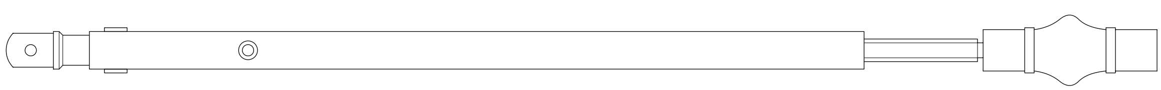


Figure 40

- ❏ Install the screwjack sleeves on the screwjacks. See Figure 40. Screw the screwjacks all the way so that they bottom on the end of the universal joints. Be careful to keep the left and right sides properly identified.

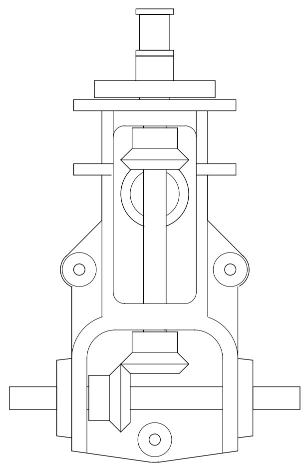


Figure 41

- ❏ Slip the P/N 520-5 shaft and P/N 520-7 miter gear in place as shown in Figure 41. Align the hole in the miter gear with the hole in the shaft. Drill through with a 11/64"Ø drill and then ream with a 3/16"Ø drill. Install the roll pin. (You may find it easier if you support the shaft with a pair of V-blocks.) Observe the note and warning above for the installation of taper pins.

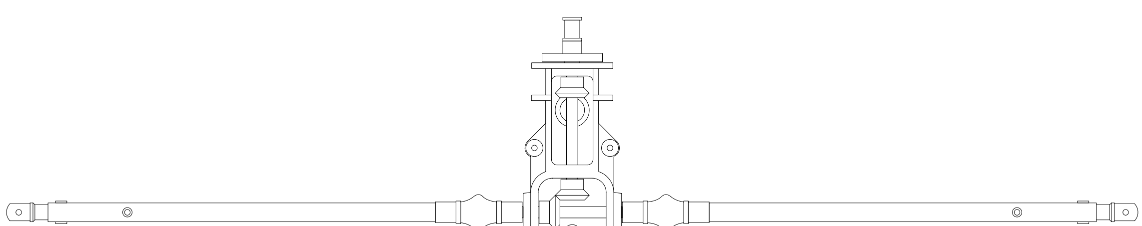


Figure 42

- ❏ You must align the shaft and miter gear so that it runs smoothly with the miter gear on the vertical shaft. Put the two universal joints (with the screwjacks and screwjack sleeves installed) in place. See Figure 42. Be sure you install the screwjack with the left hand threads on the right side and the screwjack with the right hand threads on the left side. Use shims, clamps, or any other means to hold the shaft in position. The universal joints must have a snug fit against the inner race of the ball bearing, since this is what holds the miter gear in position. Remember, the screwjack on the left side of the airplane has the same threads as the nose gear screwjack!

❏ Drill through the universal joint for the left side of the airplane with a 3/16"Ø drill, then ream with a Brown and Sharpe No. 1 tapered reamer. Observe the note and warning above for the installation of taper pins.

❏ Install the taper pin with the required hardware.

❏ Check the gear for smooth running. If necessary, the end of the universal joint may be sanded or a shim may be placed between the universal joint and the bearing.

❏ When you are sure that the shaft is properly aligned, turn the screwjack on the left side of the airplane so that the screwjack end fitting's slot is exactly vertical (check to make sure that the screwjack sleeve is still bottomed out against the end of the universal joint). With the screwjack sleeve for the right side of the airplane similarly bottomed about, turn the screwjack so that the end fitting is exactly vertical. Clamp everything in place. Drill and ream for the taper pin for the universal joint on the right side of the airplane. Observe the note and warning above for the installation of taper pins.

❏ Install the taper pin with the required hardware.

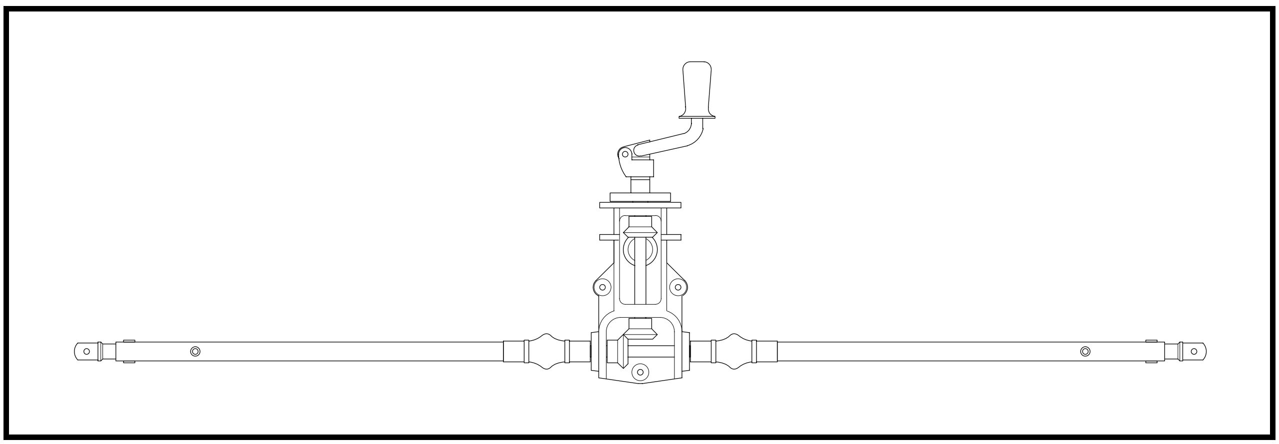


Figure 43

❏ Install P/N 821-3 collar on the upper part of the shaft.

❏ Install P/N 820 crank on P/N 821-3 collar. Check for fit. You will have to file a radius on the tang of P/N 820, and you will have to file on P/N 820 or P/N 831-3 to make things fit completely. Sand or file for final fit.

❏ Install P/N 822A handle on P/N 820 with the required shoulder screw and washer. See Figure 43. The shoulder screw should be installed with Loctite, but first check to make sure that the handle will turn freely with the shoulder screw tightened all the way. If necessary, eliminate the washer, sand the bottom of the handle or deepen the counterbore to achieve the free rotation of the handle.

❏ The gears, screwjacks and all other parts of this retraction system should be lubricated with MIL-G-22164D grease (Aeroshell 17).

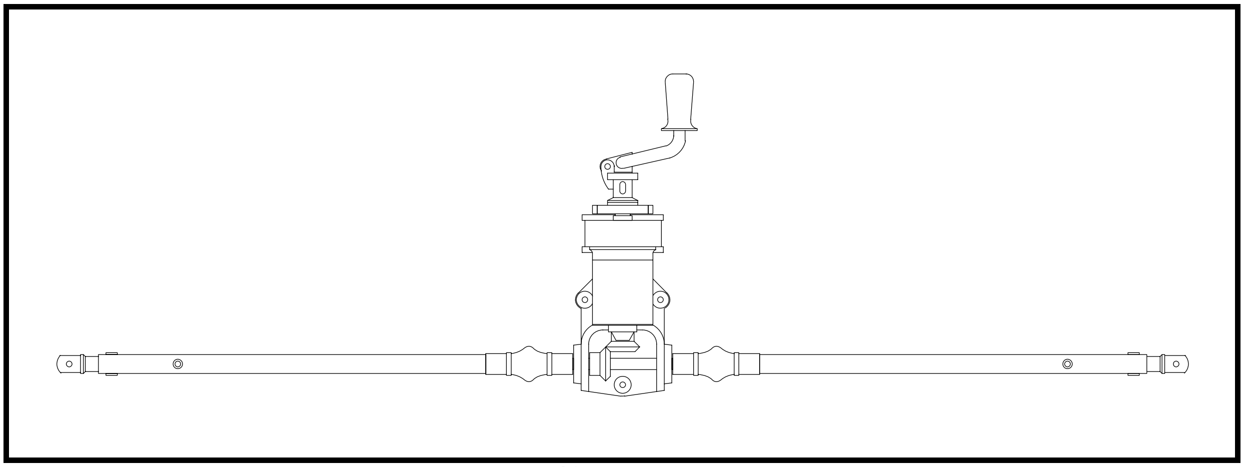


Figure 44

❏ Install P/N 530-1 landing gear motor assembly with the supplied hardware: AN3-17A (2), AN960-10L (2), MS21042-3 (2). See Figure 44.

If you wish, you may make a cover plate for the gears from aluminum or fiberglass and screw it to P/N 520-2 gearbox with two 6-32 machine screws.

Main Landing Gear Assembly

❏ Trial fit P/N 719 in the hole at the bottom of the landing gear leg. See Drawing No. 102. The washer welded on the gear leg has a machined "flat" to keep the landing gear arm pin from turning. You may have to file on the "flat" to get things to fit properly.

❏ Trial fit P/N 723 in the hole at the top of the landing gear leg. The washer welded on the gear leg has a machined "flat" to keep the oleo pin from turning. You may have to file on the "flat" to get things to fit properly.

❏ Trial fit P/N 723 in the hole at the top of the landing gear arm. The washer welded on the gear arm has a machined "flat" to keep the oleo pin from turning. You may have to file on the "flat" to get things to fit properly.

❏ Extend P/N 550 for the full length of its travel. If you wish, you may use some shop air to pump up the strut. Check the length of the oleo shockabsorber. See Drawing No. 550.

▲ **Warning**	Whenever the oleo shock absorber struts have air pressure in them, they must be completely deflated before disassembly. If you fail to do this, the piston will become a projectile with an unbelievable force. *Failure to deflate an oleo strut before disassembly can cause injury or death*. ▲

❏ If the oleo strut is not 440mm long, deflate the strut and disassemble the strut. The oleo valve is a high pressure valve and to deflate the strut you must back off the upper (5/8") hex with a wrench before pressing on the strut valve. Sand the 37.9Ø ridge of the piston until the piston will fit into the oleo nut, then carefully clean the piston to remove all sanding grit. Oil the piston and reassemble the oleo strut. See Drawing No. 550.

Note: P/N 554 has a 38mm diameter counterbore (see Drawing No. 554) into which the 37.9Ø ridge of the piston fits (see Drawing No. 555-3). Oil is trapped in this area when the oleo extends. The purpose of this is to cushion the shock and to keep the oleo strut from "knocking" metal against metal when the oleo is fully extended. During the manufacture of the oleo shock absorbers, the pistons are chrome plated. The chrome plating tends to build up with a heavier coating on the raised part. This makes the diameter of the piston's land slightly too large. This can be reduced by sanding with a fine grit emery paper (320 grit). Do not attempt to use a file as the chrome is much harder than the file and will only dull it.

- ❏ Split the main wheel by loosening the six bolts.
- ❏ Shake some talcum powder inside the tire.
- ❏ Install the inner tube in the tire.
- ❏ Place the tire and tube on the side of the wheel with the hole for the inner tube valve stem. Pull the valve stem through the hole.
- ❏ Put enough air pressure in the inner tube to round it out, but not enough so that it starts to expand.
- ❏ Install the other side of the wheel and insert the bolts. Be very careful to make sure that you do not pinch the inner tube between the two halves of the wheel.
- ❏ Tighten the nuts and bolts for the wheel.
- ❏ Inflate the wheel to about 30 psi. Remove the valve core and allow the tire to deflate. Then replace the valve core and inflate the tire to about 30 psi.
- ❏ Install the wheel on the axle. If the nut is a little short of the cotter pin hole, deepen the slots with a hacksaw.
- ❏ Install the landing gear arm on the landing gear leg.
- ❏ Install the oleo shock absorber on the landing gear leg.
- ❏ The landing gear parts may be painted at any time. It is suggested that the inside of the upper tube of the landing gear leg be coated with par-al-ketone and zinc chromate primer. Do not paint the two bearing surfaces of the landing gear leg, i.e., where the leg pivots in the fittings installed in the wing.

Main Landing Gear Bushings Installation

The main landing gear mount fittings have grease fittings installed for lubrication. There are two installations. For the first parts we made, straight grease fittings are installed, and we have subsequently changed the design of the fitting to accept angled grease fittings. It is not possible to get a grease gun on the straight grease fittings, so a needle adaptor is used. The tip of this oversized hypodermic needle is inserted into the tip of the grease fittings and grease is pumped in.

- ❏ Remove P/N 766 from the wing spar and install P/N 769. This bushing is a press fit. It will require that you tap it in to place. Use a board on the bushing and tap the bushing into place. As an alternative method you may do a "shrink fit" installation. Under this method P/N 766 is heated in an oven while the bushing is placed in a refrigerator. This will expand P/N 766 while shrinking the bushing. Remove the fitting from the oven and the bushing from the refrigerator and quickly put the bushing in the fitting.

- ❏ Remove P/N 767 from the forward wing spar and install P/N 770. This bushing is a press fit. It will require that you tap it in to place. Use a board on the bushing and tap the bushing into place. As an alternative method you may do a "shrink fit" installation. Under this method P/N 767 is heated in an oven while the bushing is placed in a refrigerator. This will expand P/N 767 while shrinking the bushing. Remove the fitting from the oven and the bushing from the refrigerator and quickly put the bushing in the fitting.

- ❏ For the installation of straight grease fittings in P/N 766—drill through the bushing with a #3 (.213"Ø) drill, then tap with a 1/4-28 tap. The grease fitting should be installed on the inboard face so you will have to drill a new hole on one `P/N 766. Install the straight grease fitting, Lincoln No. 5013, so that it enters the hole in the bushing. The object of the installation is to deliver grease to the groove inside the bushing, and the grease fitting should prevent the bushing from turning. If you wish, you can install a 45° Lincoln No. 5212.

- ❏ For the installation of the 45° grease fittings in P/N 766—drill through the bushing with a #3 (.213"Ø) drill, then tap with a 1/4-28 tap. Install the grease fitting, Lincoln No. 5212, so that it enters the hole in the bushing. The object of the installation is to deliver grease to the groove inside the bushing, and the grease fitting should prevent the bushing from turning. To install the grease fitting, the tiny grease fitting must be unscrewed from its base—it is held in place with Loctite—and then reinstalled with Loctite after the base is screwed in place.

- ❏ For the installation of straight grease fittings in P/N 767—drill through the bushing with a 3/16"Ø drill and then install the Lincoln No. 5033 grease fitting. This is a drive type of grease fitting and may be installed in the threaded hole provided. (At the time we made the part, we were under the impression that you can get grease fittings with 10-32 threads—you can't.) An angle grease fitting cannot be installed in the early-model P/N 767.

- ❏ For the installation of the 45° grease fittings in P/N 767—drill through the bushing with a #3 (.213"Ø) drill, then tap with a 1/4-28 tap. Install the grease fitting, Lincoln No. 5212, so that it enters the hole in the bushing. The object of the installation is to deliver grease to the groove inside the bushing, and the grease fitting should prevent the bushing from turning. To install the grease fitting, the tiny grease fitting must be unscrewed from its base—it is held in place with Loctite—and then reinstalled with Loctite after the base is screwed in place.

❑ Trial fit the main landing gear in the fittings mounted on the spars. The bushings compress slightly when they are installed in the fittings, and they may require that you use a piece of emery paper on the inside. The main landing gear leg should not be painted where the leg fits inside the bushing, but it should have a protective coating of paint elsewhere.

Wing Rib Preparation

❑ Draw the wing rib chord line on each rib. See the wing rib drawings.

❑ Install the aileron cable pulleys on Sta. 2 wing ribs. See Detail R of Drawing No. 201.

❑ At each rib, install the spruce block for the wiring conduit, pitot tube and antenna coaxial cable as appropriate and drill the required holes for these things.

Note: The shielded very-high-voltage wires for the strobe lights are .22"Ø, accordingly they will not fit in the 3/8"Ø plastic tubing used as the wiring conduit with the wires for the navigation lights or heated pitot. There are three solutions:

1. Use a 1/2"Ø plastic tubing in place of the 3/8"Ø tubing.

2. Install two conduits of 3/8"Ø tubing in each wing—one for the strobe light wires and one for the other wires.

3. Install the strobe light wire permanently in the wing just like the antenna coaxial cable and use the 3/8" conduit for the other wires.

❑ Cut out Sta. 1 wing rib for the flap torque tube as shown on Drawing No. 207.

❑ Check Sta. 2-1/2 wing rib for the extra spruce required by the gear door and install if needed. See Drawing No. 218.

❑ Install the 10mm thick block of spruce, P/N 202-1, on Sta. 14 wing rib and install the Whelen navigation/strobe light. See Drawing No. 202 and 216. The center of the hole should be halfway between the top and bottom of the Sta. 14 rib.

❑ Install spruce blocks in the gusset pockets of the ribs for Sta. 9, 10, 11 and 12 for the installation of the Com antenna as shown in Chapter 24, Figure 35.

❑ Varnish the wing ribs prior to installation so that all of the nooks and crannies can be easily reached with a brush. Refer to the wing assembly drawings to note those areas that should not be varnished—use masking tape at these places to remind you. These include the following:

- Corner block for Sta. 1, 2, 3 and 4 at the main wing spar and forward wing spar.
- Possible access door installation for autopilot servo on inboard face of Sta. 1.

- Wing walk and wheel well framing between Sta. 1 and 2 and more wheel well framing inboard of Sta. 1.
- Flap torque tube support blocks on Sta. 2 rib.
- Landing gear nut access door between Sta. 2 and 3—forward of the front wing spar.
- Landing gear access panel between Sta. 2 and 2-1/2—aft of the main wing spar.
- Transponder antenna on outboard face of Sta. 3 and inboard face of Sta. 4 in right wing.
- DME antenna on Sta. 5 rib in left wing.
- Nav and com antennas on Sta. 9, 10, 11 and 12 ribs aft of the main wing spar. See Chapter 24, Figure 35 and 37.
- Aileron bellcrank access door on outboard face of Sta. 10 and inboard face of Sta. 11. The pitot heat block is installed only in the left wing.
- Wing tip strobe light installation on the outboard face of Sta. 14.

Wing Skins

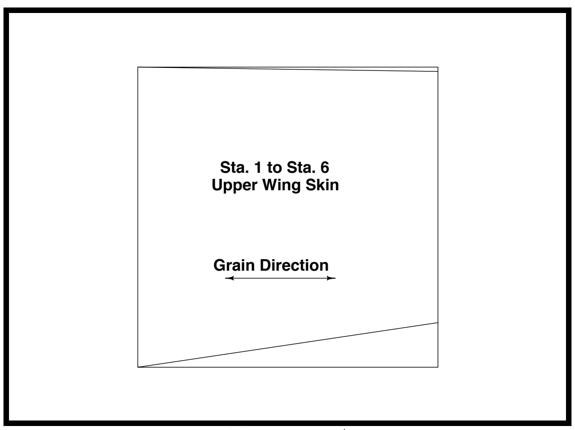


Figure 45

❏ Use two 50”x50” sheets of 2.5mm birch plywood as shown in Figure 45. Cut to fit the aircraft.

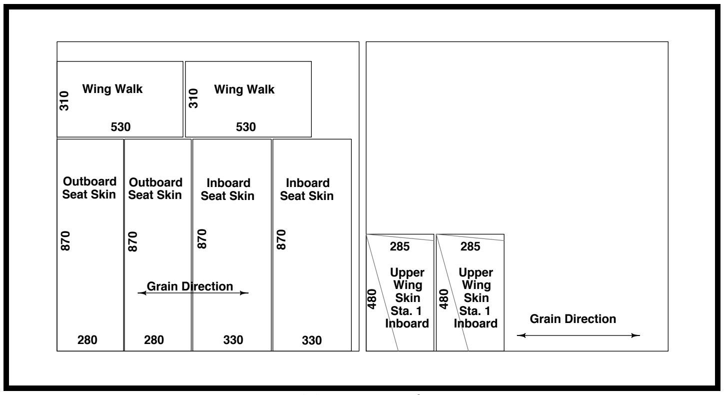


Figure 46

❑ Use two 50”x50” sheets of 2.5mm birch plywood and cut in accordance with Figure 46.

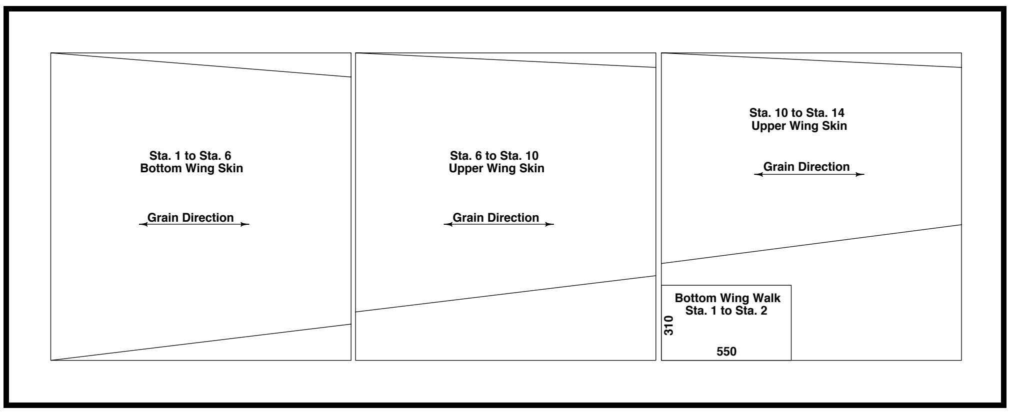


Figure 47

❑ Use six 50”x50” sheets of 2mm birch plywood as shown in Figure 47. Two of each are required. Cut the bottom wing walk and then cut the other skins to fit the aircraft.

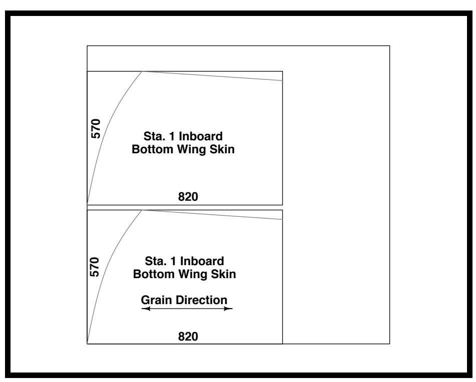


Figure 48

❑ Use one 50”x50” sheet of 2mm birch plywood and cut in accordance with Figure 48.

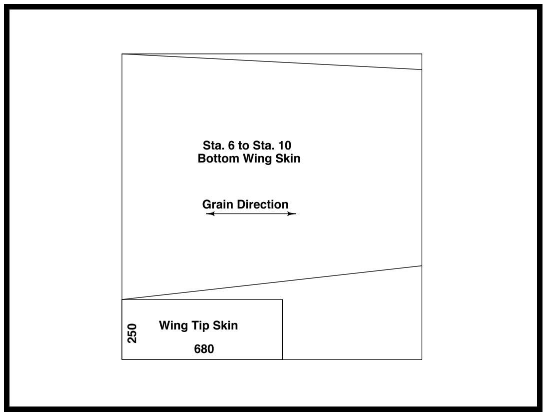


Figure 49

❏ Use two 50"x50" sheets of 1.5mm birch plywood as shown in Figure 49. Cut the wing tip skins and then cut the wing skin to fit the aircraft.

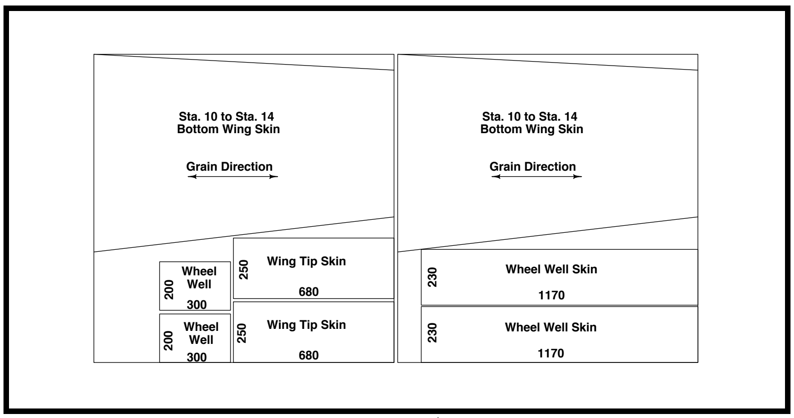


Figure 50

❏ Use two 50"x50" sheets of 1.5mm birch plywood as shown in Figure 50. Cut the wheel well and wing tip skins and then cut the wing skins to fit the aircraft.

Chapter 24
Wing Assembly

This chapter will cover the assembly of the wing. If you wish, you may do this work simultaneously with the work covered in Chapter 25 “Fuselage, Preliminary Assembly”.

Kits on Hand

To do the work covered in this chapter, you should have the following:

Kit No. 804 Flap Controls & Equipment

We also suggest that you purchase the wing tip lenses and the strobe system at this time.

You will also need additional spruce for blocking and plywood for skinning the wing. We suggest that you order enough spruce for the fuselage and enough plywood to skin the fuselage.

Wing Assembly Jig

The wing assembly jig consists of three jigs: a fuselage centerboard, a template for wing Sta. 1 and a template for wing Sta. 14. The use of these jigs will become clear to you as we discuss the assembly of the wing, so it might be a good idea to read this entire chapter before making the jigs.

The fuselage centerboard (see Figure 1) is made of 1” or 3/4” plywood. It is essential that the jig be constructed accurately and that all lines be drawn perpendicular to W.L. 0. Lay out the centerboard, but do not cut the four slots until after the two braces are made and installed.

The centerboard has two braces which are made of the same 1” or 3/4” plywood. Cut two pieces of plywood to 100mm by 1300mm and install with bolts as shown on Figure 2. The centerboard will be weakened when the slots are cut, and by installing the braces first the bolts keep the centerboard from distorting.

Remove the braces and cut the slots. The two rectangular holes are for the flap torque tube and control stick assembly. Trial fit the fuselage centerboard to each fuselage frame (and each wing spar) that will be installed in the jig.

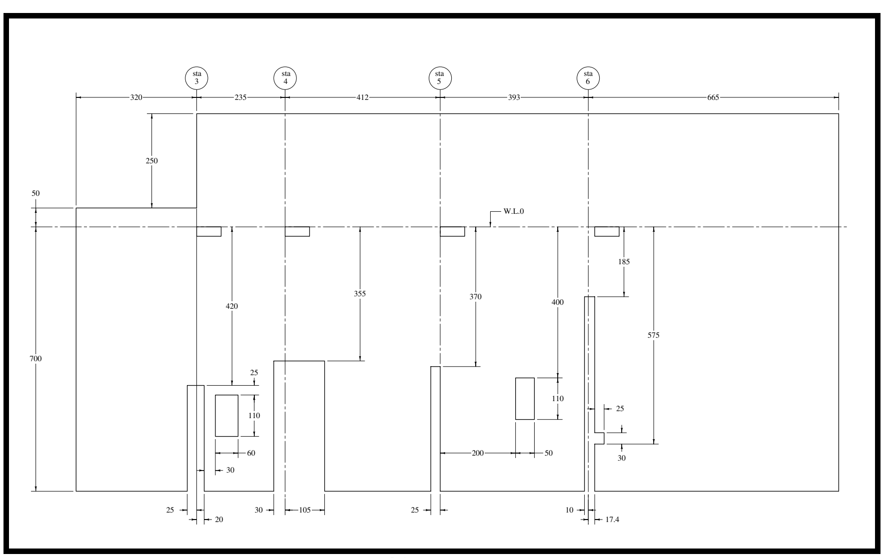


Figure 1

The wing will be assembled with the leading edge up as may be seen in many illustrations in this chapter. The four slots in the centerboard will support the forward wing spar, main wing spar, fuselage frame No. 5 and fuselage frame No. 6. The top of fuselage frame No. 3 will be supported by the centerboard. The four fuselage frames must also be supported at W.L. 0. Cut four straight boards—say one-by-two's—long enough to fit just inside the upper side longerons. These could be longer, but you may want to clamp a few dummy longerons in place during the wing assembly to strengthen things and to reassure yourself that everything is going to fit together in the end. Cut four holes in the centerboard for these braces. Note that the brace for fuselage frame No. 6 is for the aft face, thus it is 17.4mm aft of fuselage station 6.

These horizontal braces should be glued in place and supported with triangular pieces of wood. Use a carpenter's square to make sure that the braces are square with the centerboard.

Figure 2 shows the fuselage centerboard in position. This jig supports and locates fuselage Sta. 3, 4, 5 and 6 along with the main wing spar and the front wing spar. The shop floor is shown to the right side of the drawing. The jig is positioned so that W.L. 0 is exactly vertical. You should use a plumb bob to check this; in fact, we suggest that you have a plumb bob on each of the parts of the fuselage and wing jig.

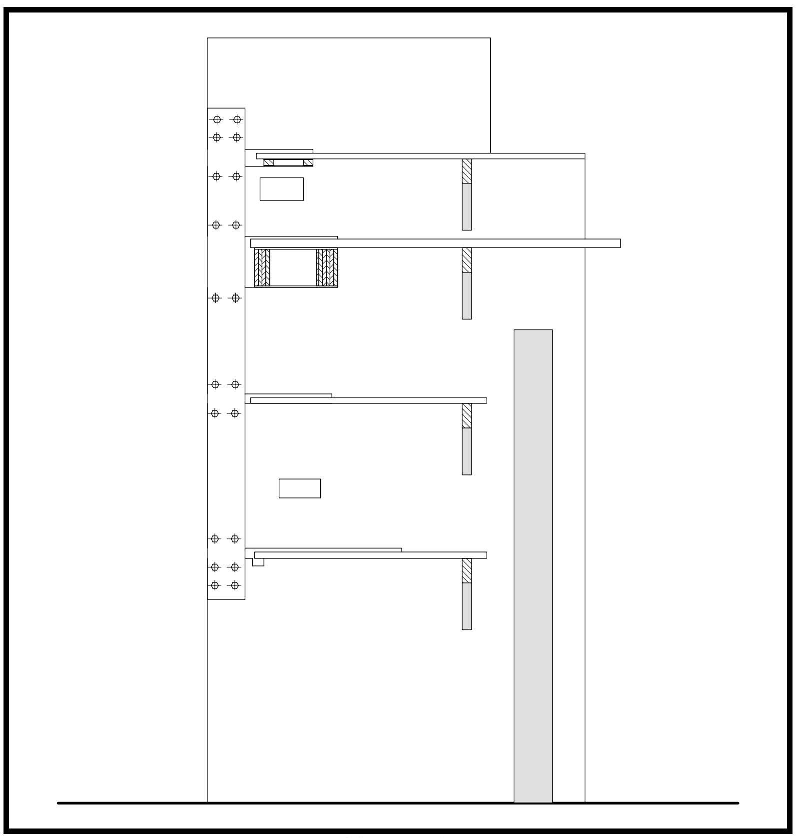


Figure 2

The centerboard should be supported in some manner. Some builders support it with diagonal braces from the floor, as shown in Figure 2. Others clamp, screw or nail the top of the board to the ceiling of the shop.

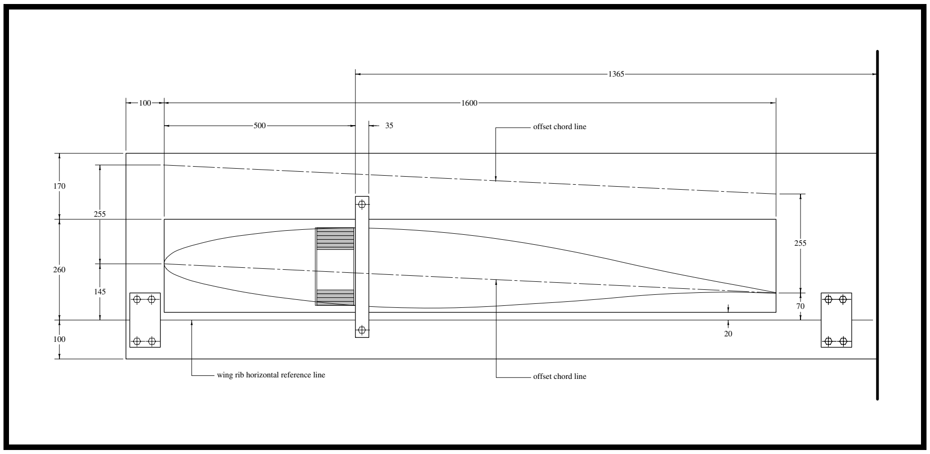


Figure 3

The template for wing Sta. 1 is shown in Figure 3. The shop floor is shown to the right side of the illustration. Note that an offset chord line is drawn on the template. The horizontal reference line must be exactly vertical when the jig is used. Be sure to mark the aft face of the main wing spar on the template since the spar support must be removed when the rib aft of the spar is installed. The template is made of 1" or 3/4" plywood and a brace of the same material is bolted in place to support the main wing spar. Two templates are required.

Make this template from a single piece of plywood and install a cross brace for the aft face of the wing spar. Because the template must be removed while the wing is being assembled, the template should be made in several pieces for easy dissassembly. Bolt plywood plates as shown on Figure 3 and then saw the template into two pieces. As an alternative, the template may be made entirely of boards.

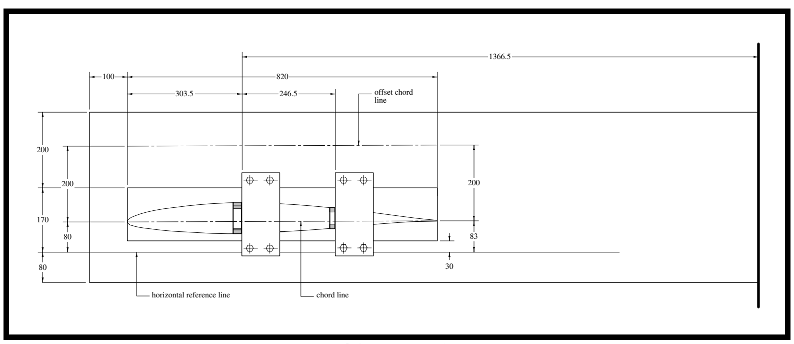


Figure 4

The template for wing Sta. 14 is shown in Figure 4. Make it out of 1" or 3/4" plywood and install the braces for the main and aft wing spars. Two templates are required.

A number of methods may be used to support and brace the wing jig in place. Regardless of the method used, the jig should hold the wing with considerable rigidity for the sanding and skinning process. The normal method is to brace the centerboard and the templates for Sta. 14 so that they support the weight and supply all of the rigidity. Be careful to locate the braces so that they will not interfere with your work.

The templates for wing Sta. 1 may be joined to the centerboard. One builder installed a diagonal brace on each side of the centerboard. This diagonal brace was screwed to the Sta. 1 template and a support from fuselage frame No. 6 extended out the the wing template. Other builders have used the Sta. 14 template to supply all bracing for side loads. The centerboard and other templates were screwed to the shop floor with shelf brackets. Wires and turnbuckles were used to hold the top of the templates in place.

When the wing is float sanded, you may find it easier to make a raised walkway of sawhorses and board so that you do not have to reach up while sanding. If your arms are raised up high while sanding, they will fatigue quickly. Keep the space for such a walkway in mind when you brace the fuselage jig.

Remember that the wing templates will be aligned to the chord lines already drawn on the main wing spar. It will not be possible to remove or install frames No. 5 and 6 once the jig is set up. Due to the weight of the main spar, the centerboard will become quite weak if the brace shown in Figure 2 is removed. As these frames extend out to wing Sta. 1, they will be inside the open area of the template. This provides you with the opportunity to install support braces on the inboard face of the Sta. 1 template to support these frames. It also means that the frames must be installed in the jig early.

The front spar/frame No. 3 assembly will be allowed relatively little movement while in the jig. You will have to lift the front spar slightly to install the intermediate leading edge ribs.

You should install the main landing gear legs to make sure that the landing gear fittings are in the proper alignment. To check this alignment, the position of the landing gear leg should be checked in both the extended and retracted position. Because of the wing template, the landing gear leg will not be able to swing inboard so you will have to remove the landing gear leg to place it in the two positions. Another way is to check the alignment by swinging the leg outboard.

The principal purpose of the template at wing Sta. 1 is to locate the leading edge alignment strings. These strings will be extended to the centerboard where a small hole will be drilled and then the string will extend to the other wing. While it is technically possible to use only one Sta. 1 template, this assumes that the wing spar is perfect. We think that two Sta. 1 templates should be used and the common meeting point at the centerboard should be used as a cross-check, not as the primary reference point.

If you wish, use small screweyes for the leading and trailing edge alignment strings on the Sta. 1 template. Cut a small notch for the screweye and then screw it in place. The screweye should have a diameter of 1/8” or so, and the alignment string can be stretched from the Sta. 14 template to the centerboard. When everything is in alignment, the string will be centered in the little “gun sight” provided by the screweye.

Wing Assembly

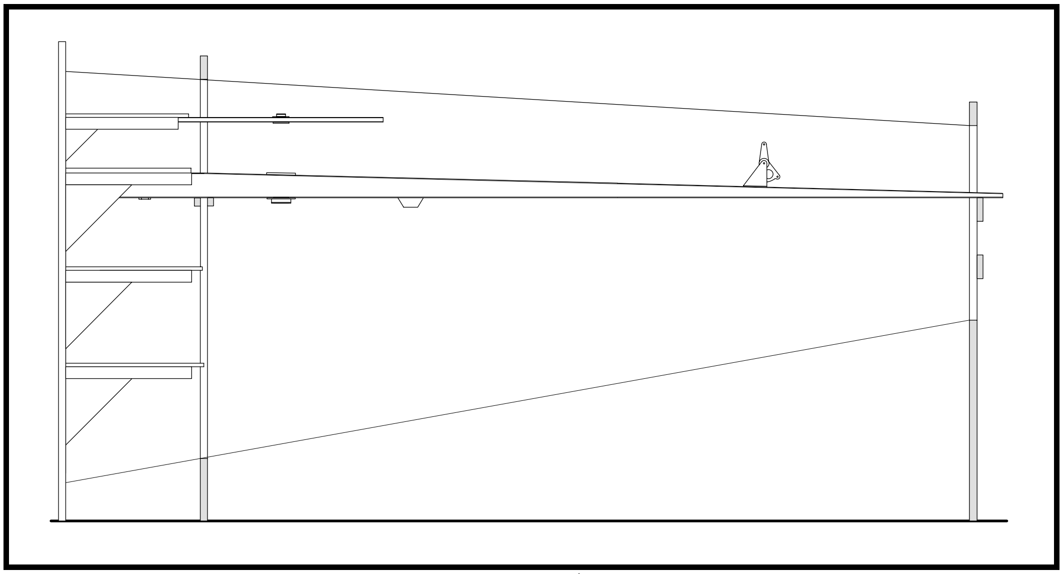


Figure 5

- ❏ Set up the fuselage centerboard.
- ❏ Put fuselage frame No. 6 in the fuselage centerboard.
- ❏ Put fuselage frame No. 5 in the fuselage centerboard.
- ❏ Put fuselage frame No. 4 and the main wing spar in the fuselage centerboard. The landing gear fittings and aileron bellcrank supports should be installed. The retraction system gearbox should not be installed. You may use the wing templates to support the ends of the spar. (This operation is one for which it would help to have a few extra hands available.)
- ❏ Put fuselage frame No. 3 and the front wing spar in the fuselage centerboard. The landing gear fittings should be installed on the front wing spar. The four control stick support brackets should be installed on the aft face of the front wing spar. The rudder pulley brackets do not have to be installed at this point.
- ❏ Install the braces (see Figure 2) on the fuselage centerboard.
- ❏ Set up the templates for wing Sta. 1 on each side.
- ❏ Set up the templates for wing Sta. 14 on each side.
- ❏ True up the fuselage centerboard. Use plumb bobs to make sure that W.L. 0 and the aircraft centerline are exactly vertical. Plumb bobs should be installed on the fuselage centerboard for the duration of the wing assembly. This way, you can always tell at a glance that things are still in the proper position.
- ❏ Use a water level to level the main wing spar. Use the aft face of the spar and measure from each wing tip. Also check to make sure that the wing tips are the same level as the

aft face of the spar at the center of the aircraft—the tips are actually 1.5mm higher than at the center because of the thinner plywood.

- ❑ Fix the templates at wing Sta. 14 in place. Use the offset chord line to align the template from the chord line on the spar. This offset chord line is located 200mm from the chord line on the spar. These templates should have plumb bobs installed to make sure that they are correctly aligned. Be sure to use a plumb bob at the line for the horizontal reference line.

- ❑ Fix the templates at wing Sta. 1 in place. Use the offset chord line to align the template from the chord line on the spar. This offset chord line is located 255mm from the chord line on the spar. These templates should have plumb bobs installed to make sure that they are correctly aligned. Be sure to use a plumb bob at the line for the horizontal reference line.

Note: We will assume that all parts are correctly aligned. It is quite easy to bump things out of alignment. You should check the alignment of the jigs throughout the construction of the wing.

- ❑ Install a string for the alignment of the leading edge. See Figure 5. This string should be anchored on the outboard face of the Sta. 14 template. It should align with the chord line at the leading edge of the template at the Sta. 14 and Sta. 1 template. Stretch this string tight and extend it to the fuselage centerboard. Drill a hole in the fuselage centerboard.

- ❑ Pass the leading edge alignment string through the hole in the fuselage centerboard and continue it to the template for Sta. 14 on the other wing tip. Anchor the alignment string at the far end.

- ❑ Check the alignment of the leading edge strings at all templates. You will probably have to make some adjustment in the location of the string at the fuselage centerboard. Remember, the leading edge string should arrive at a common point at the center of the aircraft. This is an automatic check that both wings are the same.

- ❑ Install a string for the alignment of the trailing edge as shown in Figure 5. This string should be anchored on the outboard face of the Sta. 14 template. It should align with the chord line at the trailing edge of the template at the Sta. 14 and Sta. 1 template. Stretch this string tight and extend it to the fuselage centerboard. Drill a hole in the fuselage centerboard.

- ❑ Pass the trailing edge alignment string through the hole in the fuselage centerboard and continue it to the template for Sta. 14 on the other wing tip. Anchor the alignment string at the far end.

- ❑ Check the alignment of the trailing edge strings at all templates. You will probably have to make some adjustment in the location of the string at the fuselage centerboard. Remember, the trailing edge string should arrive at a common point at the center of the aircraft. This is an automatic check that both wings are the same.

- ❑ Install the aileron cable pulleys on the inboard face of the wing rib at Sta. 2..

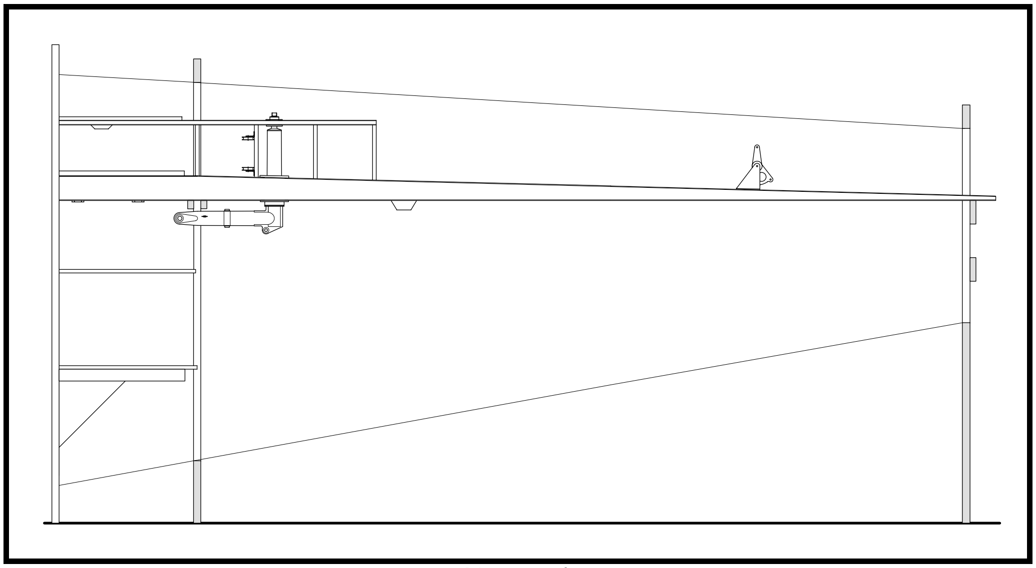


Figure 6

❏ Clamp the intermediate leading edge ribs (those ribs between the main wing spar and the front wing spar) for wing Sta. 1, 2, 3 and 4 to the main wing spar as shown in Figure 6. Do not sand the ends of the ribs at this time. Use a straightedge against the chord line drawn on the rib at Sta. 4 to check the alignment of this rib. The chord line on the rib should match the chord line drawn on the forward face of the spar and should be aligned with the leading edge alignment string.

Note: In the past, there has been some confusion about the exact location of the ribs at Sta. 1. It is important that these ribs be installed on the centerline of the wing station—the side load fittings (P/N 772-1 & 772-2) must be cleared, and when the landing gear is retracted, the upper side load arm will nearly hit this rib as can been seen in Drawing No. 102. Aft of the aft spar the rib is installed slightly outboard of the rest of the Sta. 1 ribs.

In Figure 6 and all subsequent illustrations in this chapter, the supports of the centerboard are not shown for frames No. 3, 4 and 5 so that you can see the details.

❏ Clamp the front wing spar to the intermediate leading edge ribs. Check for the correct 340mm dimension between the aft face of the main wing spar and the forward face of the front spar (see Drawing No. 207). Use a water level to check that the front spar is correctly installed. Trial fit the main landing gear leg to see that it will fit and that things are correctly aligned (see Drawing No. 102).

❏ Sand the intermediate leading edge ribs as necessary so that they are in the proper position and so that the front spar is in the correct position. These ribs may be sanded on both the forward and aft ends.

❏ Glue the intermediate leading edge ribs to the main wing spar. It is a good idea to have the front wing spar clamped in place and the landing gear leg in place.

❏ Glue the front wing spar to the intermediate leading edge ribs. The landing gear leg must be in place during this operation.

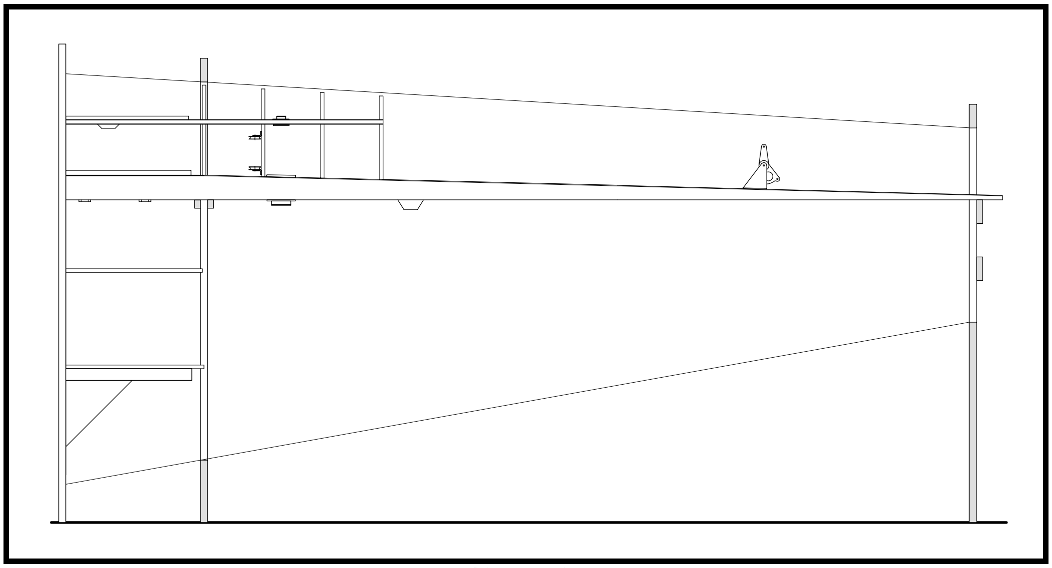


Figure 7

❏ Clamp the leading edge ribs for Sta. 1, 2, 3 and 4 in place as shown in Figure 7. Sand the aft faces of the ribs as necessary for alignment with the leading edge alignment string.

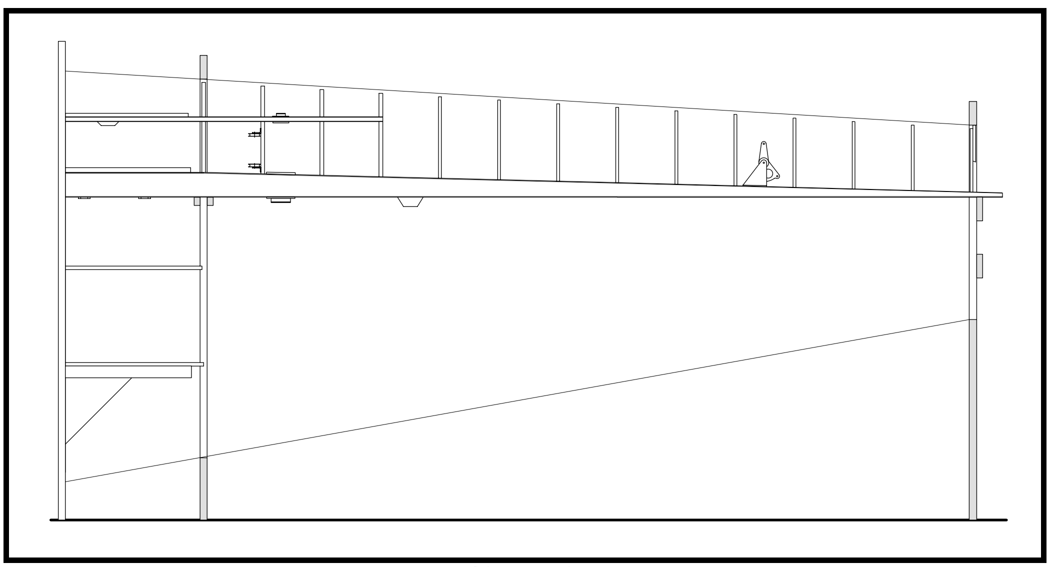


Figure 8

❏ Clamp the remaining leading edge ribs in place as shown in Figure 8. Sand the aft faces of the ribs as necessary for alignment with the leading edge alignment string.

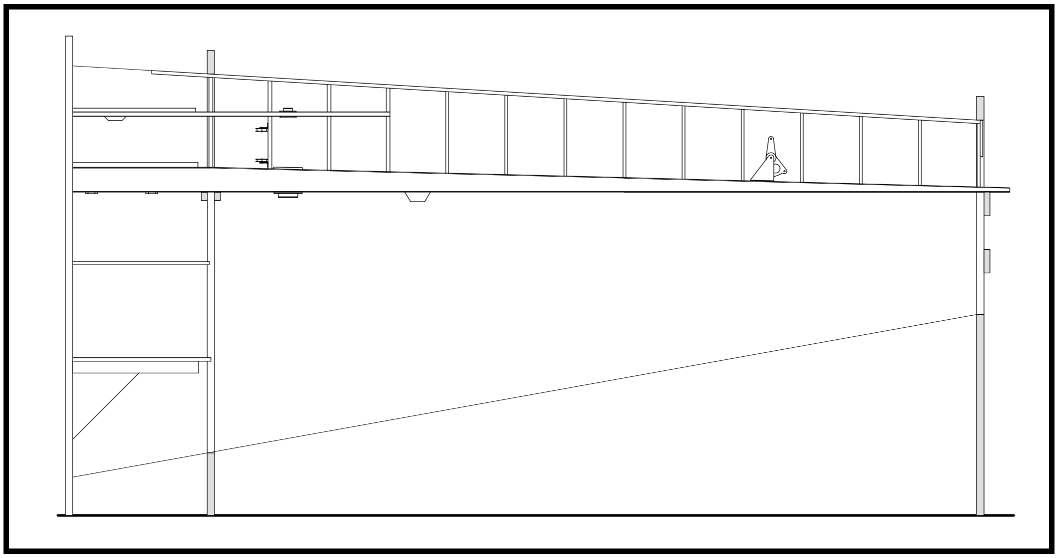


Figure 9

- ❑ Clamp the leading edge strip in place as shown in Figure 9. Sand the ribs as necessary to match the angle of the leading edge strip. During this and later operations, you will find it helpful to clamp a long board along the top or bottom of the wing to stabilize the ribs and to keep them from racking over—remember “top” or “bottom” refers to the top or bottom of the wing in its normal position in the aircraft, *not* in the jig.

- ❑ Glue the leading edge ribs in place. During this operation it is advisable to have the leading edge strip in place.

- ❑ Sand or plane the leading edge strip to the approximate airfoil contour. This will save you a lot of sanding while it is glued in place.

- ❑ Glue the leading edge strip in place.

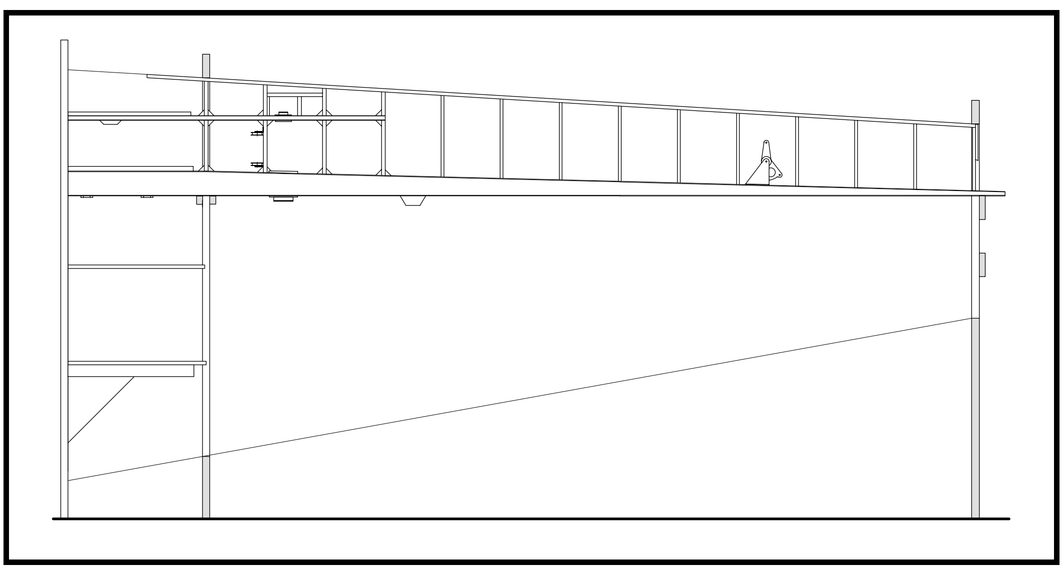


Figure 10

❏ Install the framing for the landing gear inspection doors. See Figure 10. Do not install the corner blocks at this time.

Note: Some builders have installed inspection doors for the aileron pulleys. If you wish to do so, you may, but we don't see the need. These pulleys are lubricated for life. The likelihood that you will ever have to get to these is very remote.

❏ Install the corner blocking for the leading edge ribs at Sta. 1 through 4. See Figure 11. These corner blocks may be continuous from the top of the wing to the bottom. This is the simplest installation, but it is also the heaviest. The best approach is to make the corner blocks so that they are the same thickness at the underlying rib capstrips. The corner blocks should be 25x25 triangles.

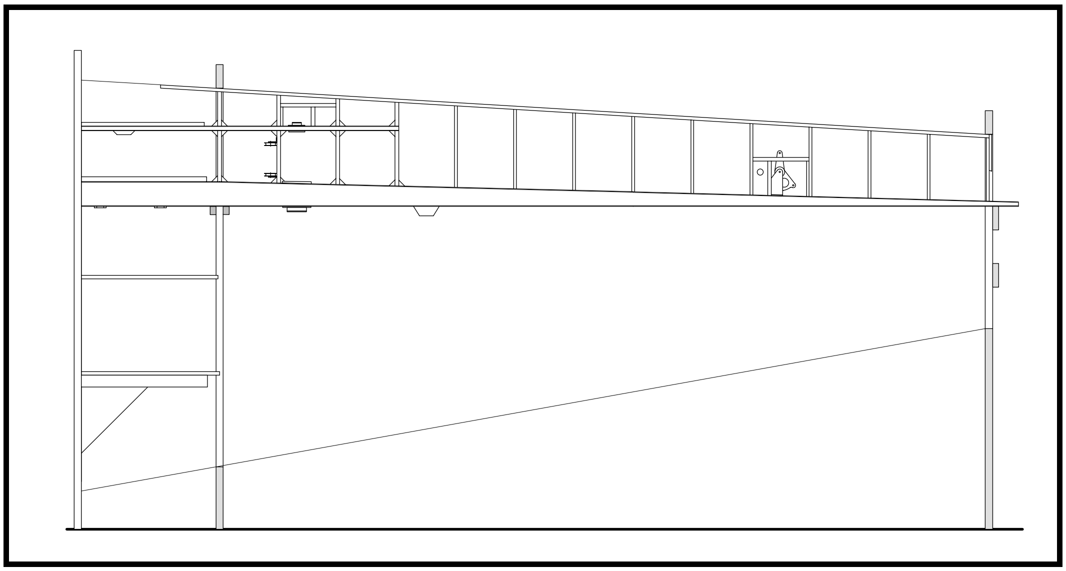


Figure 11

❏ Install the framing for the access door for the aileron bellcranks. See Figure 11. On the left side of the aircraft, install the extra block of spruce for the pitot tube as shown in Detail V Drawing No. 201 Sheet 4. Drill the hole required for the pitot tube plumbing and wiring.

❏ Install a plywood plate over the end of the front wing spar to cover the end grain of the wood since end grain can sometimes cause the finish to crack.

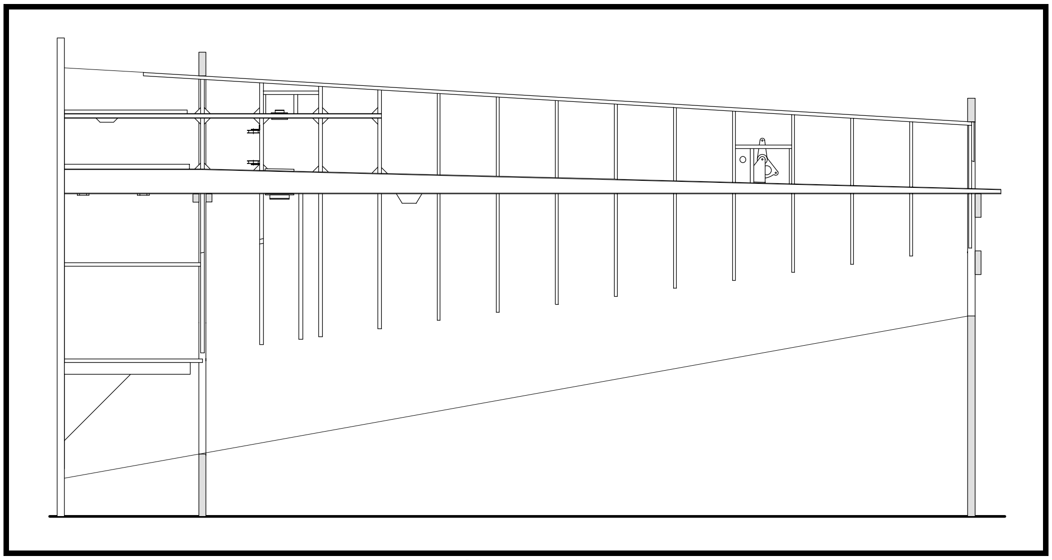


Figure 12

❏ Clamp all intermediate trailing edge ribs (the ribs between the main wing spar and the aft wing spar) to the main wing spar as shown in Figure 12. The Sta. 2-1/2 wing rib must be installed with the plywood face inboard.

❏ Assemble P/N 709-2, 711-2A and 853. See Drawing No. 709-1 and Drawing No. 201 Sheet 4. The flap actuator will automatically insure the correct 30mm spacing and will align the two tubes with each other.

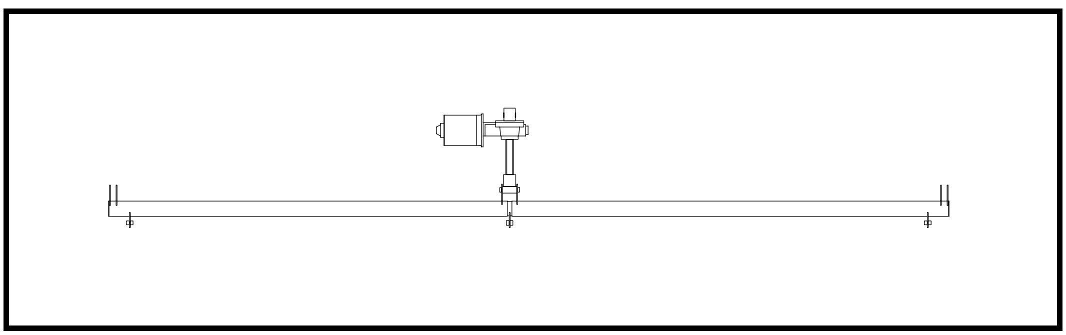


Figure 13

❏ Drill the torsion tubes for the two AN3-15A bolts. See Drawing No. 709-1. Some of the flap torque tubes are made with the smaller diameter tube shorter than intended, so you will have to move the bolt holes so that you drill through the inner tubing with the intended edge clearance.

❏ Install the two bolts with the required hardware.

❏ Ream the bronze bushings of the four P/N 765 with a 3/16” reamer.

❏ Install two P/N 765 on each end of the flap torque tube. See Drawing No. 201, Sheet 4. If the AN23-31 bolts are too short (some builders have reported this) the bronze bushings may be shortened on the outboard end by filing.

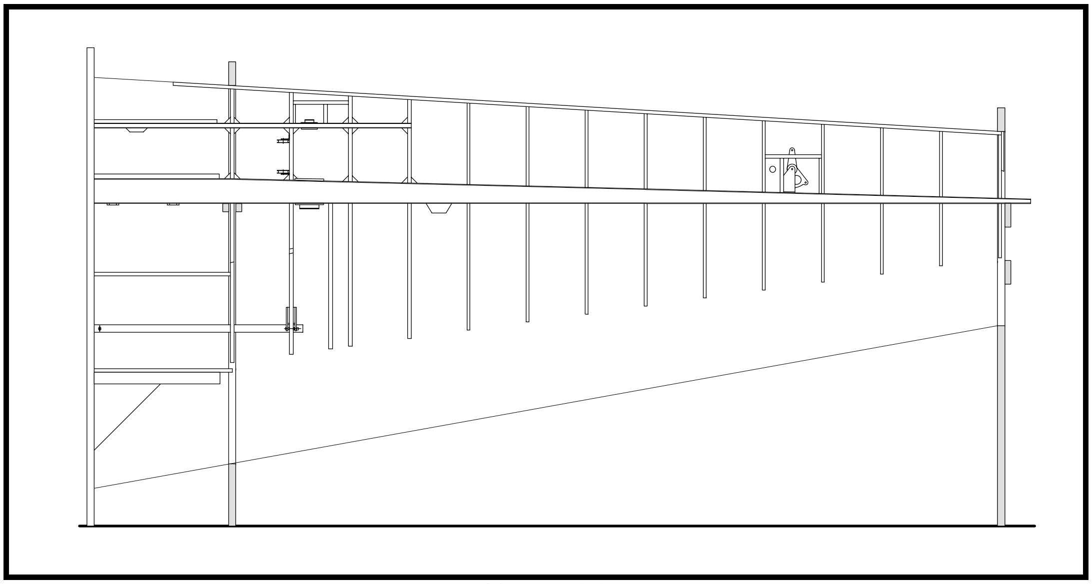


Figure 14

- ❏ Cut four wedge-shaped spruce blocks for P/N 765 as indicated on Drawing No. 201, Sheet 4, Section W-W. These blocks should be cut oversized and clamped in place.

- ❏ Clamp the flap supports (P/N 765) and the flap torque tube in place on Sta. 2 wing rib. See Figure 14.

- ❏ Sand the ribs so that they are aligned with the trailing edge string.

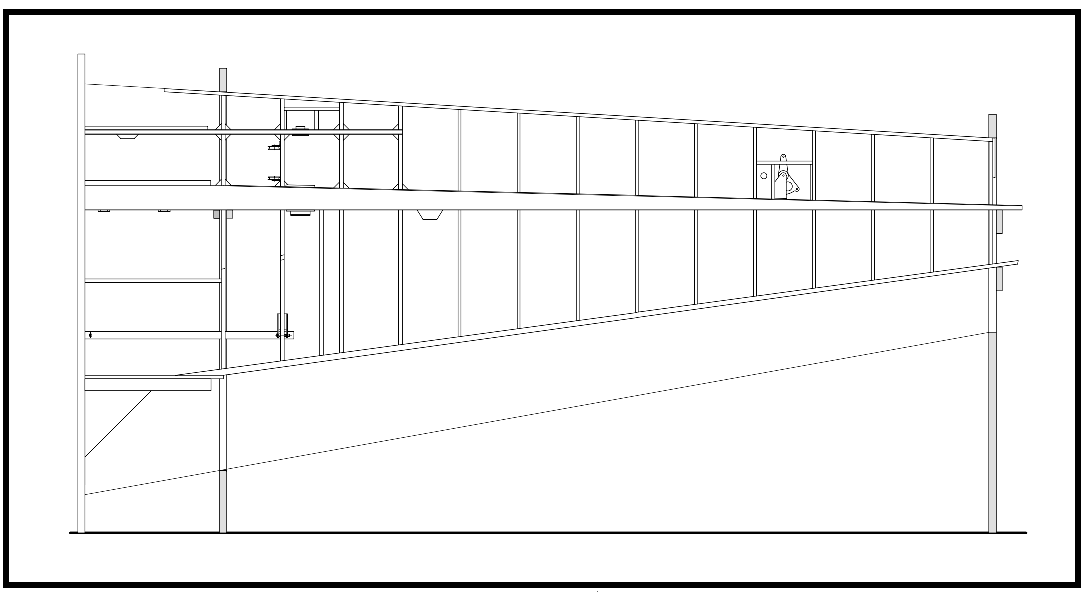


Figure 15

- ❏ Trial fit the aft wing spar in place. If not previously done, the aft wing spar must be cut at an angle to mate with the forward face of fuselage frame No. 6. See Drawing No. 206 for the angle of the cut.

Note: In the following steps you will sand the ribs to fit the aft wing spar. At the same time you will fit the aft wing spar to the forward face of fuselage frame No. 6. You will also have to check the alignment and placement of the flap torque tube and the flap pushrod.

You should use a small nail as an alignment pin to correctly locate the aft wing spar on fuselage frame No. 6. One alternative is to drill through both the spar and the frame and install a bolt with large wood blocks. This bolt should be centered in the glue area and can be used for clamping as well as alignment. After the gluing is complete, the bolt may be removed since it is not required for strength.

❑ Sand the ribs for Sta. 1 and 14 to fit the aft wing spar.

❑ Remove the aft wing spar.

❑ Check to make sure that the chord lines of the ribs for Sta. 1 and 14 align with the trailing edge string.

❑ Glue the ribs for Sta. 1 and 14 to the main wing spar.

❑ Clamp the aft wing spar in place. Use the offset chord lines on the Sta. 1 and Sta. 14 template to locate the aft wing spar.

❑ Check the alignment of all of the ribs with the chord line drawn on the forward face of the aft wing spar.

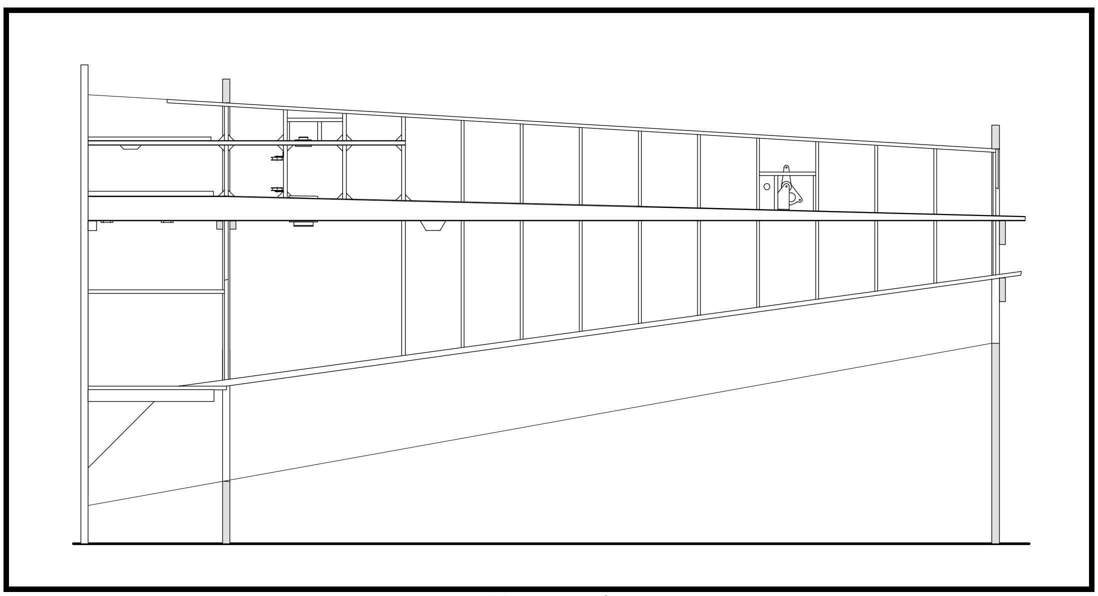


Figure 16

❑ With the aft wing spar clamped in place, glue all of the remaining ribs to the main spar *except* for the ribs at wing Sta. 2, 2-1/2 and 3. See Figure 16.

❑ Install P/N 713A on the flap torque tube. See Drawing No. 201, Sheet 4. Remove P/N 743 from the flap and install on the support hinges (P/N 742) on the aft wing spar.

❑ Clamp the Sta. 2 wing rib in place.

❏ Check the alignment of the flap pushrod with the flap hinge. You will have to file on the inside of the fork end of P/N 713A and on P/N 743 for clearance when the flaps are all the way down. At this time, you are primarily concerned about the alignment of the pushrod between the support hinges (P/N 742). Be sure to check to make sure that the flap torque tube is correctly positioned so that the actuator will be 40mm to the left side of the aircraft centerline.

❏ When you are sure that the flap torque tube is properly positioned, final fit the wedge-shaped blocks for the flap torque tube supports. Glue these blocks to Sta. 2 wing rib.

❏ Do a final check of the position of the flap torque tube. Clamp the outboard torque tube supports (P/N 765) in place. Remove the rib and drill the four 3/16"Ø holes on a drill press. If you wish, you may start drilling the holes with all parts clamped in the wing to assure that you have the supports in the proper position, but we suggest the use of a drill press to assure parallel holes.

❏ Clamp the rib back in place and install all of the supports for the flap torque tube. Do one final check of the location of the flap torque tube and pushrod.

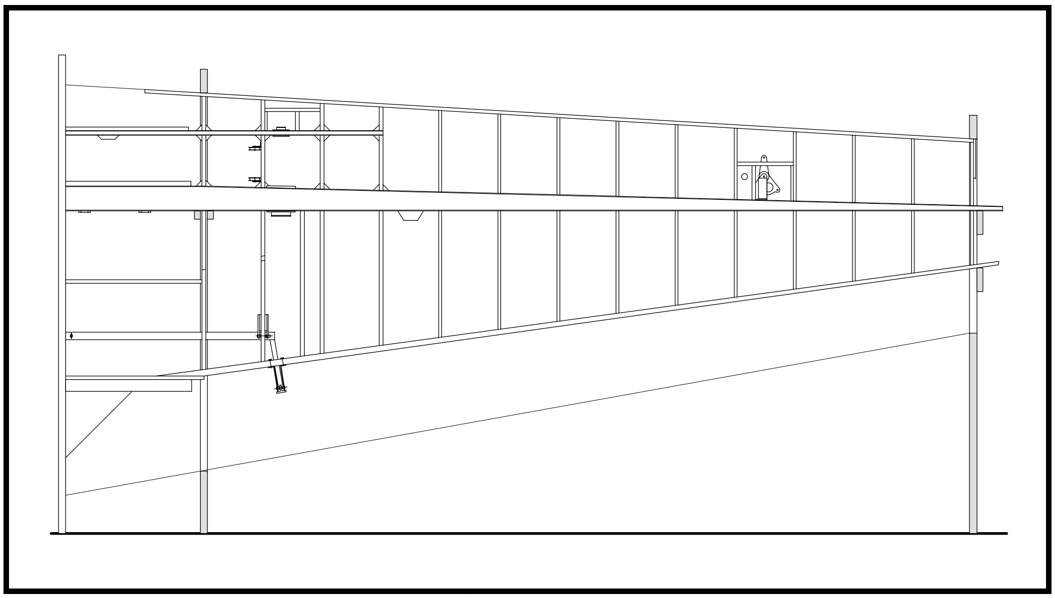


Figure 17

❏ Glue Sta. 2, 2-1/2 and 3 wing ribs to the main wing spar. While clamping, check to make sure that the flap torque tube swings easily on the supports. See Figure 17.

❏ Glue the aft wing spar to the wing ribs and to fuselage frame No. 6.

❏ Clamp the trailing edge rib for wing Sta. 1 to the aft wing spar. This rib is installed so that it is glued to the outboard end of fuselage frame No. 6 and to the aft face of the aft wing spar. Check the alignment with the trailing edge string.

❏ Clamp the trailing edge rib for wing Sta. 14 to the aft wing spar. Check the alignment with the trailing edge string.

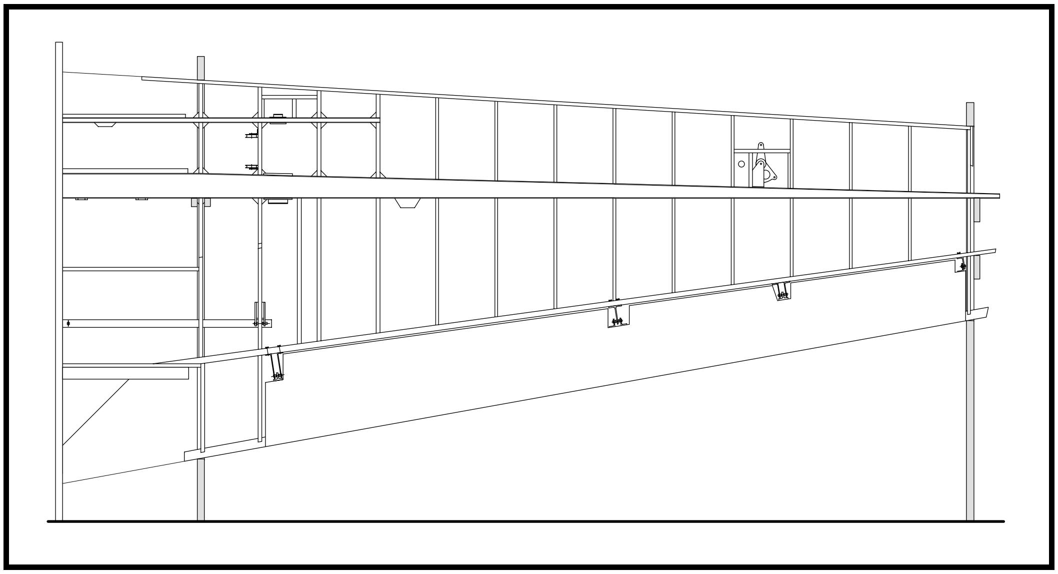


Figure 18

❑ Install the aileron/flap assembly on the aft wing spar as shown in Figure 18. All hinges must be installed.

❑ Fit the trailing edge strip to the trailing edge rib at wing Sta. 1 and 14.

❑ Fit the trailing edge rib for wing Sta. 2 in place. Fit this to the aft wing spar and to the trailing edge strip.

❑ Glue the trailing edge ribs for wing Sta. 1, 2 and 14 to the aft wing spar and to the trailing edge strip.

❑ Remove the Sta. 1 template. The leading edge string and trailing edge string should remain in place as long as possible and should be used to check the alignment while skinning.

In the following steps leading up to the skinning of the wing you will do a number of minor installations: wheel well framing, wing walk framing, jack pad fitting, wing tip bow, aileron controls, wiring conduit, pitot line and four antennas. You may do these installations in any order, and you may find it quicker to work on several of them at the same time. So while you are waiting for the glue to dry on the wheel well, go ahead and start on the antenna installation.

This is also a convenient time to skip ahead and cut the wing skins. In particular, the skins for Sta. 1 to 6 require that a piece be scarfed and glued on to accommodate the trailing edge between Sta. 1 and 2.

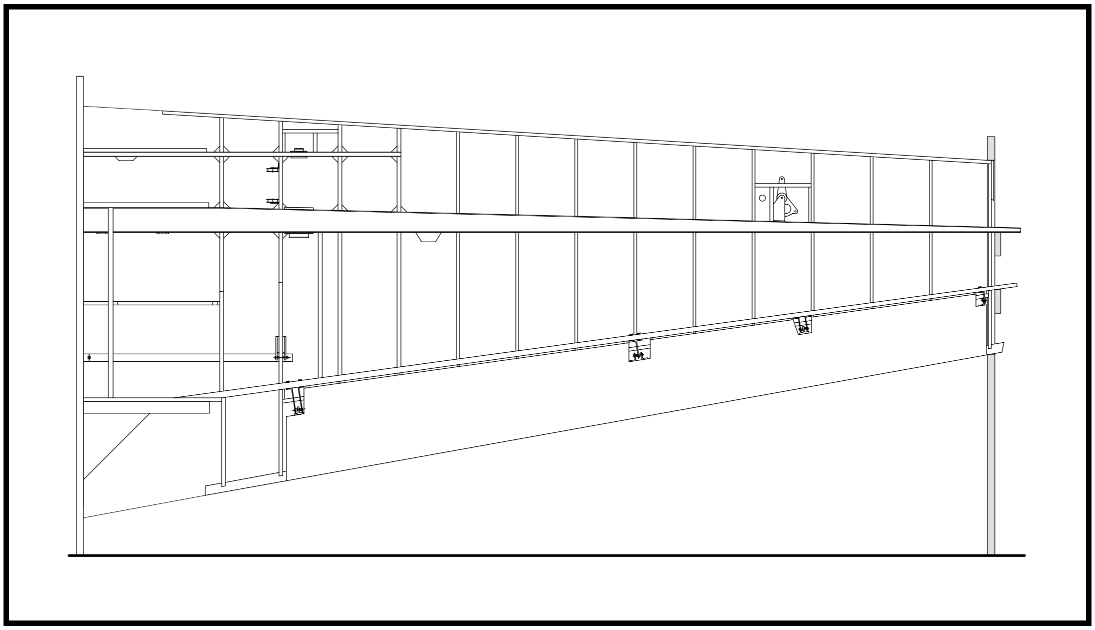


Figure 19

❑ Glue the two 20x20 stringers on the bottom of the fuselage. See Figure 19. At the forward end, the stringers are glued to the bottom of the main wing spar, and at the aft end they are glued to the two saddle gussets on the front face of fuselage frame No. 6. The outboard face of these stringers is at B.L. 140, regardless of what type of wheel well is planned. These stringers are bowed into place, that is, they take a bend that follows the curve of the bottom of the fuselage.

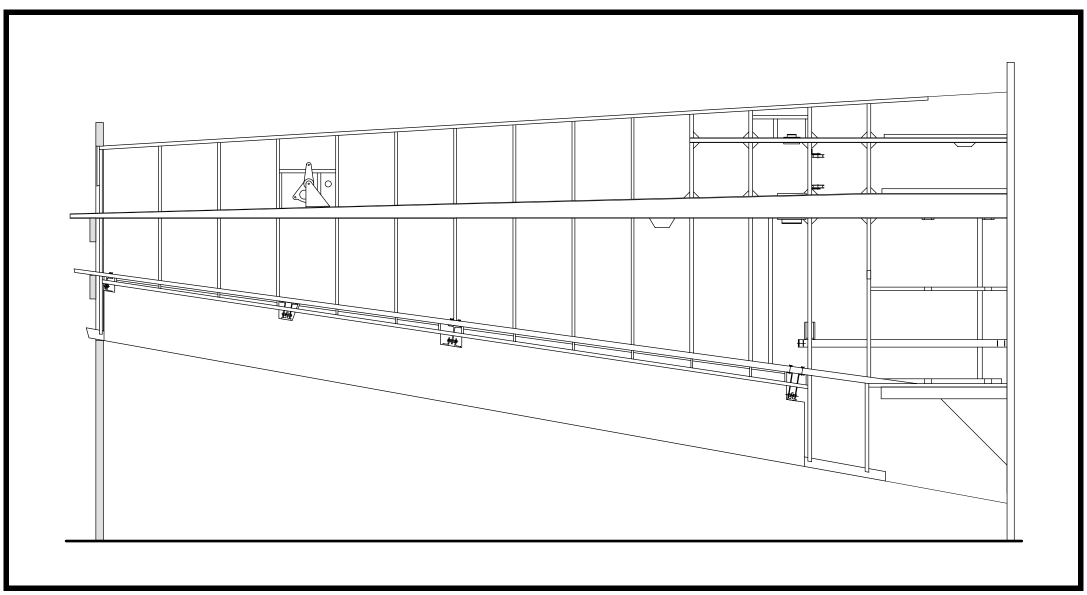


Figure 20

❑ Glue the two 20x20 spruce members on the front face of fuselage frame No. 6. See Figure 20—which shows the top of the left wing. These parts must be cut and fitted to the aft wing spar. The notches in these members must match the seat support required for the two types of wheel wells. The "open air" wheel well uses four 30x15 seat supports. The wheel well door installation has two 60x15 seat supports inboard and two 30x15 outboard.

❑ As shown in Figure 20, glue the 17 cove ribs to the aft face of the aft wing spar and install the wing gap trailing edge strip, P/N 206-5. See Drawing No. 201 Sheet 2.

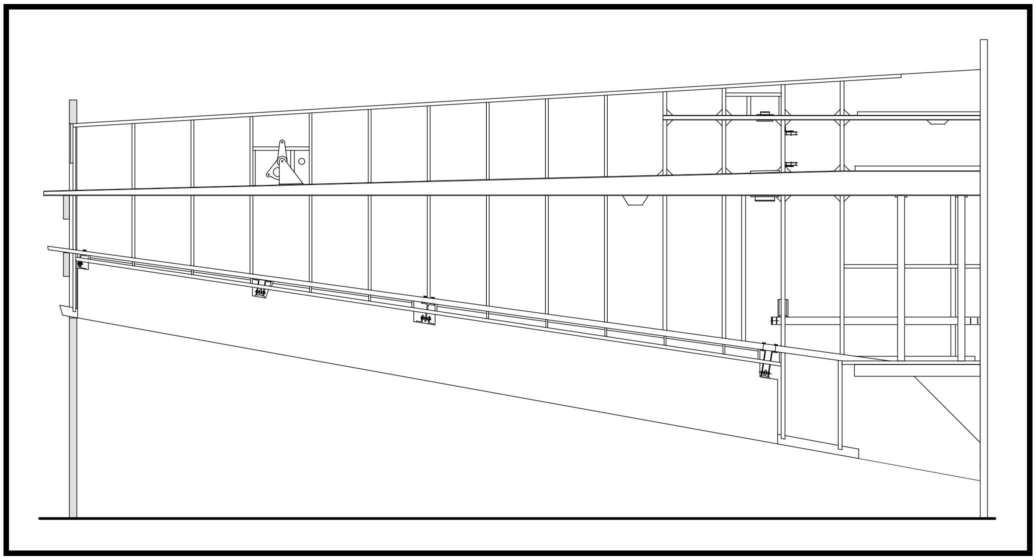


Figure 21

❑ For "open air" wheel well installation—fit the four 30x15 seat supports in place, but do not glue these in place yet. See Figure 21.

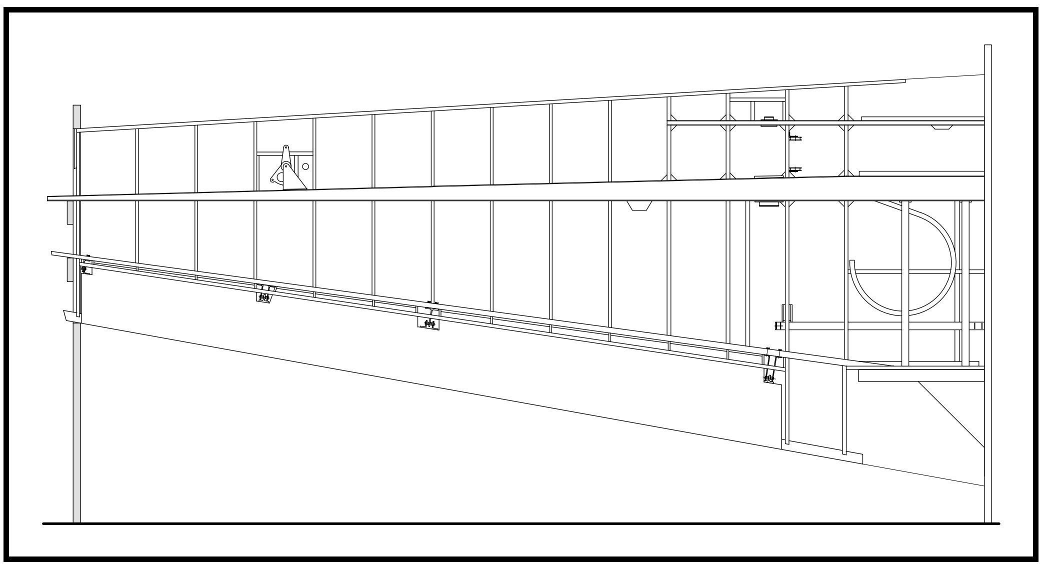


Figure 22

❑ For "open air" wheel well installation—fit the two upper wheel well rings in place. See Figure 22. Because of the contour of the seat supports, these rings are installed at an angle, with the front end higher than the aft end. To make things work out right, the ring is made thicker so that it will be 20x20 when it is sanded to the final contour. At the aft face of the wing spar, the bottom of the laminated ring should be 20mm below the top of the wing spar. At fuselage frame No. 5, the notch in the frame is only 15mm, and the laminated rings must be notched from the bottom so that the top of the un-sanded rings will be 4mm above the top of fuselage frame No. 5 at the forward face. This will place the rings at the correct angle—5.5° nose high from horizontal, in case you wondered. After this is done, the rings should be notched for the outboard seat supports.

❏ For "open air" wheel well installation—sand the upper wheel well rings to the approximate contour of the seat supports.

❏ For "open air" wheel well installation—glue the upper wheel well rings and the seat supports in place.

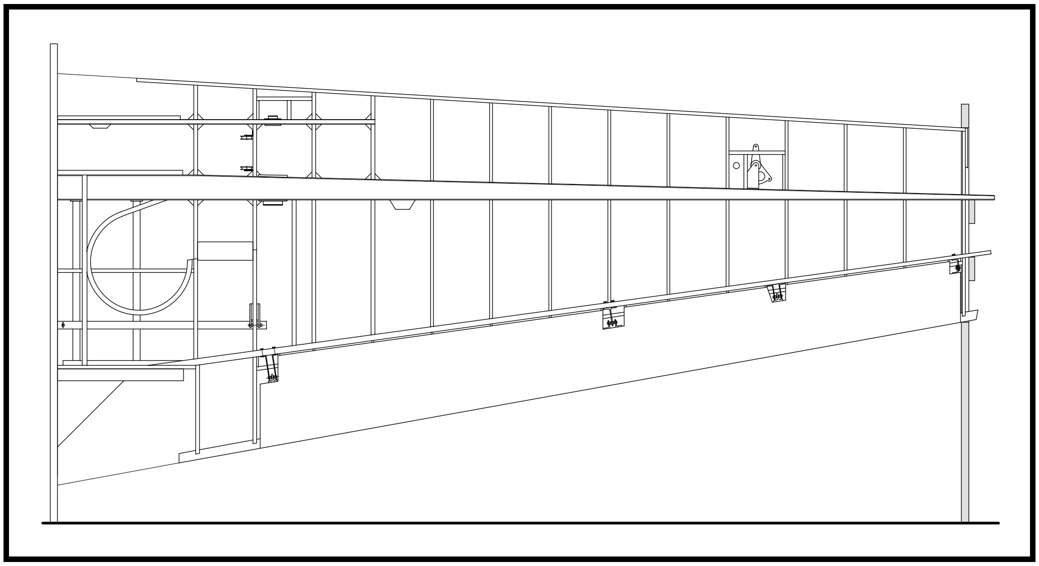


Figure 23

❏ For "open air" wheel well installation—fit and install the lower wheel well ring. See Figure 23. At the aft end of the wheel well, install a 20x10 spruce post between the upper ring and the lower ring. This will support the lower ring while it is being sanded.

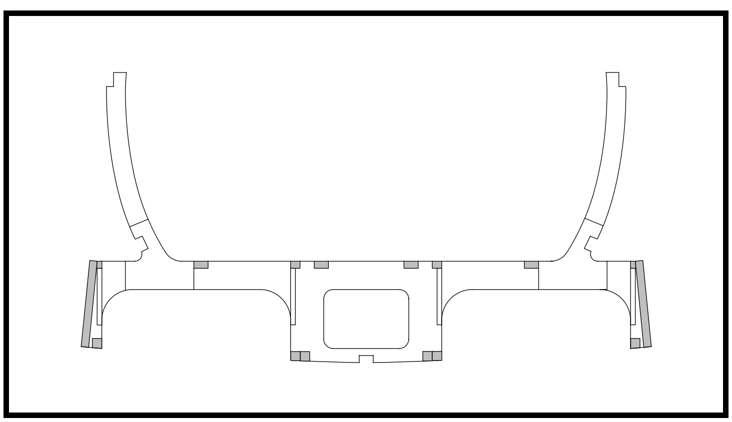


Figure 24

❏ For "open air" wheel well installation—install 10x10 spruce gluing strips on the forward and aft face of fuselage frame No. 5 for the wheel well skin. Before they are installed, these strips must be cut the angle of the skin. See Figure 24.

❏ For wheel well door installation—fit the four seat supports in place. See Figure 25. Remember the inboard supports are 60x15 and the outboard supports are 30x15.

❑ For wheel well door installation—fit the 75x15 spruce strip between the inboard and outboard seat support as shown in Figure 25. This is shown in Detail A, Drawing No. 201.

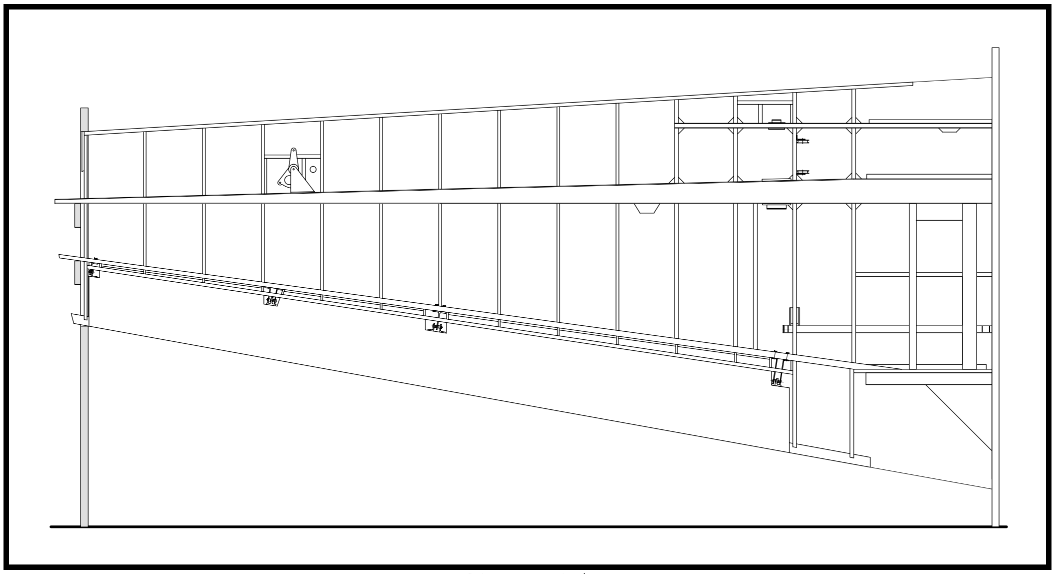


Figure 25

❑ For wheel well door installation—glue the 60x15 inboard supports and the 75x15 spruce strips in place.

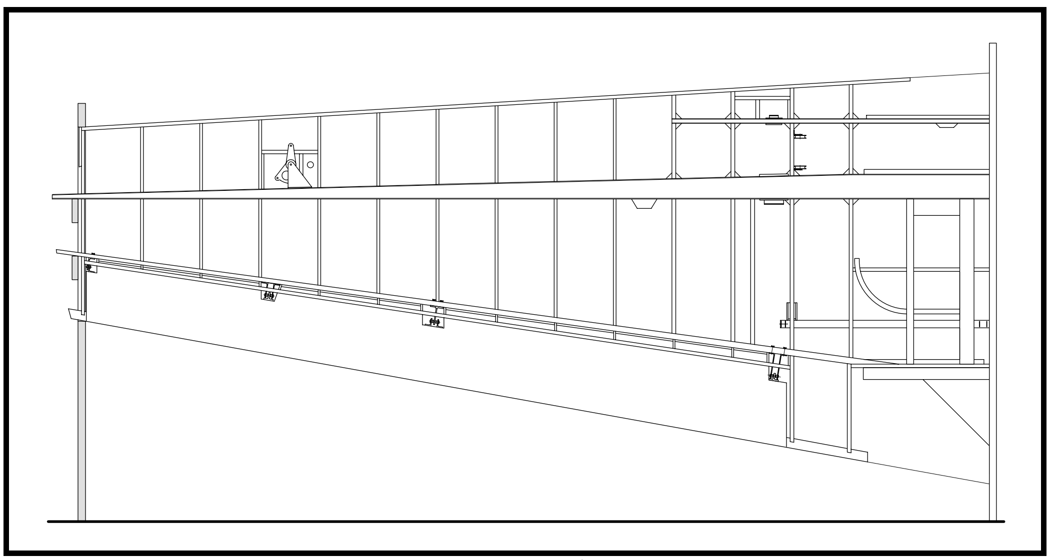


Figure 26

❑ For wheel well door installation—fit the upper wheel well ring. This ring must be notched to match the upper seat support. The notches in fuselage frame No. 5 should be only 15mm deep, thus the bottom of the ring must be notched as well. See Figure 26.

❑ For wheel well door installation—sand the upper wheel well rings to the approximate contour of the seat supports.

❏ For wheel well door installation—glue the upper wheel well ring and outboard seat supports in place.

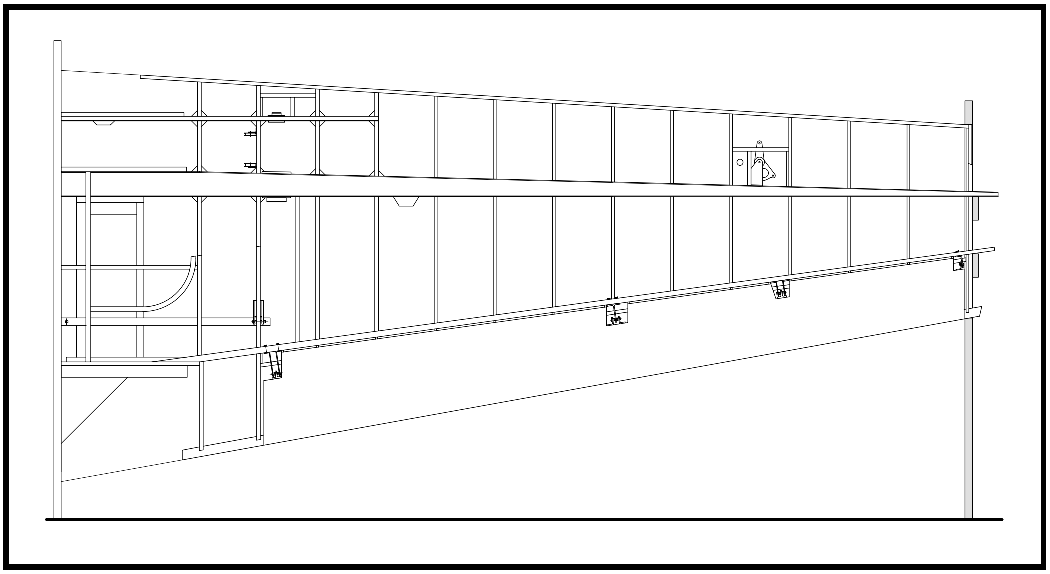


Figure 27

❏ For wheel well door installation—fit and install the lower wheel well ring. See Figure 27. At the aft end of the wheel well, install a 20x10 spruce post between the upper ring and the lower ring. This will support the lower ring while it is being sanded. Between the inboard seat support and the 20x20 stringer on the bottom of the airplane, install a 20x20 spruce post to make the corner with the wheel well skin. The aft wheel well skin will be glued to the aft face of this post, then the inboard skin will be glued in place.

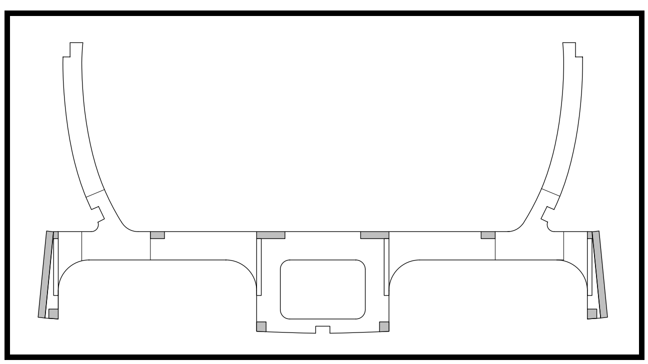


Figure 28

❏ For wheel well door installation—install 10x10 spruce gluing strips on the forward and aft face of fuselage frame No. 5 for the wheel well skin. Before they are installed, the outboard strips must be cut the angle of the skin. See Figure 28.

❏ As shown in Figure 28, install the 10x40 piece of spruce between Sta. 2 and Sta. 2-1/2. This may be seen on Detail S and Detail T of Drawing No. 201, Sheet 4. This is part of the framing for the access panel for the removal of the landing gear leg.

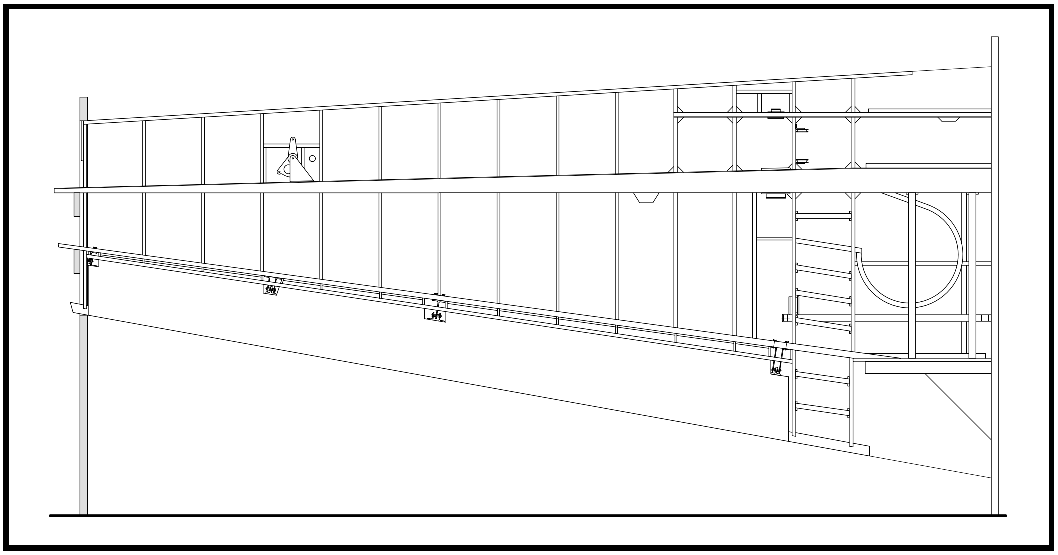


Figure 29

- ❏ Install the *seven* wing walk supports between Sta. 1 and 2 as shown in Figure 29. See Drawing No. 201, Sheet 1. Note carefully that one of these pieces forms the aft upper end of the opening for the landing gear—install this with a partial saddle gusset, with support on the bottom and aft face only.

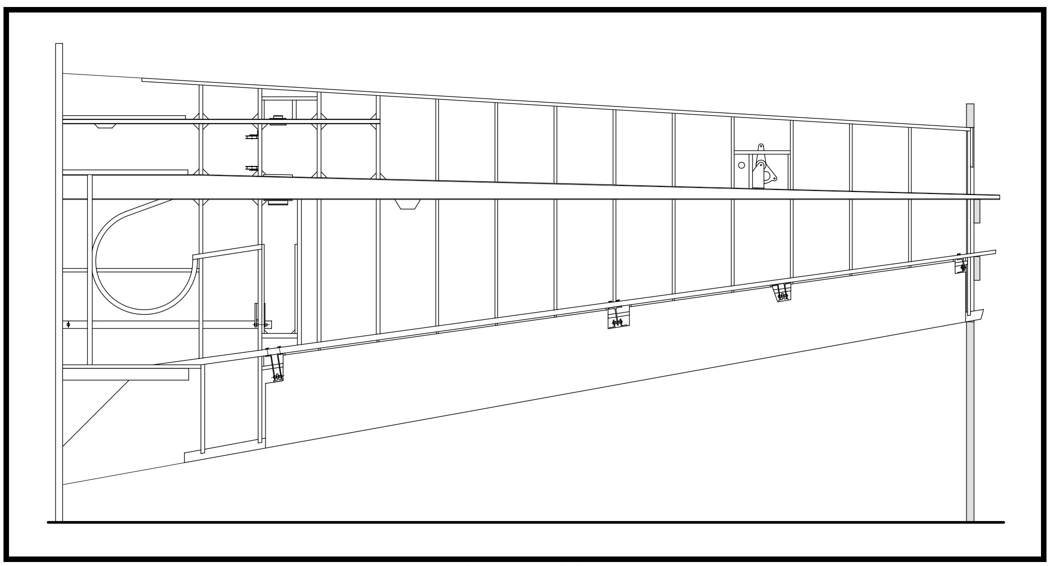


Figure 30

- ❏ On the bottom of the wing, install the 20x20 spruce strip between Sta. 1 and 2 which forms the aft lower end of the opening for the landing gear. See Figure 30—for clarity all framing on the upper side of the wing has been eliminated from this illustration.

- ❏ On the bottom of the wing, install the framing for the access panel between Sta. 2 and 2-1/2. See Figure 30. The piece at the aft end of the bay is 10x20 spruce and its forward face should be located 80mm forward of the aft face of the aft wing spar. This will make things work out right for the flap hinge fairing—see Drawing No. 814. The other framing for the access panel are 10x10 spruce strips which follow the lower wing contour and then up on the inboard face of the Sta. 2-1/2 rib and the outboard face of the Sta. 2 rib to the 10x40 cross piece at the top of the wing. All of this may be seen on Detail S and T of Drawing No. 201 Sheet 4.

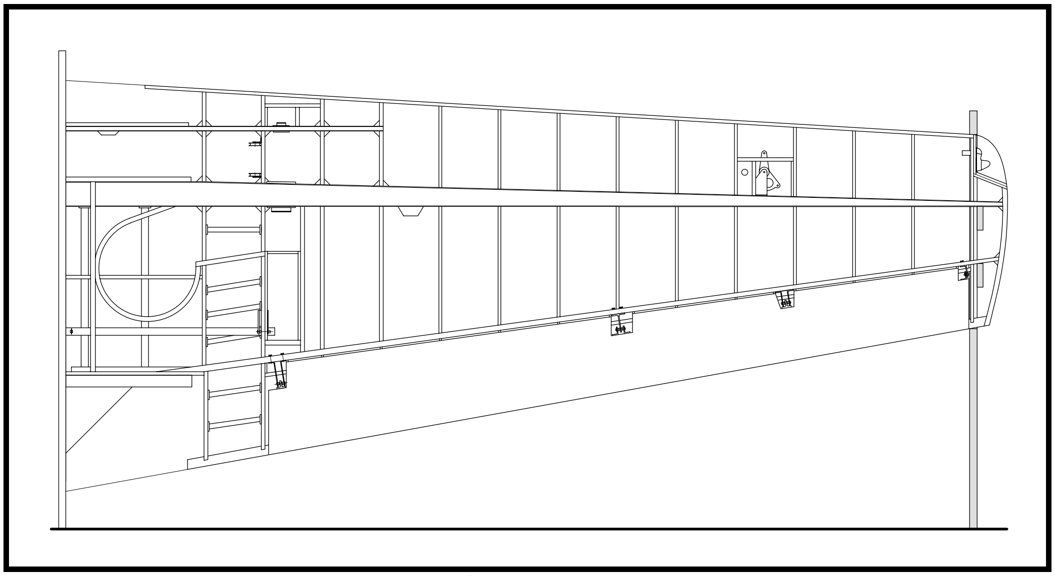


Figure 31

❏ Fit the wing tip bow in place. See Drawing No. 202.

❏ Fit the 10mm thick piece of spruce (P/N 202-3) at the aft end of the wing tip light opening to the rib and to the wing tip bow. See Drawing No. 202.

❏ Trial fit the plexiglass wing tip lens in place. The lens is supplied about 1/4” oversized. See Drawing No. 201, Sheet 2 and Drawing No 202.

❏ Glue P/N 202-2, P/N 202-3 and the wing tip bow in place.

❏ Install the wing tip navigation and strobe lights.

❏ Glue the corner blocks shown at the outboard ends of the main wing spar and aft wing spar in place.

❏ Install the corner blocks on the aft face of the main wing spar at Sta. 1 and 2. It is desirable that these corner blocks be as tall as the rib at the spar.

❏ For wheel well door installation—install the 25x25 corner blocks at the aft outboard ends of the 75x15 piece of spruce between the seat supports. It is also a very good idea to install plywood over these corner blocks on the bottom to reinforce the end grain joints—a 2mm plywood gusset at each end will do.

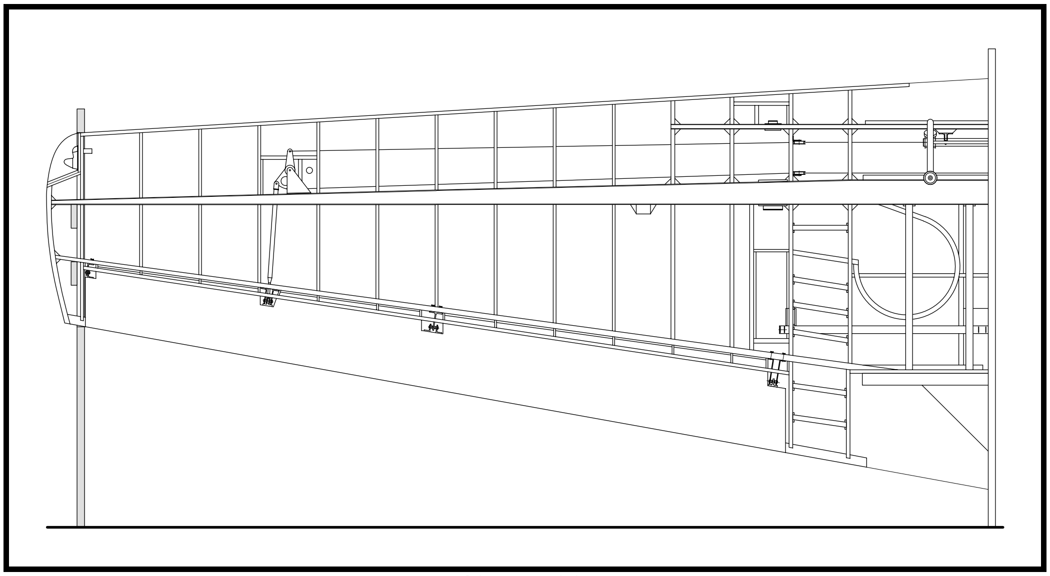


Figure 32

- ❏ Install the control stick assembly on the aft face of the front wing spar.

- ❏ Install the aileron control cables. The control cable assemblies are shown on Drawing No. 150-2 and -3. The installation of the control cables are shown on Drawing No. 201 Sheet 1, Detail V Drawing No. 201 Sheet 4 and Drawing No. 126. The turnbuckle for the aft aileron control cable assembly is located on the left side of the aircraft. (You may be working from the bottom of the aircraft, so remember which is the left side!) Do not tighten the control cables. Note that at the aileron bellcrank the bolt head for the aft aileron cable must be installed with the bolt head on the bottom.

- ❏ Check that the control cables are centered on all of the holes drilled in the wing ribs. “Adjust” the holes as needed with a round file.

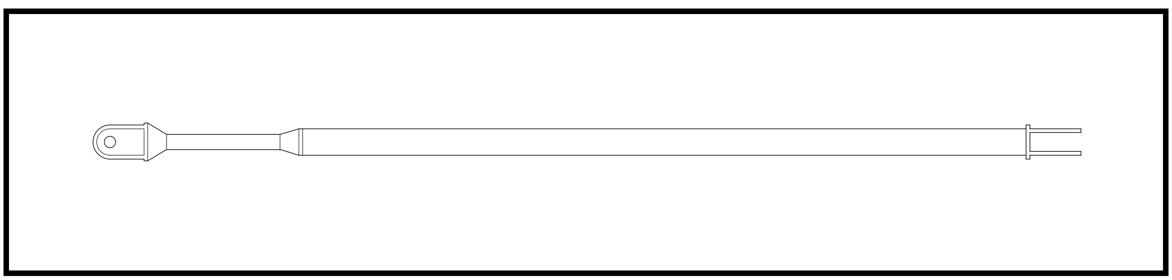


Figure 33

- ❏ Temporarily assemble P/N 781 aileron control rod. See Drawing No. 781 for this assembly. Do not drill for, or install, the rivets at this time. The tubing for this control rod is supplied slightly too long so that you can trim it to the exact length required on your airplane.

- ❏ Install P/N 781 on the aileron control arm and aileron bellcrank. See Detail V Drawing No. 201 Sheet 4. Adjust the length of the aileron control rod so that the aileron bellcrank is in the neutral position shown with the aileron in the neutral position. (With the aileron and flap trailing edge still installed as one piece in the wing, the aileron must be in the neutral position.)

❏ Drill one rivet hole for P/N 714 with a #30 (.128"Ø) drill. See Drawing No. 781. Remove the aileron pushrod from the airplane and drill the second rivet hole for P/N 714. Install the rivets for P/N 714.

Note: The normal practice when installing 5/32" rivets is to first drill with a 5/32"Ø drill and then ream with a #21 (.159"Ø) drill before installing the rivet. We suggest that you drill the first hole with a #30 (.128"Ø) or a 1/8"Ø drill, then ream up to 5/32" and #21. Drilling the first hole smaller will be a safer way to proceed.

After drilling a hole for a rivet, the normal practice is to use a Cleco to hold the parts in position. If you do not have Clecos you may use drills for the same purpose. If the first rivet hole is a #30, then insert a #30 drill in the hole while you drill the second hole with a 1/8"Ø drill. Leave one of the drills in place while you ream the other hole up to 5/32"Ø and finally with a #21 drill. Deburr the hole by lightly twisting a larger drill in the holes and insert the rivet. If you do not have a rivet gun, you may set the rivet with a hammer, although it is best to use a rivet set on the opposite end of the rivet. When this rivet is set, you may ream up the other hole and set that rivet.

❏ Put the aileron pushrod back in the airplane and check the length of the pushrod. Make any final adjustments necessary in the length of the pushrod and then drill for one of the rivets for P/N 712—see Drawing No. 781.

❏ Remove the pushrod from the airplane and install the rivets for P/N 712.

❏ Install the aileron pushrod in the wing.

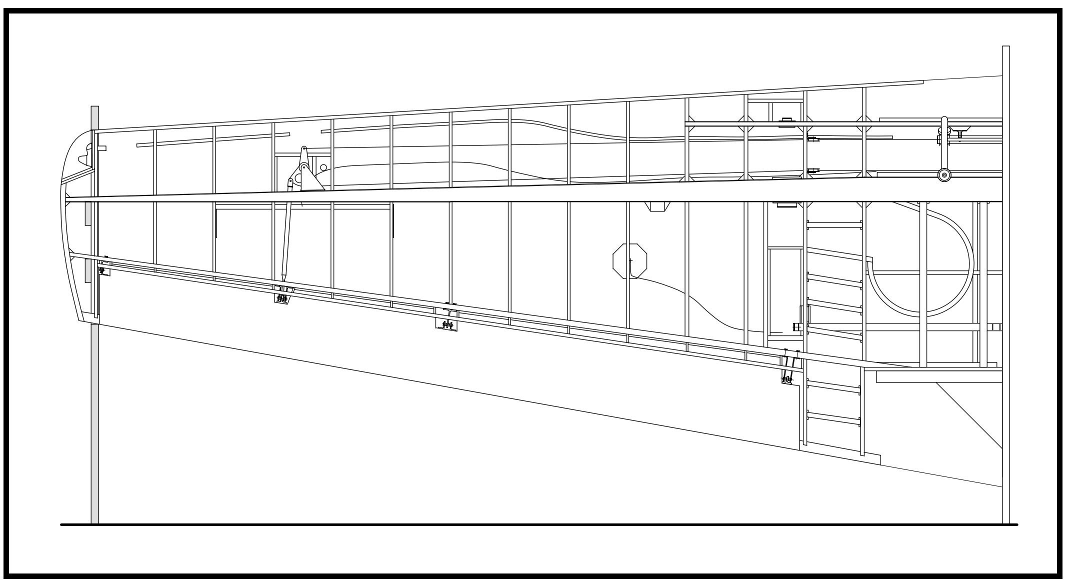


Figure 34

❏ In the left wing, install the plastic tubing as conduit for the wires for the navigation and strobe light and for the heated pitot. The position of the couduit is shown on the rib drawings. The tubing has a break between Sta. 10 and 11 as shown on Drawing No. 201 Sheet 1. The reason for this break in the conduit is that the wiring for the heated pitot must be routed to the pitot tube. Note that the 1/4" O.D. pitot line will also be routed with the conduit in the left wing.

Note: For the wiring conduit, 3/8"O.D. plastic tubing has been supplied with the kits. A number of builders have pointed out that the wires will not fit in this size tubing, thus we suggest that 1/2" tubing be used in its place.

The tubing should be installed so that it is permanently secured in place. The simplest method is shown on the rib drawings and consists of small blocks of wood. The tubing is glued in place with epoxy. As an alternative, clamps or nylon ty-wraps may be used.

❏ Install the pitot line (P/N 151-11) in the left wing. See Drawing No. 201 Sheet 1, Detail V Drawing No. 201 Sheet 4 and Drawing No. 151. This tube should be routed with the conduit. The pitot tube (P/N 151-10) is purchased separately from Instruments & Flight Research, and the pitot tube mast (P/N 791-1) is supplied with Kit No. 815-3 Instruments and Equipment. You do not need either of these at this time.

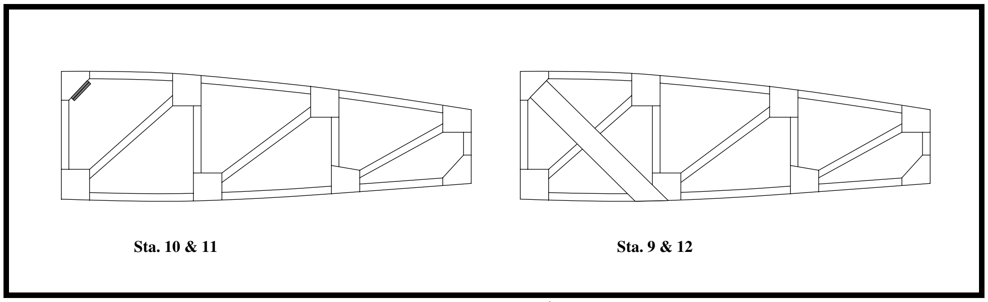


Figure 35

❏ Install the No. 2 COM antenna in the left wing. See the instructions in Chapter 14 "Antenna Installation". See Drawing No. 160 and 161. As shown in Figure 34, epoxy the antenna between two strips of spruce or plywood and glue this to spruce blocks installed in the gusset pockets of the Sta. 9, 10, 11 and 12 ribs. At each end, the antenna foil element is glued to the inboard face of the Sta. 9 and 12 ribs, again sandwiched between two plywood or spruce strips. Install spruce corner blocks to reinforce the corners of the antenna.

❏ Install the coaxial cable in the wing. The location for the cable is shown in the wing rib drawings.

❏ Install the DME antenna in the left wing. See the instructions in Chapter 14 "Antenna Installation". See Drawing No. 160 and 162. If you are going to use a DME which is mounted in the instrument panel, install the antenna on the outboard face of Sta. 3 rib. Position the antenna as low as possible in the wing so that the tip of the antenna is within a few millimeters of the bottom skin and centered between the two aileron cables. If you plan to use a remote DME receiver, such as the King or Narco units we recommend, install the antenna on the inboard face of the Sta. 5 wing rib as shown on Drawing No. 201.

❏ If the DME is installed forward of the wing spar, install the coaxial cable for the DME antenna by running it into the cockpit area along with the coaxial cable for the No. 2 COM antenna. If the DME antenna is installed in the aft section of the wing, install the cable as shown on Drawing No. 201. See Drawing No. 209 and 210 for the location of the antenna cable spruce block at the rib. The coaxial cable must be positioned so that it will not interfere with the landing gear removal. The fuel tank vent lines (1/4" O.D. nylon tubing) will be routed from the cockpit to this access area. These vent lines may be installed in the same holes with the coaxial cables or in separate holes. Both the fuel tank vent lines and the antenna coaxial cable must be installed so that they are not fouled by the flap torque tube or the flap pushrod.

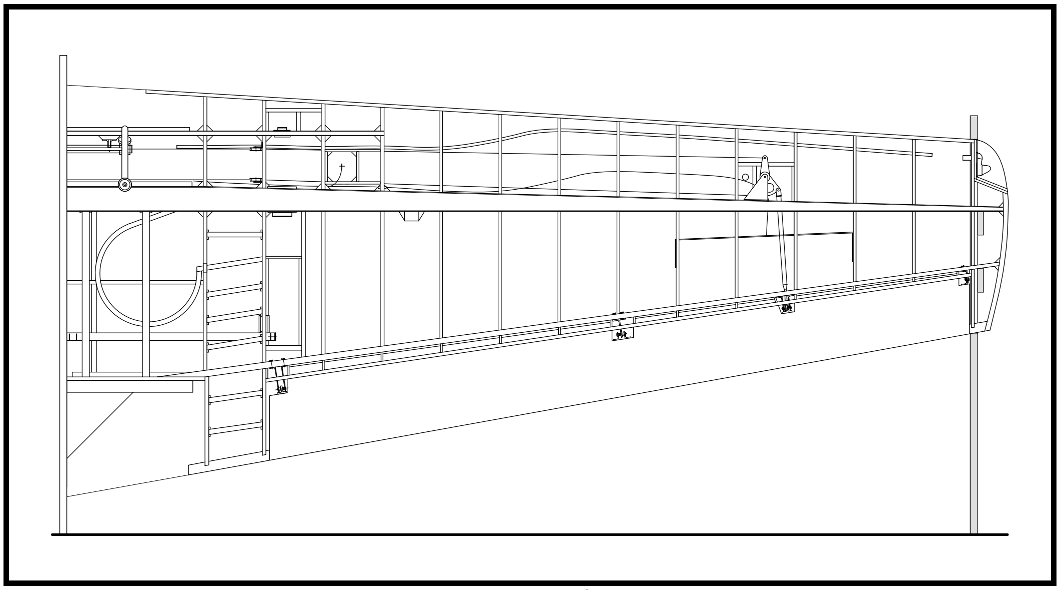


Figure 36

- ❏ In the right wing, install the plastic tubing as conduit for the wires to the navigation and strobe light. The position of the conduit is shown on the rib drawings. The conduit is continous from Sta. 13 to the fuselage. The conduit should extend into the fuselage (through the fuselage skin) to a place that is accessible when the cockpit floor (see Drawing No. 315) is removed.

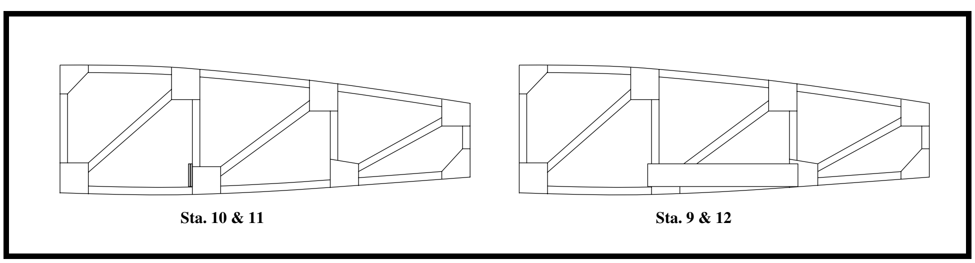


Figure 37

- ❏ Install the VHF NAV antenna in the right wing. See the instructions in Chapter 14 "Antenna Installation". See Drawing No. 160 and 161. As shown in Figure 37, epoxy the antenna between two strips of spruce or plywood and glue the vertical braces of the Sta. 9, 10, 11 and 12 ribs. At each end, the antenna foil element is glued to the inboard face of the Sta. 9 and 12 ribs, again sandwiched between two plywood or spruce strips.

- ❏ Install the transponder antenna in the right wing. Install the antenna on the outboard face of Sta. 3 rib. Position the antenna as low as possible in the wing so that the tip of the antenna is within a few millimeters of the bottom skin and centered between the two aileron cables. See the instructions in Chapter 14 "Antenna Installation". See Drawing No. 160 and 162.

- ❏ Install the NAV antenna coaxial cable in the wing. The location for the cable is shown in the wing rib drawings. At Sta. 4 inboard, the transponder coaxial cable witll be routed with it—see next step

- ❏ Install the coaxial cable for the transponder antenna into the cockpit along with the coaxial cable for the NAV antenna.

- ❏ If you plan to install a Loran antenna in your airplane, review Chapter 14 "Antenna Installation". Install ground wires as needed.

Skinning the Wing

- ❏ Install the skins for the wheel well. These skins extend from the top of the wing to the bottom and will be sanded to the wing skin contour after they are glued in place. Cut the openings for the screwjacks as shown on Drawing No. 102. These openings may be enlarged as necessary later.

- ❏ In preparation for float sanding the wing, remove the side load fittings. If you have not primed the other metal parts that are installed in the wing, this is a good time to do that. The aileron and flap hinges may be removed as required for local float sanding—obviously, you cannot remove all of them at the same time.

- ❏ Float sand the entire wing in preparation for skinning. You should sand the top and bottom of the wing from Sta. 1 to Sta. 14. The center top of the wing—the seat floor—should be sanded now. Do not worry about the wing tip at this point. If you intend to have a mirror-smooth wing, this is where it all begins. Getting the ribs and spars smooth for the skin is what causes the wing skin itself to be smooth.

- ❏ Fit the upper wing skin for Sta. 1 to Sta. 6. This will require a 50"x50" piece of 2.5mm birch plywood. An extra piece of plywood at the trailing edge must be scarfed and glued to the skin before it is installed. This extra piece may be installed with the grain direction fore-and-aft for slightly greater strength of the wing walk.

Note: As designed, the upper wing skin stops with the little triangular strip at the aileron and flaps. At the bottom, the skin stops at the aft face of the aft wing spar. If you are interested in speed-at-all- costs, the skins may installed so that they almost touch the flaps—or you can fill in the bottom with a strip of spruce or sticky-back foam later.

The geometry of the ailerons does not permit such aerodynamic tricks, and bear in mind that if you close up the slot for the aileron, any gain in speed will be offset by a loss in aileron effectiveness since this slot does for the aileron exactly what it does for the flaps—turning it into a high-lift device. Closing up the slot for the flaps will have less effect since the slot will open with the flaps' greater deflection and lower hinge line.

And what about skinning the "cove ribs" that form part of this slot? This was not done on the production Falcos, but if you want to you may—use a 1mm birch plywood skin. Will it make your Falco faster? Dang if we know, but it does make it look pretty.

The leading and trailing edge strings may be removed while the skins are fitted—and these strings are not shown in any of the remaining illustrations in this chapter—but you should use them to double check the aligment of the wing while gluing on any skins.

- ❑ Scarf this upper wing skin for the next inboard and next outboard skins. If you wish, for this and all subsequent skins, you may install the skin and *then* scarf the plywood.

- ❑ Bend the leading edge for the upper wing skin between Sta. 1 and 6.

- ❑ With this upper wing skin clamped in place, install two small nails as alignment pins so that the skin may be glued in place accurately.

- ❑ Trace the outline of the ribs and spars on the inside surface of the skin for varnishing.

- ❑ Draw the internal structure of the wing on the outside of the skin to assist in nailing or stapling when the skin is installed.

- ❑ Fit the lower wing skin for Sta. 1 to Sta. 6. This will require a 50”x50” piece of 2mm birch plywood. An extra piece of plywood at the trailing edge must be scarfed and glued to the skin before it is installed. This extra piece may be installed with the grain direction fore-and-aft for slightly greater strength of the wing walk.

  Note: You should not cut out the wheel well opening and landing gear access door until the skin is glued in place. This will apply to all access panels and openings. The reason for this is that the skin will not be smooth around the opening otherwise. Builders who have cut access doors in the skin first have found that the skin would be “flat” around the opening and would not be the proper wing contour.

- ❑ Scarf the lower wing skin for the next inboard and next outboard skins.

- ❑ Bend the leading edge for the lower wing skin between Sta. 1 and 6.

- ❑ Draw the internal structure of the wing on the outside of the skin to assist in nailing or stapling when the skin is installed.

- ❑ Measure the location of the center of the jack pad fitting so that you will be able to locate this after the skin is glued in place. The aft face of the spar will be easy to find by using a long straightedge, but you will need to mark an offset—such as a point exactly 500mm outboard of the center of the hole you must drill.

- ❑ Varnish the interior of the entire wing from the outboard face of wing Sta. 1 outboard except for those areas to be glued.

  Note: After the bottom wing skins are installed, you will varnish the inside of the skins, so you may concentrate your varnishing efforts at this point on those areas which are most easily reached from the bottom of the wing. You must varnish under all fittings at this point. Be careful to varnish the holes in the main wing spar and front wing spar for the landing gear leg. This is very important as grease will be allowed to enter these openings.

- ❑ Mask and varnish the inside surface of the upper wing skin between Sta. 1 and 6.

  Note: On the upper wing skin, the landing gear bay and access area between Sta. 2 and 2-1/2 does not need to be varnished at this time since it will be accessible later.

❏ Install the side load fittings in the wing and any other fittings which you may have removed. The fittings on the wing spars should be bedded down in a waterproof sealant to prevent moisture from collecting under the fittings. The channel-nuts may be bedded down in (and coated with) epoxy.

❏ Cut openings in bottom wing skin between Sta. 1 and 6 for the side load fittings.

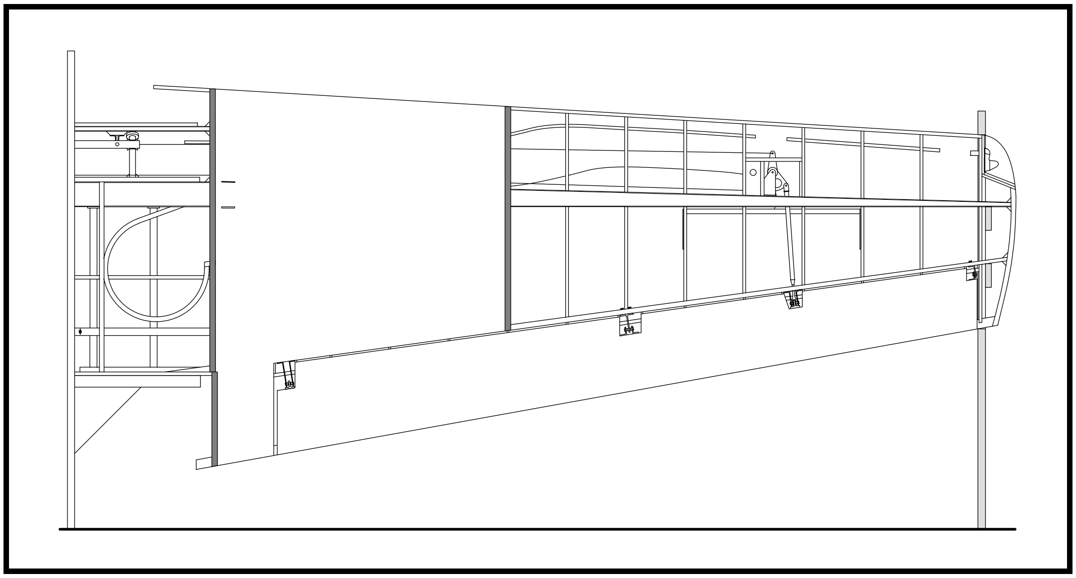


Figure 38

❏ Glue on the bottom wing skin between Sta. 1 and 6. Check the alignment of the wing. Use plywood nailing strips over the scarfed plywood.

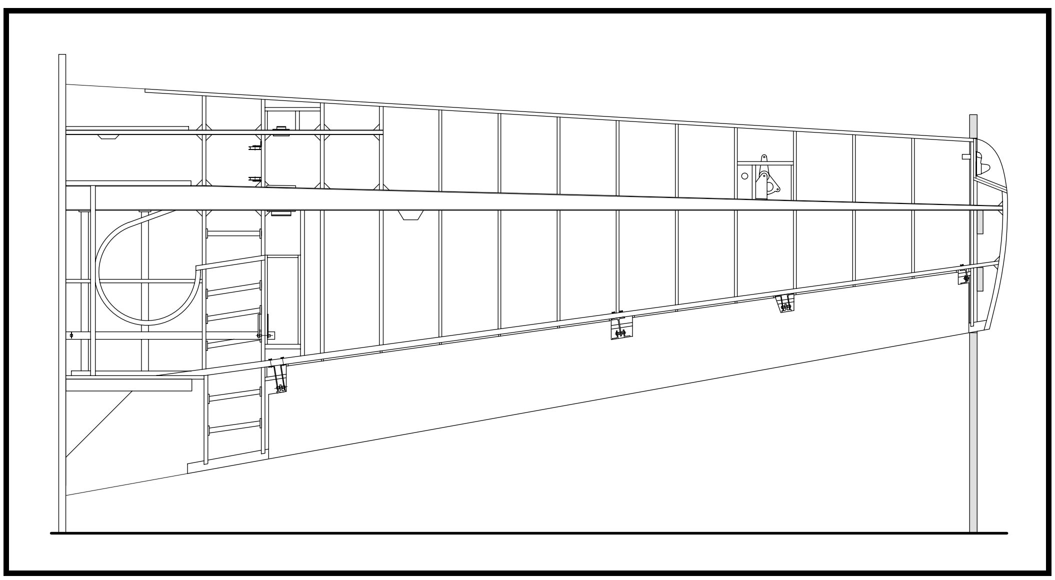


Figure 39

❏ As shown in Figure 39, cut the bottom skin for the landing gear nut access panel, for the wheel well and for the access panel between Sta. 2 and 2-1/2.

❏ Locate and drill the hole for the jack pad fitting.

❏ Install the jack pad fitting as shown on Detail C, Drawing No. 201.

❏ Drill drain holes in the bottom wing skin as shown on Drawing No. 201 Sheet 2.

❏ In preparation for closing the wing between Sta. 1 and 6, varnish the inside of the bottom wing skin and all interior surfaces of the wing except for those areas to be glued.

❏ At the leading edge, scarf the plywood of the lower wing skin to receive the upper wing skin between Sta. 1 and 6. This scarf is a rounded type of scarf, due to the radius of the leading edge.

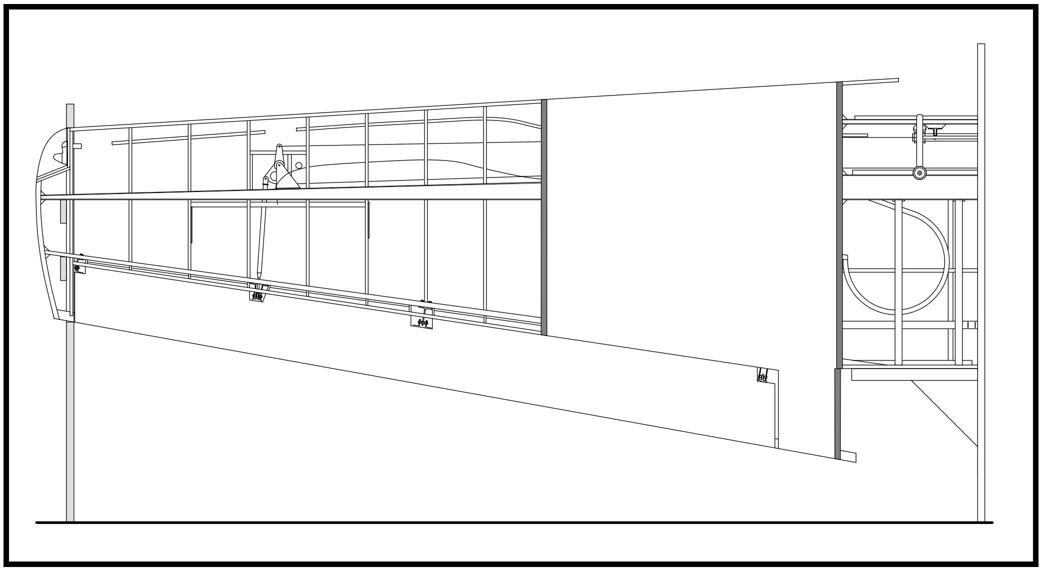


Figure 40

❏ Glue on the upper wing skin between Sta. 1 and 6. Check the alignment of the wing! After this skin is glued on, the wing will be torsionally rigid from Sta. 1 to 6 and reasonably rigid on the un-skinned outboard section. Use plywood nailing strips over the scarfed plywood.

❏ Fit the upper wing skin between Sta. 6 and 10. This will require a 50"x50" piece of 2mm birch plywood.

❏ Scarf this skin for the next inboard and next outboard skins.

❏ Bend the leading edge for the upper wing skin between Sta. 6 and 10.

❏ With this upper wing skin clamped in place, install two small nails as alignment pins so that the skin may be glued in place accurately.

❏ Trace the outline of the ribs and spars on the inside surface of the upper wing skin for varnishing.

❏ Draw the internal structure of the wing on the outside of the skin to assist in nailing or stapling when the skin is installed.

- ❑ Fit the lower wing skin between Sta. 6 and 10. See Drawing No. 118. This will require a 50"x50" piece of 1.5mm birch plywood.

- ❑ Scarf this skin for the next inboard and next outboard skins.

- ❑ Bend the leading edge for the lower wing skin from Sta. 6 to 10.

- ❑ Draw the internal structure of the wing on the outside of the skin to assist in nailing or stapling when the skin is installed.

- ❑ Mask and varnish the inside surface of the upper wing skin between Sta. 6 and 10.

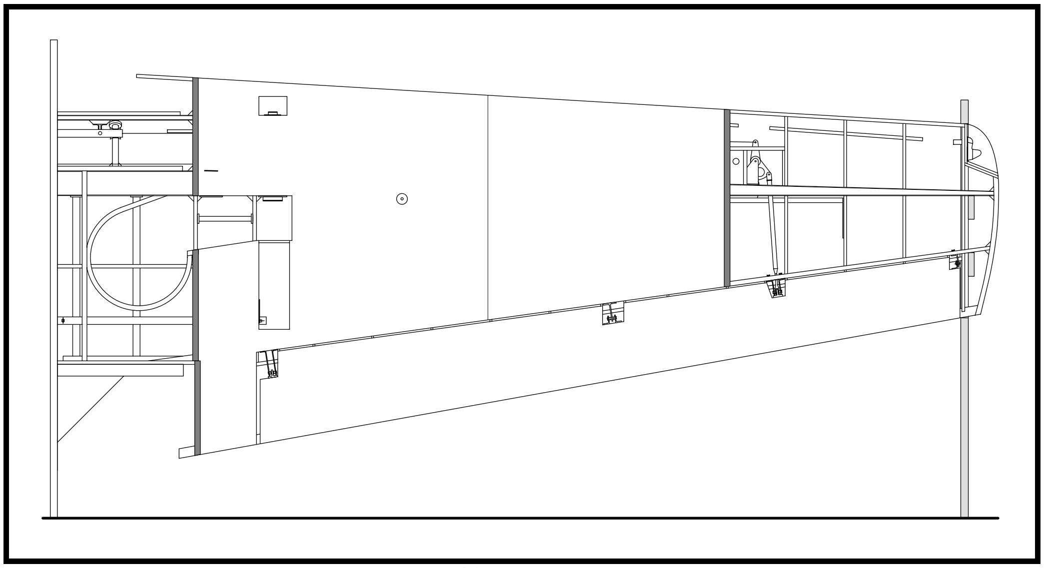


Figure 41

- ❑ Glue on the bottom wing skin between Sta. 6 and 10. Check the alignment of the wing. Use plywood nailing strips over the scarfed plywood.

- ❑ Drill drain holes in the bottom wing skin as shown on Drawing No. 201 Sheet 2.

- ❑ In preparation for closing the wing between Sta. 6 and 10, varnish the inside of the bottom wing skin and all interior surfaces of the wing except for those areas to be glued.

- ❑ At the leading edge, scarf the plywood for the lower wing skin to receive the upper wing skin between Sta. 6 and 10. This scarf is a rounded type of scarf, due to the radius of the leading edge.

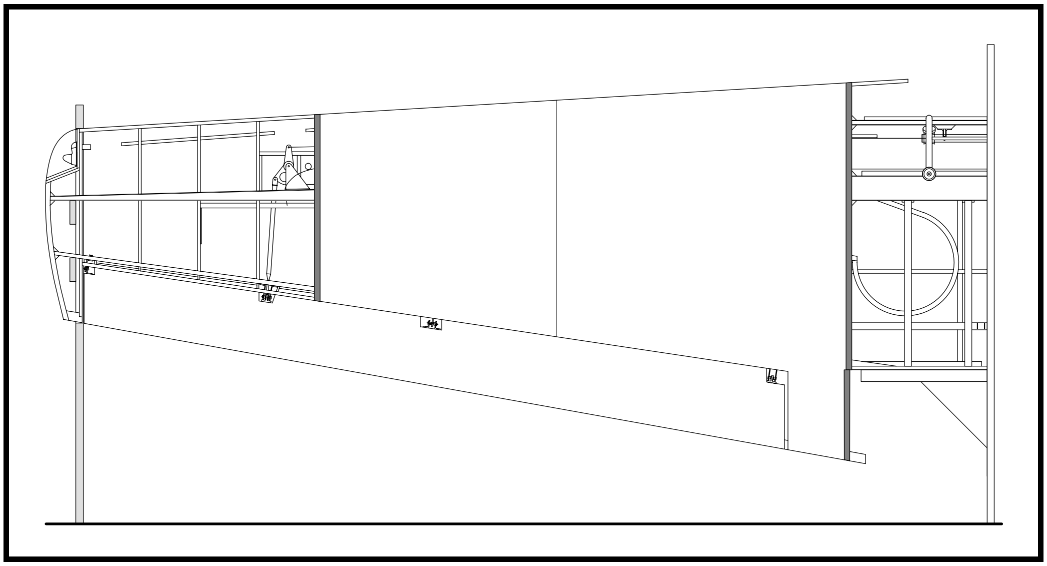


Figure 42

- ❏ Glue on the upper wing skin between Sta. 6 and 10. Check the alignment of the wing! After this skin is glued in place, the wing will be torsionally rigid to Sta. 10 and fairly rigid on the un-skinned outboard section. Use plywood nailing strips over the scarfed plywood.
- ❏ Fit the upper wing skin between Sta. 10 and 14. This will require a 50”x50” piece of 2mm birch plywood.
- ❏ Scarf this skin for the next inboard and next outboard skins.
- ❏ Bend the leading edge for the upper wing skin between Sta. 10 and 14.
- ❏ With this upper wing skin clamped in place. Install two small nails as alignment pins so that the skin may be glued in place accurately.
- ❏ Trace the outline of the ribs and spars on the inside surface of the skin for varnishing.
- ❏ Draw the internal structure of the wing on the outside of the skin to assist in nailing or stapling when the skin is installed.
- ❏ Fit the lower wing skin between Sta. 10 and 14. This will require a 50”x50” piece of 1.5mm birch plywood.
- ❏ Scarf this skin for the next inboard and next outboard skins.
- ❏ Bend the leading edge for the lower wing skin between Sta. 10 and 14.
- ❏ Draw the internal structure of the wing on the outside of the skin to assist in nailing or stapling when the skin is installed.
- ❏ Mask and varnish the inside surface of the upper wing skin between Sta. 10 and 14.

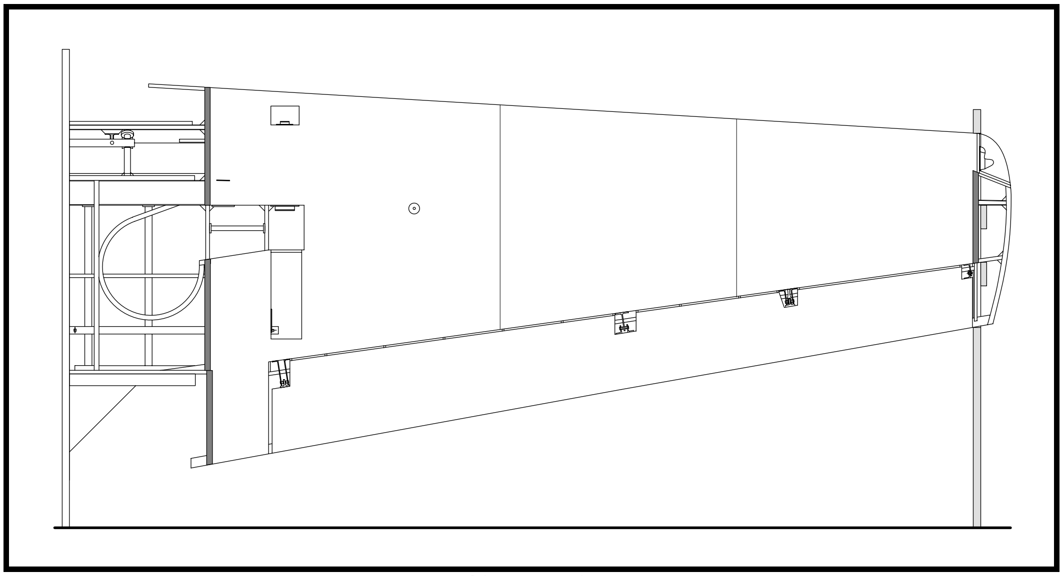


Figure 43

❑ Glue on the bottom wing skin between Sta. 10 and 14. Check the alignment of the wing. Use plywood nailing strips over the scarfed plywood.

❑ Drill drain holes in the bottom wing skin as shown on Drawing No. 201 Sheet 2.

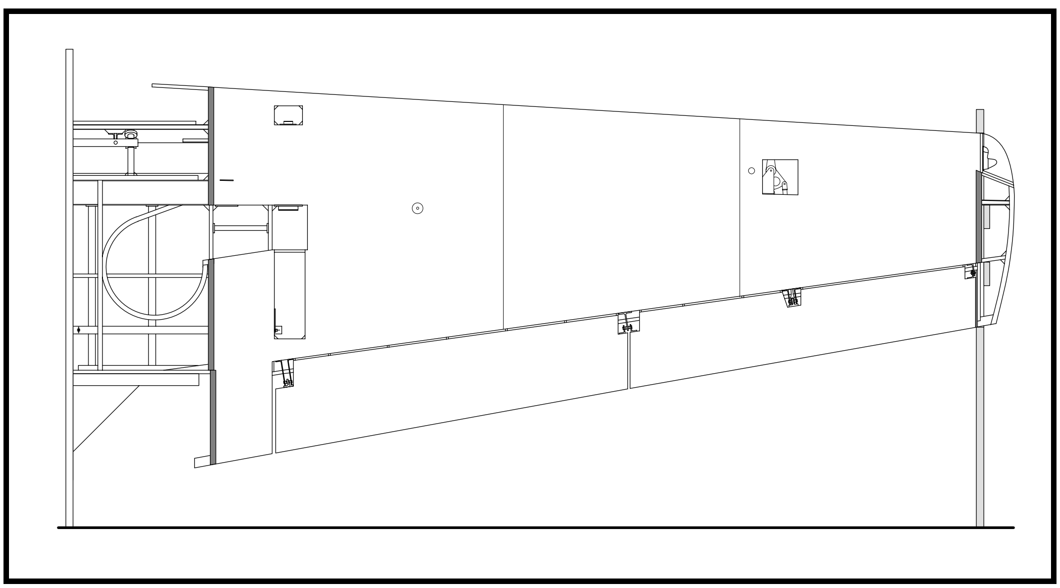


Figure 44

❑ Remove the aileron and flap from the wing by sawing the trailing edge strip.

❑ Separate the aileron and flap from each other by sawing then apart.

❑ Put the aileron and flap back on the wing and check the movement of these control surfaces. You may need to “adjust” the openings in the main and aft spars for the pushrods.

❑ Cut the opening for the aileron bellcrank access panel.

❏ Cut the hole in the plywood for the pitot heat plumbing and wiring.

❏ If necessary, secure the conduit for the navigation and strobe light wires in place so that the end of the conduit is accessible through the wiring hole for the light.

❏ If necessary, secure the ends of the conduit between Sta. 10 and 11 in the left wing.

❏ In preparation for closing the wing between Sta. 10 and 14, varnish the inside of the bottom wing skin and all interior surfaces of the wing except for those areas to be glued.

❏ At the leading edge and at the tip of the wing, scarf the plywood for the lower wing skin to receive the upper wing skin. This scarf is a rounded type of scarf, due to the radius of the leading edge and end of the wing.

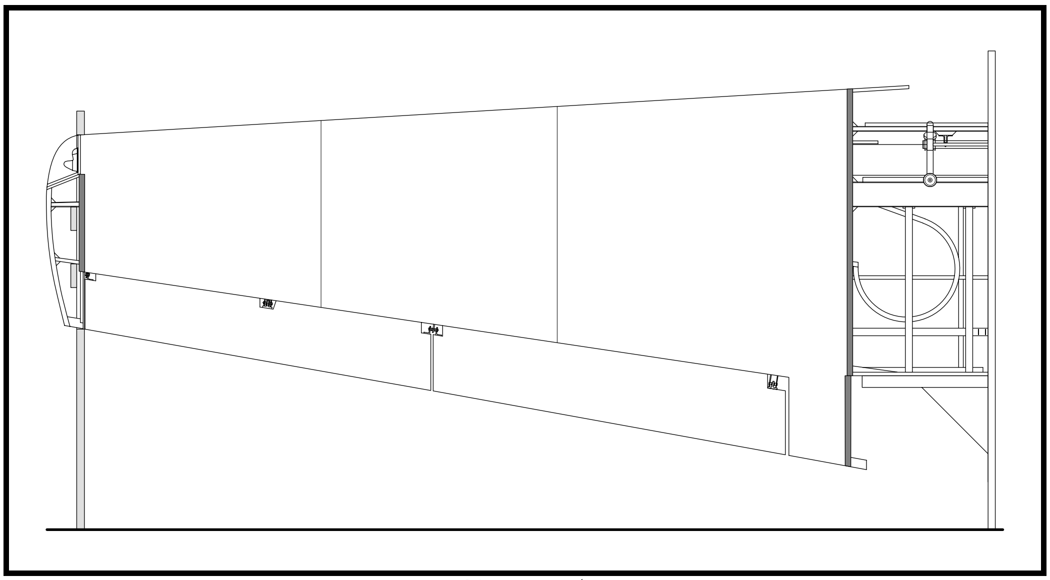


Figure 45

❏ Glue on the upper wing skin between Sta. 10 and 14. Check the alignment of the wing. After this skin is glued in place, the wing will be torsionally rigid. Use plywood nailing strips over the scarfed plywood.

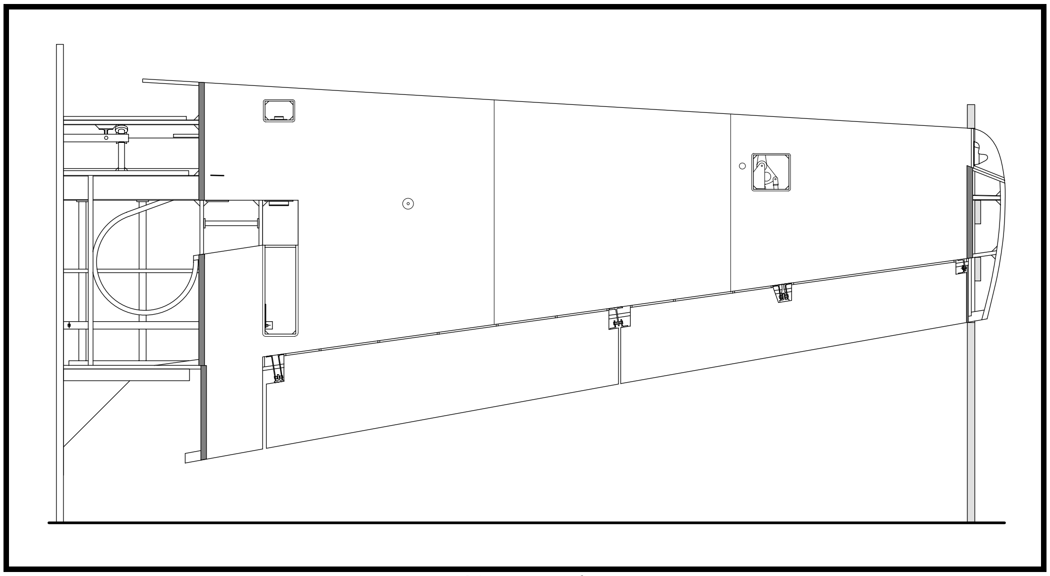


Figure 46

❏ Feather sand the leading edge to a smooth radius.

❏ Install the stall strip. See Drawing No. 201 Sheet 2.

❏ Use a back rabbet bit and rout the plywood for the three access panels in each wing.

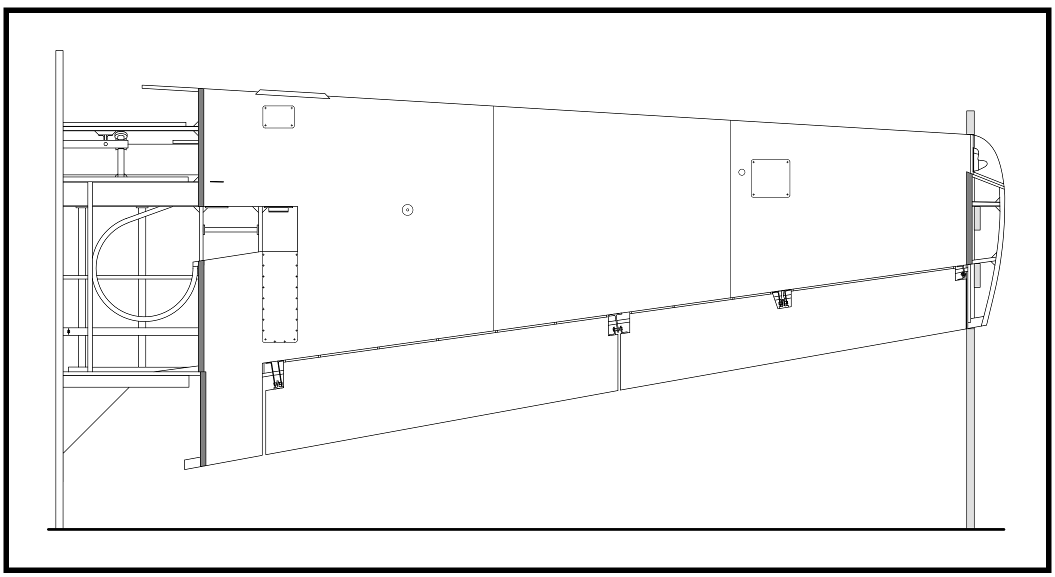


Figure 47

❏ Make and install the three access panels. See Figure 47.

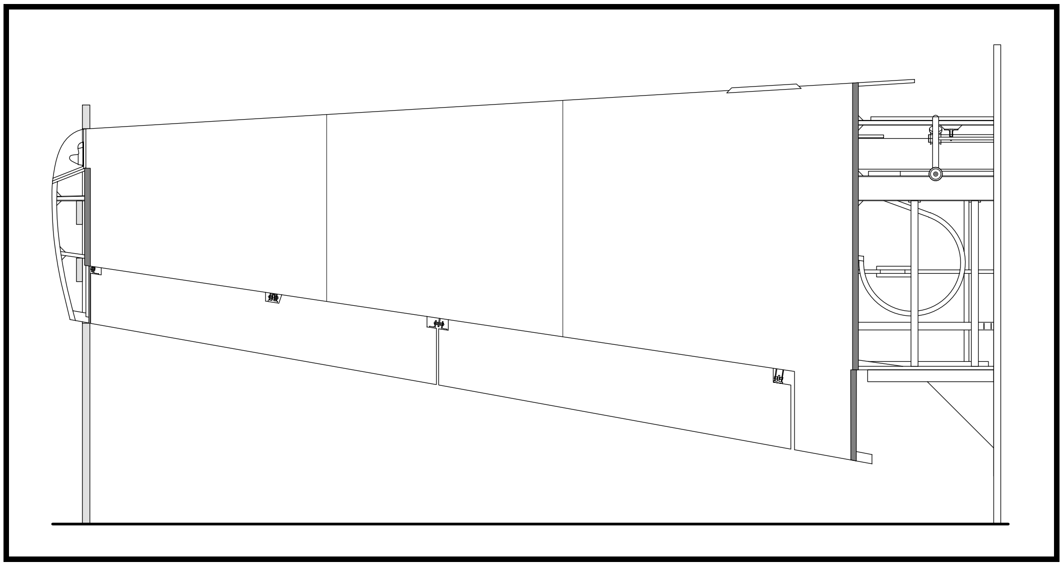


Figure 48

❑ On the forward and aft faces of fuselage frame No. 5, install 15x15 spruce blocks as shown in Figure 48. These blocks will support the upper wing skin where it has to be cut out for the fuselage frame. Before installing the spruce blocks, cut them to an angle to match that of the upper wing skin in the center.

❑ Cut and fit the upper wing skin between wing Sta. 1 and the outboard seat support. See Figure 50. This skin must be soaked in water and clamped in place.

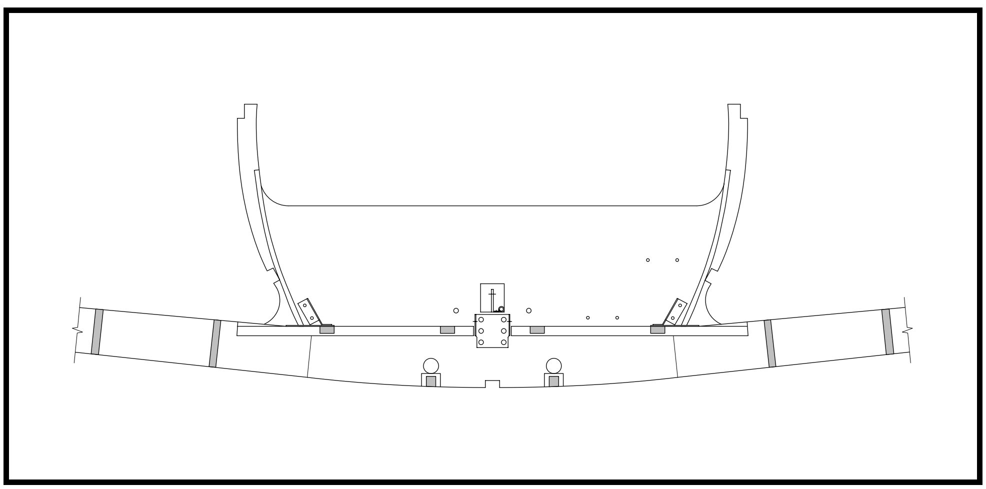


Figure 49

❑ Clamp the gluing strip in place on the aft face of fuselage frame No. 6. See Drawing No. 311.

❑ As shown in Figure 49, use a small piece of plywood to simulate this skin and drill the holes through fuselage frame No. 6 and the gluing strip on the aft face for the outboard seat belt fittings. See Drawing No. 123.

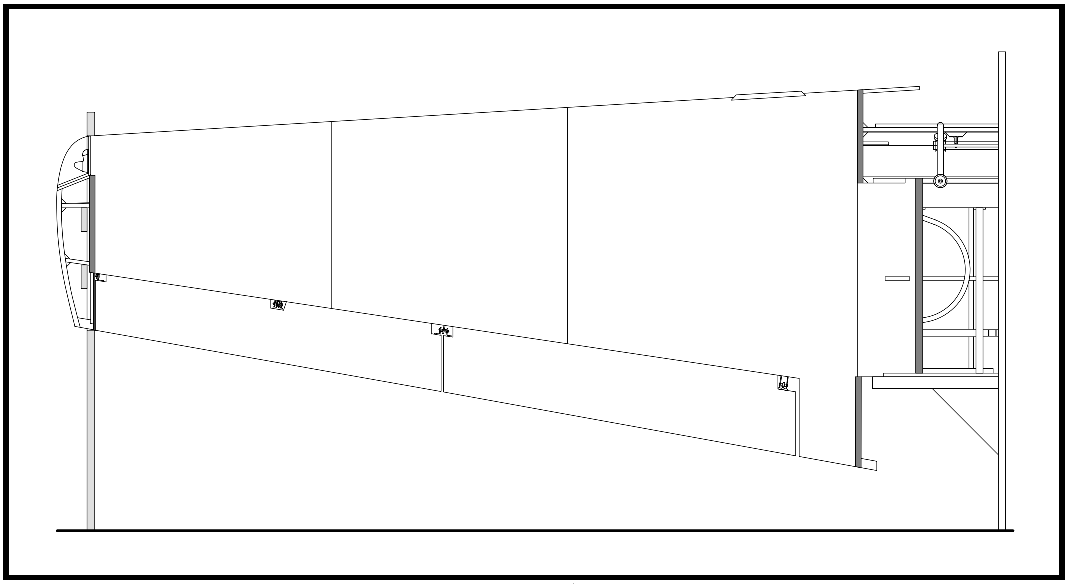


Figure 50

❏ Remove the outboard seat belt fittings and glue the upper wing skin in place as shown in Figure 50.

❏ Cut and fit the inboard upper wing skin as shown in Figure 51. This skin should extend inboard to B.L. 60. At the aft end—for 100mm forward of the forward face of fuselage frame No. 6—cut it to match the seat support. This will provide clearance for the rudder cable and access to drill the flap motor and torque tube mounting holes.

❏ With this skin clamped in place, drill the holes for the outboard seat belt fittings through this skin and through the 30x15 seat supports.

❏ Mark offset lines on the already-installed skin so that you can accurately locate the seat supports once the inboard skin is glued in place.

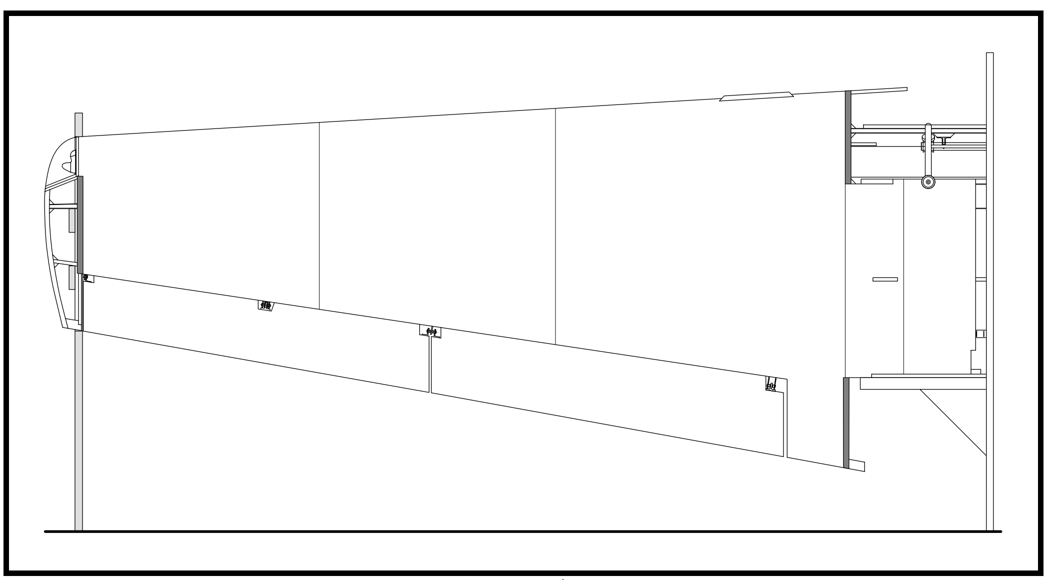


Figure 51

❏ Glue the inboard skin in place.

❏ Mark the locations of the seat supports on the top of the upper wing skin.

❏ Support the wing with additional braces, then remove the Sta. 14 template.

❏ Using the wing tip lens as a guide, shape the wing tip to a smooth shape for the skin. See Drawing No. 202.

Note: When we made the mold for the wing tip lenses, we had to decide on the final shape of the wing tip. The tip of the wing follows a line that is halfway between the upper and lower wing skins. Thus, the tip of the wing is slightly curved when viewed directly from the end.

The end of the main wing spar is shaped with the same faired curve method used for the fuselage frames or the leading edge of the wing tip (see Drawing No. 205).

❏ Cut and fit the upper wing tip skin. For easier bending, use 1.5mm birch plywood with the grain direction fore-and-aft. You will need a little extra material on the inboard and outboard end—say 30mm or so—for clamping while the end is being bent. The extra material on the outboard end should be notched so that you will not have to pleat the plywood while you bend it!

❏ Soak and bend the upper wing tip skin.

❏ When dry, cut off the extra inboard material and scarf this skin for the joint at Sta. 14.

❏ With this skin clamped in place, install two small nails as alignment pins so that the skin may be glued in place accurately.

❏ Trace the outline of the ribs and spars on the inside surface of the upper tip skin for varnishing.

❏ Draw the internal structure of the wing on the outside of the skin to assist in nailing or stapling when the skin is installed.

❏ Cut and fit the lower wing tip skin.

❏ Soak and bend the lower wing tip skin.

❏ When dry, cut off the extra inboard material and scarf this skin for the joint at Sta. 14.

❏ Draw the internal structure of the wing on the outside of the skin to assist in nailing or stapling when the skin is installed.

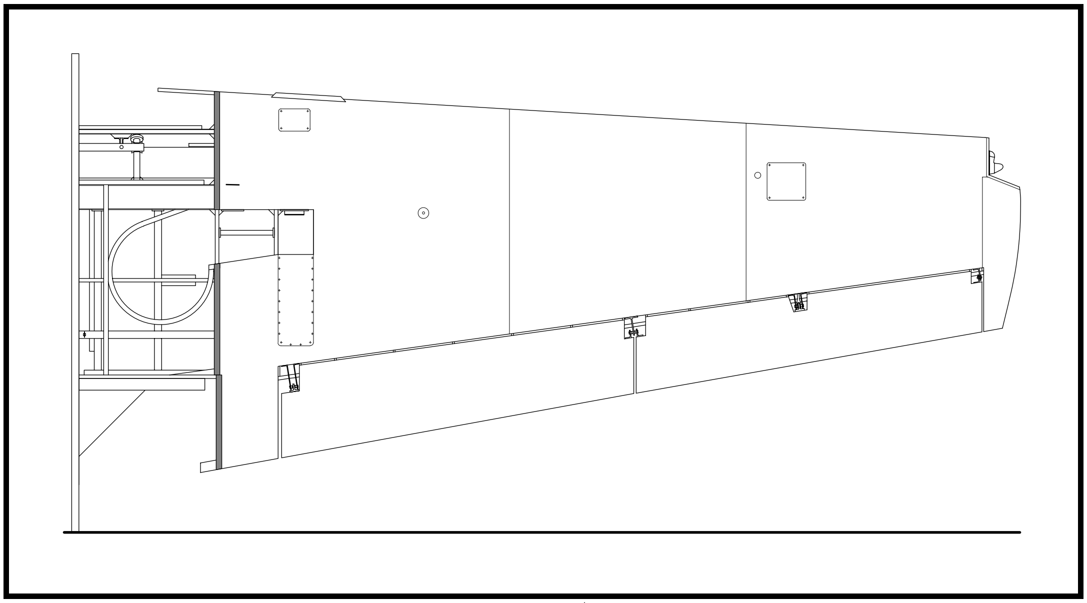


Figure 52

❑ Glue on the lower wing tip skin.

❑ Scarf the lower wing tip skin at the tip for the upper tip skin. This scarf is a rounded type of scarf, due to the radius of the wing tip.

❑ Mask and varnish the inside surface of the upper wing tip skin.

❑ In preparation for closing, varnish the interior surfaces of the wing tip except for those areas to be glued.

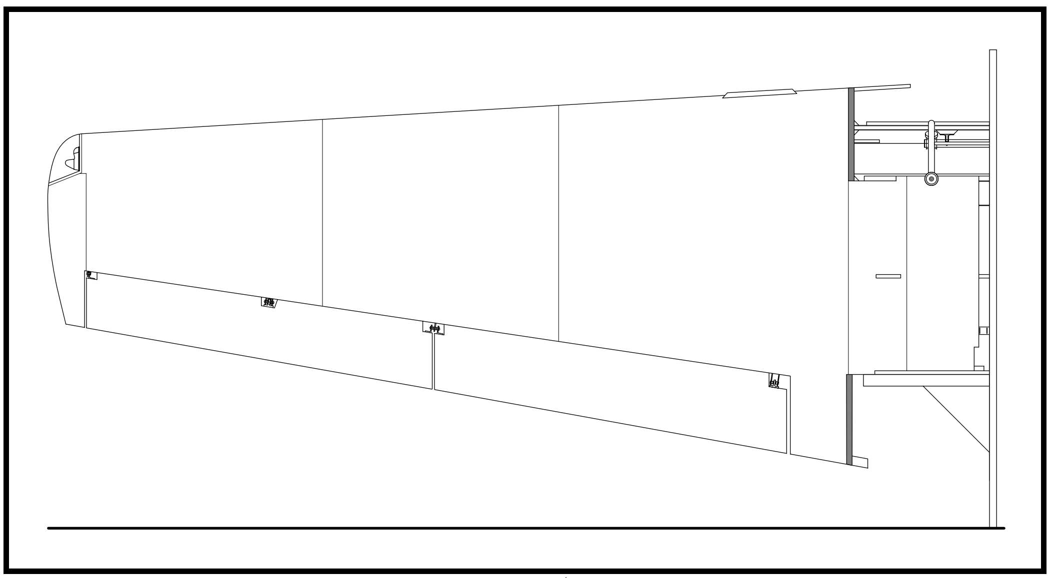


Figure 53

❑ Glue on the upper wing tip skin.

❑ Sand the wing tip to a smooth radius.

❏ Install the wing tip lens.

❏ Remove the wing from the jig and place in a horizontal position in preparation for the fuselage assembly.

Chapter 25
Fuselage, Preliminary Assembly

This chapter will cover the preliminary assembly of the fuselage. If you wish, you may do this work simultaneously with the work covered in Chapters 22 "Aileron/Flap Assembly", Chapter 23 "Wing, Preliminary Assembly" and Chapter 24 "Wing Assembly". You should consider the purchase of the instrument panel and instrumentation so that you can proceed with the installation of the electrical system in the instrument panel. You will be unable to proceed with the airframe wiring until the instrument panel is wired.

Kits on Hand
To do the work covered in this chapter, you should have the following:

Kit No. 808-3 Engine Mount & Equipment (or 808-1 or -2 as applicable)
Kit No. 809-1 Fuel Tanks & Equipment
Kit No. 811 Nose Gear & Equipment
Kit No. 813-1 Cowling & Equipment
Kit No. 817-1 Engine Controls & Equipment

If you wish to postpone the purchase of the cowling, you may do so. See discussion below on "Cowling Supports Installation."

Other Materials
To do the work covered in this chapter, you should have the following:

Nose gear tire and tube
Christen Inverted Oil System (if applicable)
Stainless steel for firewall
Firewall insulation (Fiberfrax or asbestos)

The firewall is made of .015" stainless steel. Asbestos or "Fiberfrax" ceramic paper insulation is installed between the firewall and the fuselage frame. Fiberfrax is a relatively new material (you can get it from Wicks Aircraft or Aircraft Spruce and Specialty), and it is very effective. Stainless steel should be purchased locally—the exact alloy is not important.

Cowling Supports Installation
There are two ways to install the cowling supports—the aluminum angles bent to match the shape of fuselage frame No. 1. If they are installed now—as we recommend—the firewall must be cut to the shape of fuselage frame No. 1 and then the cowling supports are installed to match. Because of the taper of the fuselage, the firewall and cowling supports must be slightly smaller—or you must add a strip of spruce around the frame for sanding. The cowling supports are easily clamped in place for drilling.

The alternative is to wait until the fuselage is completely skinned and then the cowling supports are installed so that the cowling matches the fuselage. Plywood shims—the same thickness as the cowling—are used to correctly position the cowling supports. The cowling supports cannot be clamped in place and must be held in place by hand while the holes are drilled—clamping is preferable since it isn't easy to drill through stainless steel.

We believe that the cowling supports should be installed now for the quickest and easiest construction, but there is really nothing wrong with installing them later.

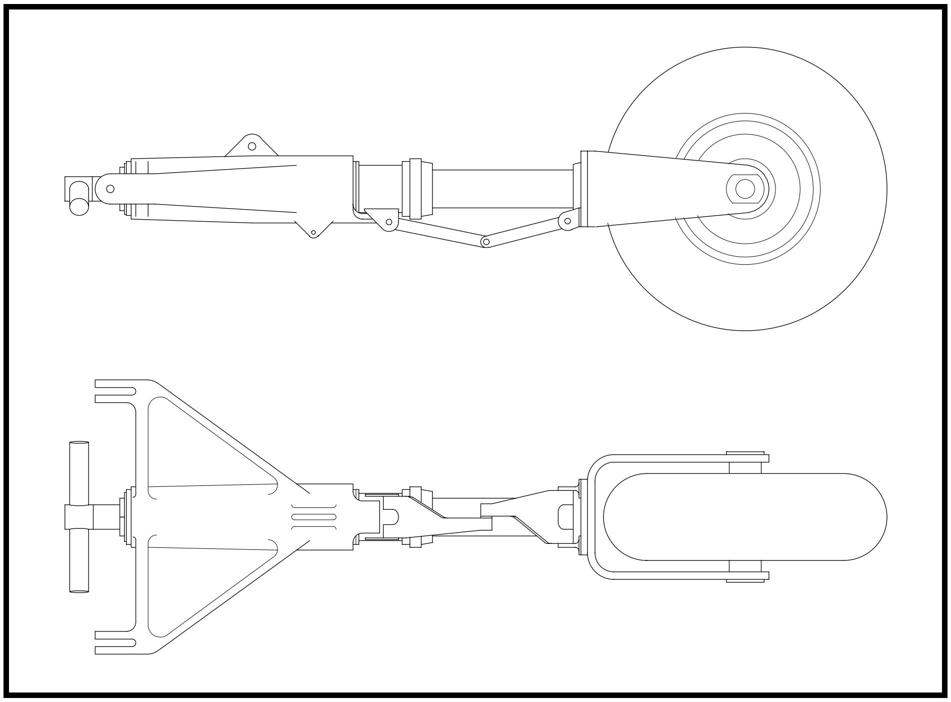


Figure 1

Nose Gear Assembly

The nose gear is supplied partially assembled for protection during shipment.

- ❏ Remove the Schrader No. 7607AH valve and AN901-5C crush washer. See Drawing No. 601.
- ❏ Remove P/N 616 upper ring nut.
- ❏ Remove nose gear strut from P/N 654A trunnion.
- ❏ Check to make sure that P/N 658 bushing is fully inserted in P/N 654A trunnion.
- ❏ Check to make sure that P/N 657 bushing is fully inserted in P/N 654A trunnion.
- ❏ Put nose gear strut back in P/N 654A trunnion.
- ❏ Check to see if the nose gear strut will turn in the bushings. If necessary, use emery cloth or 400 grit wet-or-dry emery paper on the inside of the bushing. We prefer to wet sand with a little oil on the paper. Wipe all grit from the inside of the bushing and re-install the nose gear strut. The nose gear strut should be able to turn with just a minimum amount of effort. The nose gear strut does not need to be loose, although this will do no harm. The steering pressure will come from your feet, which are much stronger than your hands. When you have the bushings properly sized, remove the nose gear strut from the trunnion.
- ❏ Drill completely through P/N 658 and P/N 657 bushings with a #3 (.213”Ø) drill. This is for the two grease fittings shown.
- ❏ Tap the two holes with a 1/4-28 tap for the two grease fittings.

- ❑ Deburr the holes on the inside of the bushings. Wipe the inside of the bushings clean.

- ❑ Install the two Lincoln No. 5013 grease fittings. These grease fittings should be installed through the trunnion and into the bushings so that the grease fittings will prevent the bushings from turning in the trunnion. Note however, that the grease fitting in P/N 657 should not protrude into the inside of the bushing, or it will interfere with the installation of the nose gear strut.

- ❑ Unscrew P/N 655 lower ring nut from the nose gear strut.

- ❑ Gently remove the nose gear piston from the nose gear cylinder. The split piston bushing, P/N 659 (not labeled on Drawing No. 601 but see Drawing No. 659) will fall free. Remove P/N 660 guide and stop. Make sure the upper part of the piston is lubricated with oil, then gently slide P/N 655 lower ring nut from the piston.

  Note: Whenever you handle the chrome plated nose gear piston, you should exercise extreme care. The chrome plating is easily damaged. Chipping the chrome plating will require its replacement.

- ❑ Slide P/N 664 over the end of the piston. Slide P/N 664 part of the way down the piston.

- ❑ Lubricate the upper part of the piston with oil, then gently slide P/N 655 over the piston and part of the way down.

- ❑ Slide P/N 660A over the nose gear piston. P/N 660A is longer than the P/N 660 that may have been installed in the nose gear assembly.

- ❑ Install the split bushing, P/N 659, over the end of the piston and insert the piston in the nose gear strut cylinder.

- ❑ Screw P/N 655 on to the nose gear strut cylinder. It is not necessary to tighten this with a wrench at this time.

- ❑ Bolt the nose gear fork, P/N 613, to the base of the nose gear piston. Do not tighten the nuts.

- ❑ Check to see that the bolts and P/N 665 eyebolts bottom out without any tightening of the nuts. If necessary, chamfer the holes at the upper surface of the base of the nose gear piston. For this, you may use a large drill or a countersink, twisting it in your hand. Be very careful not to hit the chrome plated piston with the drill or countersink.

- ❑ Install P/N 662-2 lower torque link between the two P/N 665 eyebolts to insure that the eyebolts are lined up with the torque link bolt.

- ❑ If you wish to install the nose gear fork permanently, we suggest that you paint the bottom of the nose gear piston and the top of the nose gear fork with zinc chromate primer. Mask off the nose gear piston at 6 to 8mm above the base and paint with zinc chromate primer. Just before assembly, brush a coat of zinc chromate primer on the mating surfaces and assemble wet. This will prevent moisture from entering and creating corrosion.

❑ Paint the inside of P/N 663 and the outside of P/N 656 (where P/N 663 will be installed) with zinc chromate primer. If you use spray paint, temporarily install the Schrader valve during the painting operation.

❑ If you wish to install the nose gear fork permanently, torque the MS21042-5 nuts to 100 to 140 inch-pounds (8.33 to 11.67 foot-pounds).

❑ If the upper surface of the nose gear piston base and the first 6 to 8mm of the piston is painted with zinc chromate primer, slide P/N 664 stop to the bottom.

❑ Install P/N 661-2 upper torque link. The three bolts for the torque links should not be tightened. Tighten the nuts finger tight and then back off one half turn. The cotter pins may be installed, but you will probably want to disassemble the nose gear for final painting before flight.

❑ Centerpunch P/N 663 nose gear rocker arm on the forward side. (The two arms are angled toward the front.)

❑ Drill through one side of the large short center tube of P/N 663 with a 5/32” drill.

❑ Put P/N 663 nose gear rocker arm on the top of the nose gear strut. Do not drill the bolt hole yet.

❑ Align the nose gear rocker arm with the nose gear fork. The two arms on the rocker arm are angled toward the front, and the torque links and P/N 665 eyebolts are also on the front of the nose gear. Be sure that the rocker arm is correctly aligned before drilling through!

❑ Drill through P/N 656 and out the other side of P/N 663 with a 5/32” drill.

❑ Check the alignment of the nose gear rocker arm and correct as needed.

❑ Ream the hole with a 11/64” drill.

❑ Ream the hole with a 3/16” drill or a 3/16” reamer.

❑ Remove the rocker arm and deburr all holes.

❑ Coat the outside of the nose gear strut with oil to protect it from corrosion. This will apply only to those areas that will be enclosed in the nose gear trunnion.

❑ Coat the inside of the nose gear trunnion with oil to protect it from corrosion.

❑ Install the nose gear strut in the nose gear trunnion.

❑ Install P/N 616 upper ring nut.

Note: You should paint the nose gear at a convenient time later in the construction process, since you will find it a lot of trouble to set up to paint just one part now. For this reason, do not install the locking screws in the upper ring nut, axle and axle nut at this time.

- ❏ Install the Schrader valve and crush washer. There is no need to tighten the valve at this point.
- ❏ Install the rocker arm with the bolt. There is no need to torque the nut.
- ❏ Split the nose wheel, P/N 666, by loosening the six bolts.
- ❏ Shake some talcum powder inside the nose wheel tire.
- ❏ Install the nose wheel inner tube in the nose wheel tire.
- ❏ Place the tire and tube on the side of the nose wheel with the hole for the inner tube valve stem. Pull the valve stem through the hole.
- ❏ Put enough air pressure in the inner tube to round it out, but not enough so that it starts to expand.
- ❏ Install the other side of the wheel and insert the bolts. Be very careful to make sure that you do not pinch the inner tube between the two halves of the wheel.
- ❏ Tighten the nuts and bolts for the nose wheel.
- ❏ Inflate the nose wheel tire to about 30 psi. Remove the valve core and allow the tire to deflate. Then replace the valve core and inflate the nose wheel tire to about 30 psi.
- ❏ Install the nose wheel in the nose gear fork using the axle, axle nut and spacers. Do not install the locking screws at this time.

Engine Mount

- ❏ Install P/N 720-2 spacers on P/N 720. See Drawing No. 707-3 (or 707-1 or 707-2).

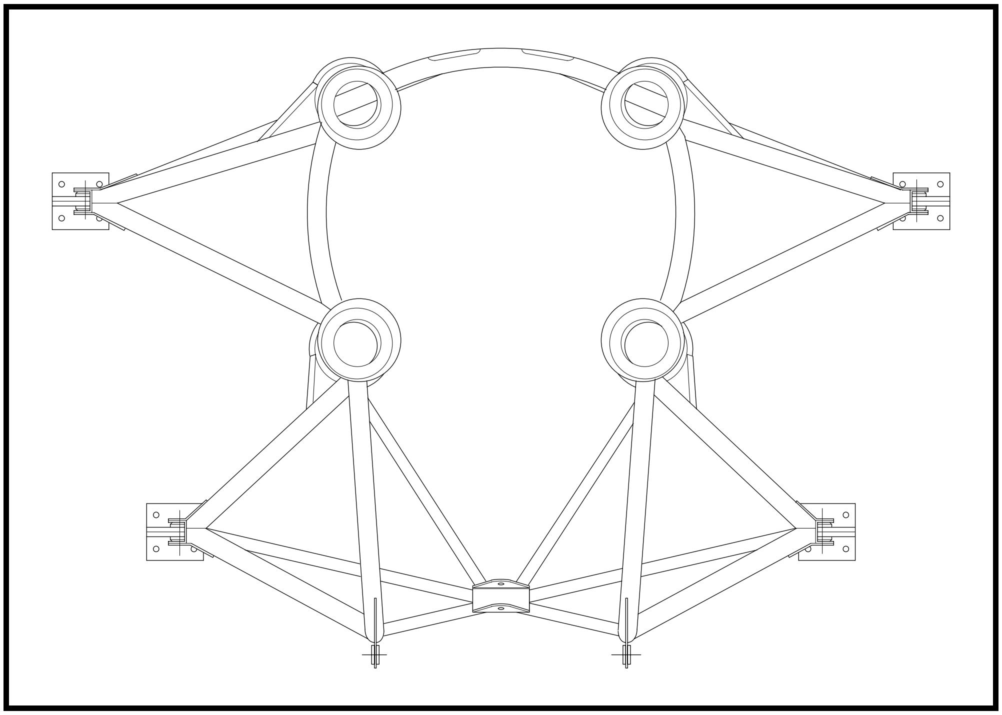


Figure 2

- ❏ Install the four P/N 720 engine mount lugs on the engine mount. See Drawing No. 707-3 (or 707-1 or 707-2). Also, see Drawing No. 114. All of the engine mount lugs are installed with the "wide" side outboard. Our experience has been that the steel bushings for P/N 720 do not require reaming for the bolt to fit. If the bolts are a relatively tight fit, we would prefer that these bushings not be reamed since it will remove the cadmium plating and the corrosion protection. If it is necessary to ream the bushings, the bolts should be installed with a wet coat of zinc chromate primer—a procedure we recommend in any case.

- ❏ Install the nose gear assembly on the engine mount. See Drawing No. 105. You may have to file on the washers of the engine mount slightly to get a good fit.

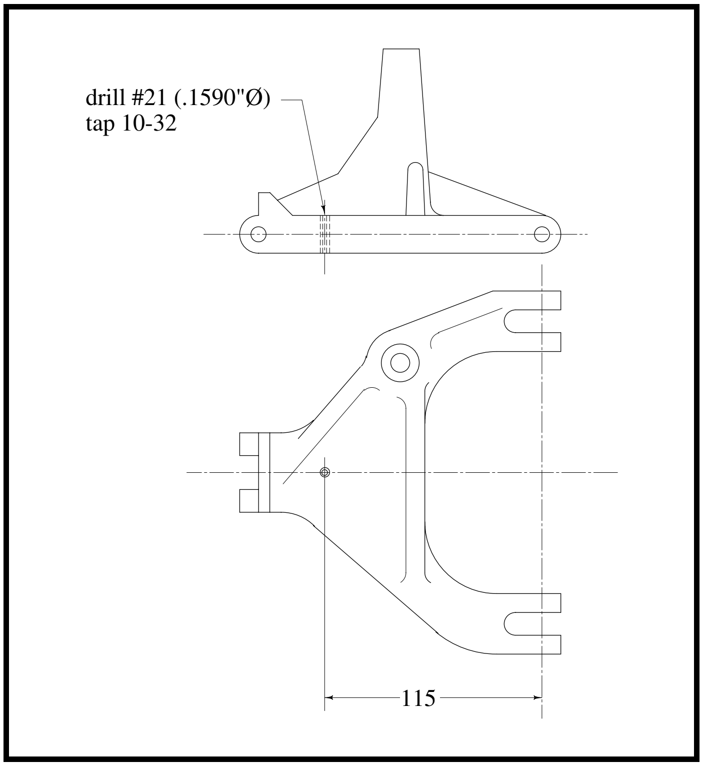


Figure 3

❏ Drill and tap the hole in P/N 618A for the gear up limit switch screw. See Figure 3.

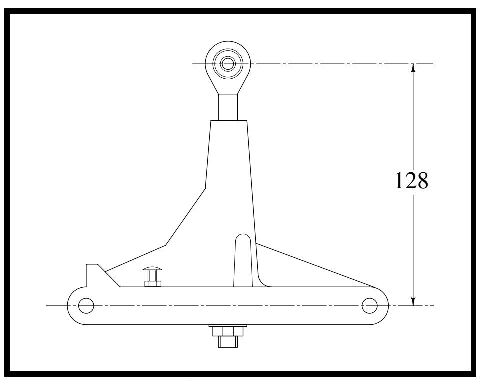


Figure 4

❏ Install P/N 605 in P/N 618A. See Drawing No. 105. The approximate installed location of P/N 605 is shown in Figure 4.

❏ Install the MS35207-267 screw and AN315-3 check nut (included in the Electrical kit) in P/N 618A upper drag strut. See Figure 4.

❏ Install P/N 708 drag strut supports in P/N 618A upper drag strut. See Drawing No. 105 and 114. If the bolts are too tight in P/N 708, ream the holes with a 5/16" reamer or drill.

❏ Install P/N 619A on P/N 618A. See Drawing No. 105.

❏ Install P/N 619A (with the other parts installed) on the nose gear. See Drawing No. 105.

Rudder Pedal Assembly

❑ Ream the bronze bushings of the four P/N 761 rudder pedal supports with a 1/4" reamer.

❑ Install two Nyliner 16L16 bearings in each P/N 778 rudder pedals. See Drawing No. 122.

❑ Fit the rudder pedals on the P/N 703A and P/N 704A rudder pedal torque tubes. After fitting is complete, the pedals may be removed. We do not recommend the installation of the foot pedal rubbers used on the right side of the aircraft at this time. These are difficult to remove and should not be installed until the torque tubes are painted.

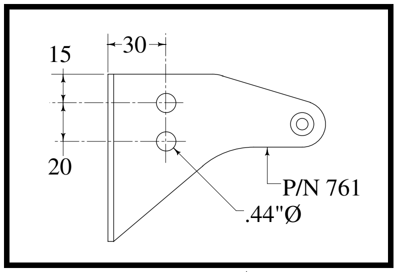


Figure 5

❑ Install P/N 761 supports on the P/N 703A and P/N 704A torque tubes. See Drawing No. 114 and 122. Be careful to install the supports with the flanges outboard.

❑ Remove the left P/N 761 for the right rudder pedal torque tube and drill the two .44"Ø holes as shown in Figure 5. These holes are for MS35489-6 grommets for the 1/4"O.D. brake lines, which will be installed later.

❑ Put the P/N 761 back on the rudder pedal torque tube.

Fuel Tank Band Mounts

❑ Prime all P/N 733-2 bands with two coats of zinc chromate primer.

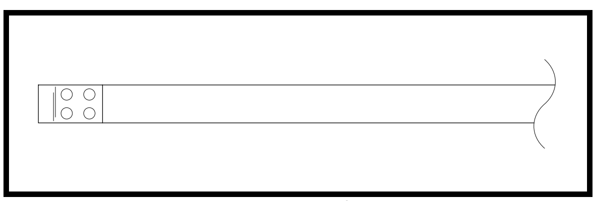


Figure 6

❑ Install P/N 733-3 upper clamps on the one end of each P/N 733-2 band. See Drawing No. 733. Drill through with a 1/8" drill, then ream with a #30 (.128"Ø) drill before installing the rivet. The hole should be deburred before riveting. Apply a wet coat of zinc chromate primer to the ends of the bands before insertion in the P/N 733-3 clamps for maximum corrosion protection. The P/N 733-4 lower clamps are not installed at this time.

Firewall

❑ Cut out the firewall. We recommend that the firewall be carefully laid out to the exact shape of fuselage frame No. 1. See Drawing No. 301. An easier method of developing this shape is discussed in the Chapter 12 "Making the Fuselage Frames". If you wish, you may just trace the shape of the existing fuselage frame No. 1, but we prefer the precise layout method.

Fuselage Frame No. 1

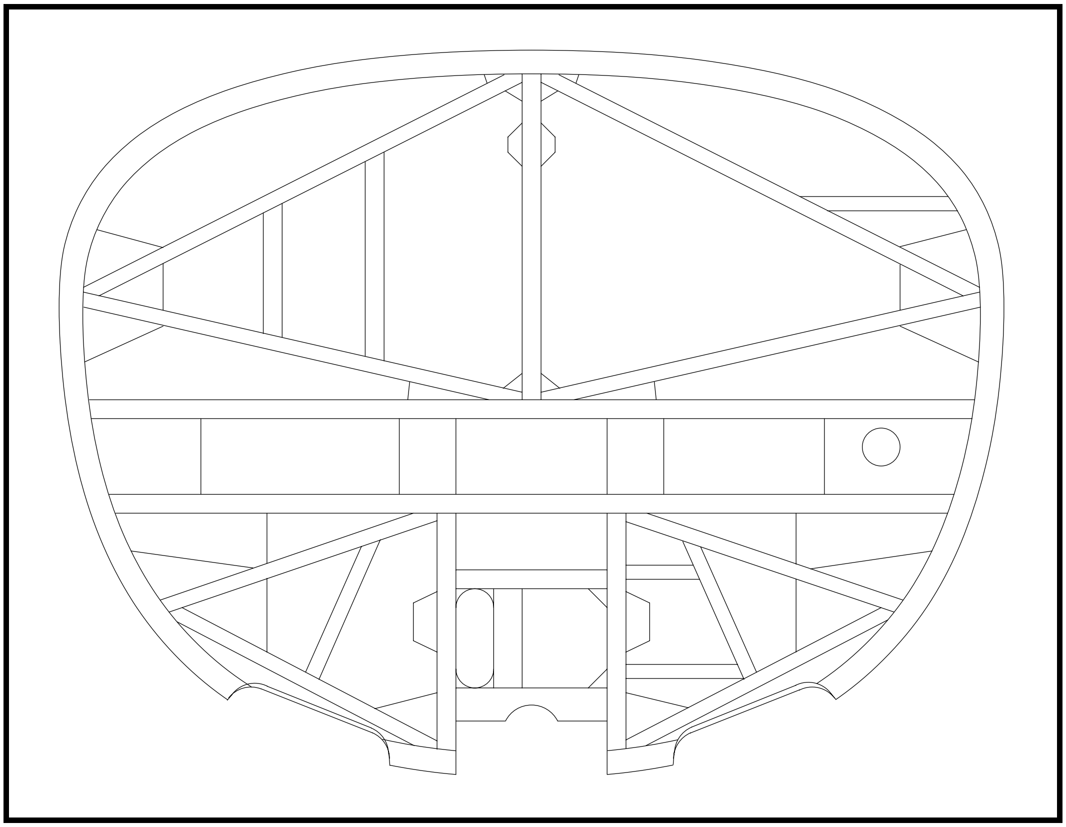


Figure 7

- ❏ Review Drawing No. 302 and if not already done, install spruce blocking for the brake reservoir, Christen P/N 803 oil separator, Christen P/N 802 oil valve, and Christen P/N 806-4 breather tee.

- ❏ If not already done, draw all of the internal structure on the outside of the fuselage frame. You should be careful to locate the closing plywood accurately (with two small nails as alignment pins) so that the fuselage centerline and W.L. 0 on the aft face will be the same as on the front face.

- ❏ If not already done, cut the exhaust ports. Cut the front face to the correct shape shown in the drawing. The exhaust port shield fit in at an angle so the frame should be cut to an included angle of 107° from the front face. If it is already cut to 90°, don't worry—you can add spruce blocks later on.

- ❏ Drill ventilation holes as required on the aft face.

- ❏ For noise suppression, insert two 2mm plywood disks in the 40Ø hole to increase the thickness of the plywood. The bulkhead fitting which will be installed here has a maximum grip length of 5/16" and will grip both the firewall and the plywood on the forward face of the fuselage frame.

❑ Mask off the inside face of the closing plywood and varnish. Varnish the interior of the fuselage frame, except for those areas to be glued. Do not varnish the exterior of the frame at this time.

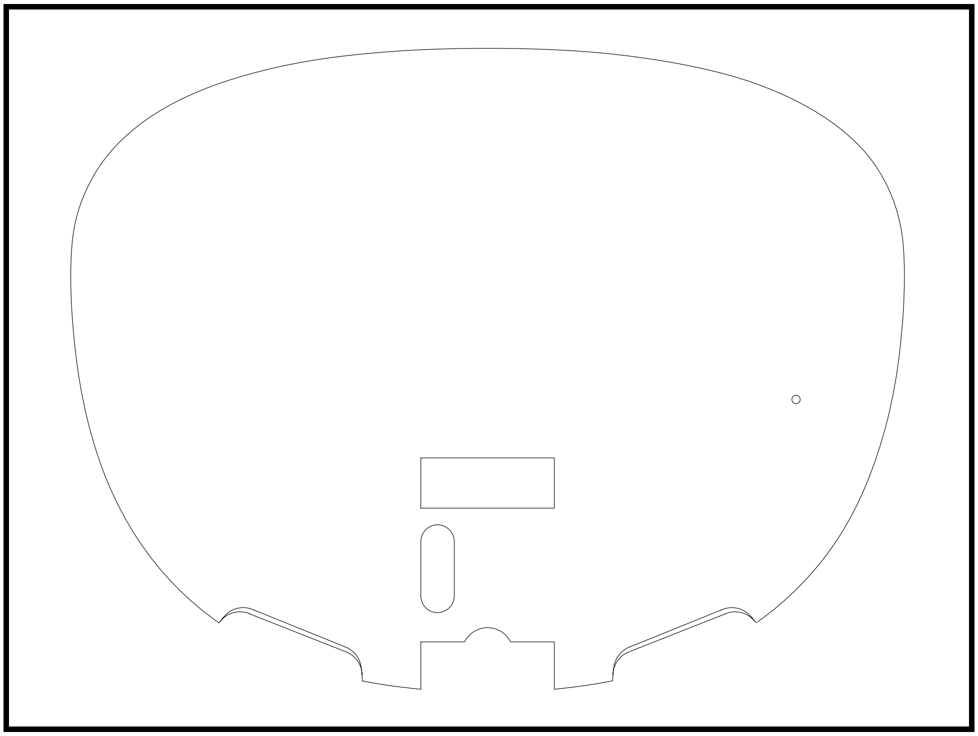


Figure 8

❑ Close fuselage frame No. 1 by gluing on the closing plywood.

❑ Draw the airplane centerline and W.L. 0 on the aft face of the fuselage frame.

❑ On the aft face of the fuselage frame, draw B.L. 340 and B.L. 200 for the fuel tank installation. See Drawing No. 121.

❑ Draw the outline of the 30x11 spruce strips shown on Drawing No. 121. These strips should extend down to W.L. –120.

❑ On the aft face of the fuselage frame, draw W.L. –150, B.L. 110 and B.L. 410 for the rudder pedal supports. See Drawing No. 114.

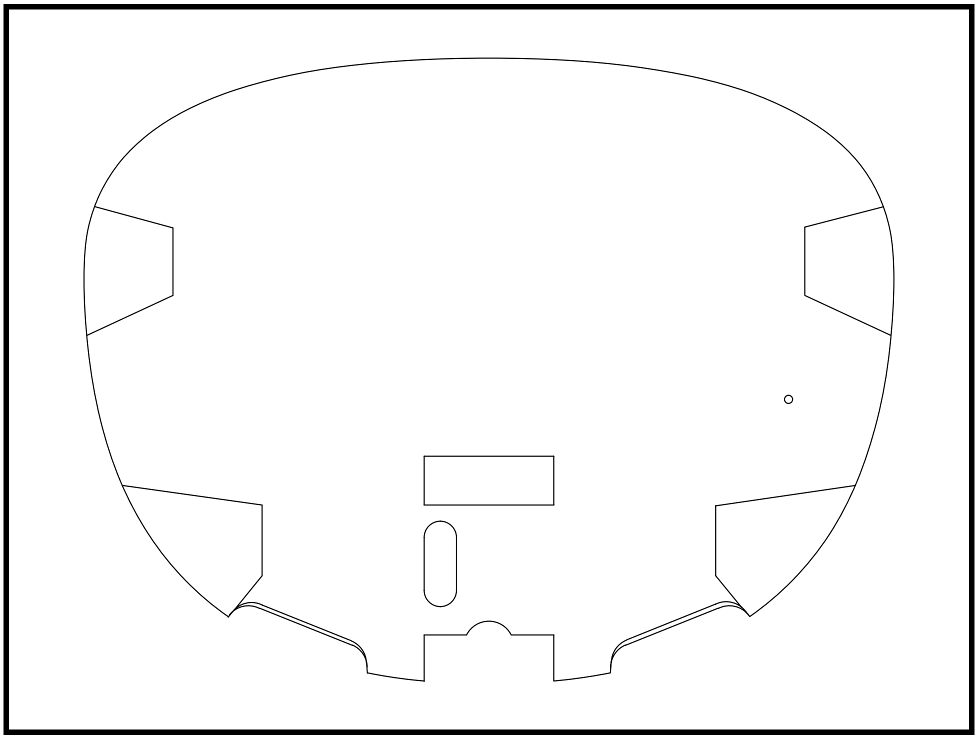


Figure 9

- ❏ Glue on the 2mm plywood pads on the face just closed. These pads are installed on both the forward and aft faces, so if they have not already been installed on the opposite face, do so now.

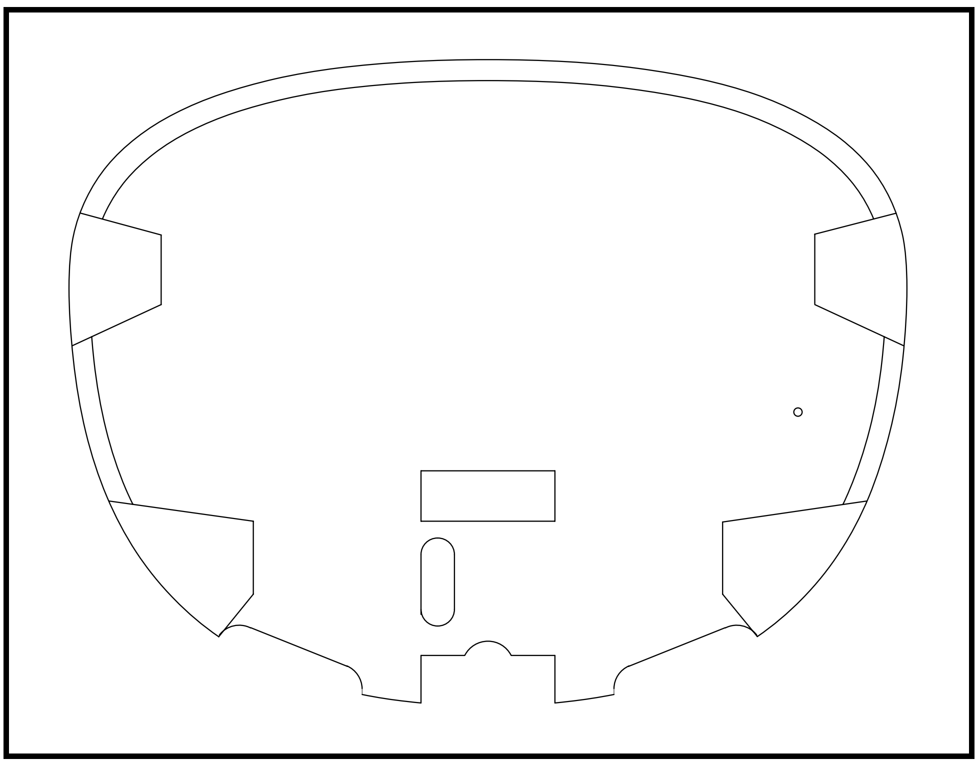


Figure 10

❏ Glue on 25mm wide 2mm plywood spacers around the perimeter of the fuselage frame on the forward face only as shown in Figure 10. The purpose of these spacers is to provide a flat surface fo the cowling supports.

❏ Draw the installation locations of the engine mount lugs on the front face of the frame. See Drawing No. 114.

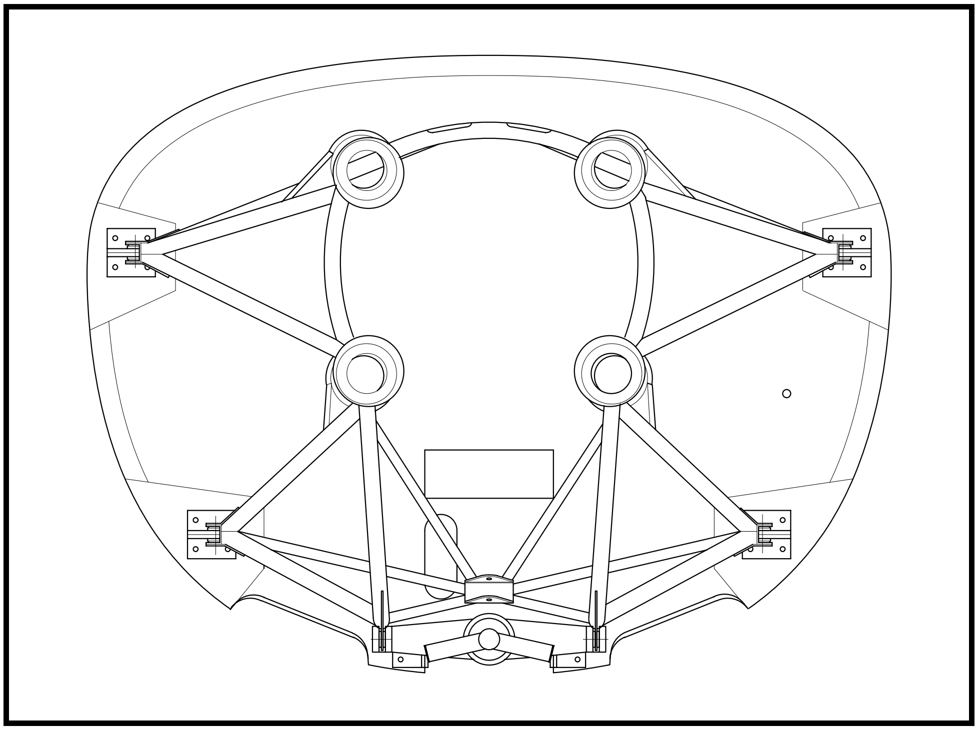


Figure 11

❏ Clamp the engine mount in position on the frame. The engine mount should have the nose gear, engine mount lugs, upper drag strut, lower drag strut and drag strut supports installed. Check the location of the engine mount.

❏ Clamp the drag strut supports in place. Check the alignment of the nose gear. It should be located in the center of the nose gear bay, and the nose gear should retract with a smooth action of the drag struts. If the "post" of the upper drag strut hits the bottom of the slot in the fuselage frame, sand the frame for clearance.

Note: When the nose gear is retracted, it will be exactly parallel to W.L. O. (or perpendicular to frame No. 1). Do not attempt to get the nose gear to retract more than this. As you will see, the three gear legs retract together, and that you cannot make one of them retract more than the others.

The retraction system for the Falco uses springs in the screwjacks, which are compressed when the landing gear is down, thus allowing for a certain degree of tolerance in the system. When the landing gear is down, all of the springs must be in compression.

This compression is released on retraction and the gear is held up by the screwjacks which are in tension. During inverted flight or negative-G turbulence, the landing gear will "flop" up into the wheel wells as the springs are compressed. This is not desirable since it will introduce shock loads into the retraction system. Accordingly, the bottom of the fuselage frame is used as a built-in stop to prevent this flopping action.

❏ When you are absolutely certain that the engine mount is in the correct position, drill the 1/4”Ø holes for the engine mount lugs through the fuselage frame. Do not drill through any of the steel plates that will be installed on the aft face of the fuselage frame.

❏ Drill the holes for the P/N 708 drag strut supports through the fuselage frame. The steel plates which will be installed on the aft face of the frame are not drilled at this time.

❏ Install the landing gear up limit switch on P/N 877 up limit switch support.

❏ Position the up limit switch support so that the roller of the up limit switch contacts the center of the MS35207-267 screw when the landing gear is in the full up position.

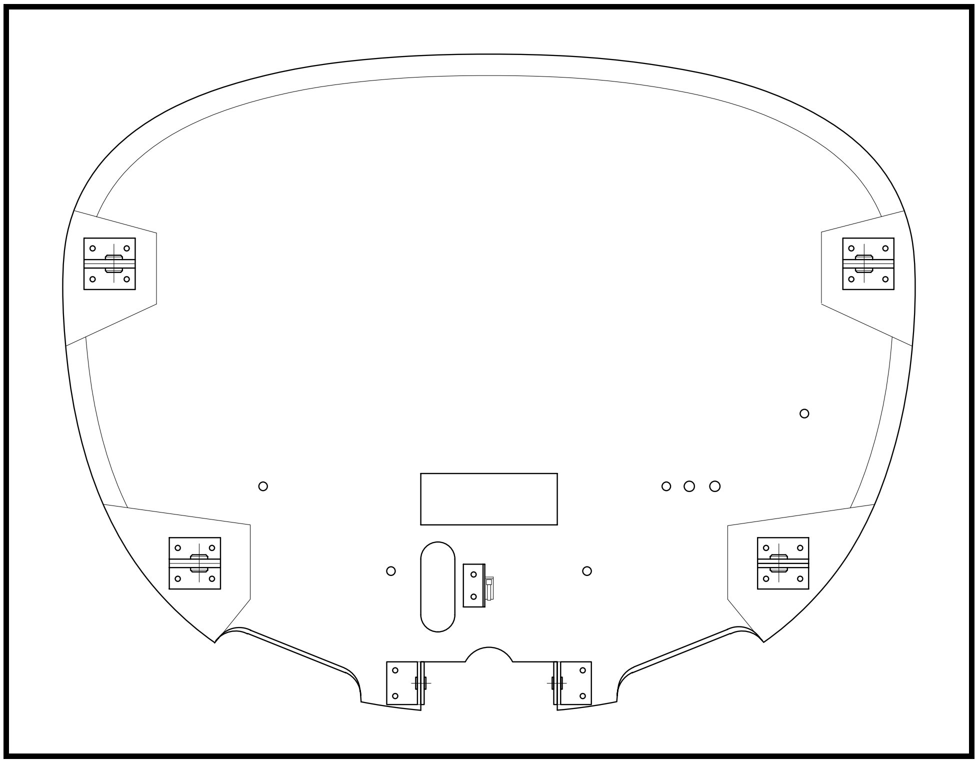


Figure 12

❏ Drill the two 3/16”Ø holes for the up limit switch support through the fuselage frame.

❏ Remove the engine mount, nose gear and related fittings from the frame.

❏ Drill the two holes for the nose gear steering cables in the frame. See Drawing No. 302. The location of these holes is for the front face of the frame. The holes should be angled up at approximately 7° (see Drawing No. 122).

❏ Drill the four holes through the triangular blocks. These holes are for the wiring.

❏ Drill the 7/16”Ø hole for the brake line. This hole is at the same location as the 40Ø hole in the underlying wood blocking. See Drawing No. 302.

❏ Drill a very small hole (say 1/32”Ø) through the frame at W.L. 0 and at the aircraft centerline. This will be used for the alignment of the fuselage in the fuselage jig. See Drawing No. 321. An alignment string will be used to determine the centerline and W.L. 0 for the other fuselage frames.

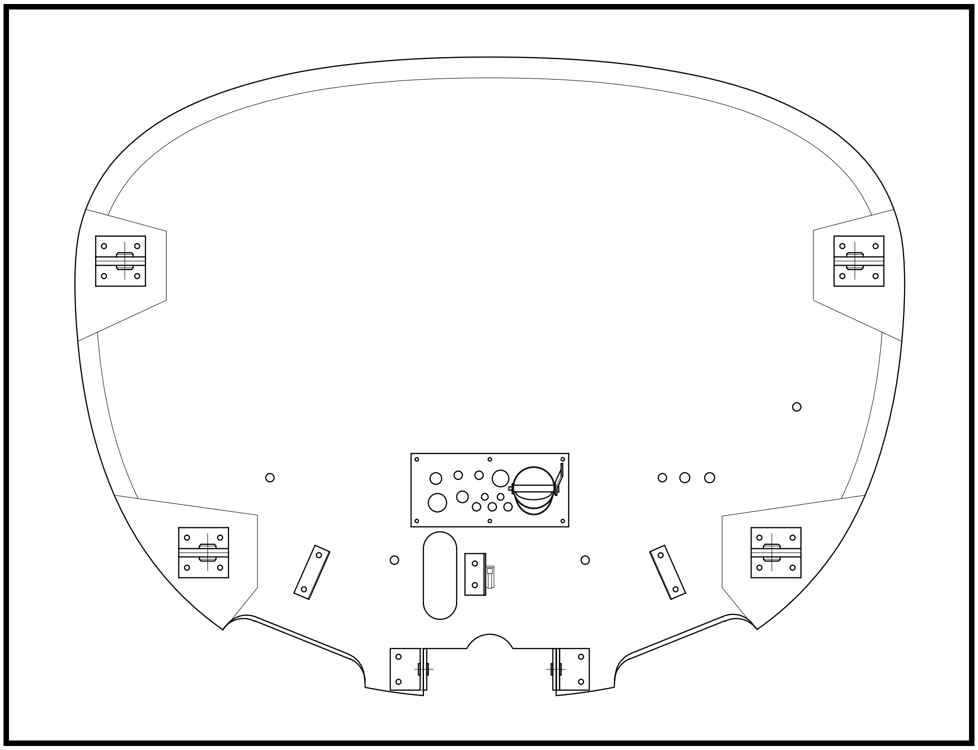


Figure 13

❏ Install P/N 824-1 cabin heat fitting on the fuselage frame. This is installed with No. 6x1/2” TRA screws. See Drawing No. 131. Center the fitting on the hole, since the vacuum system fitting that will be installed on this will just hit the bottom of the rectangular opening. If you install P/N 824-1 a little too low, the bottom of the rectangular opening can always be increased locally with a file.

❏ Drill the 3/16”Ø holes for the two P/N 772-10 exhaust hangers. See Drawing No. 302 for the location for these holes.

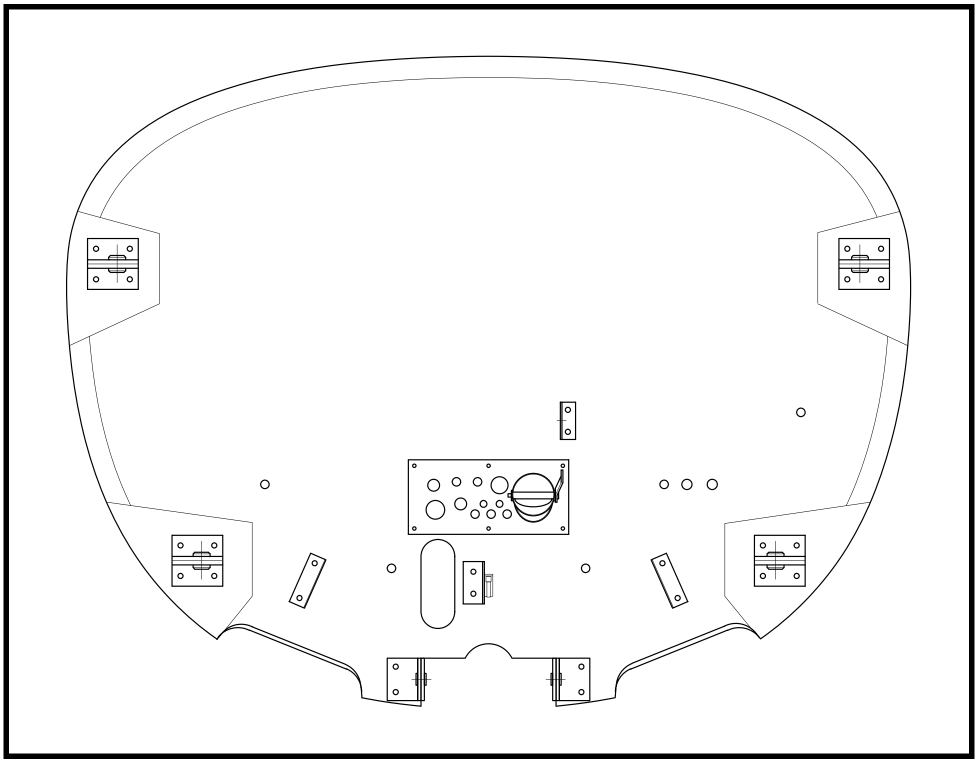


Figure 14

❏ Assemble P/N 826 cabin heat cable support with the cabin heat cable and other hardware shown on Drawing No. 131. If you wish, you may temporarily install the cable end fittings on the arm of the cabin heat valve. The only purpose of this step is to correctly locate P/N 826.

❏ Drill the two 3/16"Ø holes for P/N 826 through the fuselage frame.

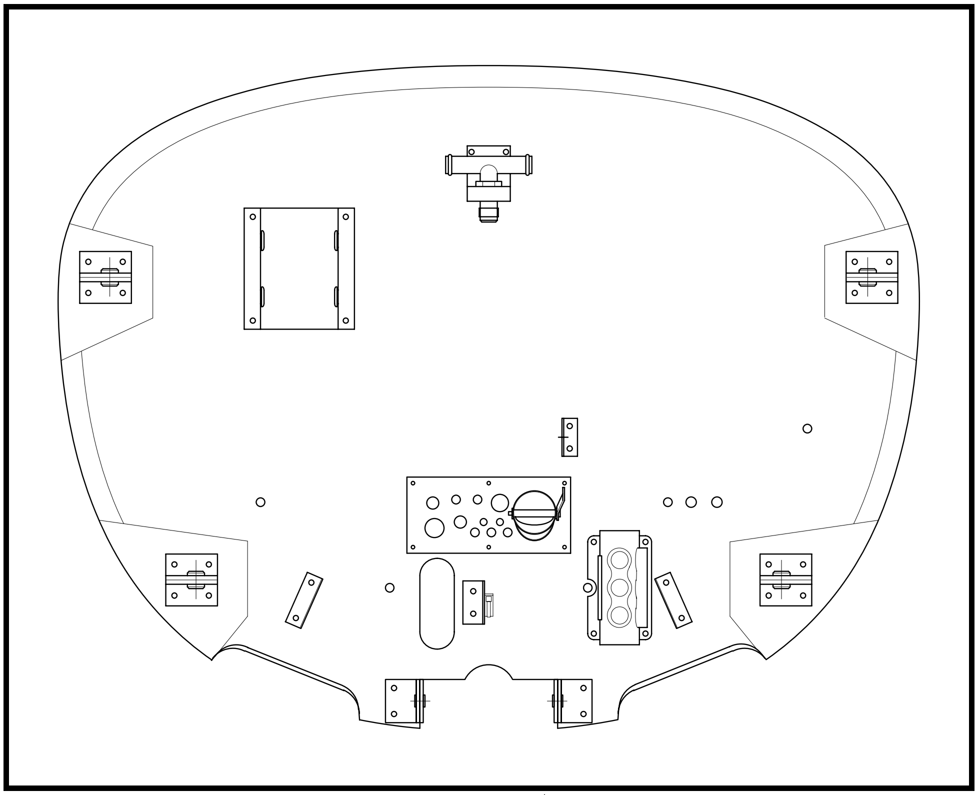


Figure 15

- ❏ If applicable, drill the four 3/16”Ø holes for the Christen P/N 803 oil separator. See Drawing No. 302 for the location of these holes. If possible, use the mounting bracket supplied by Christen.

- ❏ If applicable, drill the two 3/16”Ø holes for the Christen P/N 806-4 breather tee. See No. 302 for the location of these holes. If possible, use the actual part to locate the holes.

- ❏ If applicable, drill the four 3/16”Ø holes for the Christen P/N 802 oil valve. See Drawing No. 302 for the location of these holes. If possible, use the actual part to locate the holes.

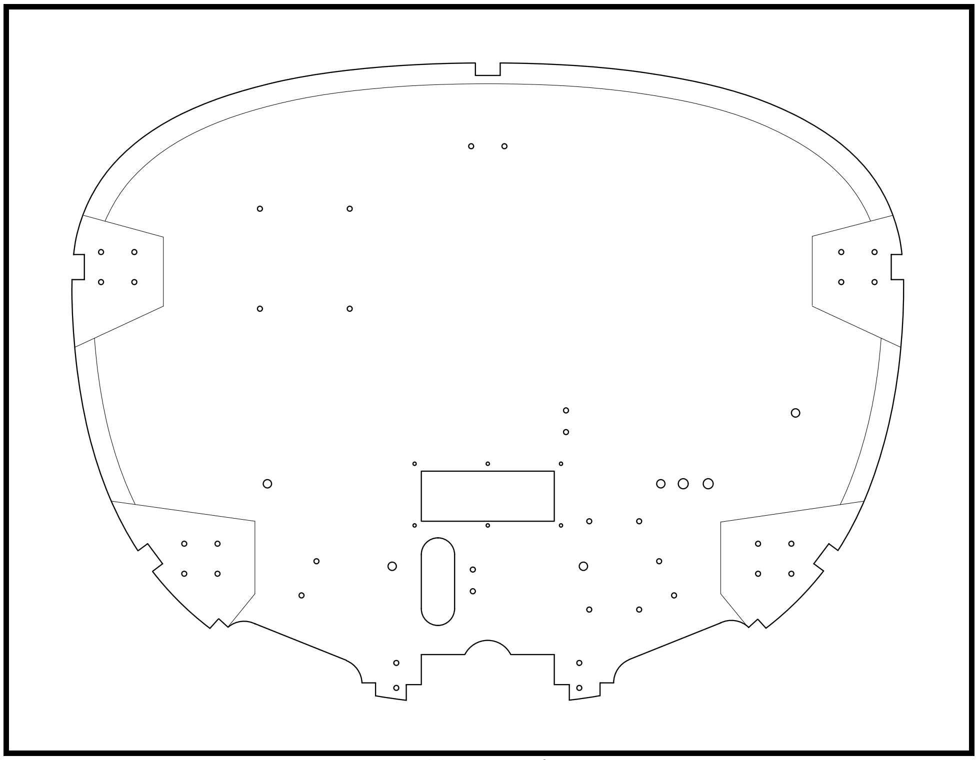


Figure 16

- ❏ Cut the five longeron cutouts. See Drawing No. 302. Use the master template. Because of the shape of the fuselage, the two lower side longerons intersect the frame at an angle. As a result, a cutout for the longeron that is perpendicular to the face of the frame will not work very well and will require substantial shimming to fit the longeron. Therefore, these lower side longeron cutouts should be undersized for final fit at the installation of the longeron.

- ❏ Cut the two 20x18 cutouts for the nose gear framing. You should allow for the thickness of the nose gear bay wall. To allow for the 2mm plywood skin of the nose gear bay wall, the width (before application of the skin) should be 164mm.

- ❏ Cut the four 15x15 cutouts for the exhaust port framing.

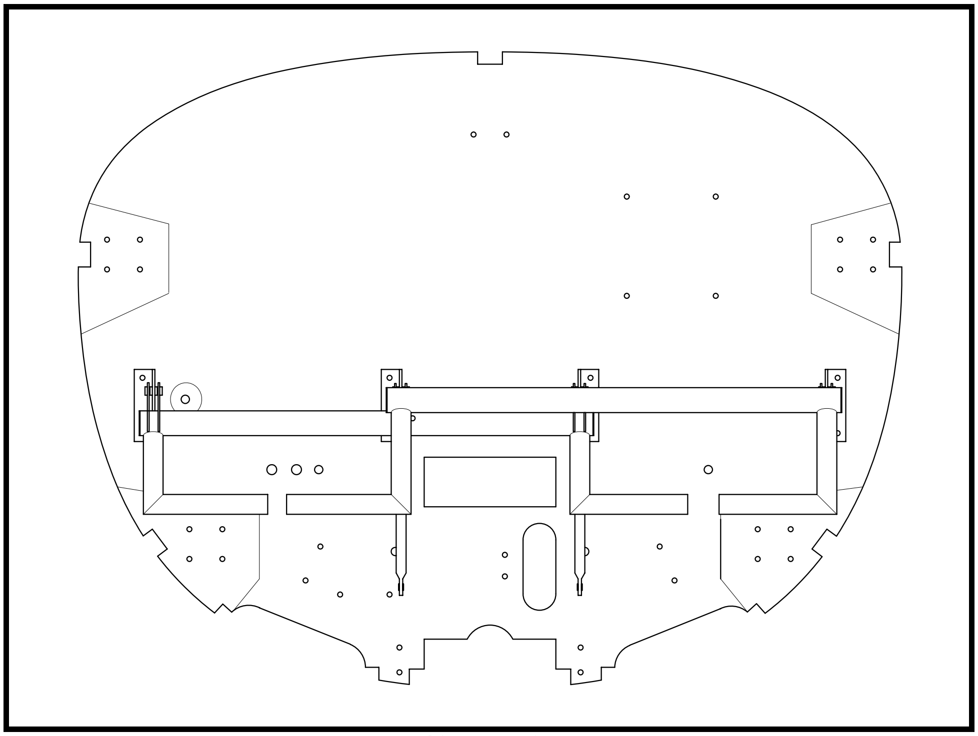


Figure 17

- ❏ Turn the frame over to work on the aft face. Position the rudder pedal torque tubes in place and clamp. See Drawing No. 114 for the location of P/N 761 rudder pedal supports. Be extremely careful to properly locate the rudder pedals.
- ❏ Drill the mounting holes for the four P/N 761 rudder pedal supports.
- ❏ On the aft face of P/N 734, draw a line connecting the centers of the two 3/16"Ø holes. This will be used for locating the band mounts vertically. The bolts for these fittings are also used to hold the cowling support angles on the forward face of the frame, so you should install these accurately. The intersection of the line connecting the centers of the two 3/16"Ø holes and the centerline of P/N 734 should be located 12 to 13mm from the outside of the fuselage frame. This will put this point at the center of the lamination.

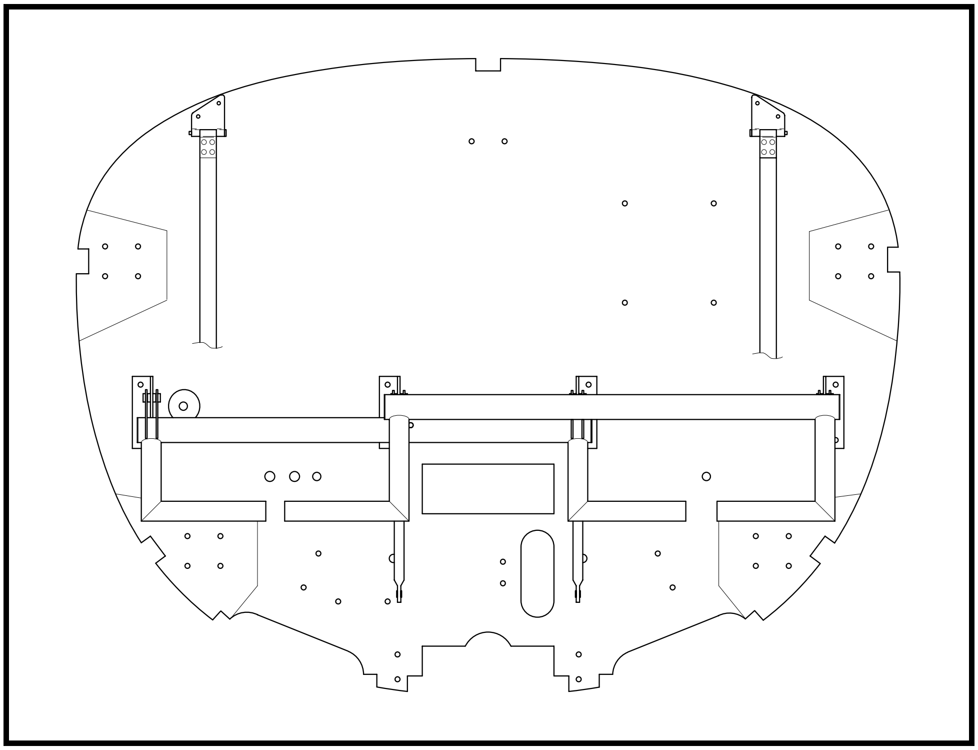


Figure 18

- ❏ Install P/N 733 fuel tank bands on P/N 734 fuel tank band mounts—this is to make sure that the bands will be vertical in the airplane.
- ❏ Clamp these band mounts and bands in place on the aft face of fuselage frame No. 1, and drill the four 3/16”Ø holes.
- ❏ Make a cardboard or paper template of the aft face of frame No. 1 to be used as a pattern for cutting the sound-deadening insulation that will be installed later. If drafting paper is used for the template, you can do a “rubbing” of the holes by rubbing a soft lead pencil over the paper, and you can trace the outline of other things. These details can later be transferred to a cardboard template. As you add more parts to the aft face of the frame, you should update the template.

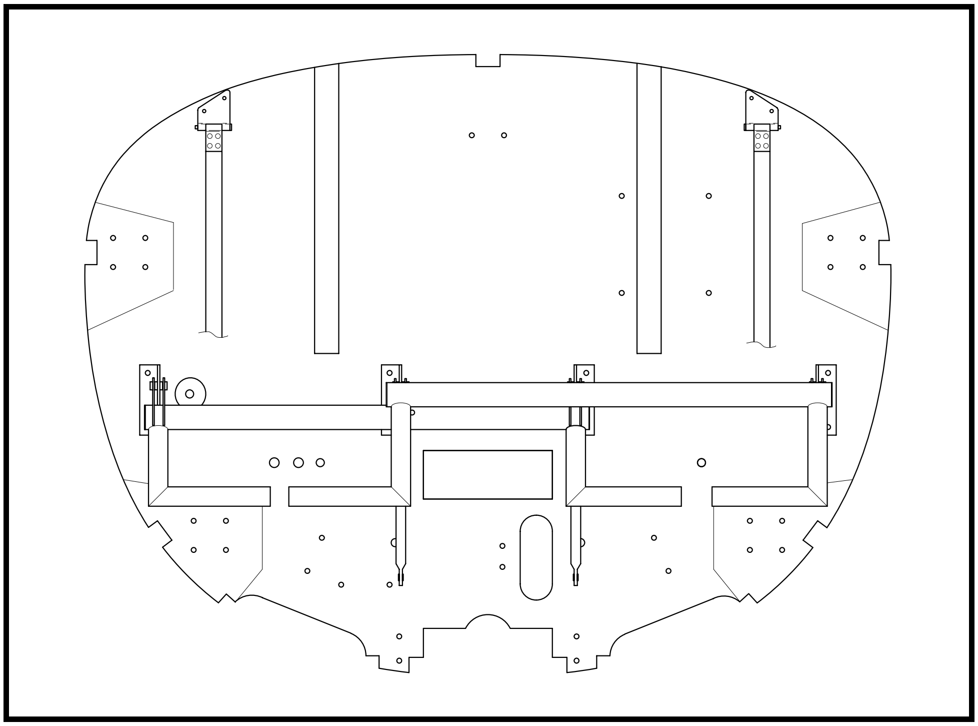


Figure 19

❏ Install the two 30x11 spruce pieces on the aft face of fuselage frame No. 1. See Drawing No. 121.

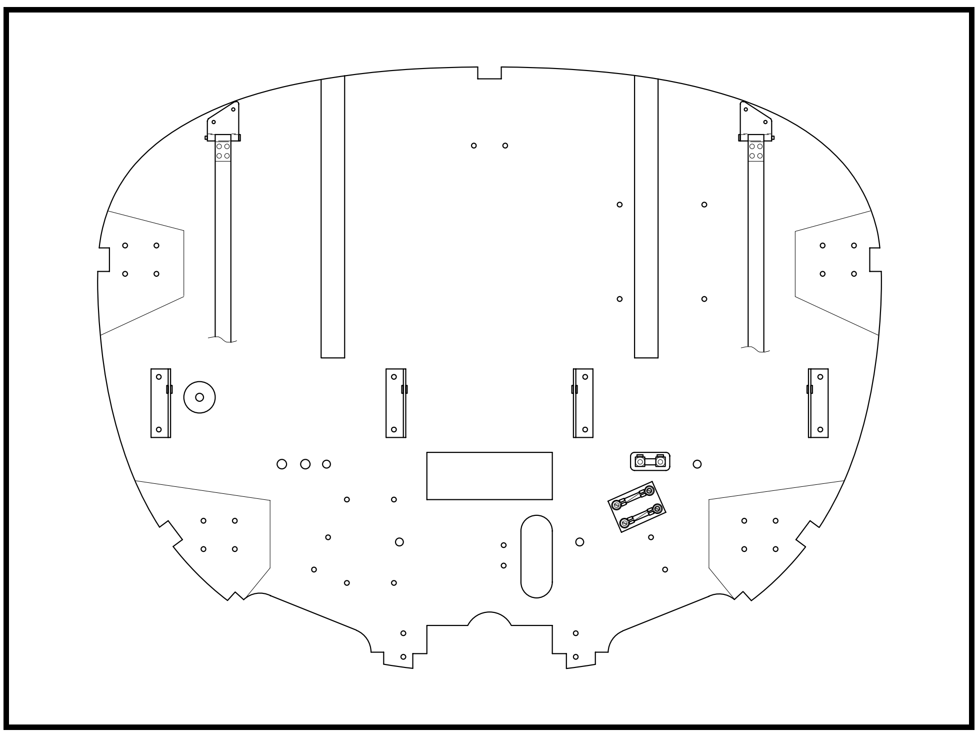


Figure 20

❏ Install P/N 116-62 alternator shunt and the fuse holder for F3 and F4 fuses on the aft face of frame No. 1.

❏ Lay out the location of the nose gear bay framing on the aft face of frame No. 1. The top of the nose gear bay (or the floor level) is at W.L. –420. Update your insulation template.

❏ Lay out the framing for the exhaust port and transfer this to your insulation template. The exhaust port framing consists of 15x15 spruce pieces in a "picture frame" around the exhaust port as shown in Figure 21. The upper members of the box between frame No. 1 and 2 will be installed at an included angle of 102°. Since you will have a similarly matching 78° on the front face of frame No. 2, make the two strips at once by ripping a piece of spruce with the table saw blade set at 12°. Because of the way the box is constructed, this angle does not match the angle on the bottom—where the exhaust port shield will be installed.

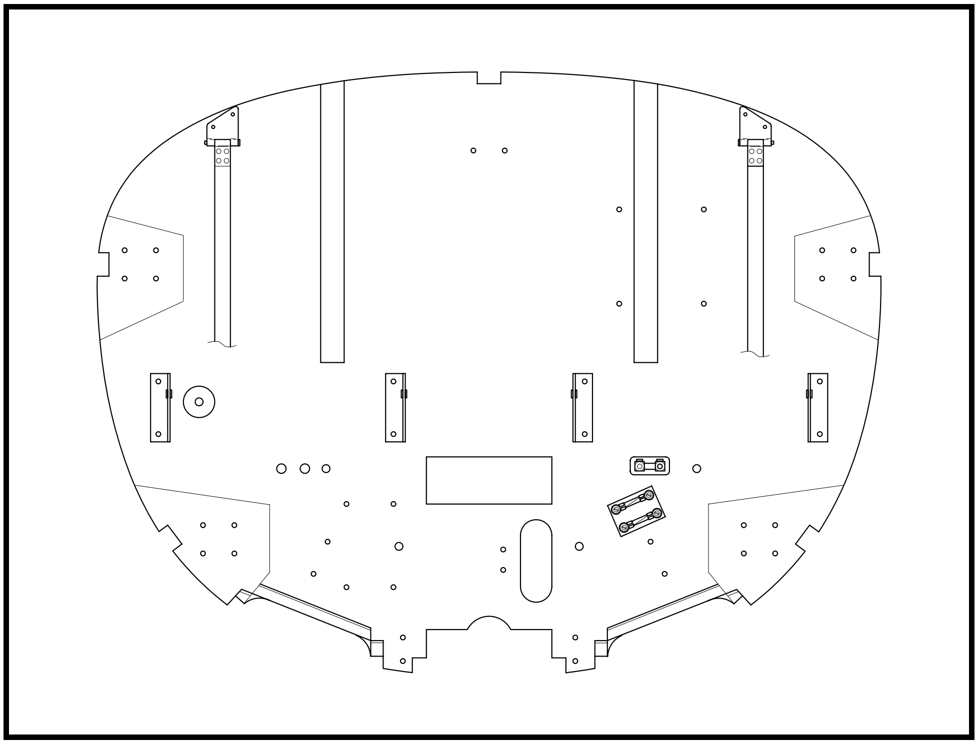


Figure 21

❏ Glue the framing for the exhaust port on the aft face of frame No. 1.

❏ Clamp the firewall in place on the forward face of fuselage frame No. 1.

❏ Use a transfer punch to locate the centers of the holes through the firewall.

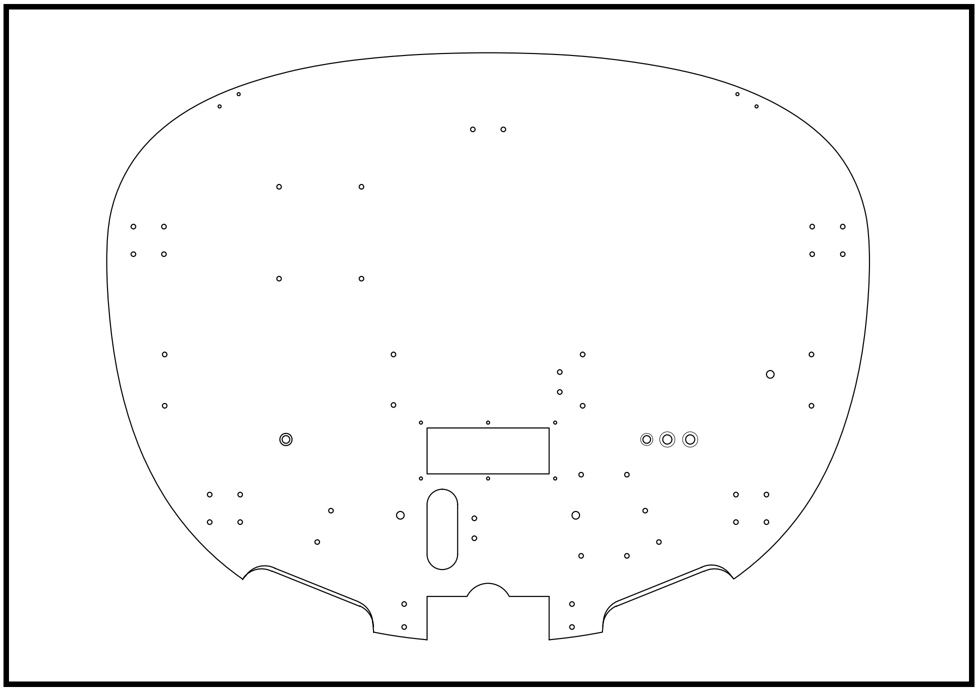


Figure 22

- ❏ Drill the holes in the firewall that you have just marked. The grommet holes must be larger than the matching hole in the frame. The MS35489-14 grommets for the 1/2”Ø wire require a 13/16”Ø hole in the firewall. The MS35489-11 grommets for the 3/8”Ø wire bundle require a 5/8”Ø hole in the firewall. The screw holes for the cabin heat fitting must be located by doing a “rubbing” with paper and a soft lead pencil.

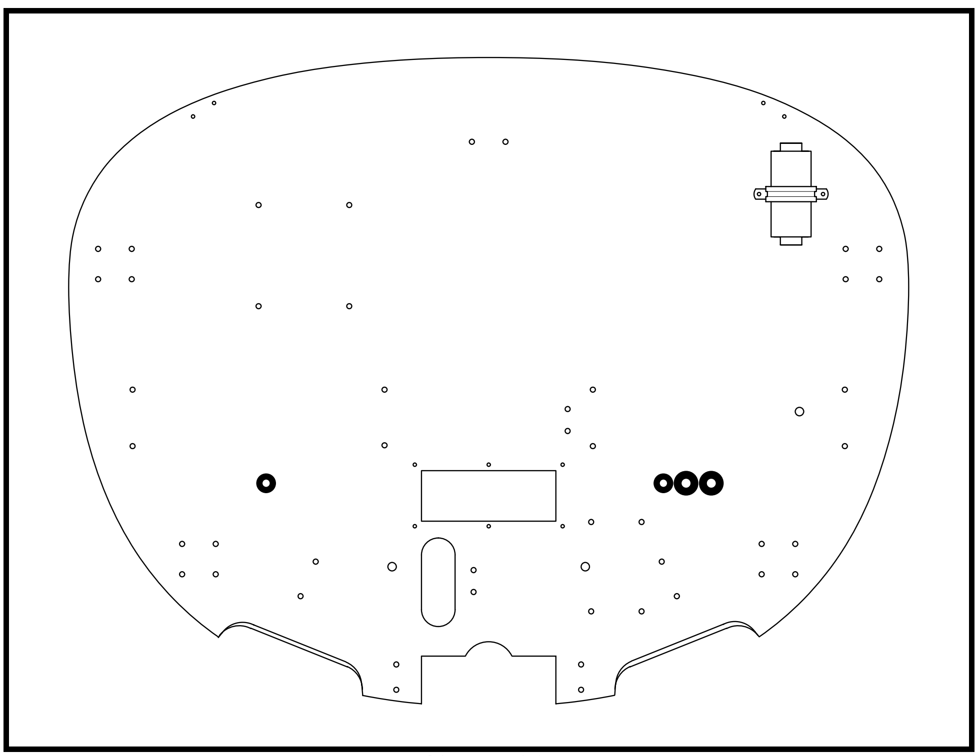


Figure 23

❑ Install the grommets in the firewall.

❑ Drill the two screw holes for the brake reservoir. Vertically, these holes are centered on the underlying spruce member. The brake reservoir is installed at B.L. 360 and is held in place with a clamp that will have two No. 6x1/2" TRA screws located 3.38" between center.

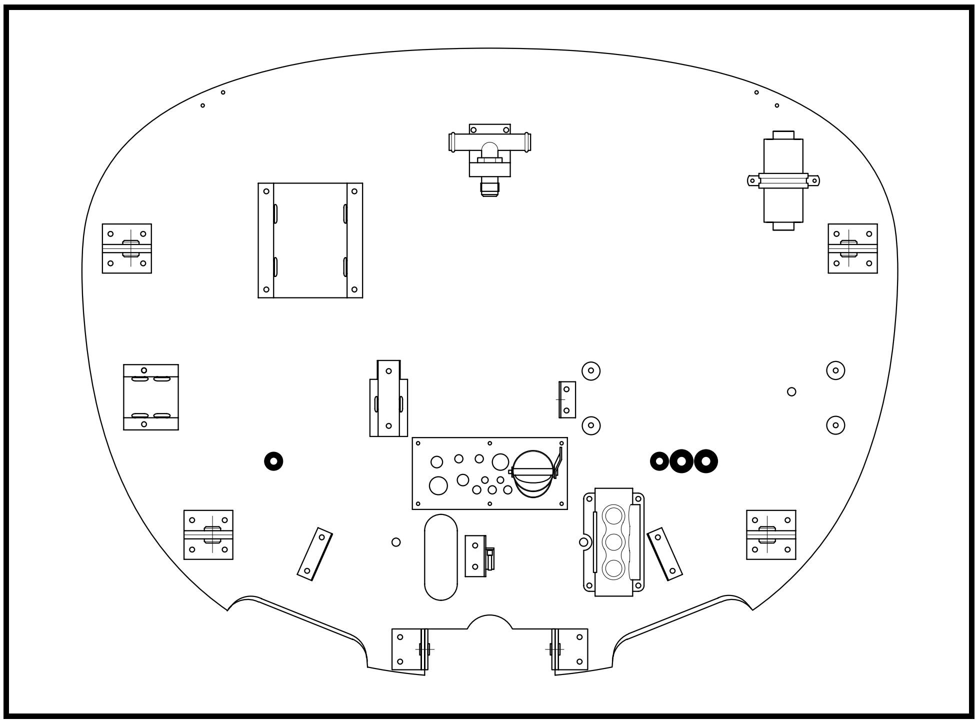


Figure 24

❑ If available, you may install P/N 867 fuel pump mounting bracket and P/N 879 gascolator mounting bracket on the bolts for the rudder pedals as shown in Figure 24. The support bracket for the Christen oil separator is also shown.

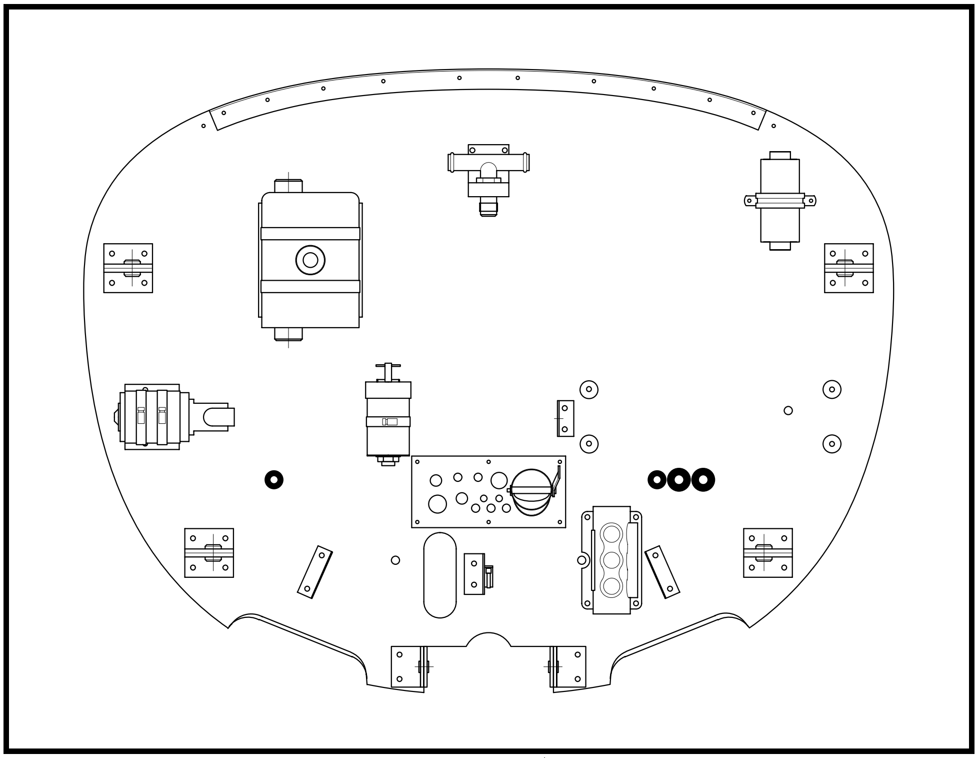


Figure 25

❏ Install the firewall on the front face of fuselage frame No. 1 by installing a number of fittings. In particular, the engine mount lugs must be installed at this point. Figure 25 shows all of the equipment that is installed on the firewall. The electric fuel pump is installed on the right side of the aircraft and the gascolator on the left.

❏ Clamp the top center cowling support, P/N 840-7, in place. The outside surface of the cowling should match the outside surface of the fuselage skin. The fuselage skin is 2.5mm plywood on the sides and 2mm plywood above and below the side longerons. The cowling is about .100" or 2.5mm thick, thus the cowling supports should be installed even with the outside of fuselage frame No. 1 at the forward face; that is, with the undersurface of the fuselage skin. The fabric covering will add a little to the thickness of the fuselage skin, and for final alignment you can build up the fuselage with microballoons or sand a little on the inside of the cowling.

❏ The ends of P/N 840-7 are already marked at their approximate ends for trimming, as well as with the fuselage centerline. The ends of P/N 840-7 should be at B.L. 340, or directly between the two bolts for the fuel tank band mounts. Cut the ends of P/N 840-7 to the correct length.

❏ When you are certain that you have P/N 840-7 in the correct position, install the No. 8x3/4" TRA screws, one at at time. First, drill with a 7/64"Ø drill to a depth of 5/8" from the face of the support angle, then ream the support angle and firewall *only* with a #19 (.166"Ø) drill. You will find this much easier if you have two drills. The screws should be located at B.L. 36, 130, 204 and 273 and about 10mm from the outside of the cowling support flange.

❏ When all of the screws are installed, use a transfer punch to locate the holes for the 3/16”Ø fuel tank band mount bolts, remove P/N 840-7 and drill these two holes. Then install the cowling support on the frame again.

Note: At some point during the installation of the cowling supports, you will probably end up putting some of the cowling pieces in place. This is harmless and probably good for your spirits. Just so that you don't dash to the telephone and call us in despair when you find that things don't fit exactly, we should tell you that the upper and lower cowling are supplied overly long on the aft end for trimming at assembly. The cowling doors are too long as well, and they also have extra material at the bottom sides.

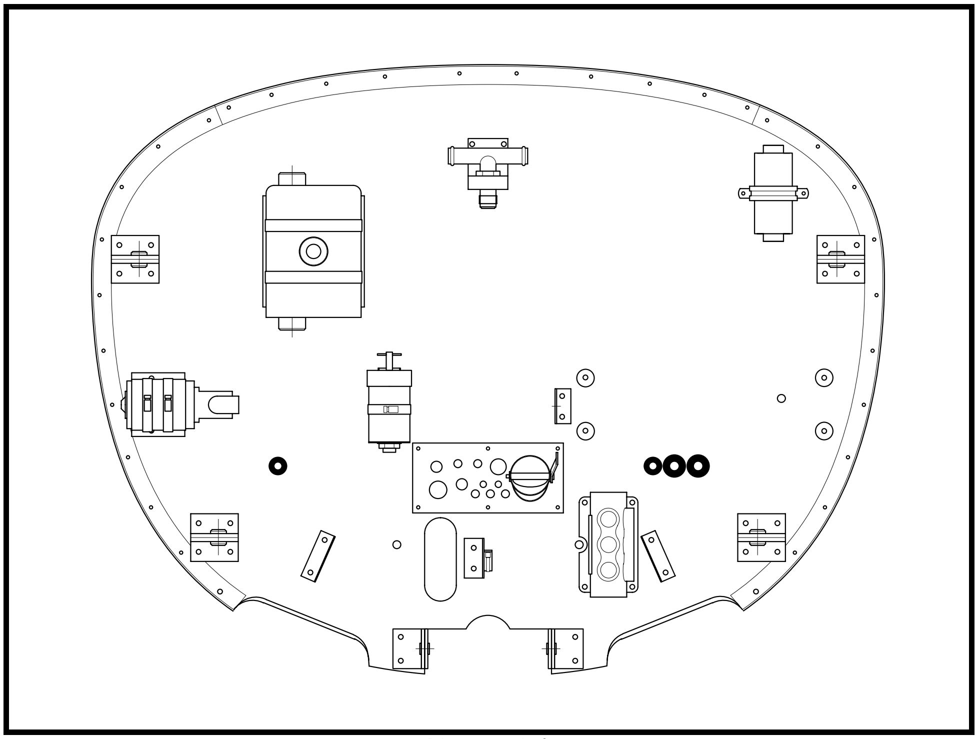


Figure 26

❏ Clamp the side cowling supports, P/N 840-8 and 840-9, in place. The ends of these parts are already marked at their approximate ends for trimming. Cut the ends to the correct length, and notch them to fit around the engine mount lugs. If the supports do not match the exact curvature of the fuselage frame, the supports may be notched with a series of saw-cuts in the side which is screwed to the frame. Locate these saw-cuts between the screws that will be installed.

❏ When you are certain that you have the side cowling supports in the correct position, install the No. 8x3/4” TRA screws, one at at time. First, drill with a 7/64”Ø drill to a depth of 5/8” from the face of the support angle, then ream the support angle and firewall *only* with a #19 (.166”Ø) drill. The screws should be located at W.L. 157, 106, 40, –30, –100, –168 –234, –297, and –354 and about 10mm from the outside of the cowling support flange.

❏ When all of the screws are installed, use a transfer punch to locate the holes for the 3/16”Ø fuel tank band mount bolts. Use a transfer punch to locate the holes for the cowling support bolts just outboard of the exhaust port shield.

❏ Remove P/N 840-8 and P/N 840-9 and drill these holes.

❏ Drill a 3/16”Ø hole for a bolt through the cowling support, firewall and fuselage frame at B.L. 338. This will place the bottom cowling support bolt just outboard of the exhaust port shield.

All of the cowling supports may be removed, along with the firewall and fittings. The two bottom cowling supports, P/N 840-10 and 840-11, are not installed at this time.

Fuselage Frame No. 2

❏ If you have not already done so, draw the internal structure on the inside face of the closing plywood for varnishing. See Drawing No. 303.

❏ Cut the inside face of the frame to a width of 164mm to allow for the 2mm plywood used for the nose gear bay wall.

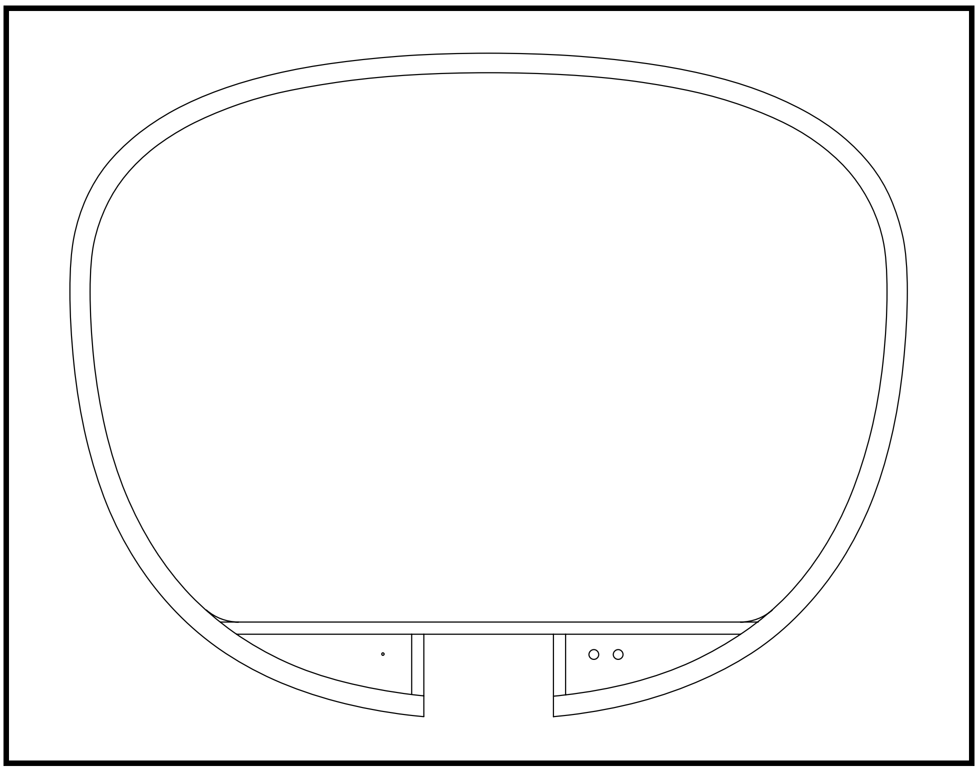


Figure 27

❏ Locate the battery cable holes on the left side of the aircraft. Drill these holes through the plywood for both front and aft faces. If the lower floor is to be installed (see Drawing No. 315), these holes should be at W.L. –490 to put them under the floor but above the lamination. This can be seen in Figure 30.

❏ Drill a small vent hole through the aft plywood face on the right side of the aircraft.

❏ Mask and varnish the inside of the plywood to be used to close the frame. Varnish the inside of the frame except for those areas to be glued.

❏ Glue the plywood on to close the frame.

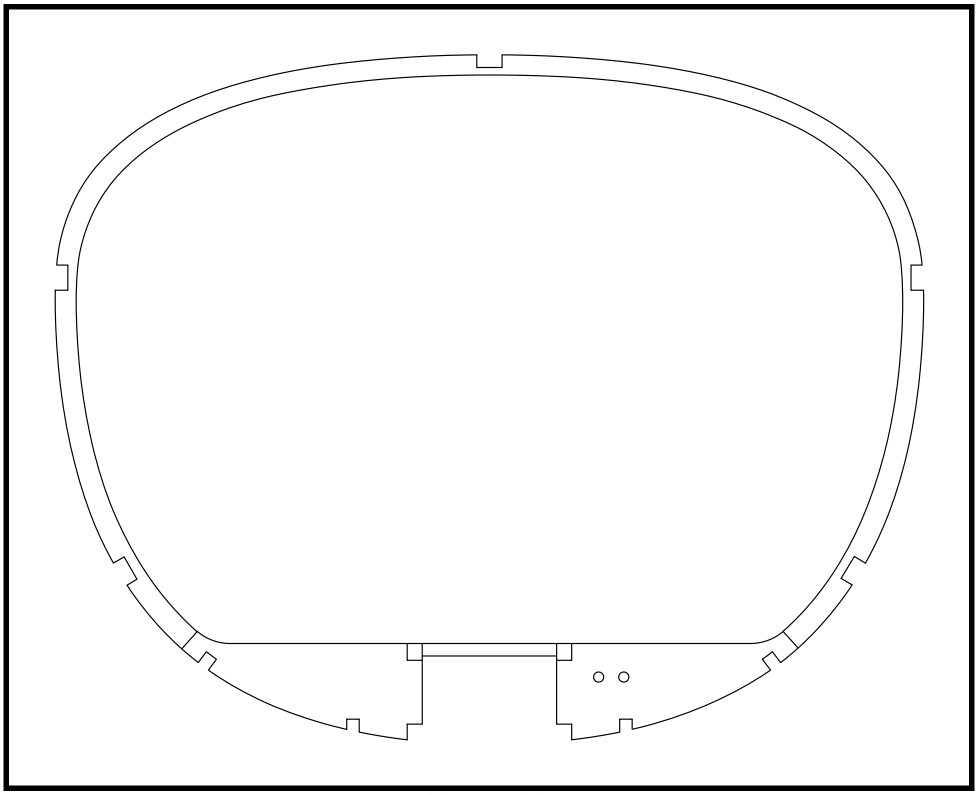


Figure 28

❏ Cut the five longeron cutouts. Use the master template to locate these cutouts. Because of the shape of the fuselage, the two lower side longerons intersect the frame at an angle. As a result, a cutout for the longeron that is perpendicular to the face of the frame will not work very well and will require shimming to fit the longeron. Therefore, these lower side longeron cutouts should be undersized for final fit at the installation of the longeron.

❏ Cut the four 15x15 cutouts for the exhaust port framing.

❏ Cut the two bottom 20x18 cutouts for the nose gear bay framing. It is best to leave the floor support uncut until the frame is intalled in the fuselage, thus the upper 20x18 cutouts for the nose gear bay framing should be marked only. If you wish to start the sawcut, you may do so.

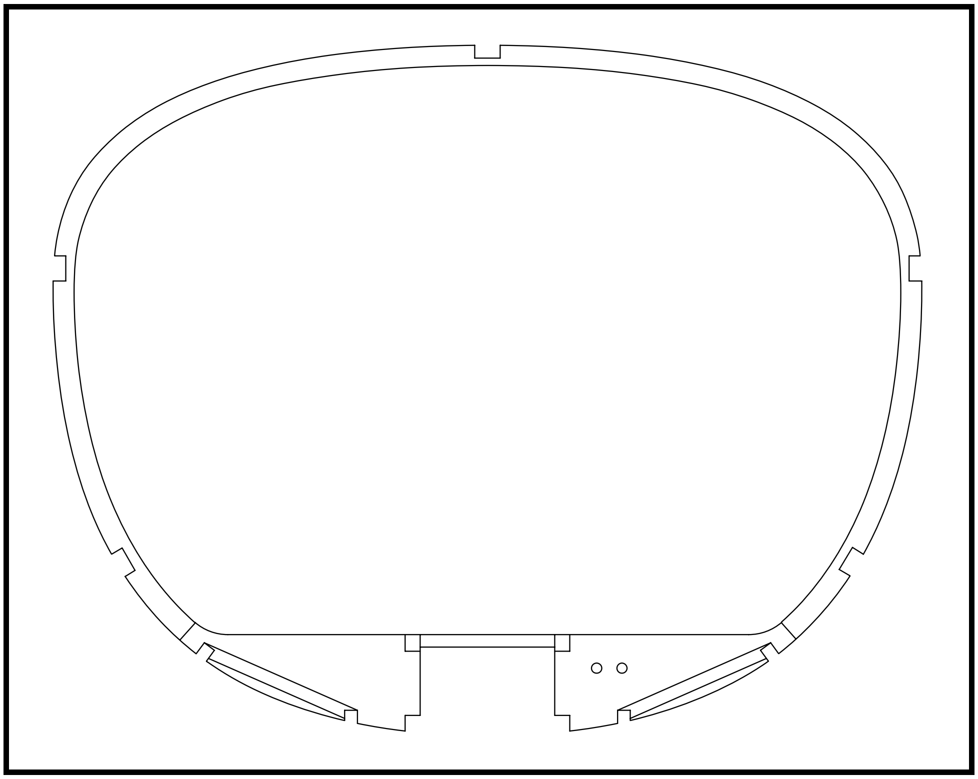


Figure 29

- ❏ On the forward face, glue on a 15x15 spruce member for the exhaust port framing. The top of these strips should match the angle of the strips installed on the aft face of frame No. 1, thus the angle between the front face of the frame and the top of the strip is 78°. The exhaust port will be skinned with a piece of 2mm birch plywood on the top of these strips.

- ❏ On the right side of the aircraft, drill a 1/8"Ø hole just to the right of the top center longeron cutout. This hole will be used for a few small wires.

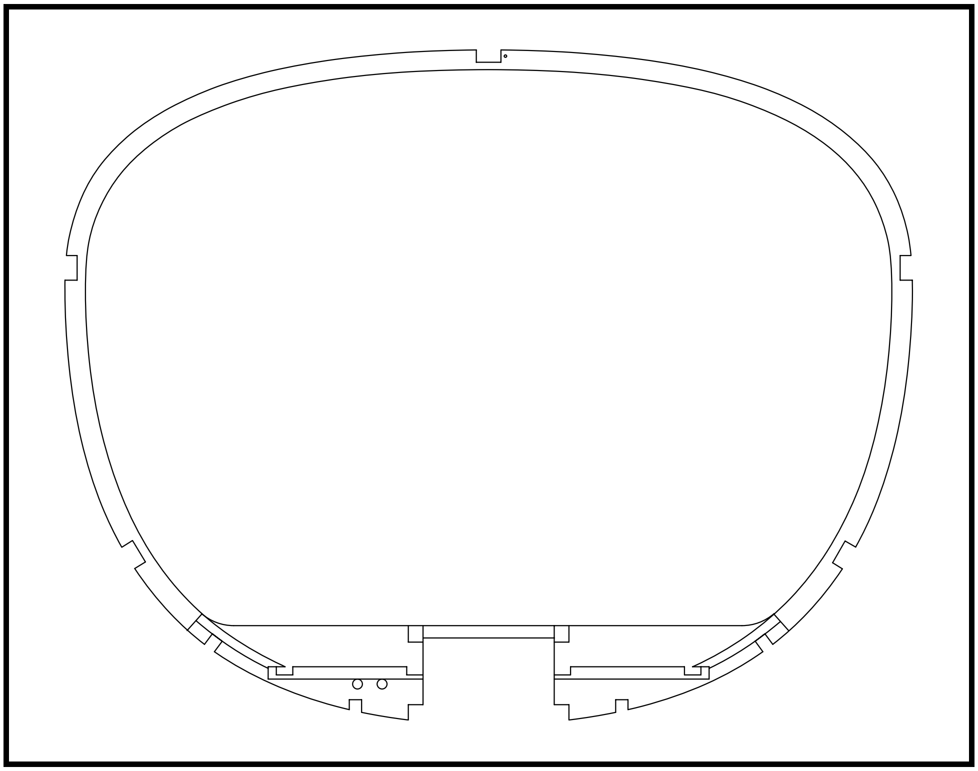


Figure 30

❑ If the lower floor is to be installed (see Drawing No. 315), install the flooring supports on the aft face of the frame. These supports may be 10x10 spruce as shown above, or you may use 10x15 spruce for greater strength under the cutouts.

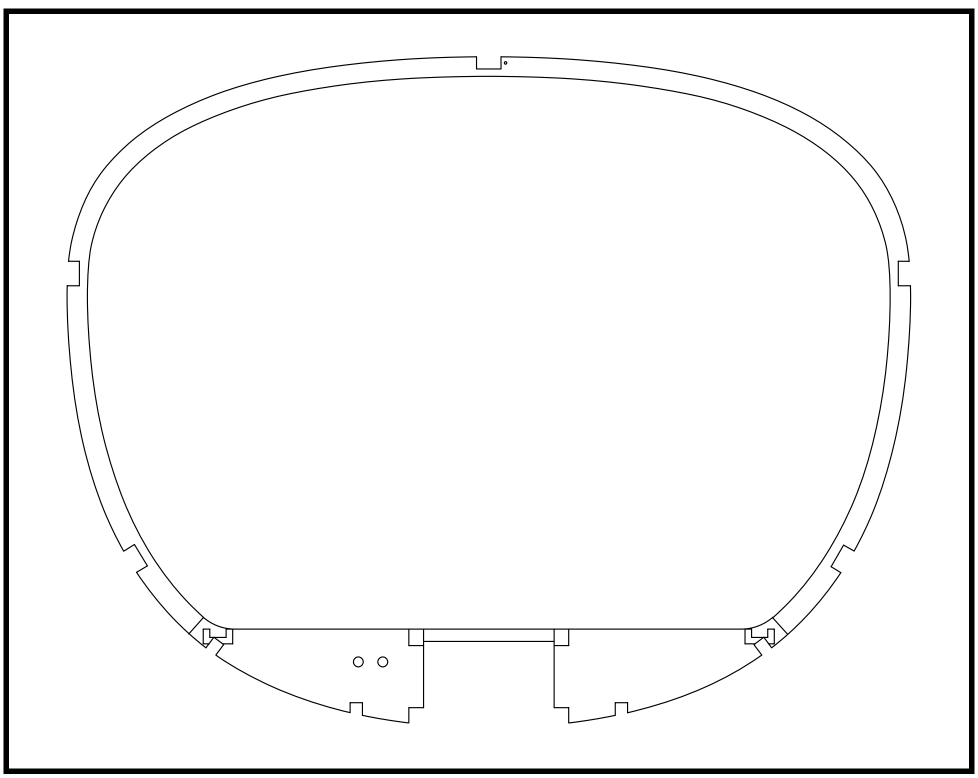


Figure 31

❏ Install saddle gussets on the aft face of the frame to support the 20x10 flooring supports that are installed between fuselage frame No. 2 and 3. See Drawing No. 315. Because of the location of the outboard exhaust port framing strips, these saddle gussets are partially cut open at the bottom. If the lower floor is installed (see Figure 30), then these gussets are not needed.

Fuselage Frame No. 7

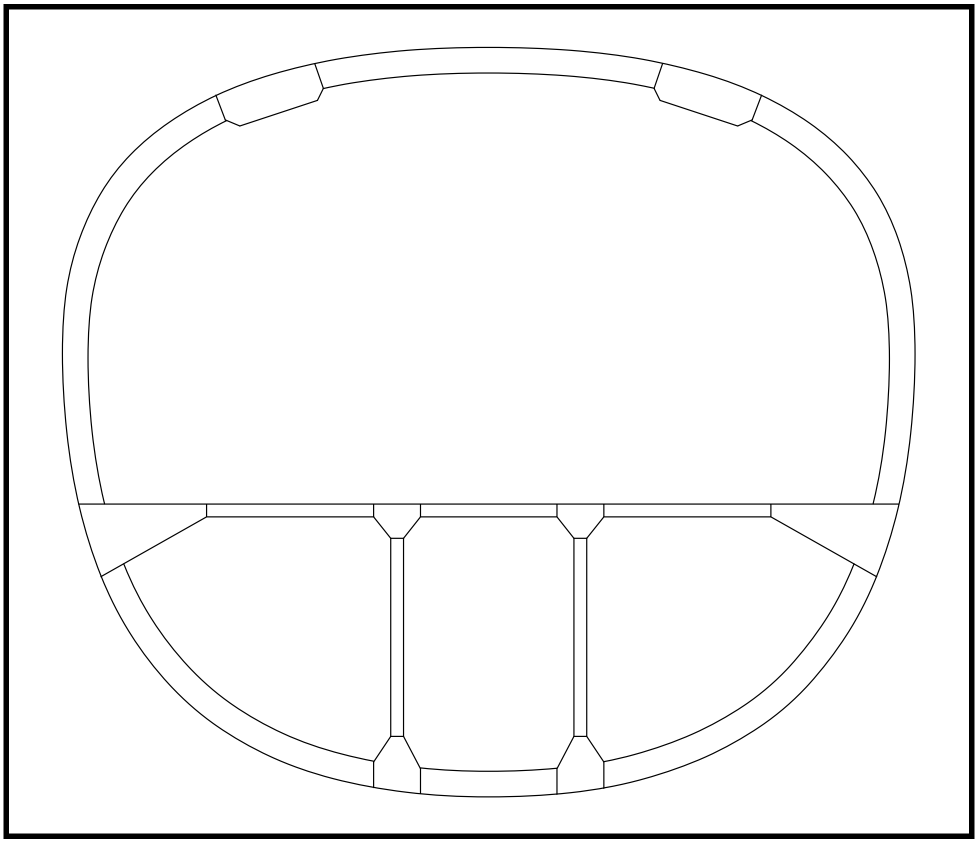


Figure 32

❏ If not already done, install the tank support blocks and glue on all plywood gussets to "close" the frame.

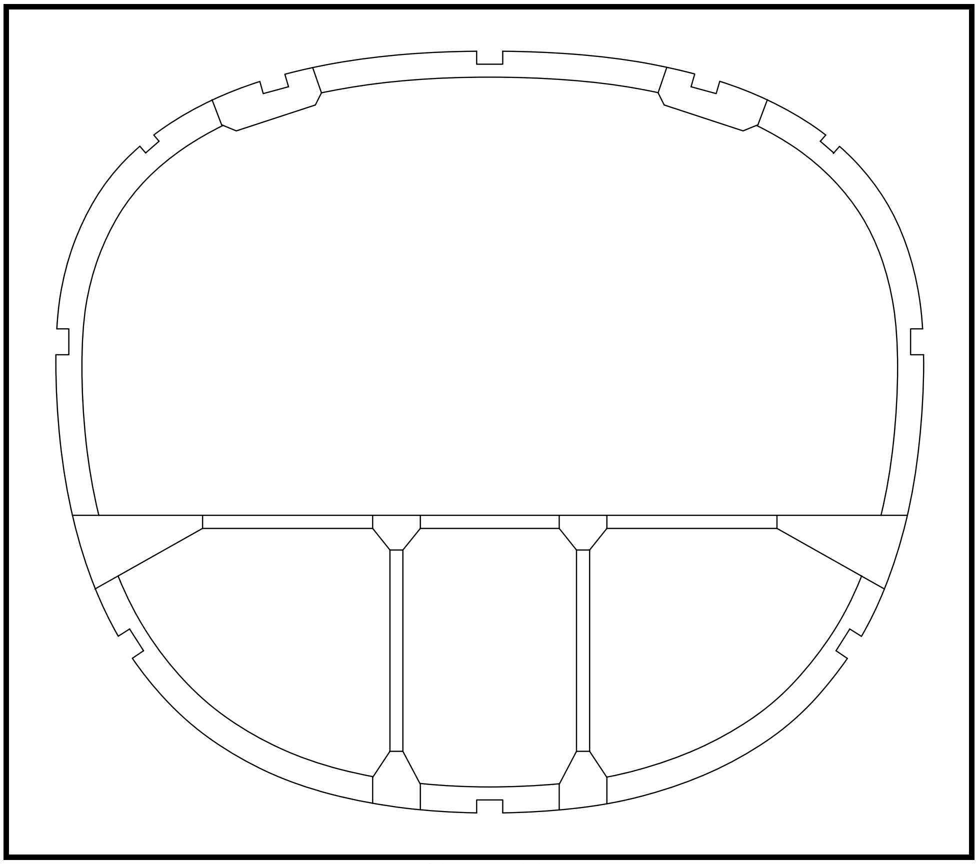


Figure 33

- ❏ Cut the six 30x15 longeron cutouts. See Drawing No. 312. Use master template to locate the longeron cutouts. Because of the shape of the fuselage, the two lower side longerons intersect the frame at an angle. As a result, a cutout for the longeron that is perpendicular to the face of the frame will not work very well and will require substantial shimming to fit the longeron. Therefore, these lower side longeron cutouts should be undersized for final fit at the installation of the longeron.

- ❏ Cut the two 20x10 stringer cutouts. See Drawing No. 312. Use master template.

- ❏ Cut the two 30x15 cutouts for the shoulder belt support. See Drawing No. 312 and 123.

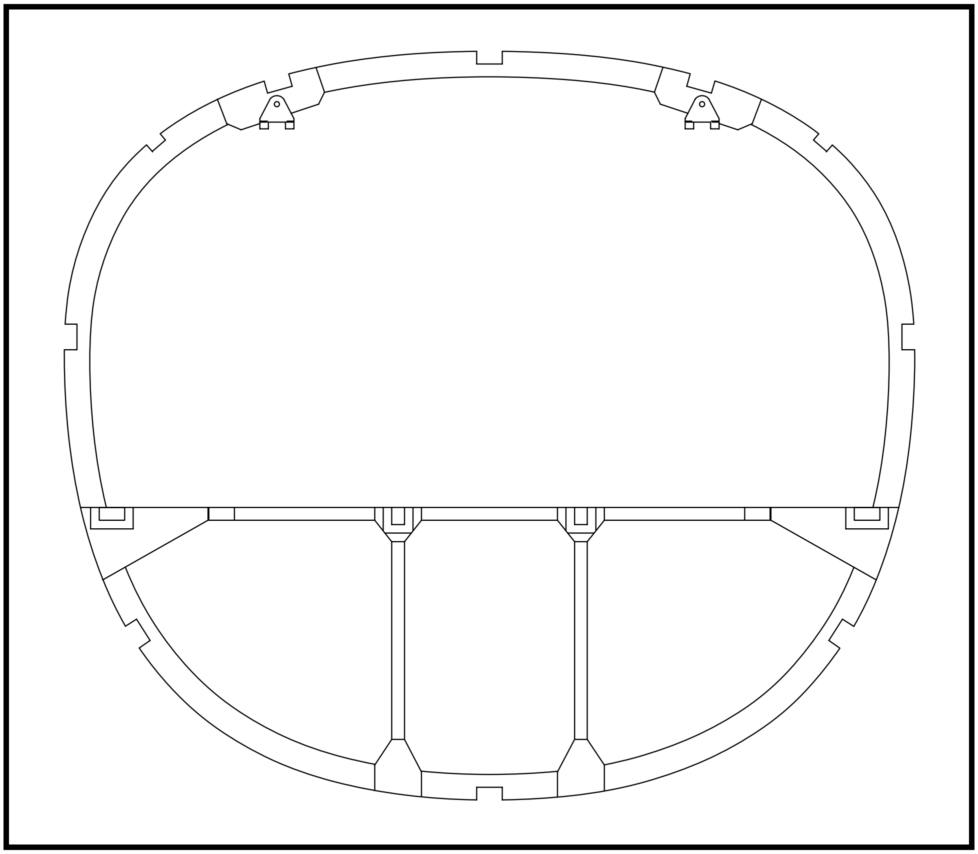


Figure 34

- ❏ Install P/N 735 fuel tank band mounts. See Figure 34, which shows the fittings on the forward face, but they are actually installed on the aft face. The fuel tank band mount installation is shown on Drawing No. 121, however drill the holes at the location shown in Drawing No. 312—to avoid interference problems between the shoulder belt supports and the fuel tank mount.

- ❏ Install saddle gussets for the two 20x15 luggage compartment floor supports located at B.L. 100. See Drawing No. 315.

- ❏ Draw the location of the two 30x15 luggage compartment floor supports located at B.L. 315. See Drawing No. 315. Saddle gussets are not possible at this location.

- ❏ Install the saddle gussets for the 30x15 luggage compartment floor supports located at the junction of the luggage compartment floor and the inside fuselage skin.

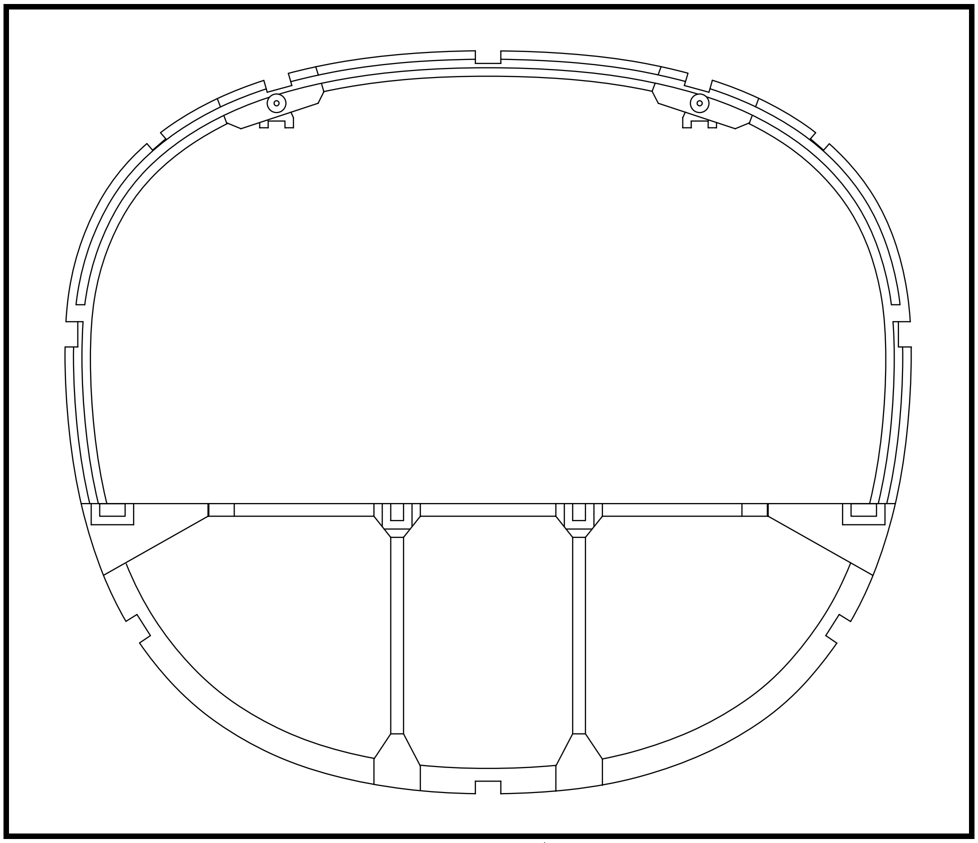


Figure 35

❑ Install the 10x10 rectangular or triangular side wall supports on the forward face of fuselage frame No. 7. See Drawing No. 315. The inside face of these strips of spruce should be located 10mm out from the inside edge of the lamination of the fuselage frame. These strips should be run all the way around the upper forward face of the frame, above the luggage compartment floor. Above the upper side longerons there should be a 20mm gap in this strip. The reason for this is that the coaming will extend all the way back to the forward face of frame No. 7.

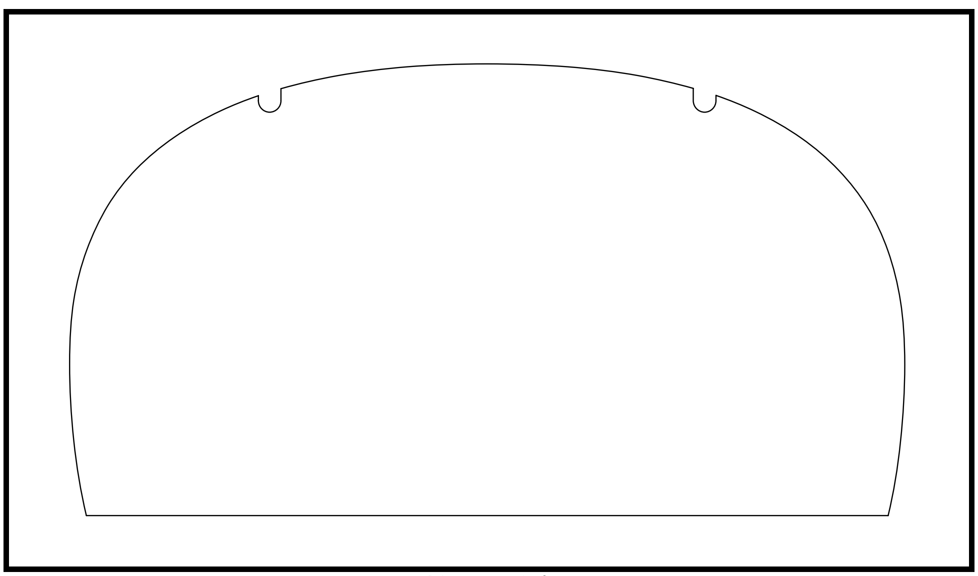


Figure 36

❏ Cut out a piece of 2mm birch plywood for the rear cockpit bulkhead. See Drawing No. 315. The rear bulkhead should fit inside the 10x10 rectangular or triangular strips just installed. Because of the installation of the 1mm inside fuselage skin, this bulkhead will have to be trimmed to allow clearance for the inside skin.

❏ If inverted tank is to be installed, install the required framing on the forward face of frame No. 7. See Drawing No. 121. The inverted header tank is 7" in diameter.

Fuselage Frame No. 8

❏ If not already done, draw W.L. 0 and the aircraft centerline on the two fuselage frames No. 8. Be particularly careful to draw the aircraft centerline on the the horizontal brace, since this will be needed in the construction of the battery box (see Drawing No. 320).

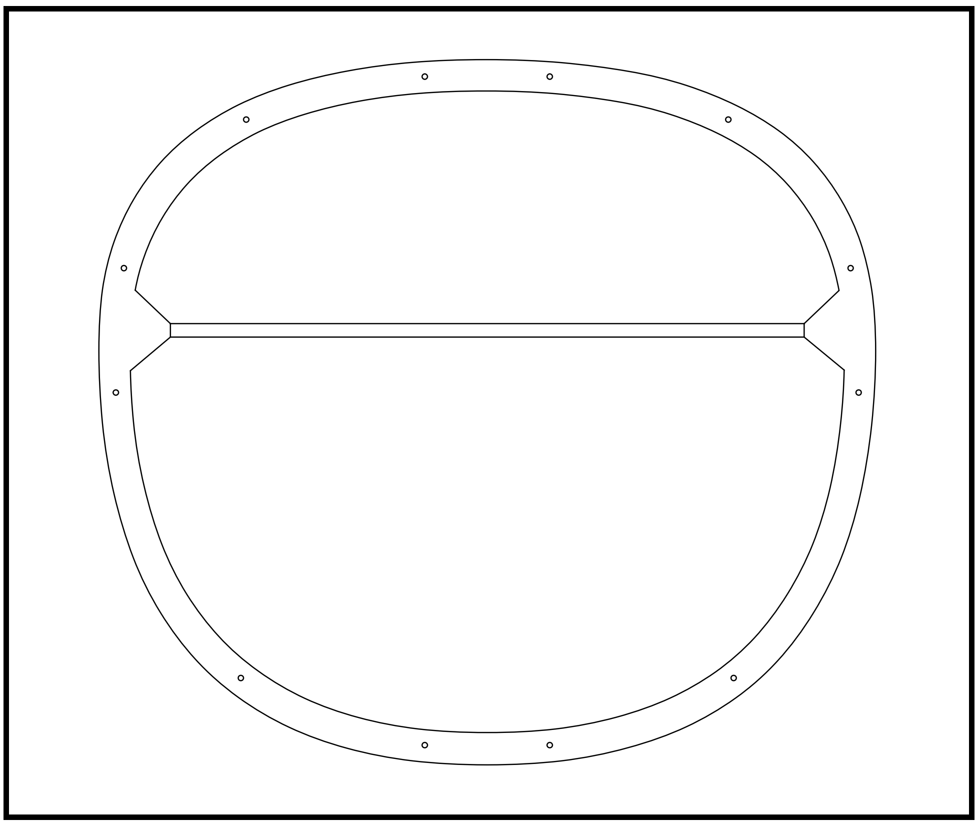


Figure 37

❏ Clamp the two frames No. 8 together and drill the twelve 1/4"Ø holes for the bolts. Install the bolts to clamp the frames together. Locate the "ten o'clock" and "two o'clock" holes at B.L. 270—this will solve some interference problems. Locate the "four o'clock" and "eight o'clock" holes at B.L. 276. All of the holes should be centered on the lamination.

❏ If not already done, add a single 3mm strip of spruce to the forward frame to allow for sanding to the taper of the fuselage.

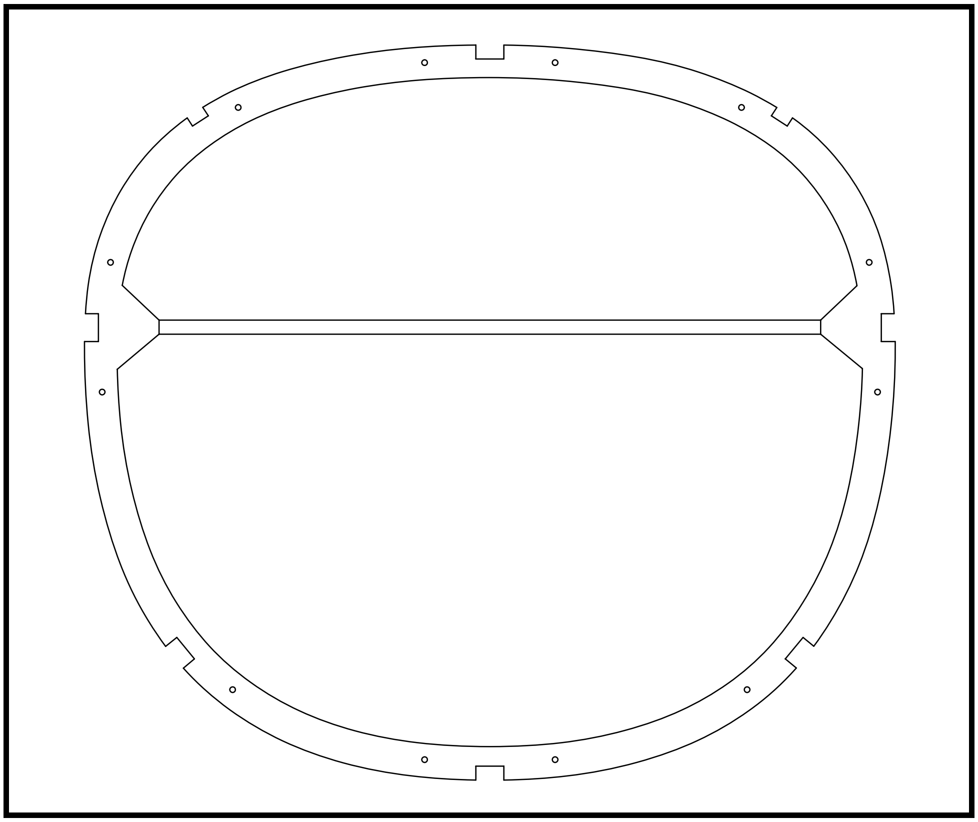


Figure 38

❏ Cut the six 30x15 longeron cutouts. Use a master template. For the bottom side 30x15 longeron cutouts, cut only the bottom two-thirds of the cutouts. Due to the taper of the fuselage, these longerons "cross" the frame, and the cutouts can only be finished with a sanding stick on the airplane. See Drawing No. 313.

❏ Cut the two 20x10 stringer cutouts, however cut only the inboard two-thirds of the cutouts. Due to the taper of the fuselage, these stringers "cross" the frame, and the cutouts can only be finished with a sanding stick on the airplane. Use a master template.

❏ To prepare for the installation of these two frames in the fuselage jig, install two AN970-4 washers between the frames. See Drawing No. 321. These washers are temporary spacers that will be used during the fuselage assembly. If you wish, you may use ordinary hardware-store washers under the bolt head and nut during this temporary assembly. The purpose of using the washers as spacers is to provide room for sawing the tail section from the fuselage center-section. When the aircraft is assembled, the AN970-4 washers are installed under the bolt head and nut. We say again—these washers are installed between the frames as *temporary spacers only*.

Battery Box Lamination

❏ In preparation for the construction of the battery box, make a 20x15 lamination. See Drawing No. 306 and 320. Lay out the curve per Drawing No. 301 or see the chapter on making fuselage frames for the formula method of laying out the fuselage curve. The lamination should be made to extend from W.L. 0 to W.L. 240. Per Drawing No. 301, the curve dimensions are: "**L**" = 415 and "**S**" = 309.

Fuselage Frame No. 9

- ❏ If not already done, draw the aircraft centerline and W.L. 0 on the fuselage frame. In particular, draw the aircraft centerline on the horizontal brace. This will be used in the construction of the battery box.

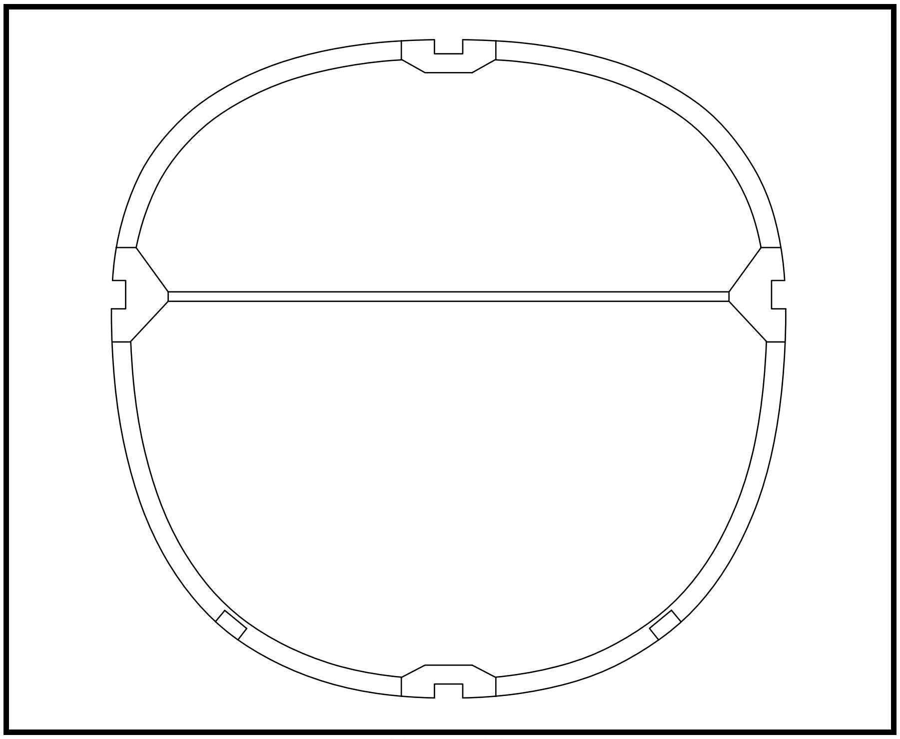


Figure 39

- ❏ Cut the four 30x15 longeron cutouts. See Drawing No. 313. Use the master template.

- ❏ Draw the installed location of the two 30x15 lower side longerons on the forward face of the frame. These are located at W.L. –350, like the other fuselage frames, but the frames are not cut out for the longerons.

Fuselage Frame No. 10

❏ If not already done, draw the aircraft centerline and W.L. 0 on the fuselage frame.

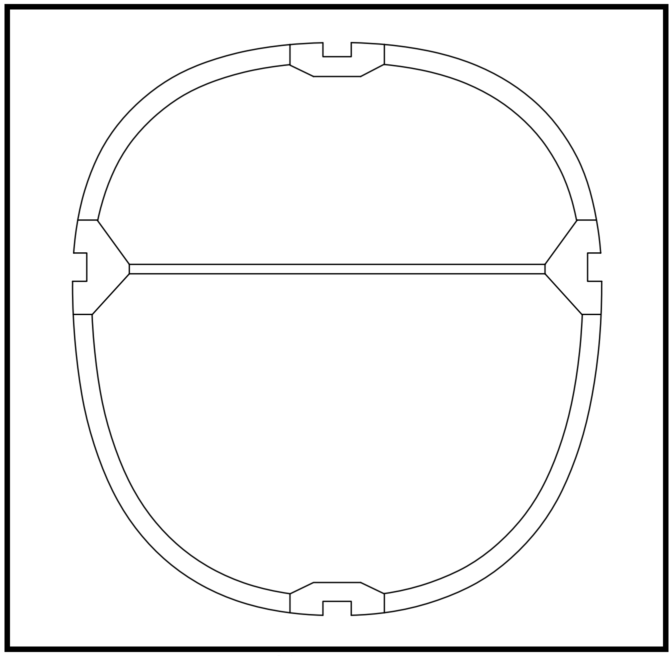


Figure 40

❏ Cut the four 30x15 longeron cutouts. See Drawing No. 313. Use the master template.

Fuselage Frame No. 11

❏ If not already done, draw the aircraft centerline and W.L. 0 on the fuselage frame.

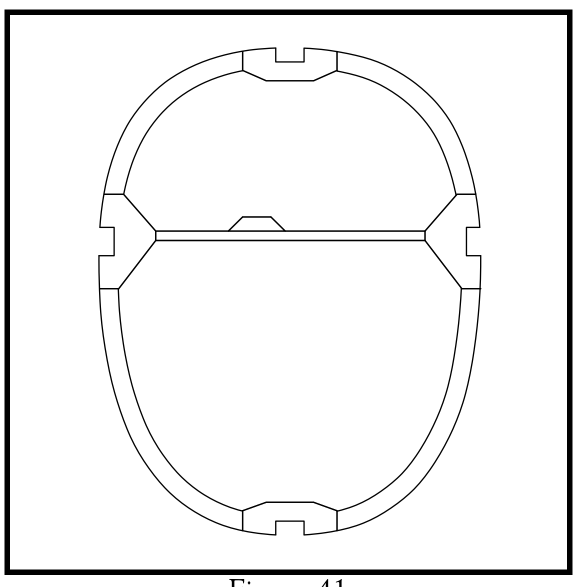


Figure 41

❏ Cut the four 30x15 longeron cutouts. See Drawing No. 313.

❏ Install a spruce block on the horizontal brace as shown in Figure 41. This brace is 15mm high, 30mm wide at the top and its center is at B.L. 35 on the right side of the airplane.

This brace will be used to screw a clamp for the elevator trim tab cable (which will be located at B.L. 30).

Fuselage Jig

- ❏ Make the fuselage jig. See Drawing No. 321. The jig will require some modifications from the drawing—it should have solid wood internally aft of Sta. 12, and the 50mm notch should be changed so that the top of the jig aft of Sta. 12 is 50mm below the top of the jig, since it is not possible to insert the forward fin spar into the notch. In order to be able to fit the forward fin spar over the jig, it must be sanded to the radiused inside shape of the spar. Notch the aft end of the jig for the channel-nut and bolt heads for the lower fin hinges.

Chapter 26
Fuselage Assembly, Part 1

General Comments

This chapter and all others that follow it are not really finished to the extent that we would like, but we are releasing these chapters now so that you can benefit from the construction order outlined here. The only thing really missing here is a list of spruce and plywood needed.

The fuselage is assembled on the jig shown in Drawing No. 321. This is used to hold the fuselage frames in place while the longerons are fitted and glued in place. The fuselage will be built around the jig, and the jig must be sawed apart to get it out of the airplane. When you first install the frames on the jig, it is a very flimsy affair. When the longerons and stringers are clamped in place, it becomes much stiffer. As the various parts are glued in place, the structure become stronger and stronger.

This fuselage jig was originally designed by a Falco builder who built the fuselage separately from the wing. The "one by two" cross members are adequate to hold the individual fuselage frames in place, but you will need additional supports for the tail surfaces, the wing (with its frames), and frame No. 1.

You should glue the vertical fin to the horizontal stabilizer before installing the tail group in the airplane. This assembly will require some additional supports. An additional "one by two" may be screwed to the bottom of the jig on the aft face of the forward fin spar. You should work out these supports and try them before assembling the entire fuselage jig.

Many early Falco builders had a problem with their nose gear not fitting in the nose gear bay and a considerable amount of re-work was necessary. This problem can be avoided by installing fuselage frame No. 1 with the engine mount and nose gear in place. This allows you to position fuselage frame No. 1 so that the nose gear is in the proper position. Because of the extra weight of this equipment, the jig will require additional supports for this frame. You should work out these supports and try them out before assembling the entire fuselage jig.

There are a number of ways to support the wing assembly with its fuselage frames. In the method described in this chapter we use a padded cradle under each wing, but you should feel free to develop your own method. Many builders support the wing assembly by using three jacks. Two of the jacks are at the wing jack pads and a third jack is installed under fuselage frame No. 6. Since the jacks are mechanical screw-type jacks, they are easily adjustable. Since you will need jacks eventually for the airplane, this is a good time to make or buy some jacks. (One Falco builder made his own of Sears floor supports welded to a heavy plate of steel at the base.)

Because the alignment of all of this will involve a series of small adjustments, the supports for the wing assembly should have jack bolts installed for precise, fine adjustments. There are a number of arrangements that work well. One is to install bolts in the "feet" of the wing or fuselage supports as shown in Figure 6. The bolt head would contact the floor and a nut would be installed to hold the support. The height of the support would be adjusted by turning the bolt while the nut is held with a wrench. If you wish, you may glue the nut to the support with epoxy. There are many variations possible on this idea.

You should also consider some way of firmly securing the jig to the shop floor. When you work on the assembly of the fuselage, it is likely that you will bump against the structure and throw something out of alignment. One way to prevent this is to substitute a threaded rod for the jack bolt as shown in Figure 6, and screw the wood block to the shop floor.

Unlike many other parts of the Falco, the exact sequence that the fuselage parts are installed is not critical and if you want to glue one longeron in place earlier than we specify, the chances are that you will not ‘paint yourself into a corner’, although it’s always best to read ahead and review the steps that still lay ahead. If you have glanced at this chapter and noticed that the bottom side longerons were not installed, you deserve a cookie. This omission is very deliberate since those longerons require a fair amount of persuasion, twisting and clamping to force them into position at the aft end. The intent is to build as much rigidity into the fuselage as possible before putting the lower side longerons in place.

Fuselage Assembly

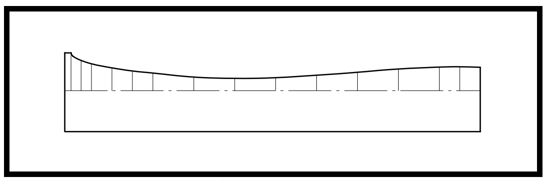


Figure 1

- ❏ Make four supports as shown in Figure 1 from two-by-ten lumber to match the underside of the wing at Station 6. See Drawing No. 212 for the rib contours. Although this support is shown extending all the way to the trailing edge, you may want to cut it off at the aft wing spar so that weight will not be placed on the flaps and so that the flaps will be free to move.

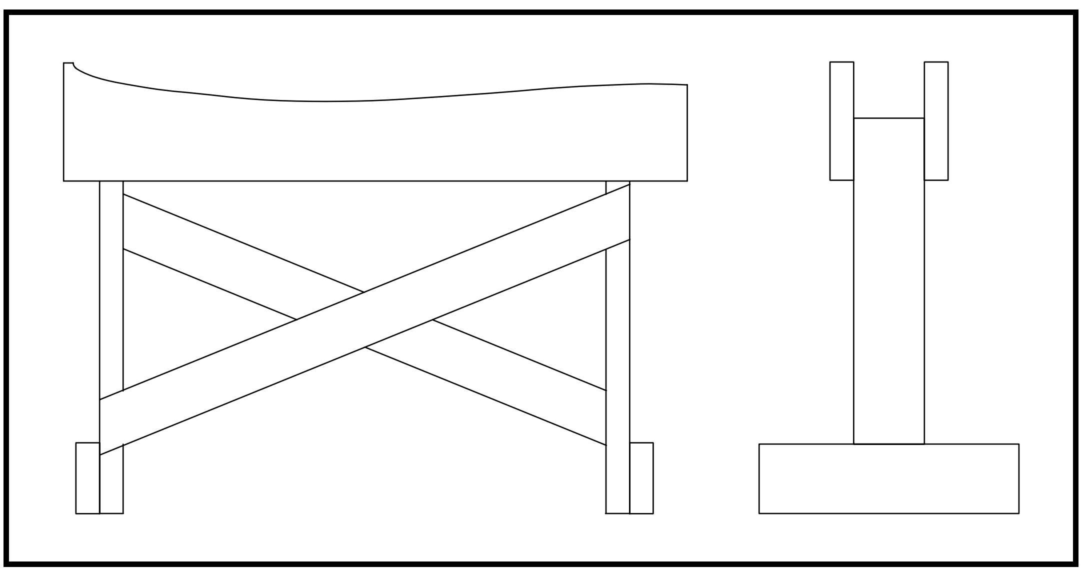


Figure 2

- ❏ Assemble the four supports with additional lumber to make the wing supports as shown in Figure 2. The fuselage W.L. 0 should be about 1280mm above the floor level to provide room to swing the nose gear up, although the exact height is not critical since the nose gear can be compressed. The inboard support must be slightly lower than the outboard support. Install additional diagonal supports as shown in Figure 3. Cover the top of the supports with something soft—carpeting, old blankets—to protect the bottom of the wing.

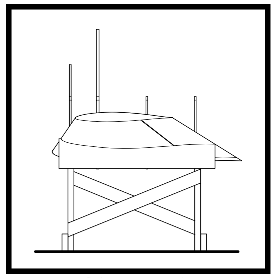


Figure 3

❏ Place the wing in the two supports as shown in Figure 3. Level the wing assembly. The supports may be moved in and out to raise or lower the wing.

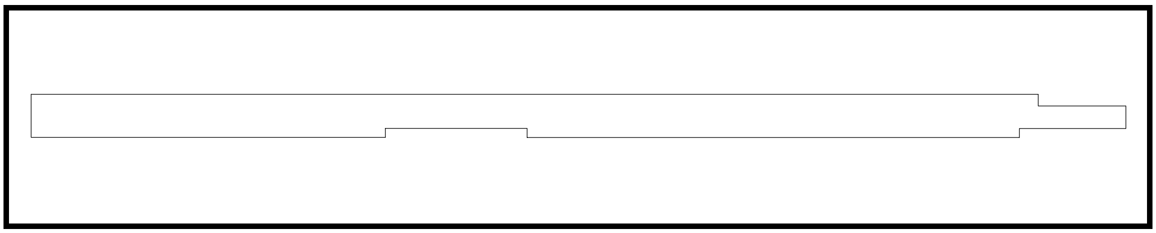


Figure 4

❏ Make the fuselage jig as shown in Drawing No. 321. See Figure 4. The aft end of the jig should be solid wood since the 50mm deep notch will not work. The aft top of the jig must be 50mm lower than the top of the rest of the jig.

❏ Draw the aircraft centerline down the top of the fuselage jig.

❏ Draw the fuselage stations on the top of the fuselage jig. Measure from a common point (Sta. 1 to Sta. 2, then Sta. 1 to Sta. 3, etc) to avoid tolerance buildup. Note that there is an extra 3mm to account for the spacer between the two frames No. 8.

❏ Trial fit the one-by-two fuselage frame supports.

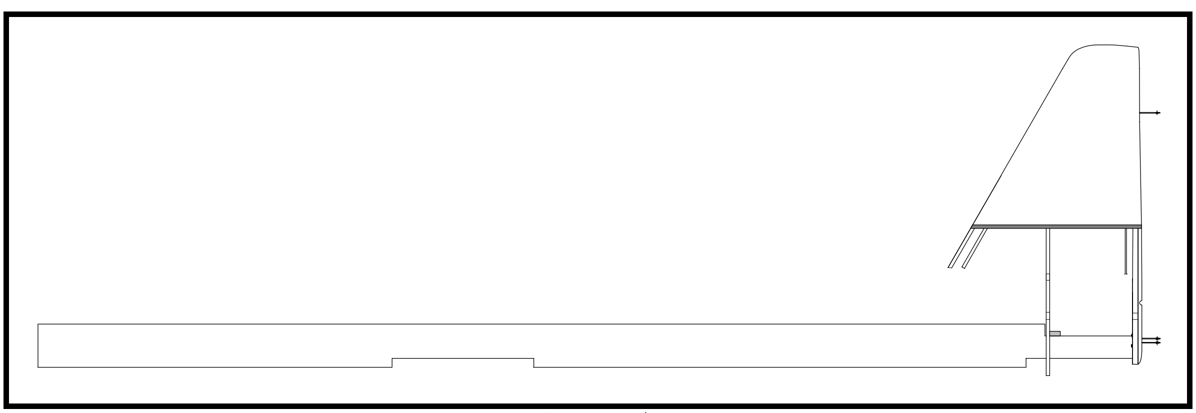


Figure 5

❏ Trial fit the fin assembly on the end of the fuselage jig. See Figure 5. You will have to shape the top of the jig to fit inside the forward fin spar, and you will have to cut notches in the end of the jig for the channel-nuts for the lower fin hinges.

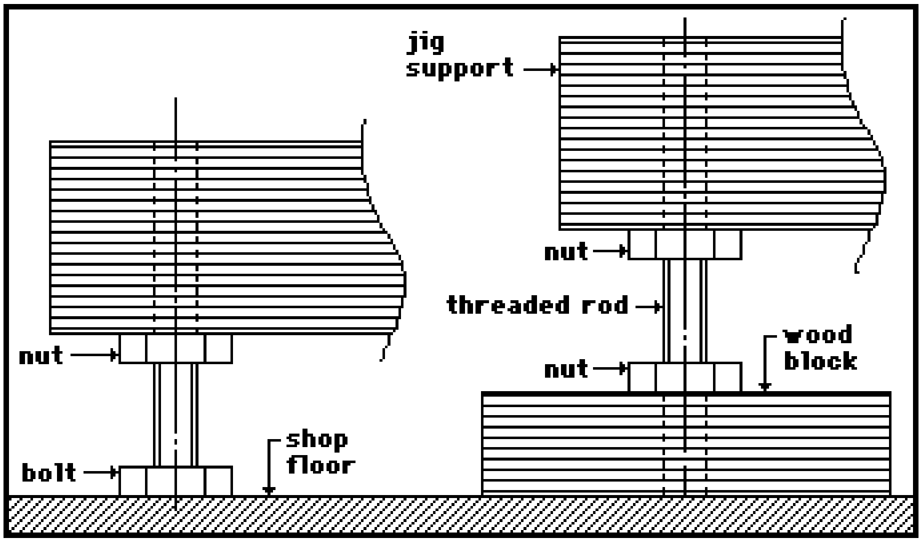


Figure 6

Note: There are a number of ways to support the fuselage jig. Drawing No. 321 shows two pipe supports, which will work. Our current thinking is that the best method is to support the jig with a single post at the forward end and a “split post” at the aft end.

The post for the forward end should be located 350mm aft of the forward end of the jig. This will place the post in the nose gear bay, aft of fuselage frame No. 2 and forward of frame No. 3, providing room for the installation of the nose gear screwjack support. The post should not be wider than a normal two-by-four (3.5”) so you will be able to retract the nose gear with the wheel removed.

The “split post” at the aft end should be two two-by-fours bolted on each side of the box beam jig. This will allow the bottom center longer to be installed between the two pieces.

The fuselage jig should be made so that W.L. 0 will be about 1280mm above the shop floor. Since you will have to make a number of small adjustments to the height of the fuselage jig to match it to the wing, you will need some method of making thise adjustments. Two methods are shown in Figure 6. In addition, hardware stores sell floor levelers which may by used.

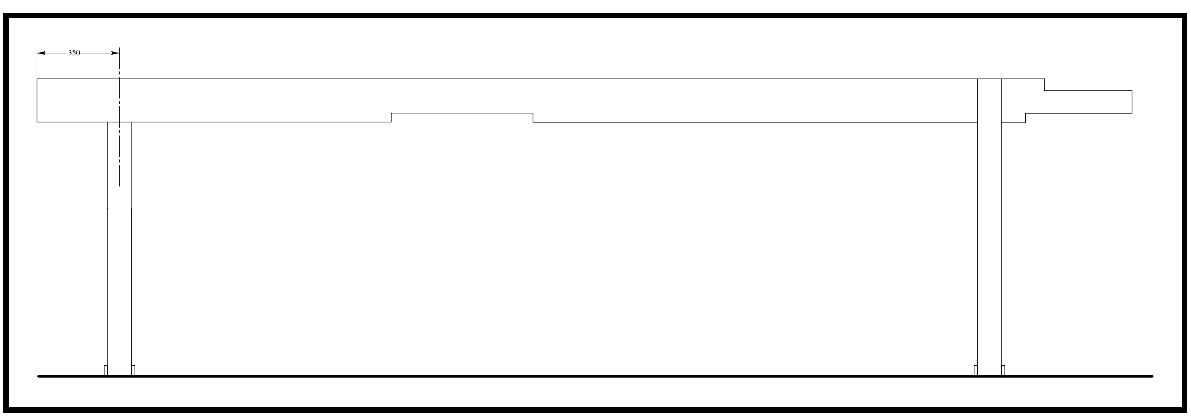


Figure 7

❏ Make and install the fuselage jig supports. See Figure 7. The aft support must be removable, so install it with bolts.

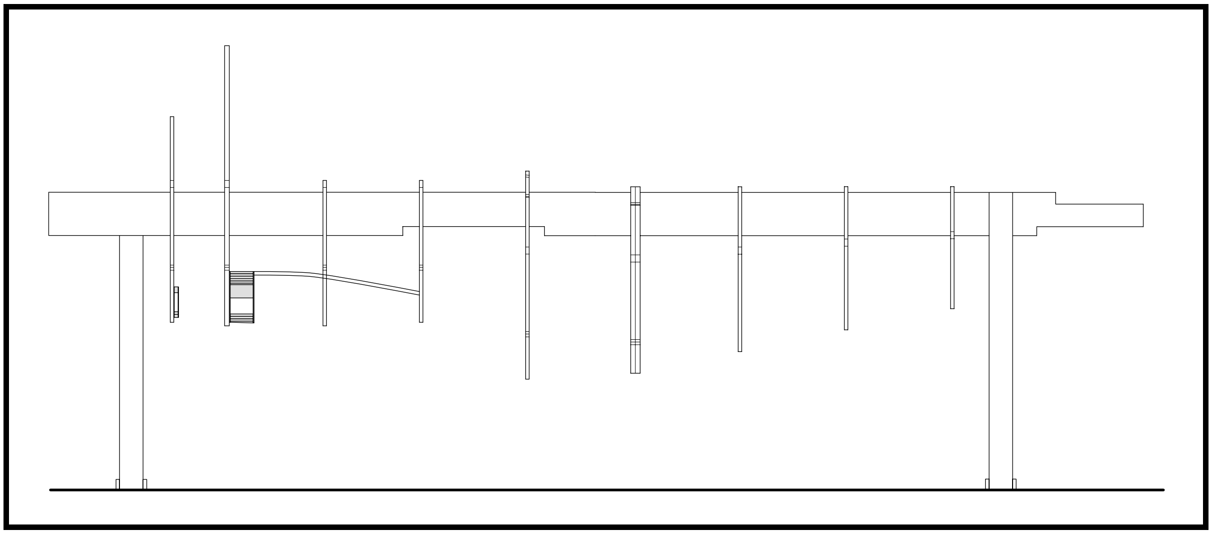


Figure 8

❏ Place the fuselage jig in place on the wing assembly. Slip fuselage frames No. 7, 8, 9, 10 and 11 over the jig. See Figure 8.

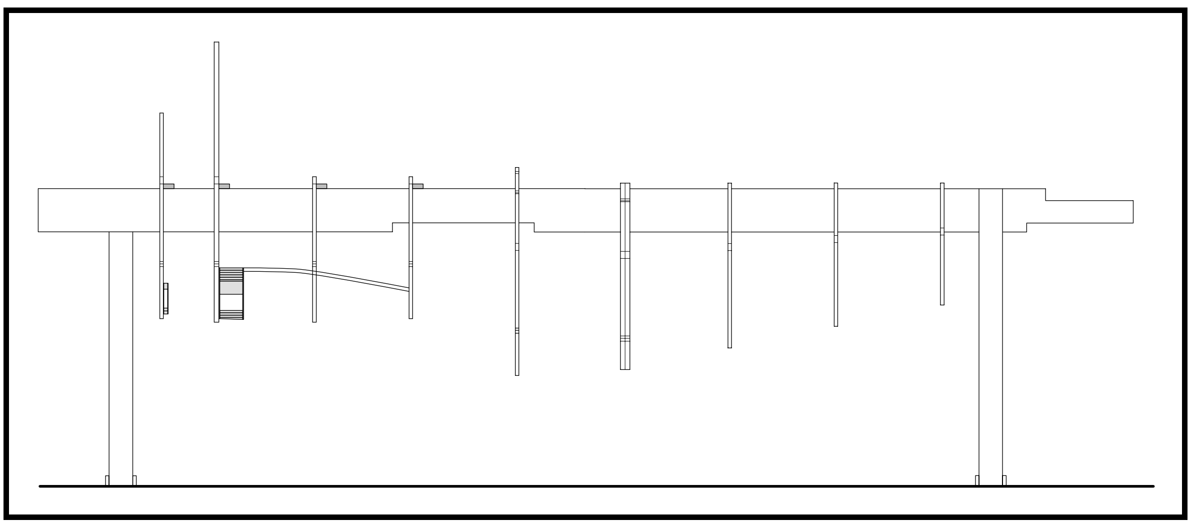


Figure 9

❏ Level the fuselage jig, align it with the wing and install the one-by-two's for fuselage frames No. 3, 4, 5 and 6. See Figure 9.

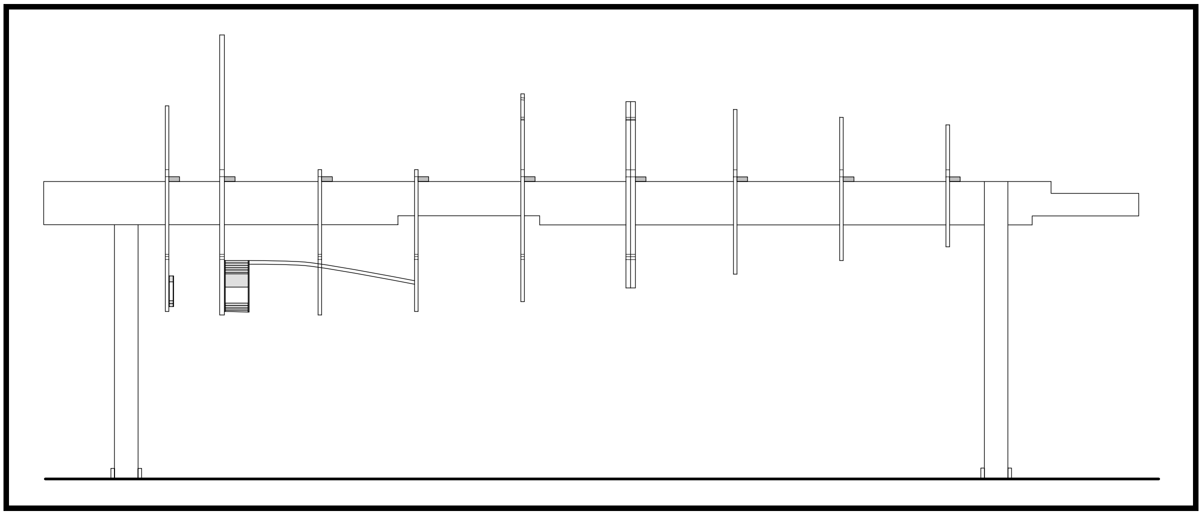


Figure 10

❏ Install the one-by-two's for fuselage frames No. 7, 8, 9, 10 and 11.

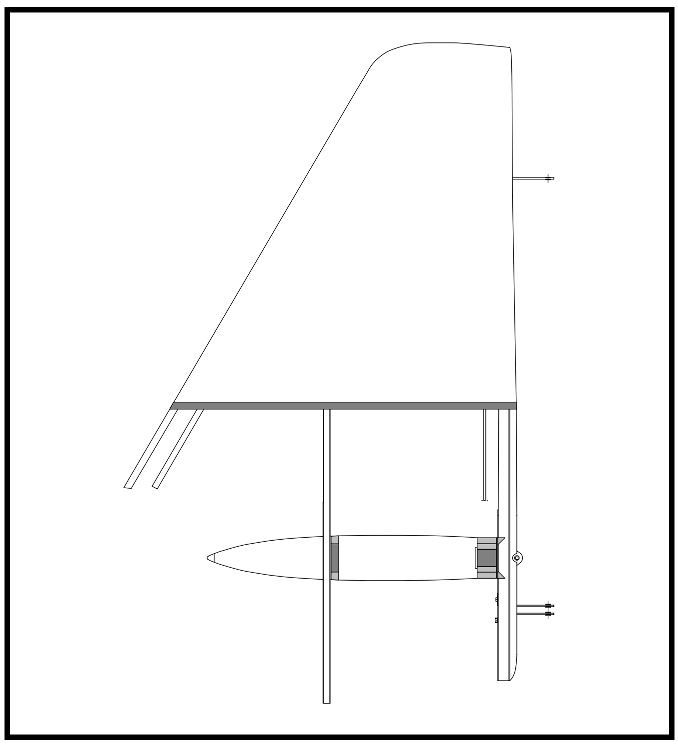


Figure 11

❏ Glue the fin spars to the horizontal stabilizer spars. See Figure 11.

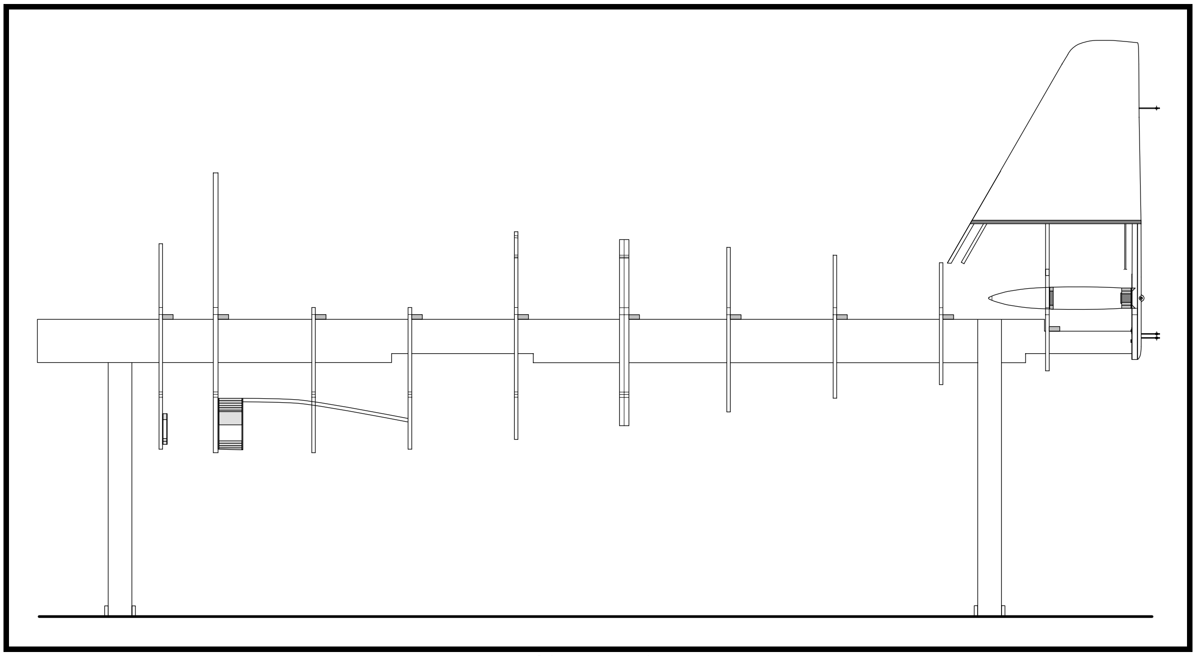


Figure 12

❏ Install the tail assembly on the fuselage jig. See Figure 12.

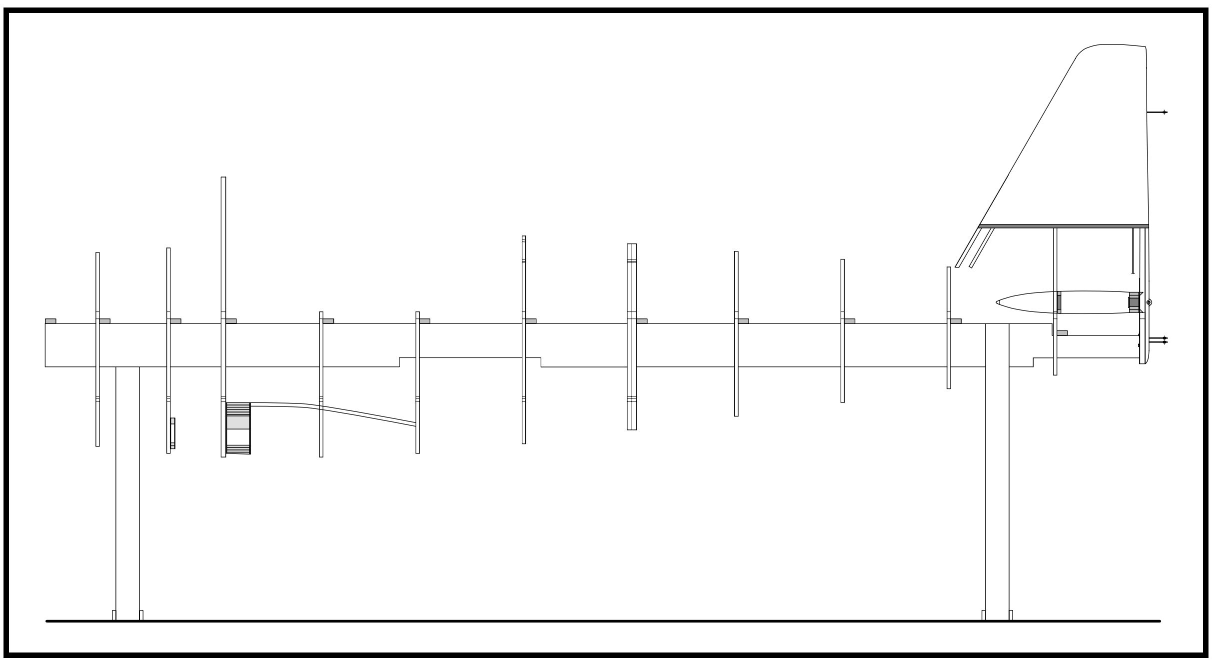


Figure 13

❏ Install fuselage frame No. 2 on the jig with its “one by two” brace. See Figure 13.

❏ Install the engine mount and nose gear on fuselage frame No. 1.

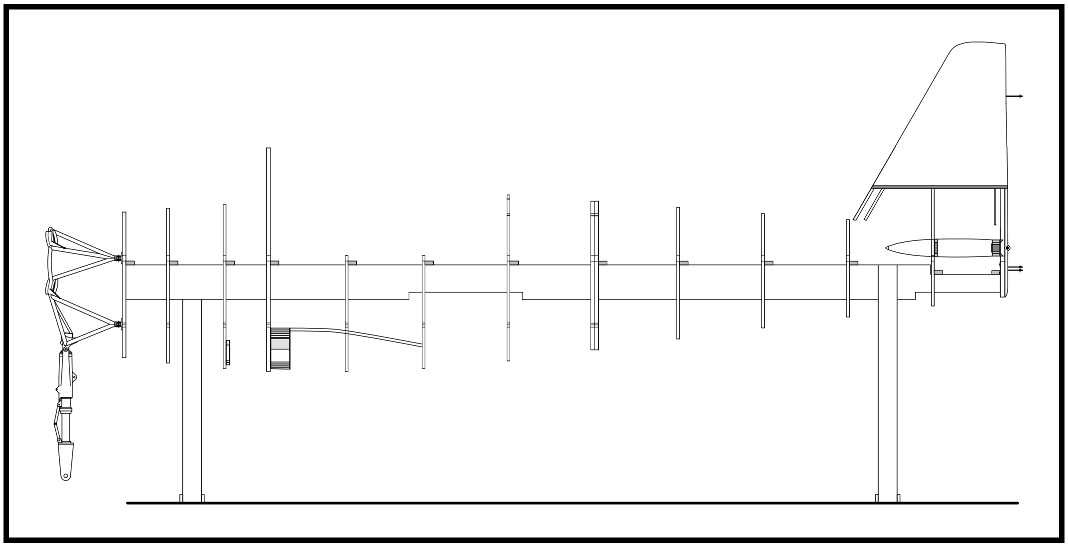


Figure 14

❏ Install fuselage frame No. 1 on the jig with its “one by two” brace. See Figure 14.

❏ Install a nylon fishing line through the hole in frame No. 1 at the aircraft centerline and W.L. 0. Run this line through the tail section. Secure this alignment string on each end and pull tight.

❏ Use a water level to check that this alignment string is level.

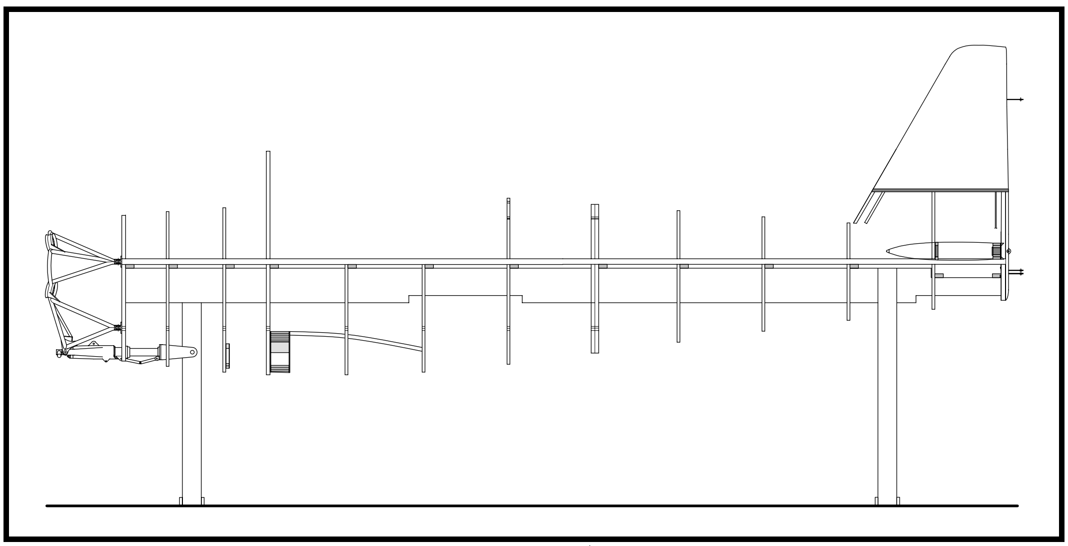


Figure 15

❏ Clamp the upper side longerons in position. See Figure 15. Until you are absolutely certain that everything is in the exact position, there is no need to do the final sanding for the longeron fit in the longeron cutouts. Align the frame so that the nose gear is located in the center of the nose gear bay.

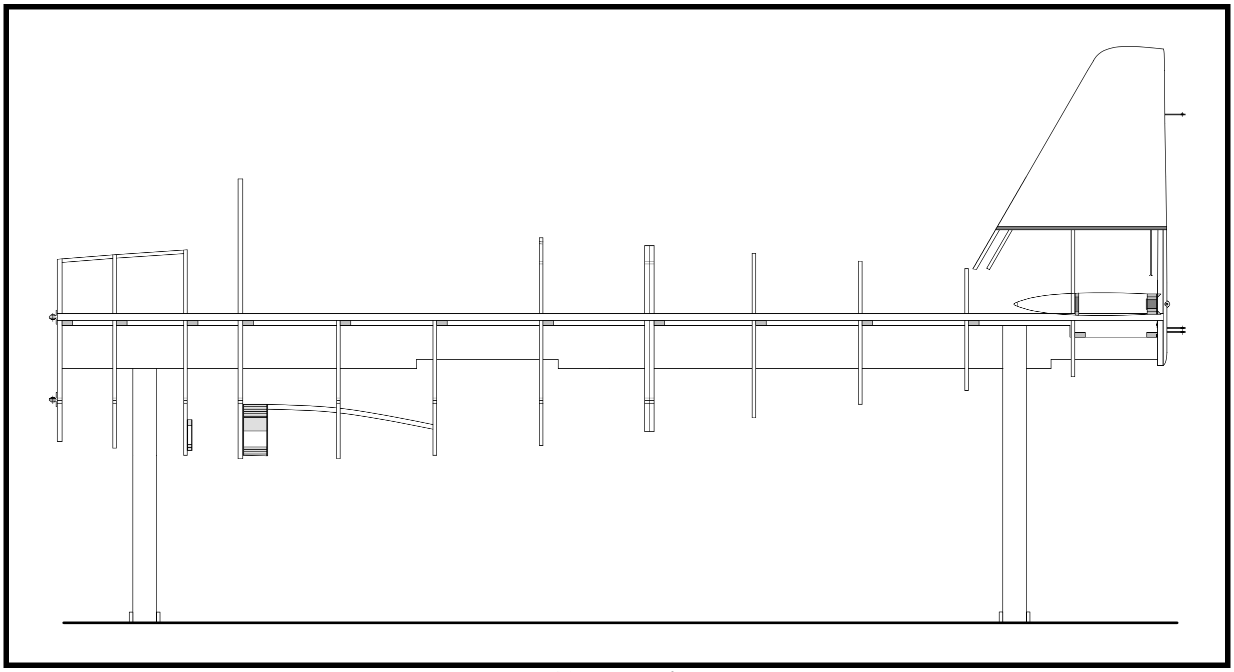


Figure 16

❑ Clamp the top front longeron in position. See Figure 16. Until you are absolutely certain that everything is in the exact position, there is no need to do the final sanding for the longeron fit in the longeron cutouts. Because there is a slight bend in this longeron, you may either soak and bend this piece into a slightly bowed shape or make it in two straight pieces joined at frame 2 with a scarf joint.

Note: In Figure 16 and thereafter, the engine mount and nose gear are not shown in the illustrations, but they should be left installed until the framework is solidly glued together.

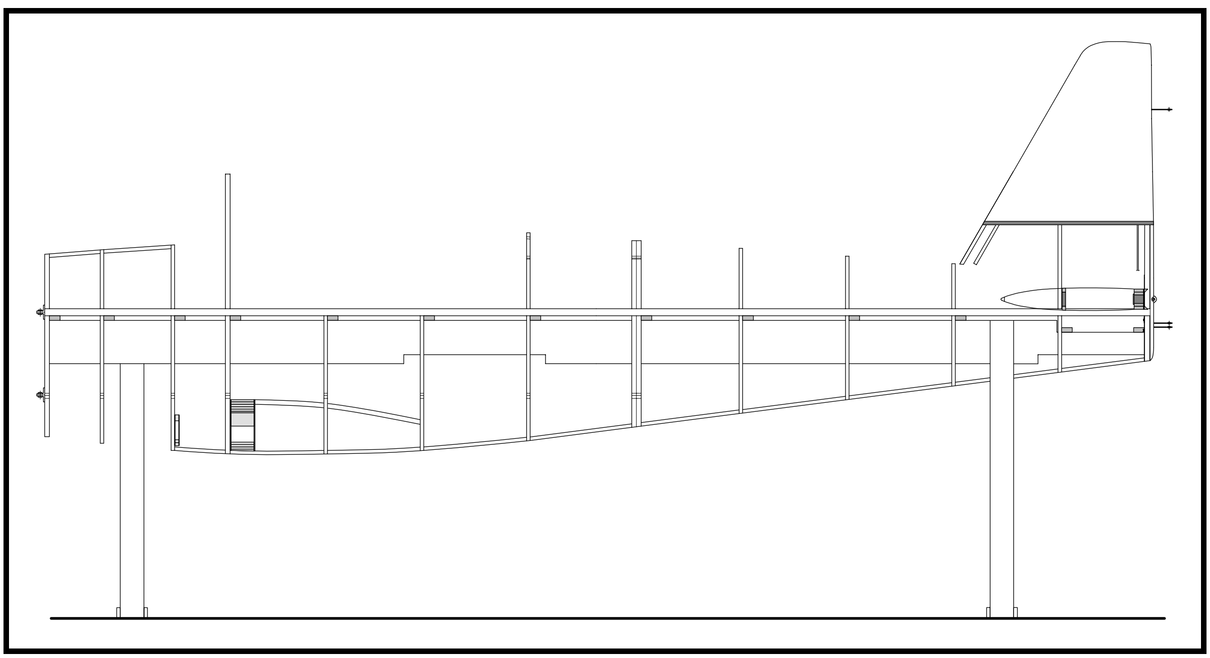


Figure 17

❏ Clamp the bottom center longeron in position. See Figure 17. Until you are absolutely certain that everything is in the exact position, there is no need to do the final sanding for the longeron fit in the longeron cutouts.

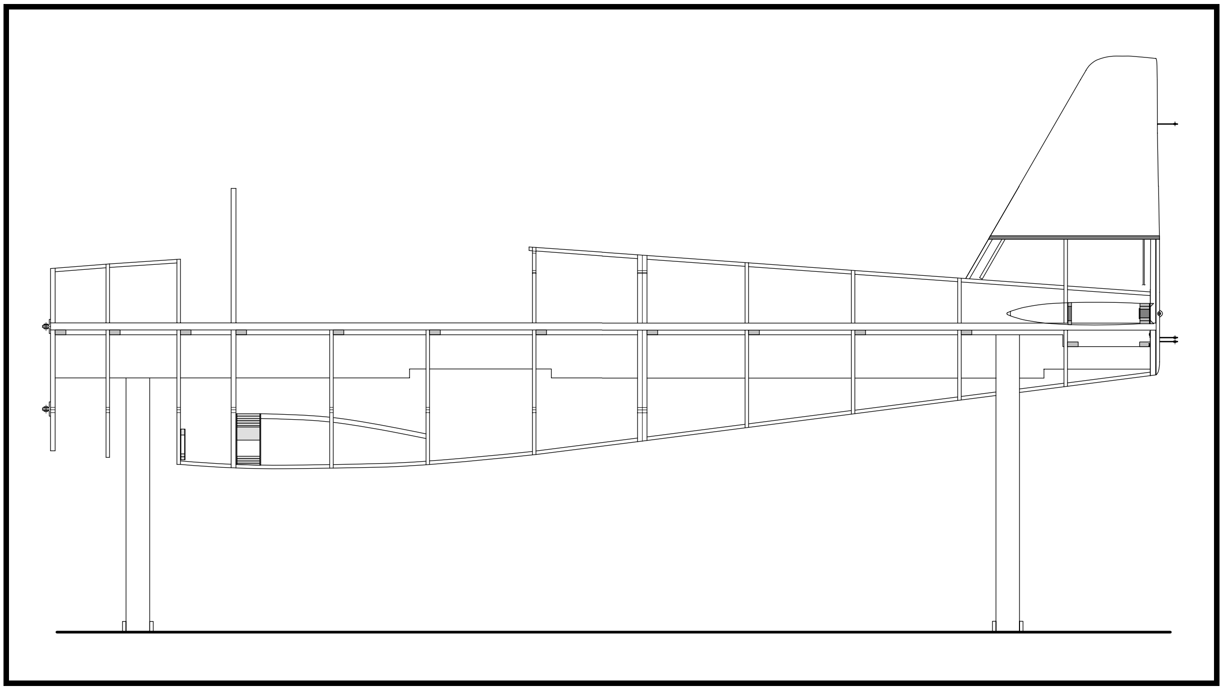


Figure 18

❏ Clamp the top aft longeron in position. See Figure 18. Until you are absolutely certain that everything is in the exact position, there is no need to do the final sanding for the longeron fit in the longeron cutouts.

❏ Check the position of all fuselage frames relative to the fuselage jig. This includes checking the level of the alignment string for W.L. 0, checking the location of the fuselage frames fore-and aft, checking that the fuselage frames are level in the jig (use a water level), and checking that the fuselage frames are vertical in the jig (use a plumb bob).

❏ Sand the longeron cutouts to fit the left side longeron. The other longerons should hold the frames in position. Clamp this longeron in position when finished. Note that the longeron must be notched for the stabilizer spars.

❏ Sand the longeron cutouts to fit the right side longeron. The other longerons should hold the frames in position. Clamp this longeron in position when finished. Note that the longeron must be notched for the stabilizer spars.

❏ Sand the longeron cutouts to fit the top front longeron. The other longerons should hold the frames in position. Clamp this longeron in position when finished.

❏ Sand the longeron cutouts to fit the top aft longeron. The other longerons should hold the frames in position. Clamp this longeron in position when finished.

❏ Sand the longeron cutouts to fit the bottom center longeron. The other longerons should hold the frames in position. Clamp this longeron in position when finished.

Note: The two lower side longerons will not be installed or fitted until later. The reason for this is that they require a significant amount of twisting at the aft end, which could cause the fuselage frames to become distorted on the fuselage jig.

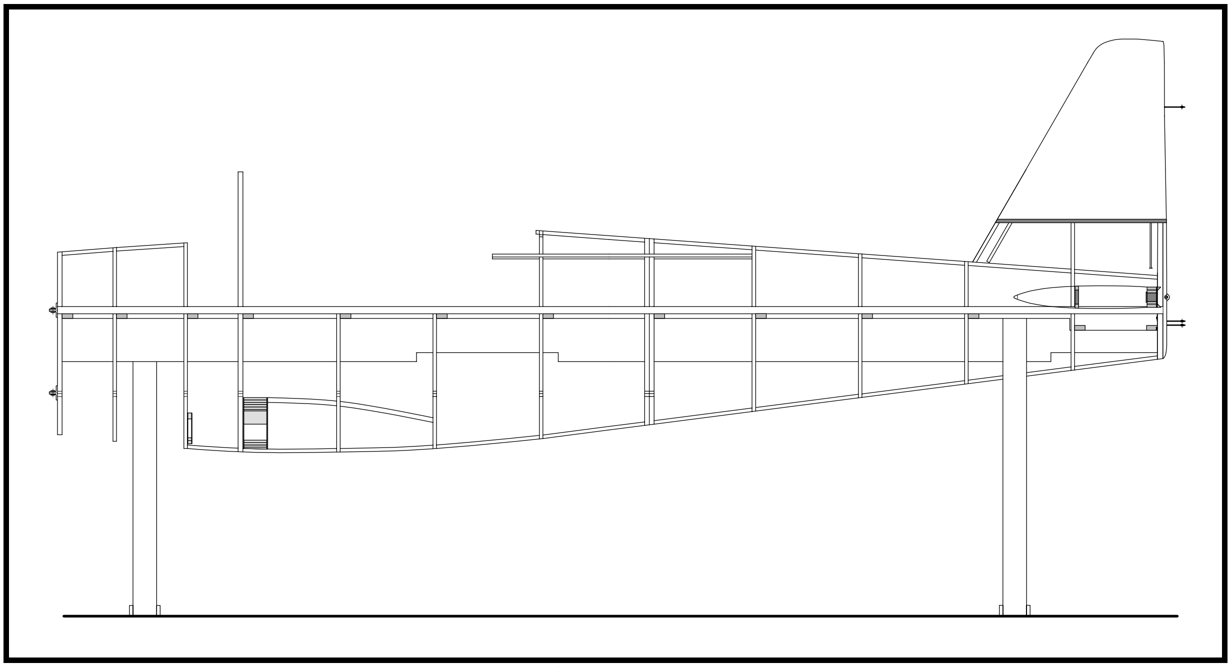


Figure 19

❑ Clamp the left 20x10 stringer in position. See Figure 19. Sand the cutouts to fit.

❑ Clamp the right 20x10 stringer in position. Sand the cutouts to fit.

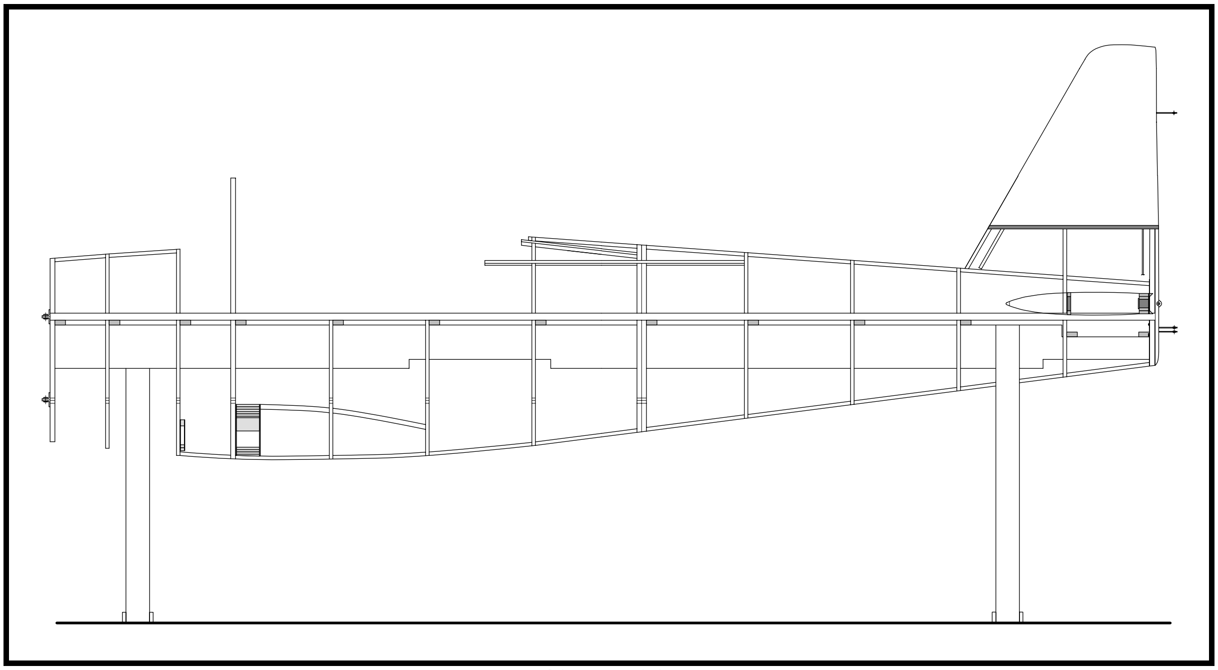


Figure 20

❏ Clamp the right 30x15 shoulder belt support framing strip in position. See Figure 20. Sand the cutouts to fit.

❏ Clamp the left 30x15 shoulder belt support framing strip in position. Sand the cutouts to fit.

❏ Check the alignment of all fuselage frames.

❏ Check the alignment of the nose gear with the nose gear bay. The nose gear should be centered at the aircraft centerline. Adjust the position of frame No. 1.

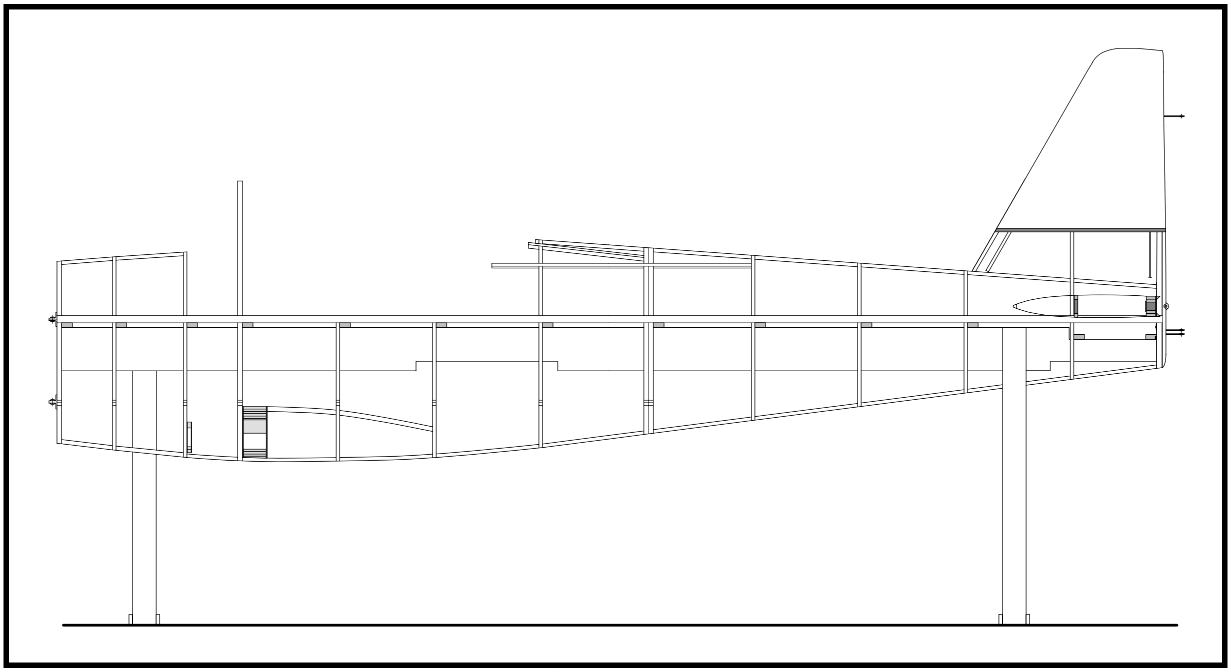


Figure 21

- ❑ Clamp the left 20x18 nose wheel bay framing strip in place. This strip is at the bottom of frame No. 1, 2 and 3. Sand the cutouts to fit.
- ❑ Clamp the right 20x18 nose wheel bay framing strip in place. This strip is at the bottom of frame No. 1, 2 and 3. Sand the cutouts to fit.
- ❑ Do one last check of the alignment of all fuselage frames, including the alignment of the nose gear in the nose gear bay.
- ❑ Glue the bottom center longeron in place.
- ❑ Glue the left side longeron in place.
- ❑ Glue the right side longeron in place.
- ❑ Glue the left 20x18 nose wheel bay framing strip in place.
- ❑ Glue the right 20x18 nose wheel bay framing strip in place.

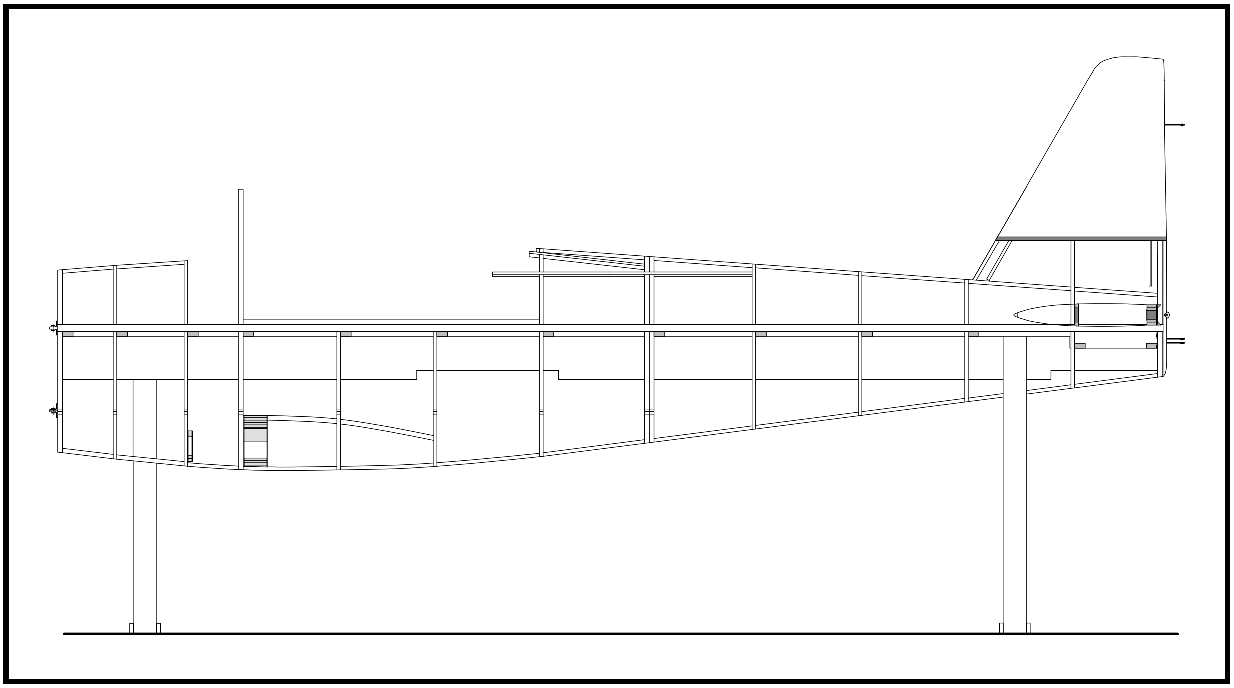


Figure 22

❏ Fit the left cockpit coaming strip in place. See Figure 22. This is the strip of spruce that is installed on the top of the side longerons and the fuselage frames. This strip extends from the aft face of frame No. 4 to the forward face of frame No. 7. The outside of the coaming should be the same as the outside of the fuselage frames. The inside of the coaming should be the same as the inside of the fuselage frames except for frame No. 7 where it is 10mm outboard of the inside of frame No. 7. This is for the inside fuselage skin (see Drawing No. 315).

The coaming strips—or gunwales to boatbuilders—may be made by laminating two or three strips of spruce. One builder simply soaked the spruce in water for a couple of days and then clamped each strip to a workbench with a steam iron on top of it to put a two-inch bow into it before fitting and gluing—"Nothing precise, just an eyeball bend so that it was close enough to the final shape that the natural flexibility of the wood was adequate to allow exact final bending and fitting."

❏ Fit the right cockpit coaming strip in place.

❏ Glue the left cockpit coaming strip in place.

❏ Glue the right cockpit coaming strip in place.

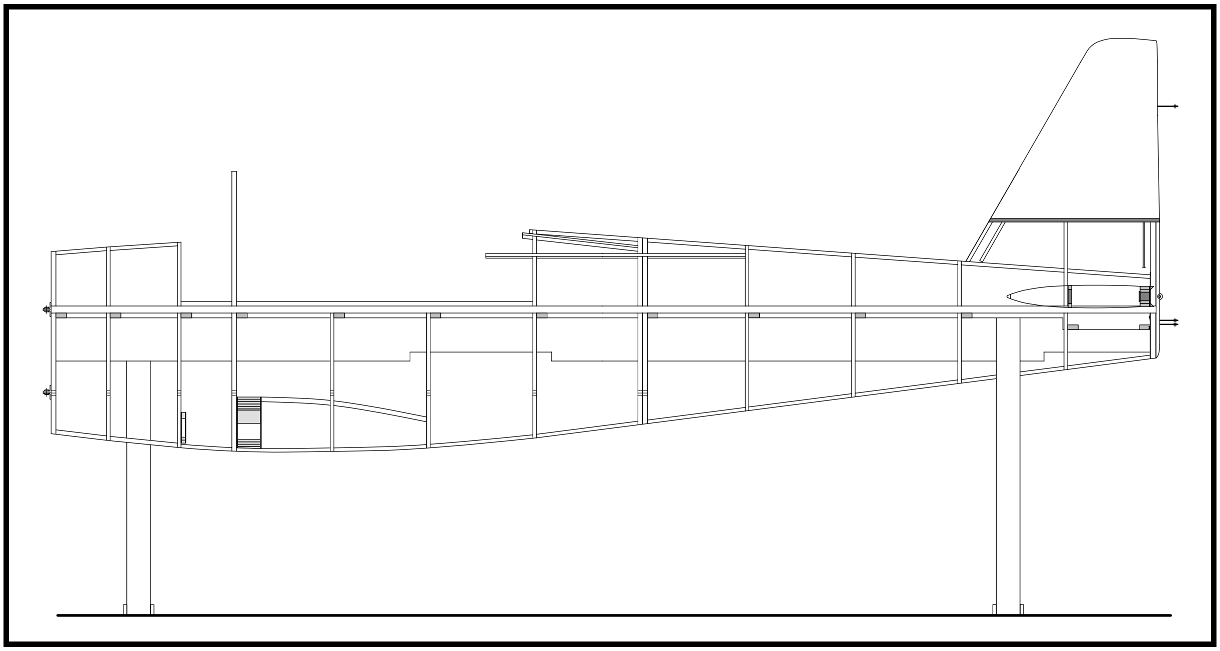


Figure 23

- ❏ Fit the left cockpit coaming strip between frame No. 3 and 4 in place. See Figure 23. At frame No. 3, the coaming should be the same width as the bottom lamination of frame No. 3.
- ❏ Fit the right cockpit coaming strip between frame No. 3 and 4 in place. At frame No. 3, the coaming should be the same width as the bottom lamination of frame No. 3.
- ❏ Glue the left cockpit coaming strip between frame No. 3 and 4 in place.
- ❏ Glue the right cockpit coaming strip between frame No. 3 and 4 in place.
- ❏ Glue a strip of spruce on the inboard face of the left upper side longeron between frame No. 2 and 3. See Drawing No. 315. The top of this strip of spruce should be even with the top of the longeron. The strip should be 10mm thick and the inner face of the strip should match the inner face of frame No. 2 and the inner face of the lower lamination of frame No. 3. The purpose of this strip is to provide a gluing surface for the inside cockpit skin.
- ❏ In the same fashion, glue a strip of spruce on the inboard face of the right upper side longeron between frame No. 2 and 3.

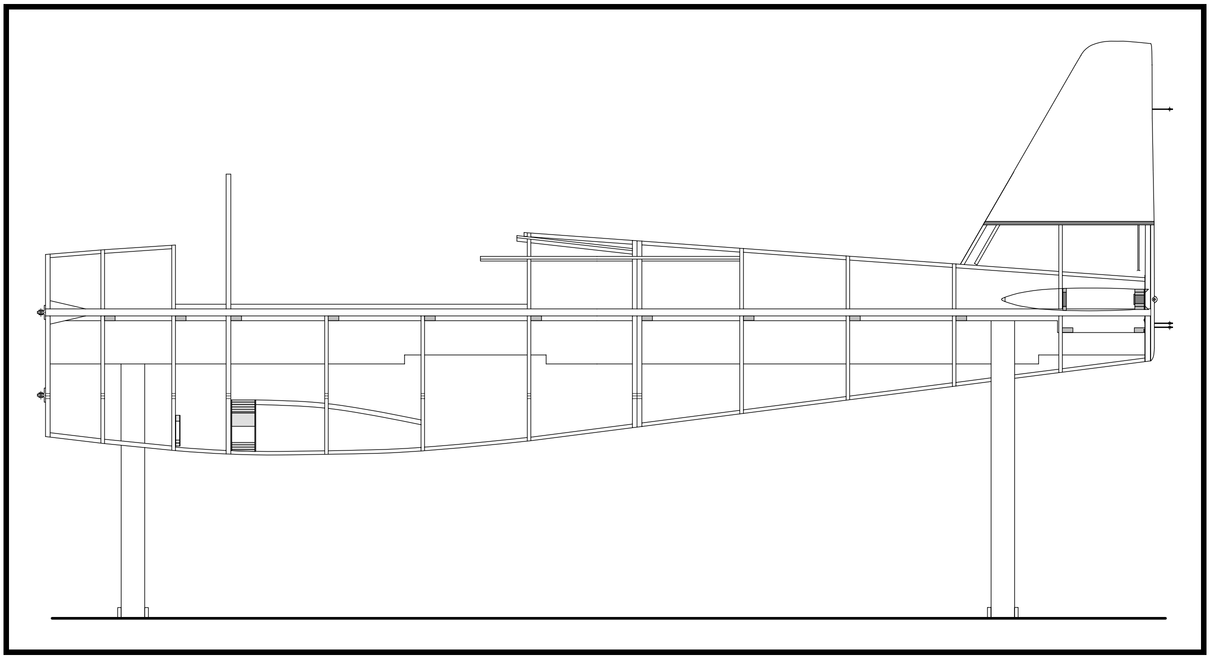


Figure 24

❑ Fit and glue the two 35x150 corner blocks for the left side longeron at frame No. 1. See Figure 24.

Note: The grain direction of the corner blocks is a matter of some confusion. The purpose of the corner blocks is to transfer the loads into the skin. In addition, these forward corner blocks are also used for the bolts which hold the engine mounts in place (see Drawing No. 114). Spruce is strongest in the direction of the grain. Also, end grain joints are not particularly strong. In general, it is best to install the grain direction of corner blocks so that as little end grain as possible is used in the glue joints. For the corner blocks on the fuselage longerons, we think the best grain direction is the same as that of the longerons to which they are glued.

❑ Fit and glue the two 35x150 corner blocks for the right side longeron at frame No. 1.

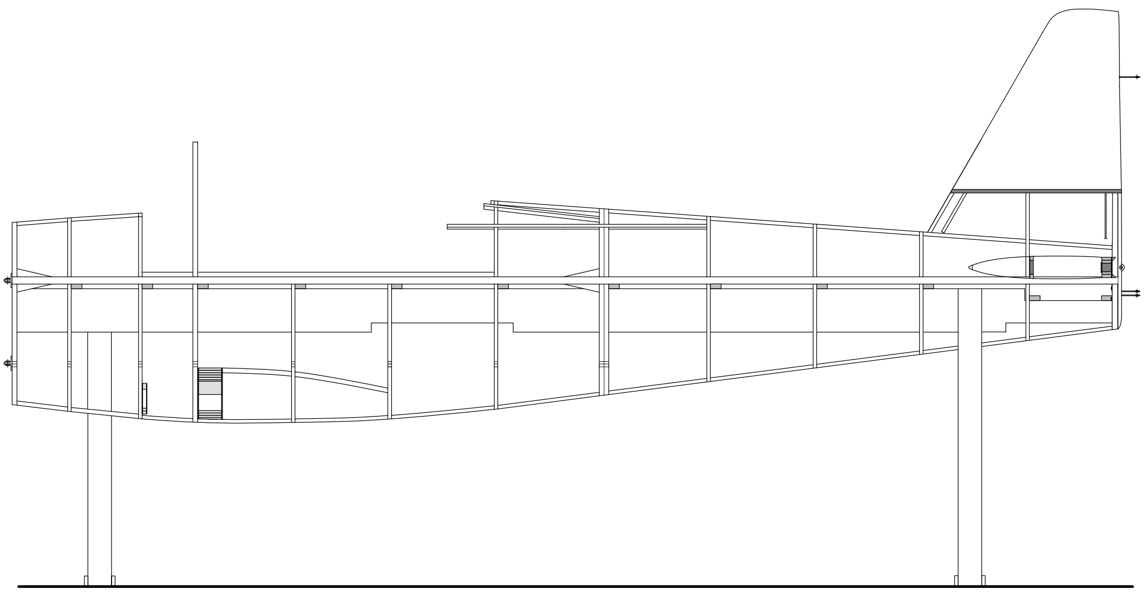


Figure 25

- ❏ Fit and glue the two 35x150 corner blocks for the left side longeron at the forward face of frame No. 8. See Figure 25.
- ❏ Fit and glue the two 35x150 corner blocks for the right side longeron at the forward face of frame No. 8.
- ❏ Fit and glue the two 35x150 corner blocks for the bottom center longeron at the forward face of frame No. 8.
- ❏ Fit and glue the two 35x150 corner blocks for the bottom center longeron at the aft face of frame No. 8.

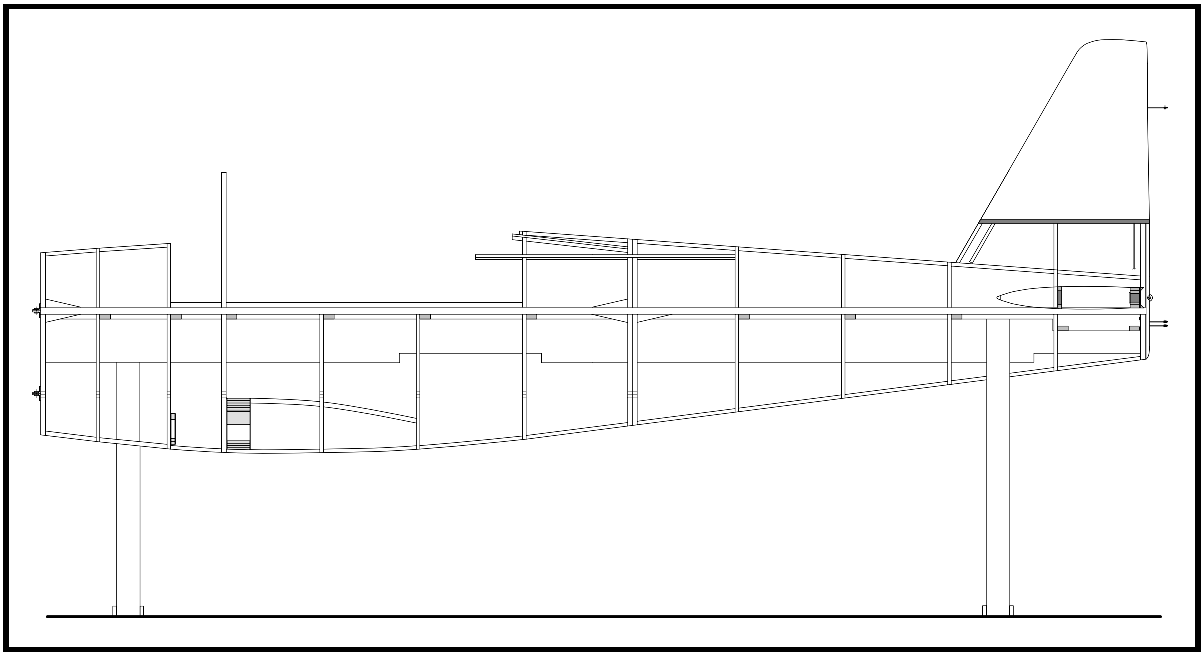


Figure 26

❑ Fit and glue the lower 35x150 corner block for the left side longeron at the aft face of frame No. 8. See Figure 26. The upper corner block is not installed at this time due to the construction of the battery box.

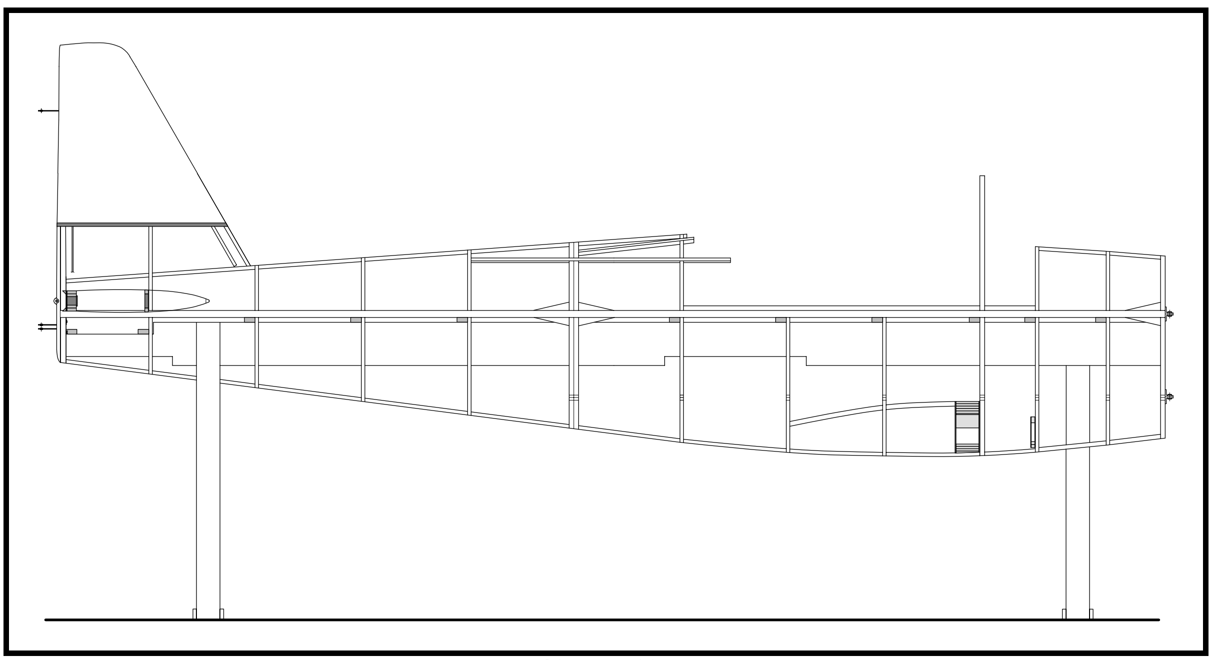


Figure 27

❑ Fit and glue the two 35x150 corner blocks for the right side longeron at the aft face of frame No. 8. See Figure 27.

❑ Remove the clamps for the top center longeron at frames No. 7 and 8. Place a small block of wood under this longeron at frame No. 8 to provide room to install the diagonal frame No. 6.

❑ Remove the two 20x10 stringers.

❑ Remove the two 30x15 shoulder belt support framing strips.

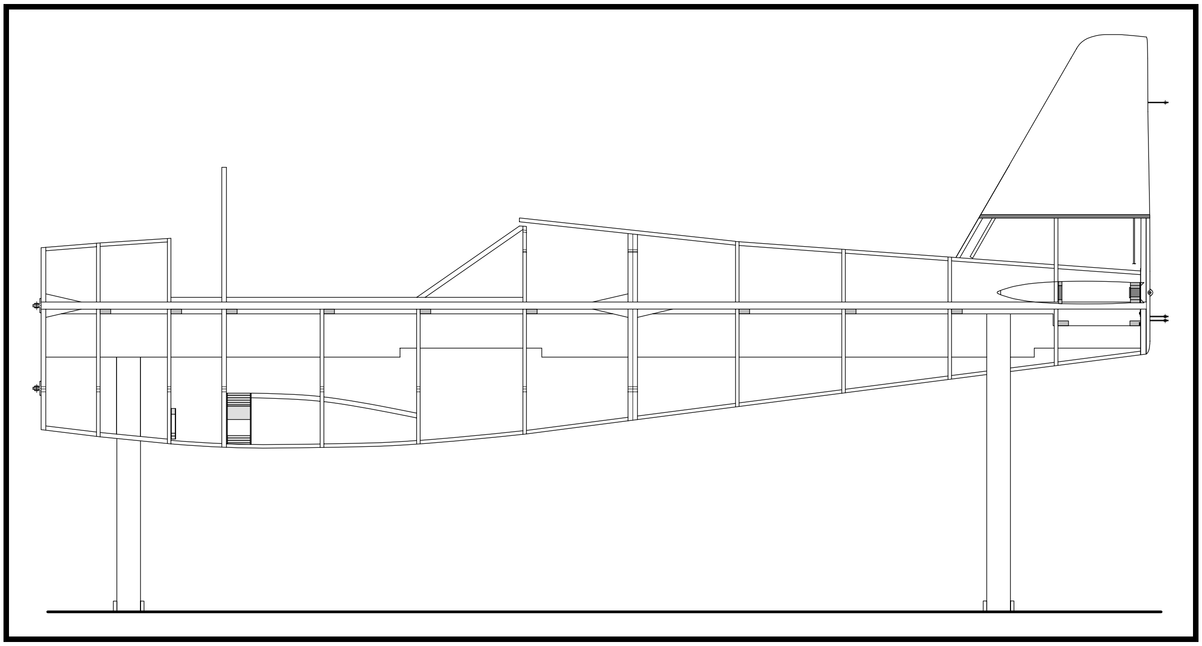


Figure 28

❑ Fit the diagonal frame No. 6 in place.

Note: This diagonal frame should be installed so that the bottom forward ends coincide with the aft face of fuselage frame No. 6. Because of the installation of the coaming aft to frame No. 7, many of the drawings are not correct, however the correct installed position is shown on Drawing No. 107. At the bottom forward ends, the inside of the lamination should coincide with the inside of the cockpit coaming.

At the aft upper end, the diagonal frame should just rest against the forward face of frame No. 7.

While fitting this diagonal frame in place, you may want to begin the cutout for the top center longeron. This will be sanded to the final fit after the diagonal frame is glued in place.

If you wish, you may sand the upper inside face of the diagonal frame for the installation of the inside fuselage skin. At this time it is not necessary, nor desirable, to do the final sanding, but you can save yourself a lot of difficult and awkward sanding later by beginning the sanding process now. See Section D-D, Drawing No. 315.

❑ Glue the diagonal frame No. 6 in place.

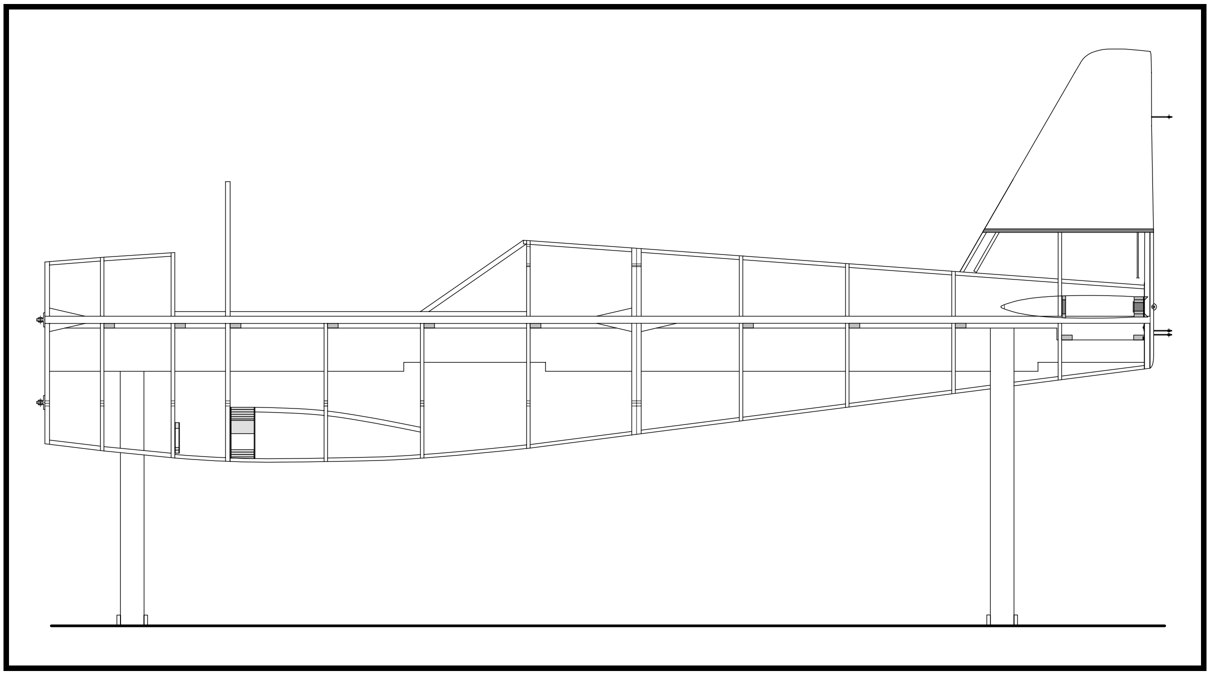


Figure 29

❏ Sand the longeron cutout for the top center longeron in this diagonal frame. Clamp the top center longeron in place.

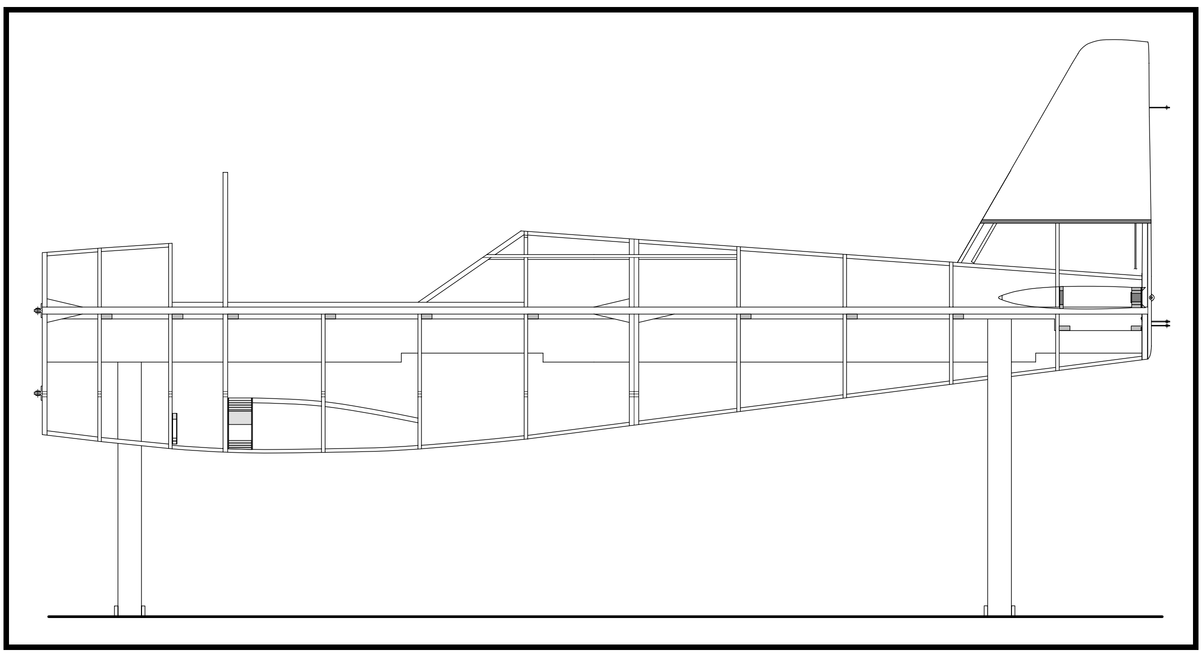


Figure 30

❏ Cut, fit and sand the cutouts for the 20x10 stringers in the diagonal frame. Clamp the 20x10 stringers in place.

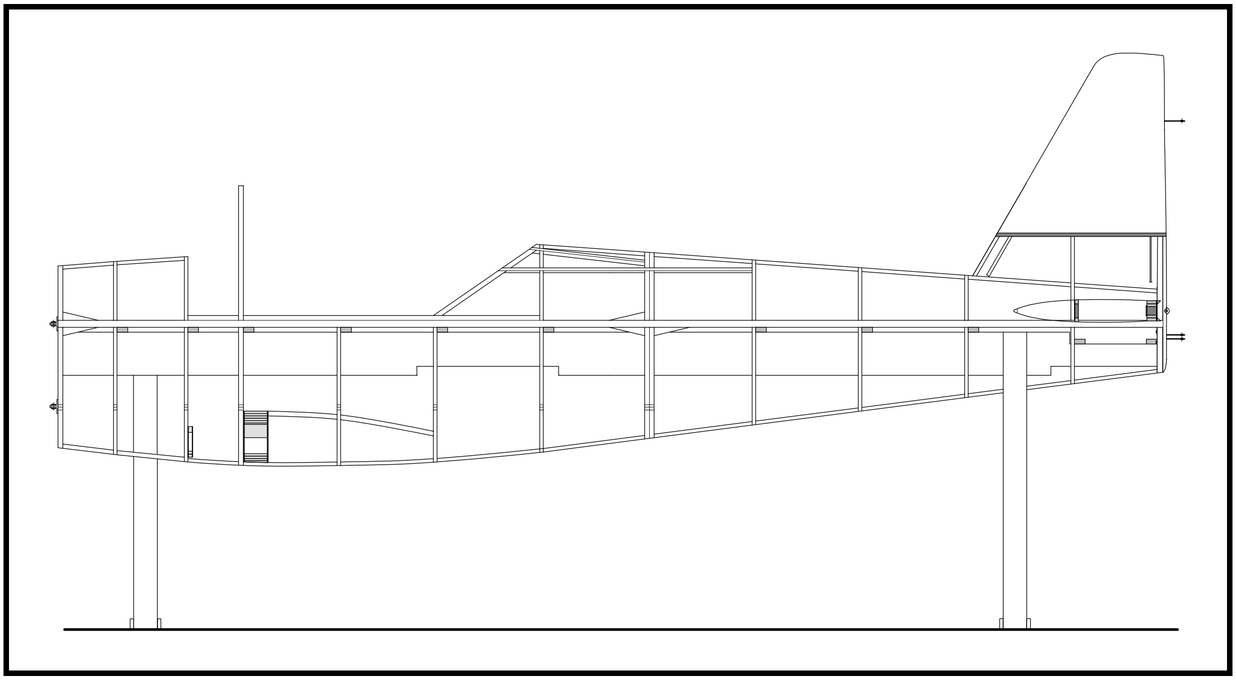


Figure 31

- ❏ Cut, fit and sand the cutouts for the 30x15 shoulder belt supports in the diagonal frame. See Figure 31.
- ❏ Glue the top center longeron in place along its entire length, from the forward face of the main fin spar to the diagonal frame No. 6.
- ❏ Fit and glue the 35x150 corner blocks for the top center longeron on the forward face of frame No. 8.
- ❏ Fit and glue the 35x150 corner blocks for the right side of the top center longeron on the aft face of frame No. 8. (Do not install the corner block on the left side at this time—you do that after you finish the battery box.)
- ❏ Glue the right 20x10 stringer in place. (The left 20x10 is not installed until after the battery box is completed.)
- ❏ Glue the 30x15 shoulder belt supports in place.

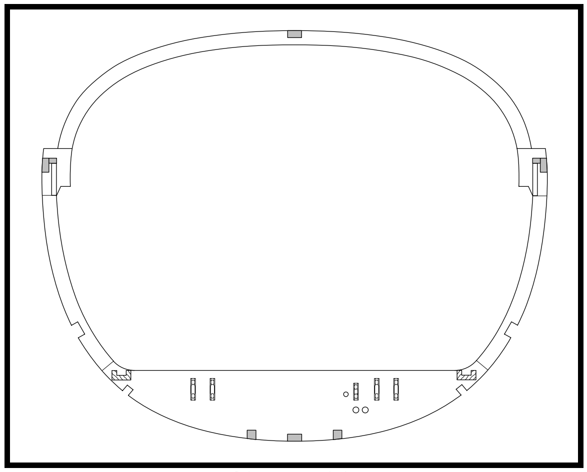


Figure 32

❏ Glue a 10mm thick strip of spruce vertically on the aft face of frame 2 and on the inside of the upper side longeron as shown in Figure 32. This strip is to pick up inside cockpit skin. Do this on the left and right sides of the airplane.

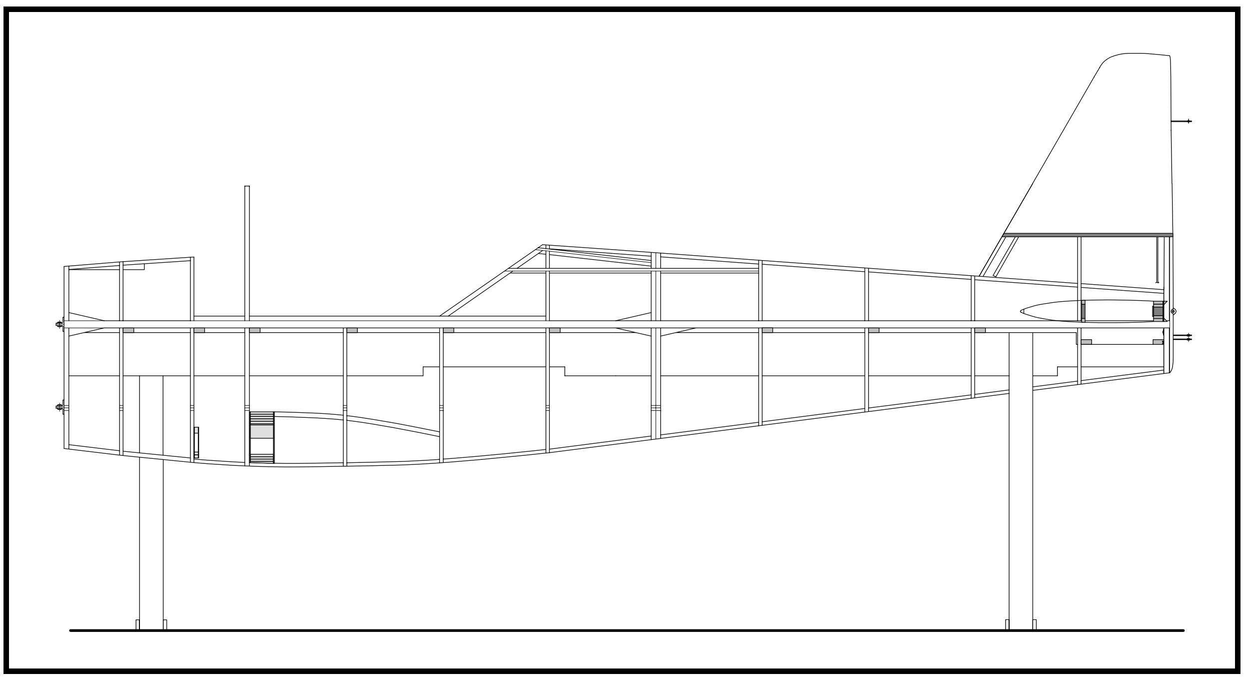


Figure 33

❏ Cut and fit the 15mm wide spruce tank support. See Figure 33. This strip of spruce is installed just under the forward top center longeron and is shown in Drawing No. 121.

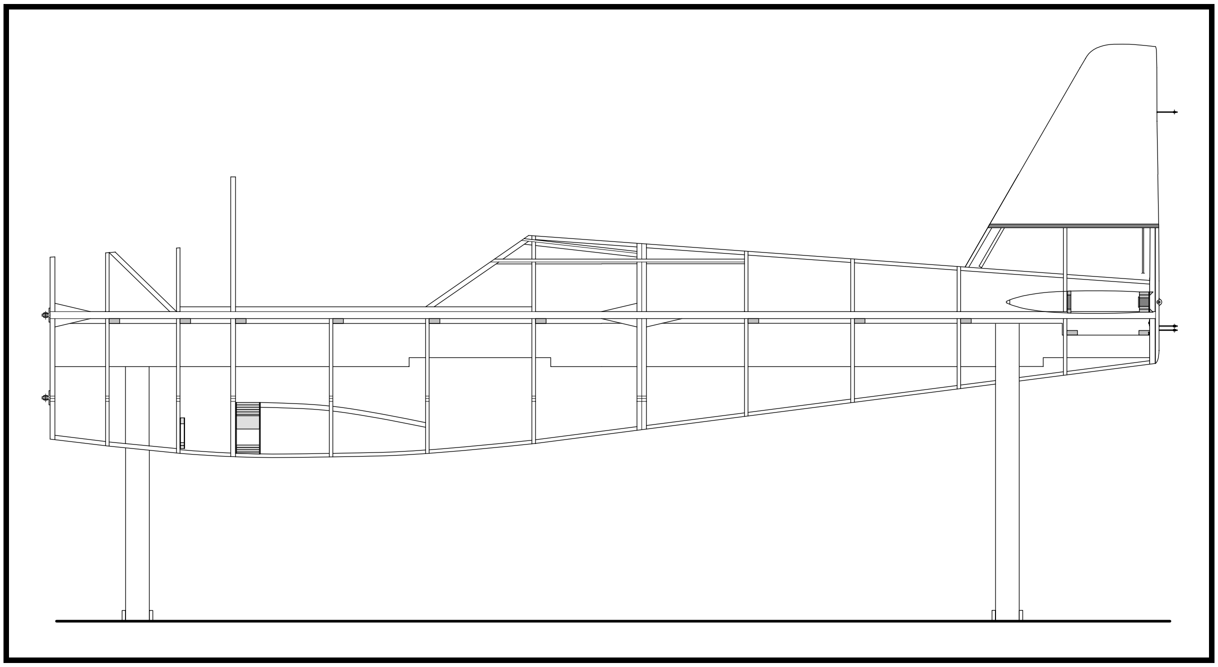


Figure 34

❑ Remove the forward top center longeron and the tank support you just made. Fit diagonal frame No. 2 in place as shown in Drawing No. 314 and the detail showing the installation of this frame. It is very important that this frame is installed exactly as shown. If you compare this to the windshield, it will not make sense to you right now, but do it according to the drawing anyway. See Figure 34.

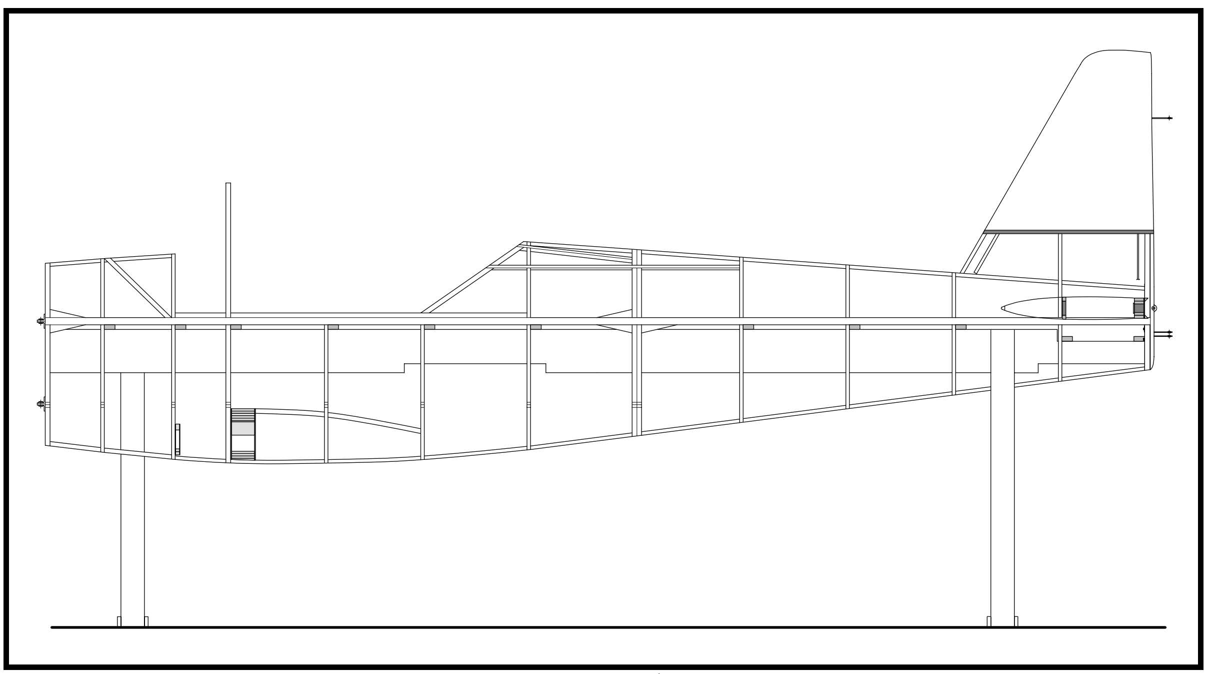


Figure 35

❑ Cut the top of the diagonal frame No. 2 for the forward top center longeron, and glue the longeron and the diagonal frame in place. See Figure 35.

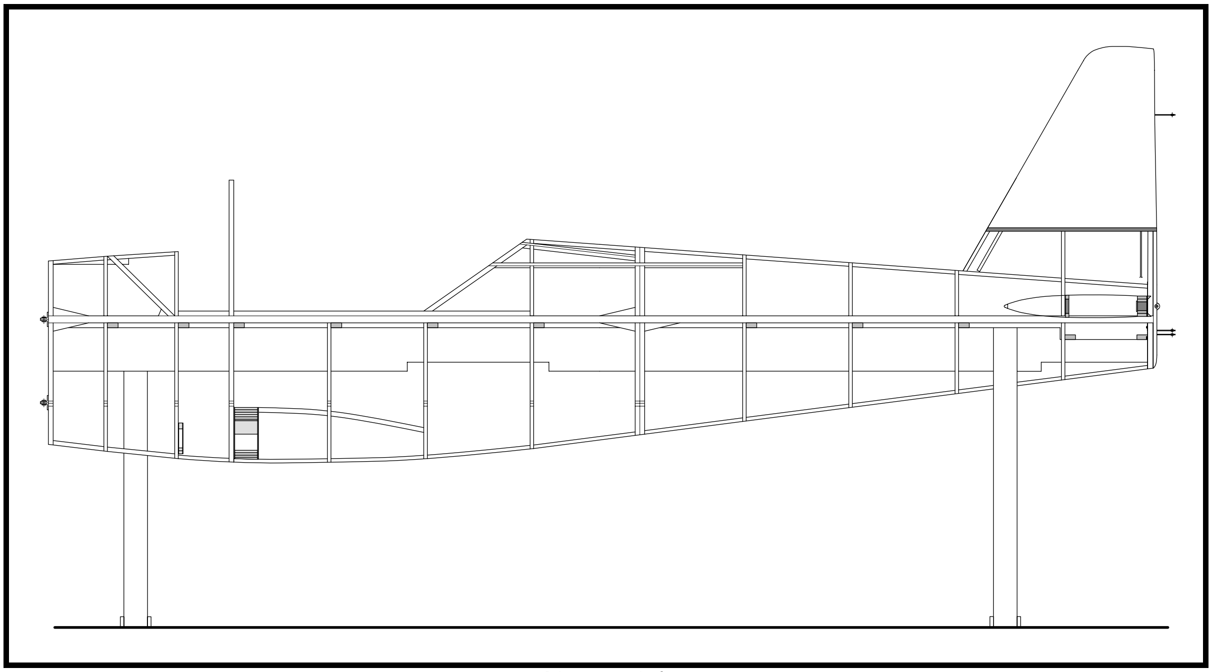


Figure 36

❏ Glue the top center tank support in place after trimming it to fit to the diagonal frame. At the outboard end of the diagonal frame, glue a 40mm corner block on the forward face of the frame and upper face of the upper side longeron. See Figure 36.

Chapter 27
Fuselage Assembly, Part 2

Nose Gear Bay Assembly

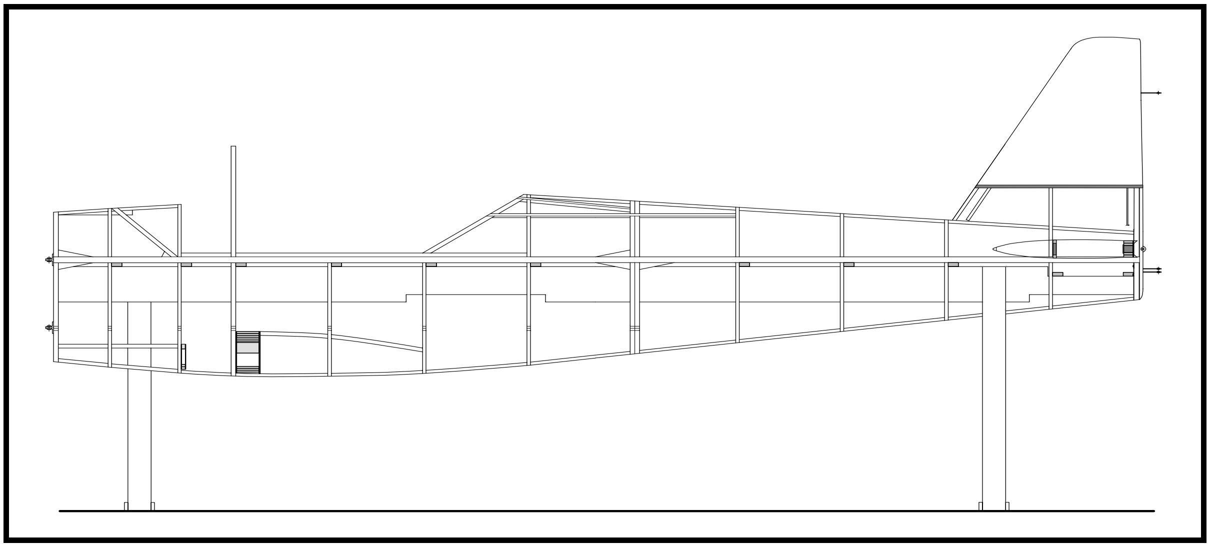


Figure 1

❏ Fit the 20x18 spruce strip for the top of the framing for the nose gear bay walls as shown in Drawing No. 306. See Figure 1. Do not glue this in place at this time.

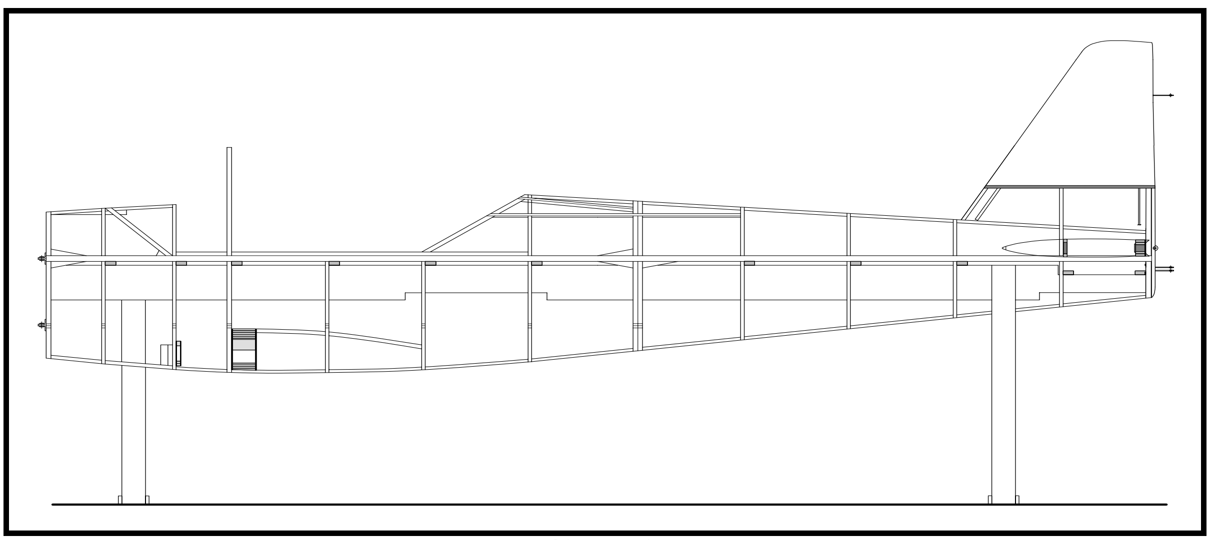


Figure 2

❏ Fit and glue in place the vertical supports for the aft end of the nose gear bay walls. See Figure 2. The vertical brace for the left nose gear bay wall is made of 20x18 spruce. The vertical brace of the right nose gear bay wall is made of 50x18 spruce as shown in Drawing No. 105.

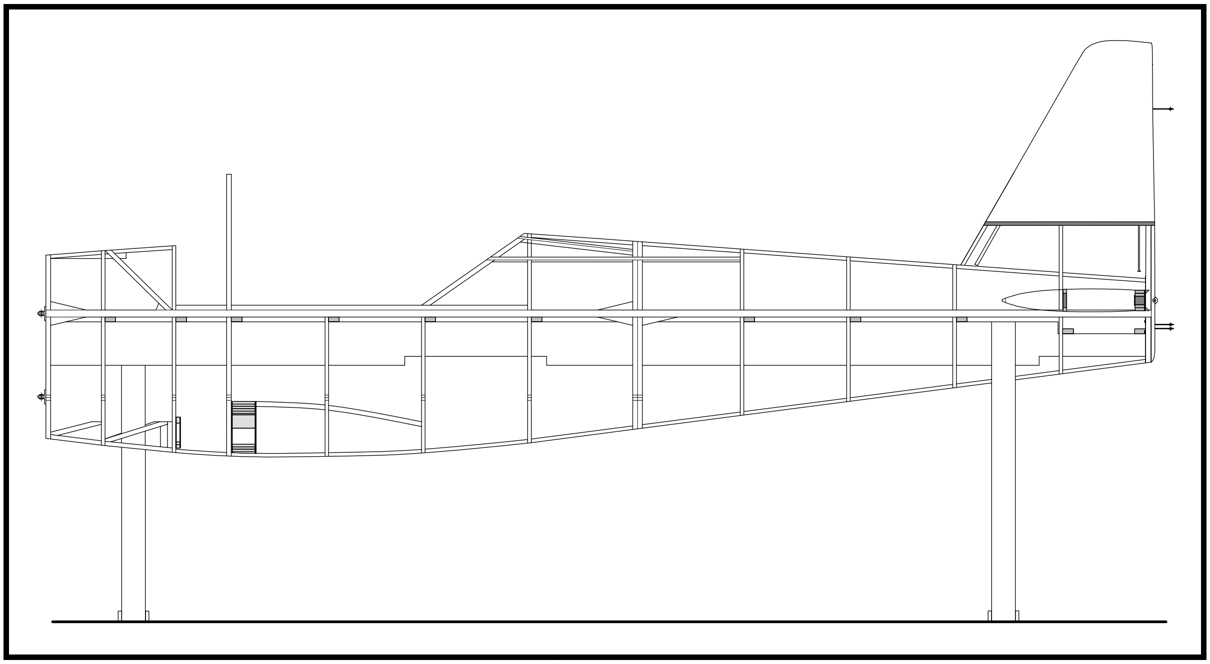


Figure 3

❏ Fit and glue in place the 20x18 diagonal braces. See Figure 3.

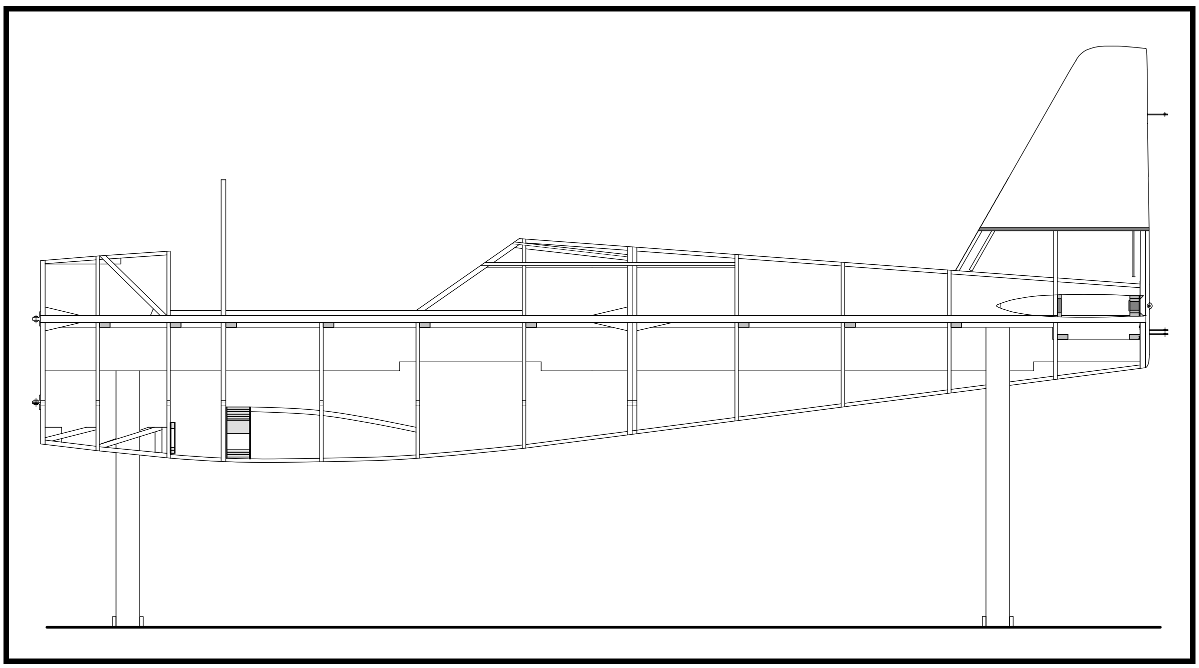


Figure 4

❏ Fit and glue in place the extra blocking for the forward end of the nose gear bay. See Figure 4. These are not dimensioned on any drawing, but we suggest that the blocking end 70mm aft of the aft face of frame No. 1.

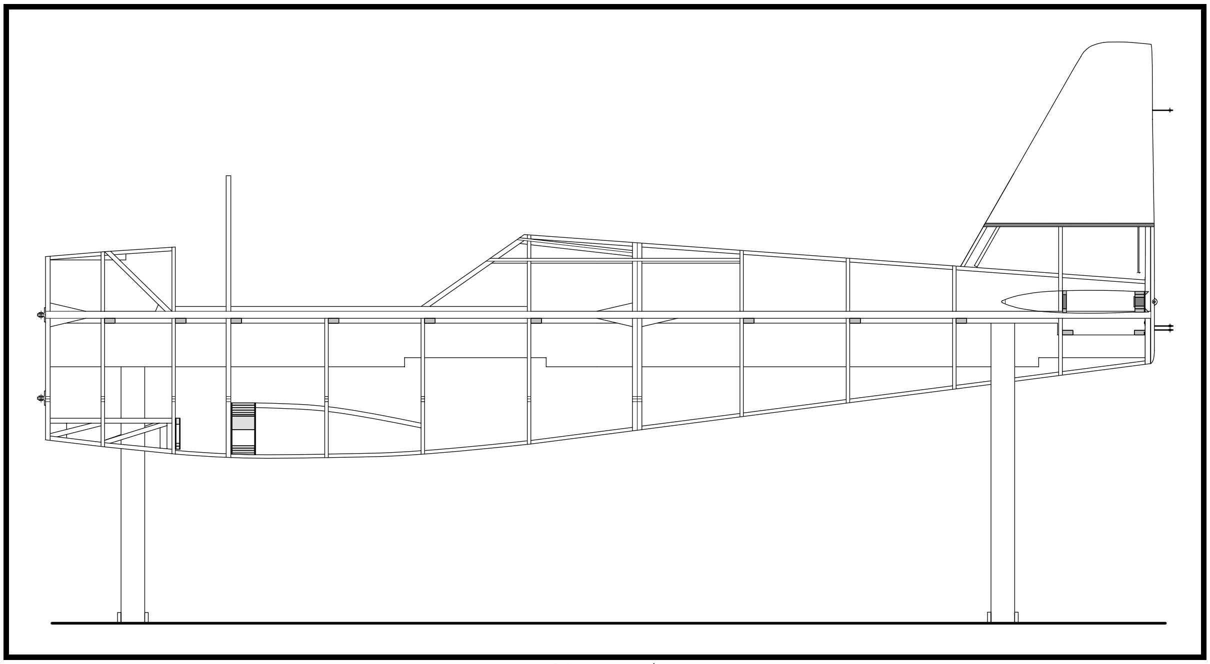


Figure 5

❑ Glue in place the two 20x18 spruce strips for the top of the framing for the nose gear bay walls. See Figure 5.

❑ Skin the nose wheel bay wall inboard faces with 2mm birch plywood.

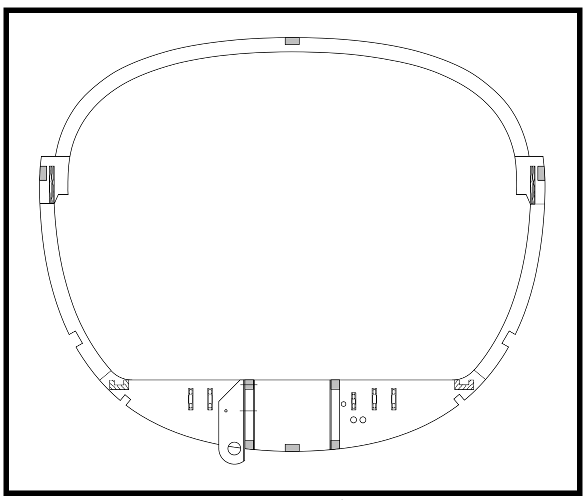


Figure 6

❑ Drill the four 3/16"Ø holes in the right nose wheel bay wall for P/N 717 per Drawing No. 105. To drill these holes, turn P/N 717-2 bracket upside down on the front face of frame No 3 as shown in Figure 6. Use a long drill to drill these holes from the right side of the airplane. The channel-nut for the rudder cable pulley must be removed for this operation.

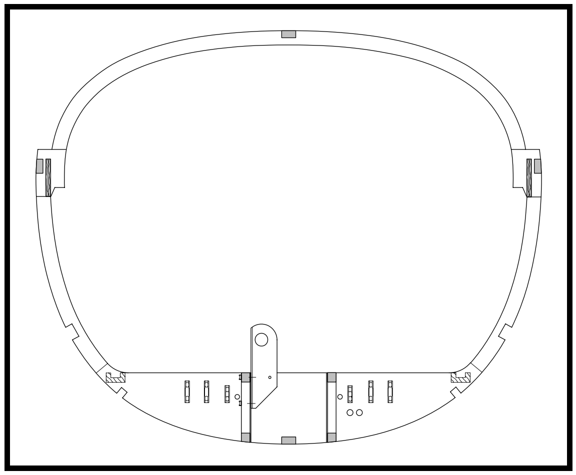


Figure 7

❏ Turn P/N 717-2 right side up, install the bolts and channel-nuts and drill the 3/16"Ø hole through fuselage frame No. 3 and the front wing spar. See Figure 7. Install the bolt. At this point you really don't want to do anything more than check the fit of P/N 717-2 and maybe draw it's outline so you can put the corner blocking in place correctly. P/N 717-2 will be removed, zinc chromated and assembled at a later stage.

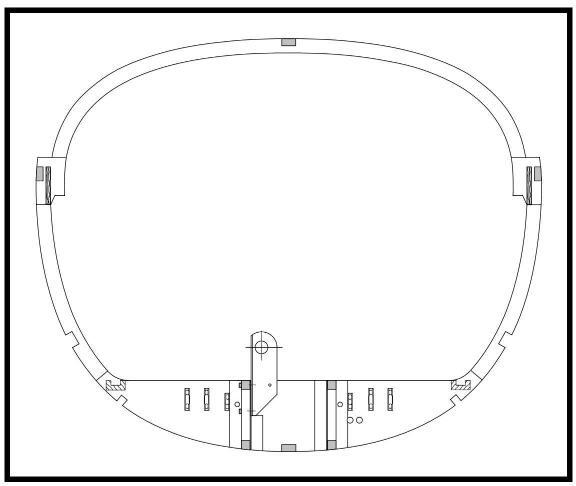


Figure 8

❏ Install 25x25 spruce corner blocking at the aft end of the nose gear bay. See Figure 8. The corner blocking below P/N 717-2 must be shorter, obviously. On the outside of the nose gear bay walls, the corner blocking must be notched to fit around the channel-nuts for P/N 717-2 and drilled for the rudder cables.

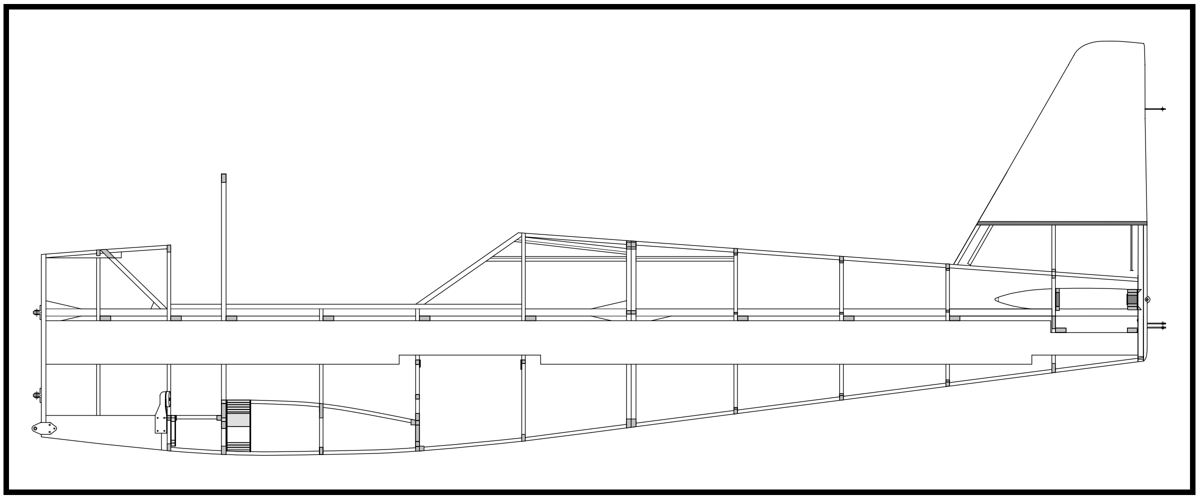


Figure 9

❏ Drill the three 3/16"Ø holes through the nose gear bay walls for P/N 708 nose gear upper drag strut support per Drawing No. 114. If you are going to line the nose gear bay walls with stainless steel, you must allow for its thickness. See Figure 9.

Note: The production Falcos had an "Italian firewall"—a stainless steel lining for the nose gear bay with an aluminum nose gear bay cover. Some measure of fire protection is advisable, although most homebuilders do nothing except paint the nose gear bay with the same paint that is used on the outside of the airplane. If you plan to use stainless steel in the nose gear bay, you should install it now and allow for the thickness of the steel under the nose gear upper drag strut supports. Because stainless steel is difficult to install, you may want to consider lining the nose gear bay with Fiberfrax insulation or using a flame blocking paint (sold by Wicks Aircraft).

On the front face of the firewall, many builders use plywood pads under all fittings so that no Fiberfrax will be between the stainless steel and the wood structure at the point of attachment since that would be a flexible sandwich. To accommodate this, some builders have put 2mm-thick plywood plates between the forward face of frame No. 1 and the drag strut supports.

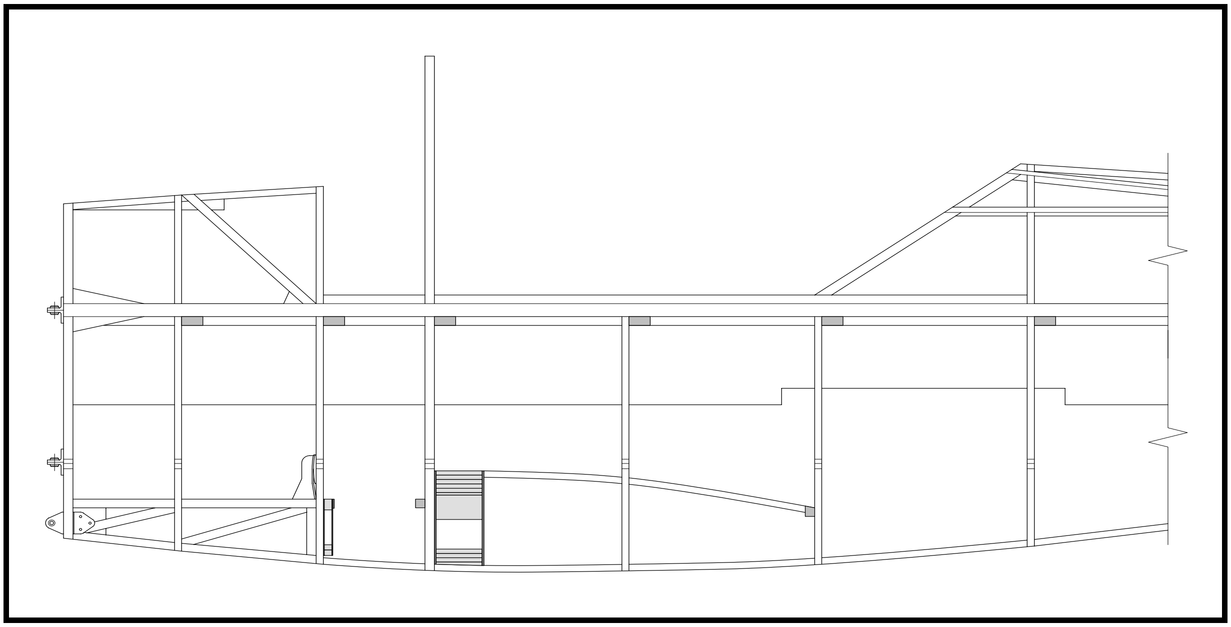


Figure 10

- ❏ Remove P/N 708. Clamp P/N 776 in place. Use a 3/16" transfer punch to locate the five holes in P/N 776. Drill these five 3/16"Ø holes in P/N 776. See Figure 10.

- ❏ Install 25x25 corner blocks above P/N 708 and 776 on the inboard and outboard sides of the nose gear bay wall. Except for the bottom strip of spruce, the nose gear bay wall is glued to the aft face of frame No. 1 in a butt joint and this should be reinforced with corner blocks.

The rest of this chapter covers a number of different little odd jobs. There is no reason to do any of these remaining jobs in any particular order, so feel free to bounce around.

Cockpit Flooring

Some parts of the work on the cockpit flooring may be difficult to do with the fuselage jig in place and you may elect to postpone some of these steps until later when you can climb into the aircraft. Our intent is to accomplish as much of this work as possible while the bottom side longerons are not installed for easier access.

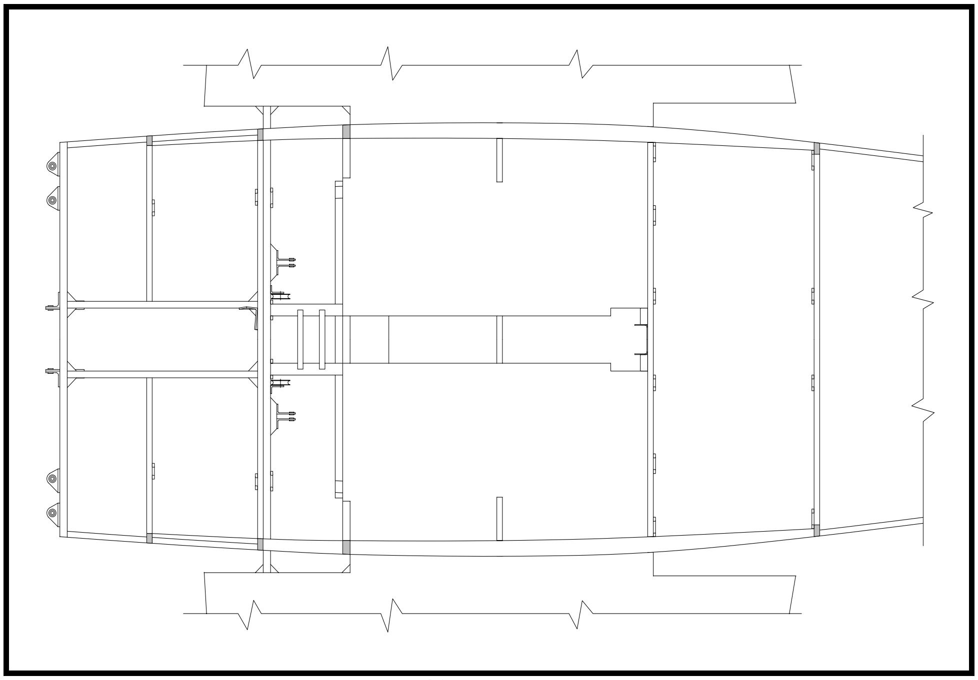


Figure 11

- ❏ Assemble and install the center flooring supports between Sta. 3 and 4 as shown in Drawing No. 315. See Figure 11. The strip on the forward face of Frame 4 should already be notched to receive the flooring supports (see Chapter 23, Figure 13). At the forward end, the 30x15 floor supports are supported by saddle gussets (see Chapter 23, Figure 18). The plans show the two 15x15 members (these are supports for the trim tab control) notched into the 30x15 fore-and-aft members. It really doesn't matter if these are notched or not since the plywood flooring will tie it all together. If you wish, you may notch the 30x15 pieces just enough so that the 15x15 are firmly located in place while gluing.

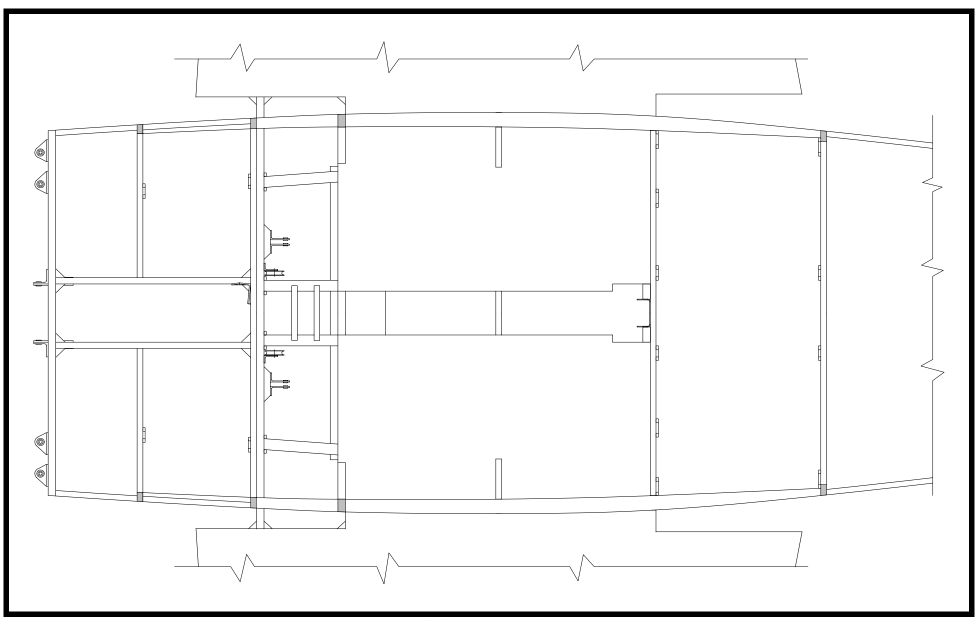


Figure 12

❏ Install outboard flooring supports between Sta. 3 and 4. See Figure 12.

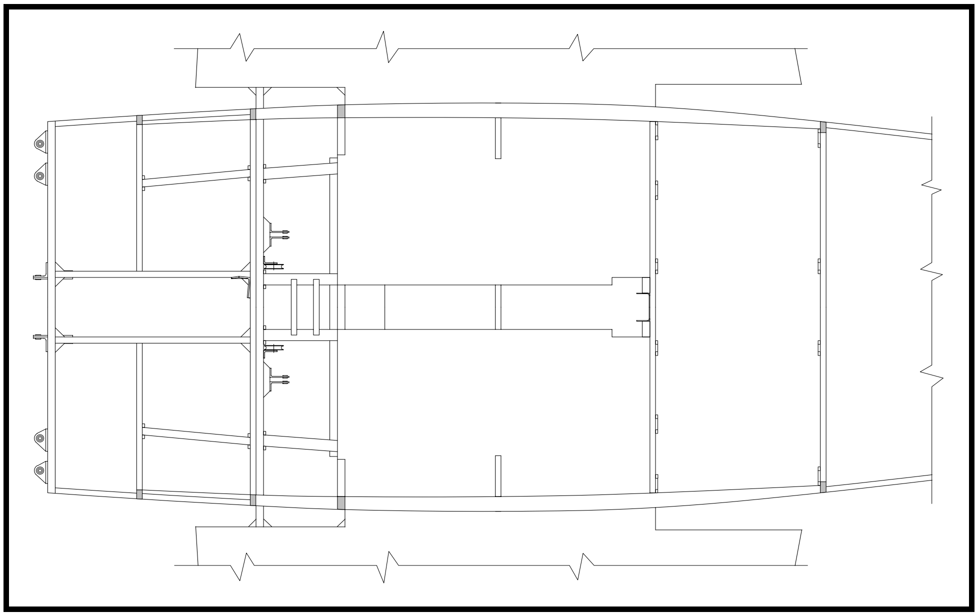


Figure 13

❏ Install the flooring supports between Sta. 2 and 3. See Figure 13.

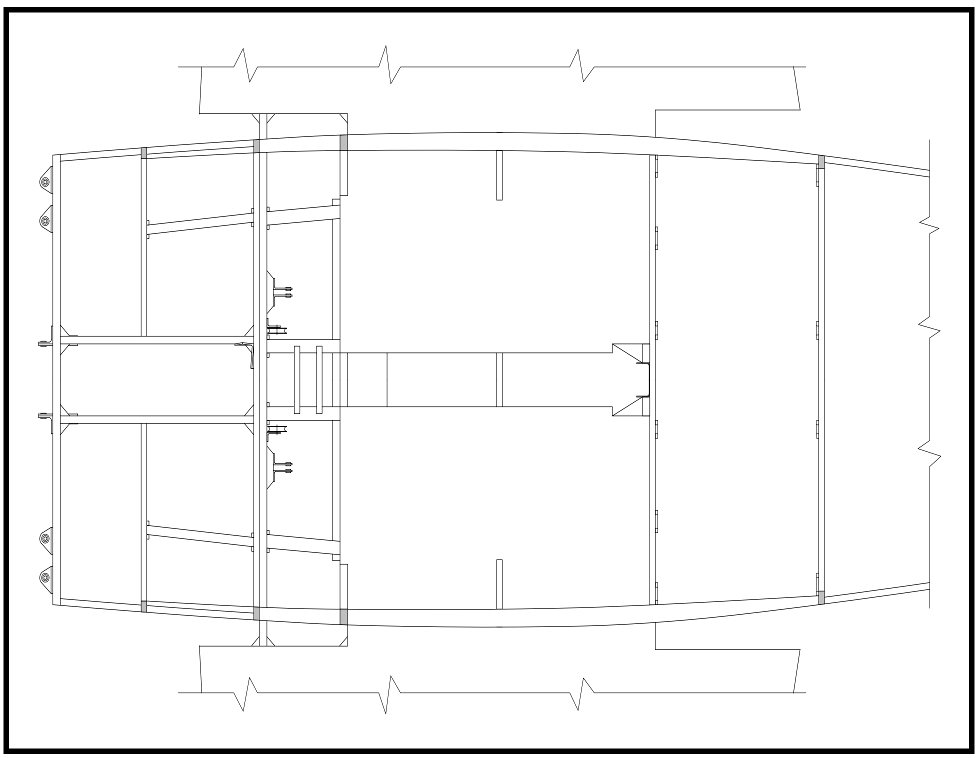


Figure 14

❏ Install corner blocks between the seat supports and the 20x20 spruce strip on the forward face of frame No. 6. The purpose of this is to provide some additional strength for the center seat belts. See Figure 14.

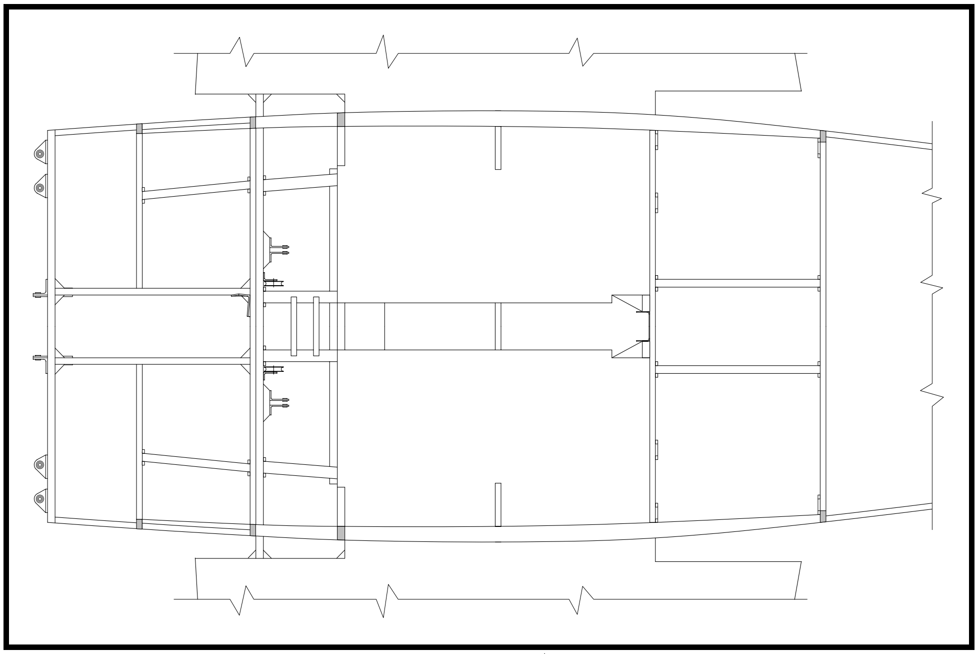


Figure 15

❏ Install the center luggage compartment floor supports. See Figure 15.

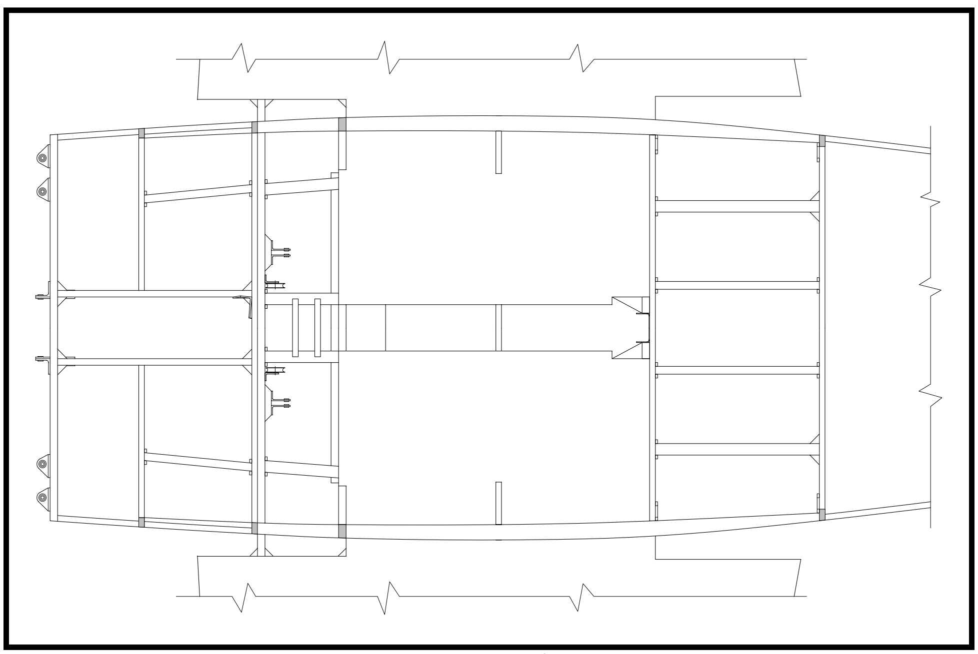


Figure 16

❏ Install the luggage compartment flooring support at B.L. 315. Because the aft end butts against the cross member of frame No. 7, the best way to make the joint is to install a 25mm corner block on each side and glue a plywood gusset on the bottom. See Figure 16.

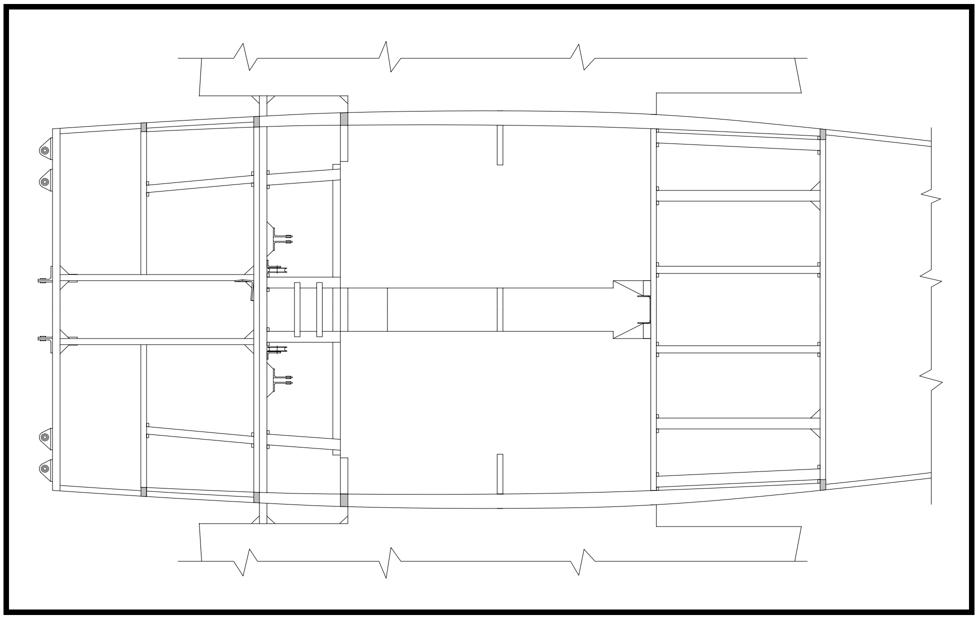


Figure 17

❑ Install the outboard luggage compartment flooring supports. See Figure 17.

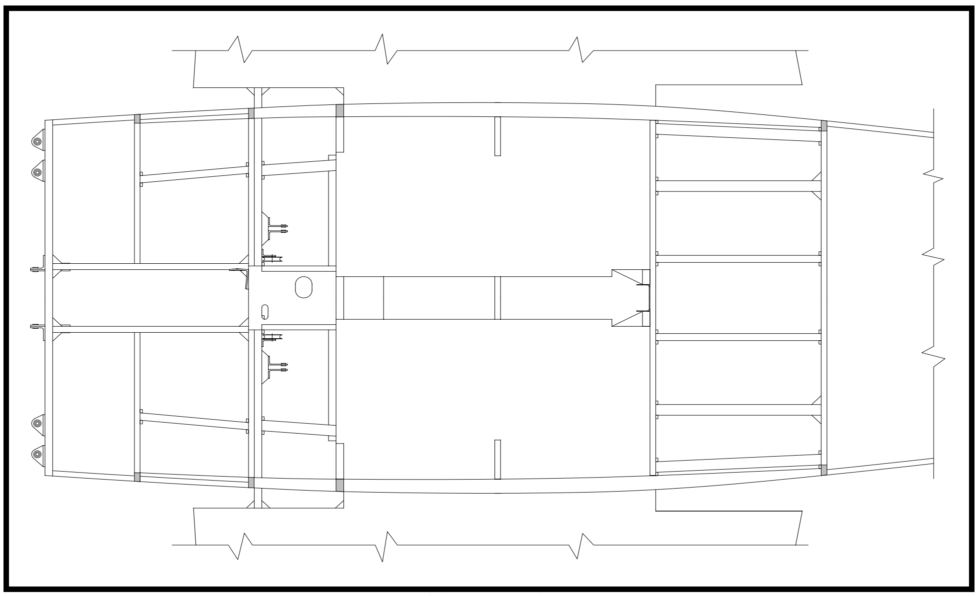


Figure 18

❑ Cut, fit and install the center floor between Sta. 3 and 4. See Figure 18. The greater width at the front is to accommodate the foot of the instrument panel pedestal, which you can see on Drawing No. 831-1. The two holes are for wiring and plumbing. The larger hole on the right side will take most of the wiring, but there will be a few things which will dive down in front of the control stick support. You don't need a big hole, say 25 wide and you can make its width to match the opening in the bottom of the instrument panel pedestal. You will have ample opportunities to varnish the bottom of the floor board later, so just glue the plywood in place.

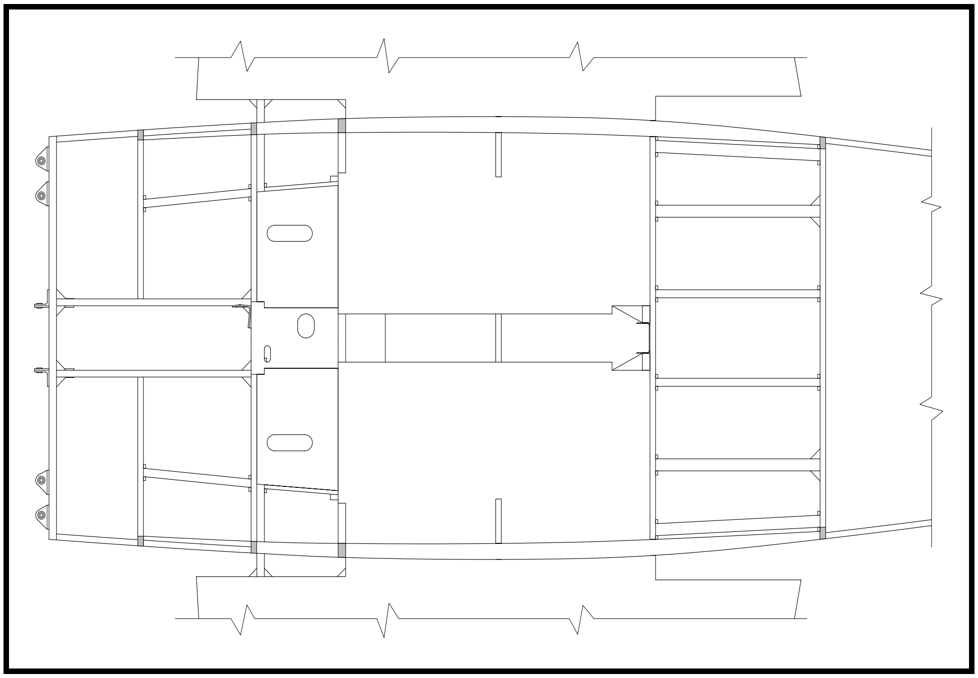


Figure 19

- ❏ Cut the two removable floor boards to fit the area between Sta. 3 and 4. See Figure 19. The outboard edge should be 10mm from the outboard edge of the outboard floor support (to leave room for the gluing strip for the inside cockpit side walls). Cut the openings for the control sticks.

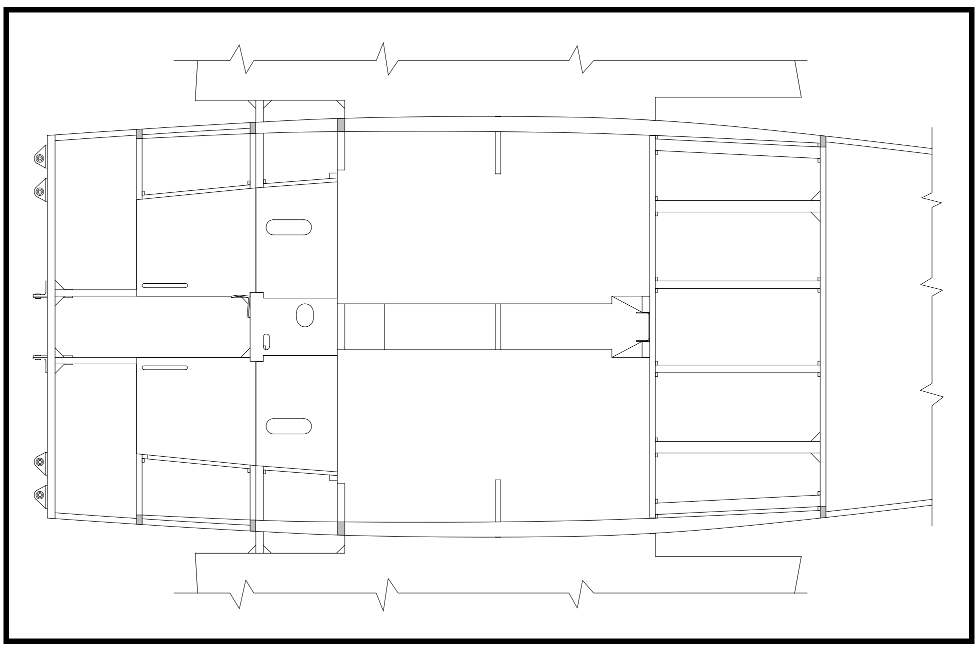


Figure 20

- ❏ Fit and install the flooring between Sta. 2 and 3. Cut the holes for the rudder cables. Leave 10mm on the outboard edge for the gluing strips for the cockpit side walls. See Figure 20.

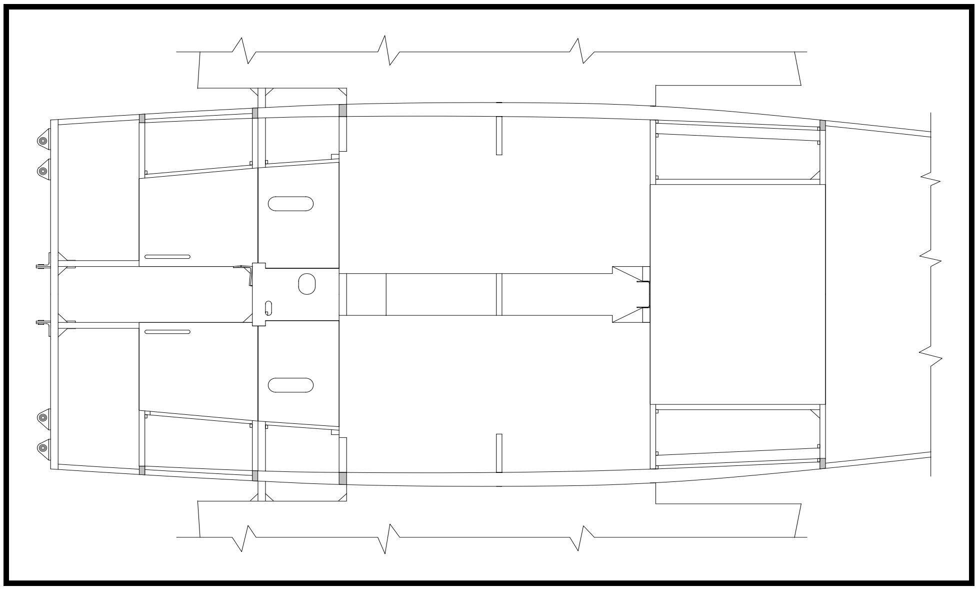


Figure 21

❏ Cut and fit the removable center floor board for the luggage compartment floor. See Figure 21. Do not install any of the screws yet since their location may conflict with the installation of the strobe power supply.

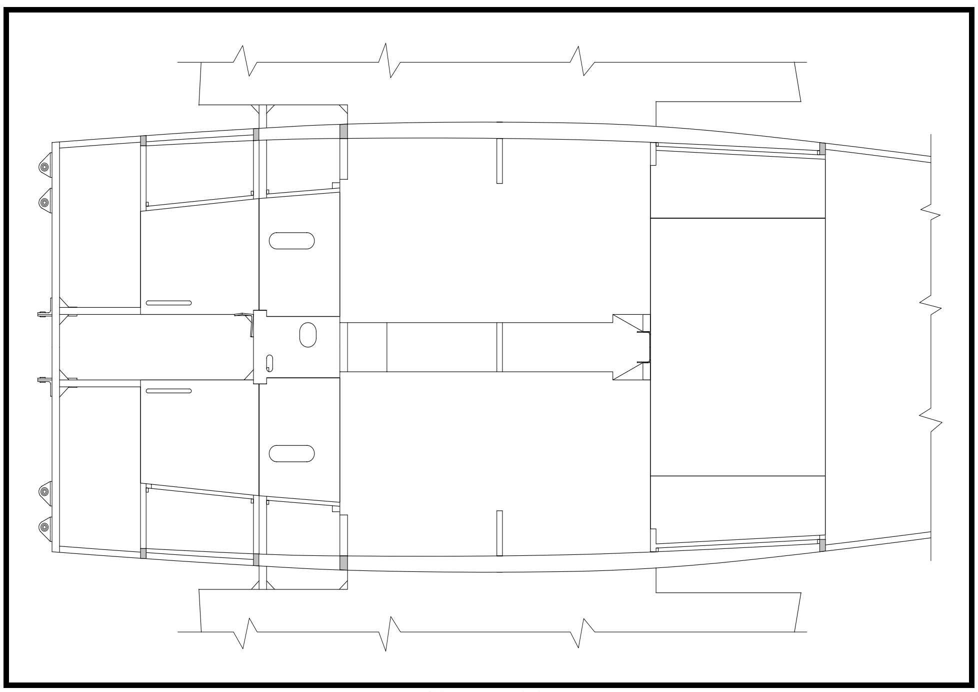


Figure 22

❏ Fit and install the flooring on the outboard sides of the luggage compartment. Leave 10mm for the side wall gluing strip.

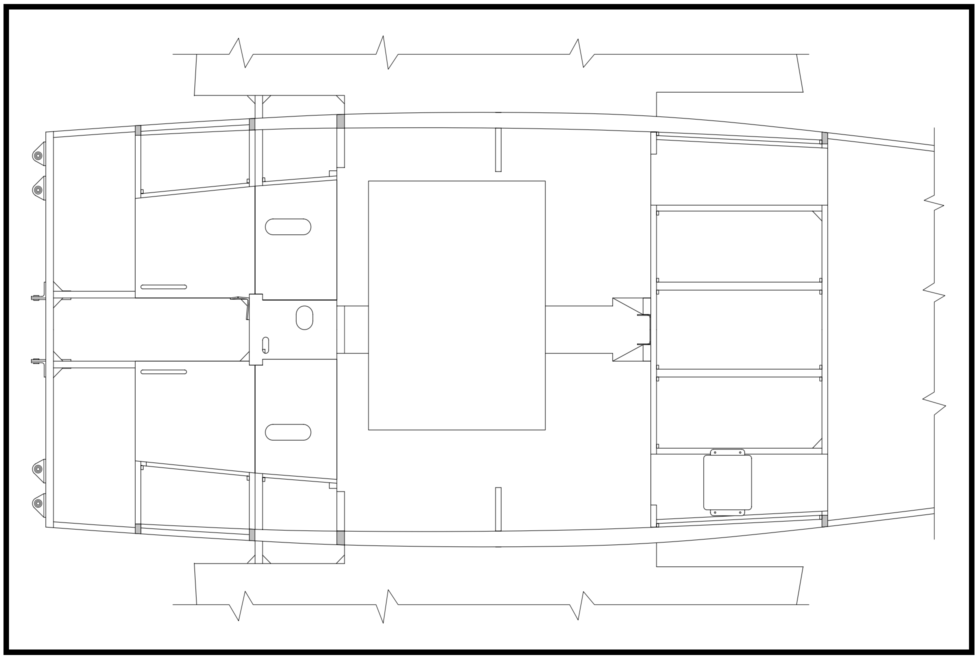


Figure 23

- ❏ Remove the center luggage compartment floor and position the strobe power supply as shown in Figure 23. (The power supply will be installed on the underside of the floor, but it's easier to locate the holes this way.) The two inboard holes should be located just inboard of the plywood floor, so that the screw heads will be hidden under the removable center luggage compartment floor. The outboard holes should be located just inboard of the cockpit side walls so that you will always be able to get to the mounting screws with a screwdriver by lifting up the edge of the carpet. Drill the four 3/16" holes and set the power supply aside.

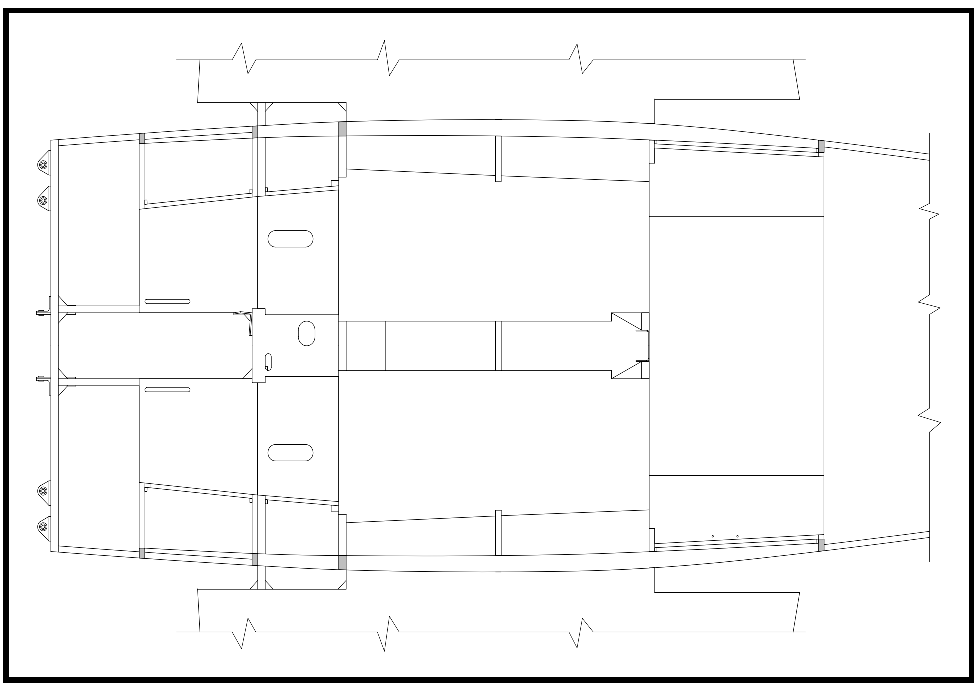


Figure 24

❏ Lay out the location of the intersection of the cockpit side walls with the upper wing skin. Note that the side walls will not attempt to follow the radiuses on frames 4 and 5. You should have previously installed gluing strips on the front face of frame No. 6 as shown in Chapter 23, Figure 28. It is essential that the side walls be as far outboard as possible just in front of frame 6 so that the seats don't hit them.

❏ Use cardboard or kraft paper and make patterns for the carpet that will be installed in the airplane. (This may seem like an extreme thing to do, but it's very easy to make these patterns now—and a real bear after everything is installed—so *do it*.) Be sure to make patterns for the forward face of frame 4 and 6. After you install the seat track supports and at other occasions, you'll need to make changes to the carpet patterns. We'll try to remind you when to do this, but you can keep your brain in gear, too.

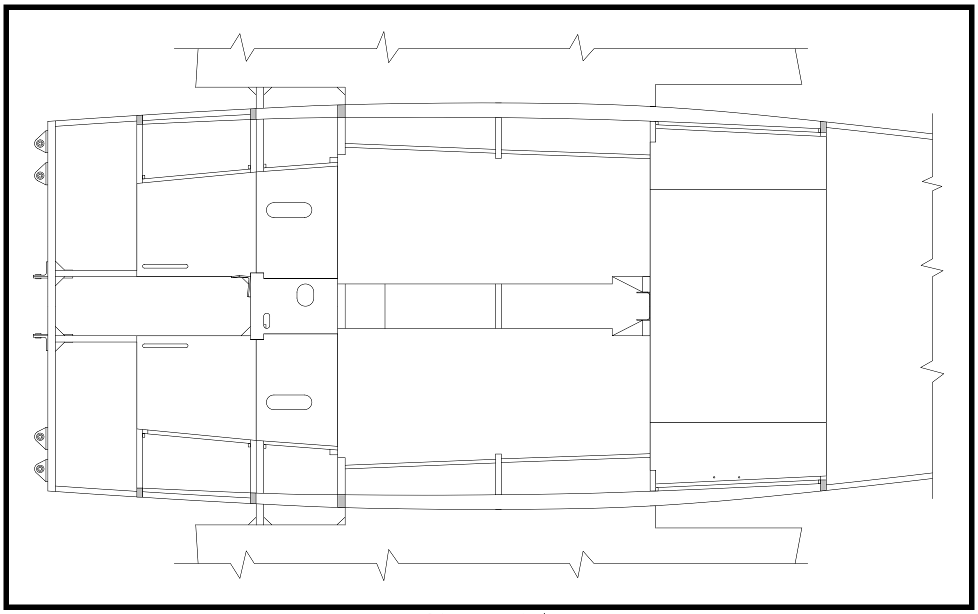


Figure 25

❏ Install the gluing strips for the inside cockpit side walls between Sta. 2 and 3 on each side of the aircraft. See Figure 25.

❏ Install the gluing strips for the inside cockpit side walls between Sta. 3 and 4 on each side of the aircraft. See Figure 25.

❏ Install the gluing strips for the inside cockpit side walls between Sta. 4 and 5 on each side of the aircraft. See Figure 25.

❏ Install the gluing strips for the inside cockpit side walls between Sta. 5 and 6 on each side of the aircraft. See Figure 25.

❏ Install the gluing strips for the inside cockpit side walls between Sta. 6 and 7 on each side of the aircraft. See Figure 25.

❏ In Chapter 25 you were supposed to make a rear cockpit bulkhead of 2mm plywood. If you didn't, do it now.

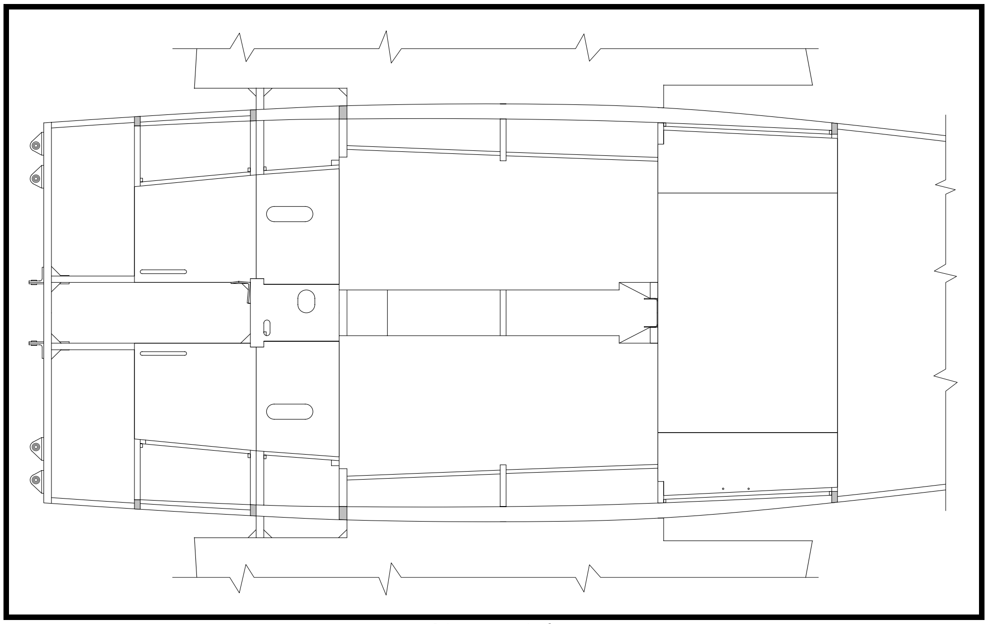


Figure 26

❏ Install the 10x15 spruce strips on the aft outboard ends of the luggage compartment floor. These strips are shown on Drawing No. 315. These strips are permanently glued in place and provide a “lip” for the rear cockpit bulkhead. See Figure 26.

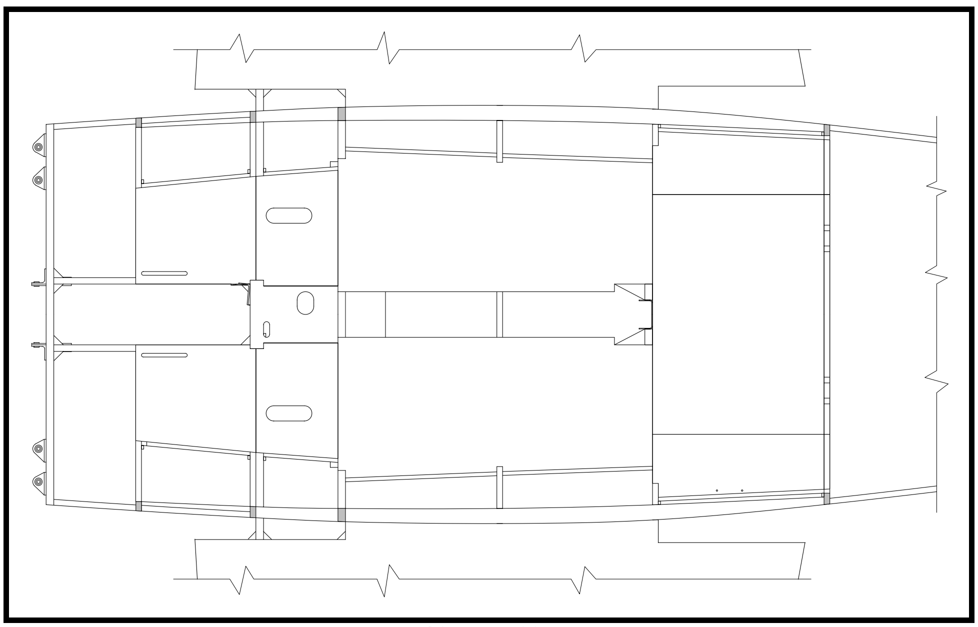


Figure 27

❏ Install the 10x15 spruce strips on the aft end of the center removable luggage compartment floor. These strips are permanently glued in place to the removable floor and provide a “lip” for the rear cockpit bulkhead. See Figure 27, which also shows the blocks installed in the next step.

❏ Install the two spruce blocks located at B.L. 200. These provide two places for screws to fasten the rear cockpit bulkhead. See Figure 27.

Battery Box Installation

There are three batteries that you should consider installing in your Falco. The Gill PS6-11 is a standard lead-acid battery that is rated for 35 amp/hour. This is the standard battery used in aircraft. It is a very good battery and has lots of cranking power. Because the acid is a liquid which can spill if you turn the battery upside-down, this battery is not suitable for negative-g aerobatics.

The Globe Gel/Cell U-128 is a 27 amp/hour battery which can be used for negative-g aerobatics. This is a lead-acid battery, too, but the acid has been converted to a jelly. The Gel/Cell batteries have a reputation for short lives, averaging something like 1-1/2 to 2 years.

A recent development is the “sealed lead-acid, starved electrolyte, flat plate, gaseous recombination” battery. Unlike the Gel/Cell, this type of battery is completely sealed and gives off no gases when it is being charged. Although these batteries are in the same amp/hour category as the Gel/Cell, the manufacturers claim that a very low internal resistance allows a higher starting current and voltage. (We don’t know if this is true or just advertising hype.) These batteries have an expected life of 6 to 8 years.

Gates makes a 2-volt battery that looks like an oversized flashlight battery but with two heavy wires coming out of the end. You are supposed to assemble these into the voltage needed. A more convenient, already-packaged, battery is the Electro Marketing 12-volt, 28 amp/hour battery. The battery looks identical to the Gel/Cell. It’s 7.75” long, 5.2” wide, 7.1” high and weighs 22.8 lbs. It appears that this battery can be installed with the installation hardware supplied in our electrical kit for the Gel/Cell battery. Electro Marketing, 7842 East Gray, Scottsdale, Arizona 85260. Telephone (602) 991-0110.

❏ Remove the 20x10 stringer on the left side of the airplane. It will just be in the way when you build the battery box.

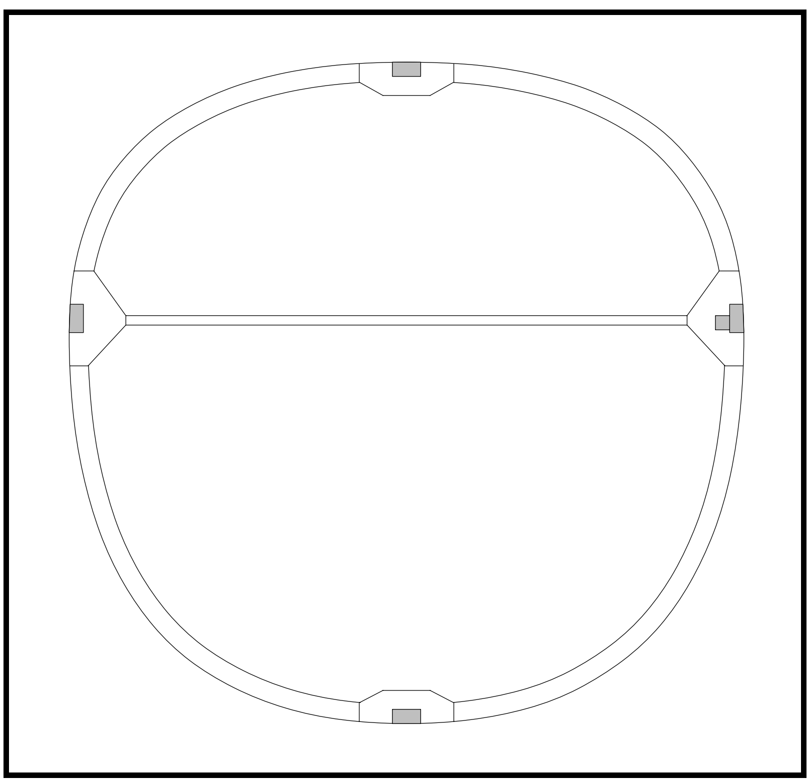


Figure 28

- ❏ Install the 15x15 spruce strip on the inboard face of the upper side longeron. This is the floor support for the battery box and is shown in Drawing No. 320. The top of this strip should be at the same W.L. as the top of the cross brace on frame 8 and 9. See Figure 28.

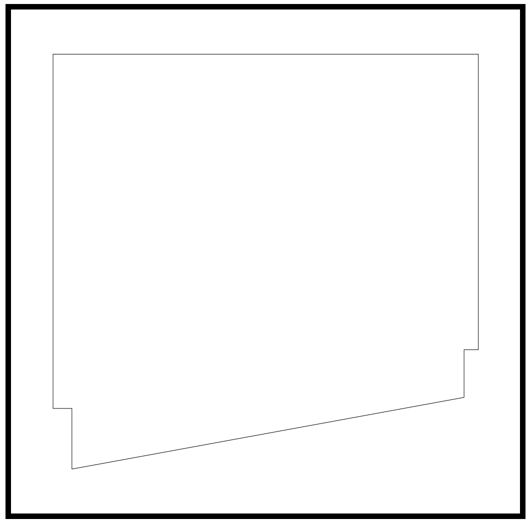


Figure 29

- ❏ Cut the battery box floor board to fit. See Figure 29. This floor board should rest on the cross braces of frames 8 and 9 and on the support just installed on the side longeron.

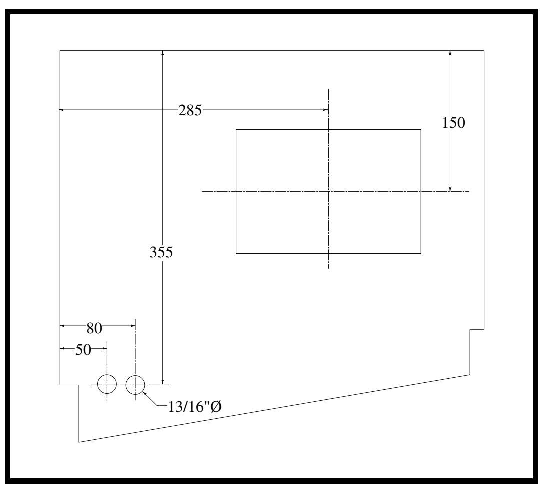


Figure 30

- ❏ Locate the center of the battery at 285mm aft of Sta. 8 and at B.L. 150. Draw the outline of the battery you plan to use. The Gill PS6-11 is 9.75” by 5.00”, the Gel/Cell U-128 is 7.66” x 5.13” and the Electro Marketing is 7.75” x 5.2”. In all cases, the long dimension runs fore-and-aft. See Figure 30.

- ❏ Drill two 13/16”Ø holes as shown in Figure 30. These are for MS35489-14 grommets for the main battery wires.

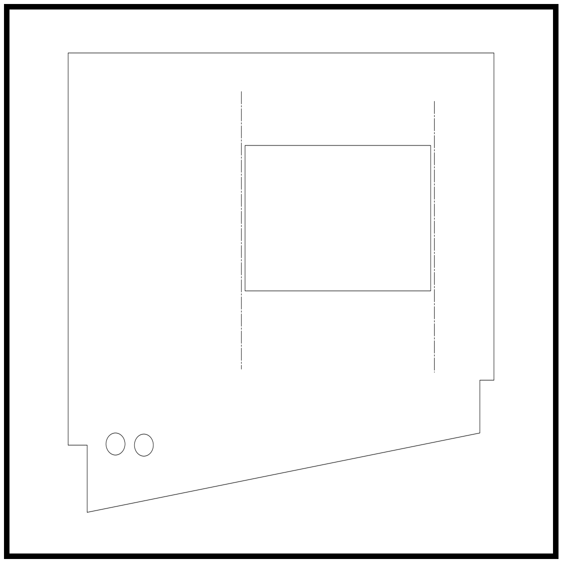


Figure 31

- ❏ Locate the center of the battery hold-down bolts. The hardware is included in the electrical kit. The battery is held down with two 1/4” bolts which are installed with a P/N 846 single-bolt channel-nut. The channel-nuts are installed under the floor with a 15mm-thick spruce block. The bolts come up through the floor on each side of the battery. A nylon bar is installed over the bolts and battery and is held in place with wing nuts. The nylon hold-down bar has the 1/4”Ø holes drilled at 10.13” between centers for the Gill PS6-11 and 8.05” between centers for the Gel/Cell battery. Until you have the battery, you will not be able to exactly locate the B.L. position of the holes. See Figure 31.

- ❏ Draw these same lines on the bottom of the floorboard.

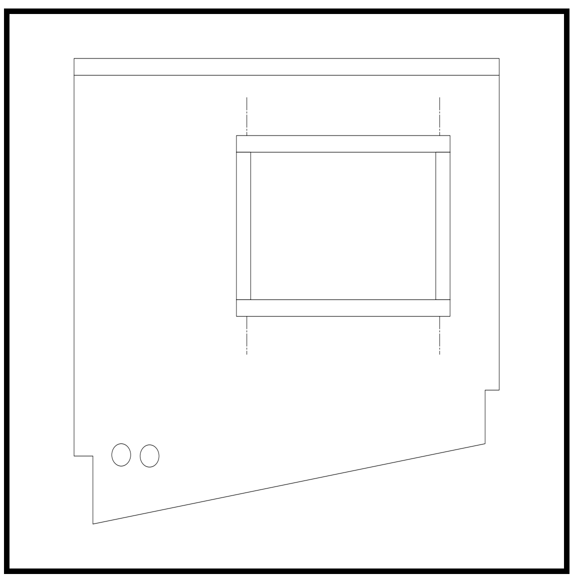


Figure 32

- ❏ Use 15x15 spruce strips and install a “picture frame” for the battery as shown in Figure 32.

- ❏ Install a 15x15 spruce strip along the centerline of the aircraft. See Figure 32.

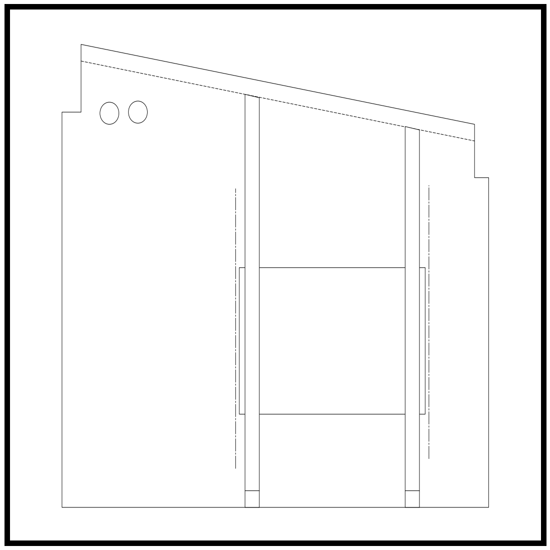


Figure 33

- ❑ Hold the floor board in place on the airplane and trace the outboard floor support on the underside of the floor board.

- ❑ Install the two 15x15 spruce supports on the underside of the floor board. Drawing No. 320 shows the location for these two supports, but the location can be improved slightly as shown in Figure 33. The best location for these supports is with the outboard edge of the supports 10mm in from the center of the holes for the hold-down bolts. This way, the blocking for the hold-down bolts can be located right next to the floor supports and will stronger for negative-g aerobatics. If you attempt to locate the supports closer to the center of the bolts, you will not have room for the channel-nuts—remember there are plywood gussets installed on the supports that go to the lower side longeron.

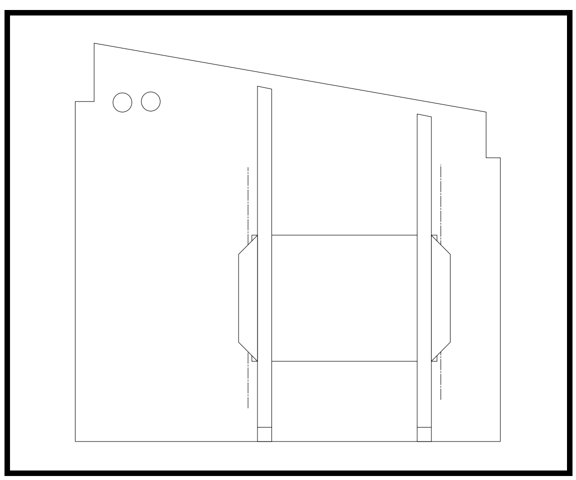


Figure 34

- ❑ Make two 20x15 spruce strips as shown in Figure 34. These will be for the hold-down bolts and channel-nuts. Do not install the blocks at this time since they will intefere with the installation of the floor braces which go to the lower side longerons.

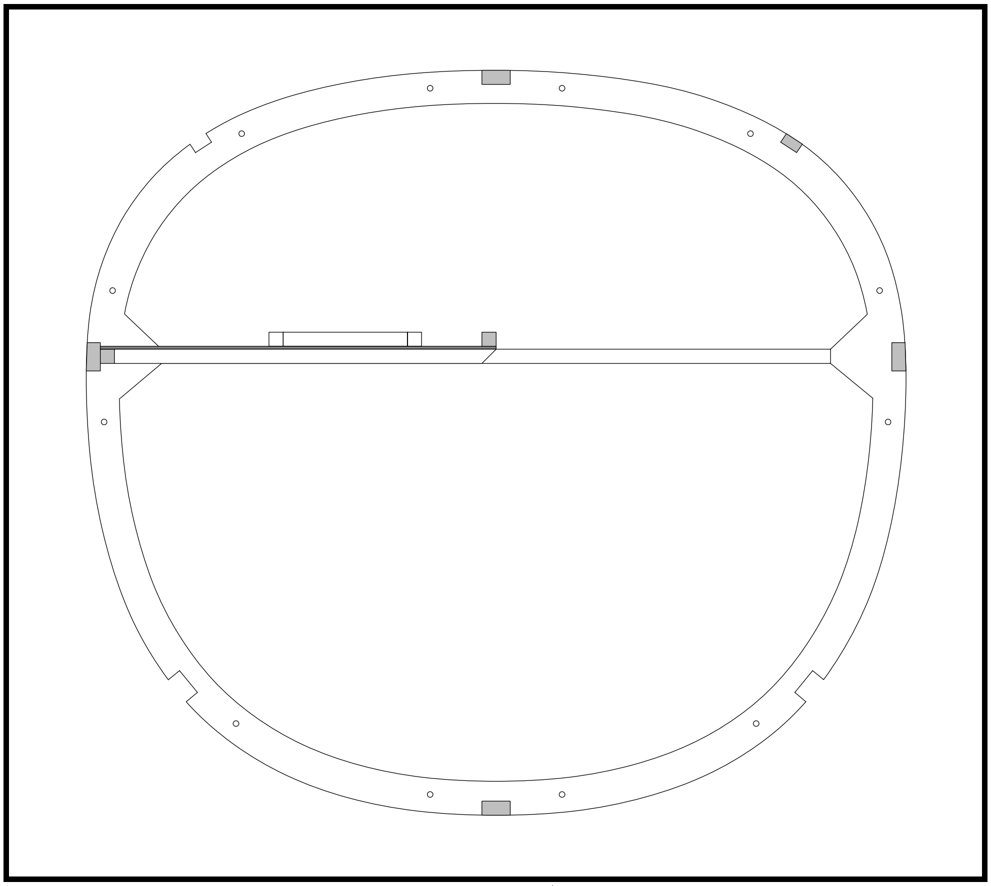


Figure 35

❏ Glue the floorboard assembly in place. See Figure 35, which is a view looking forward at frame No. 8.

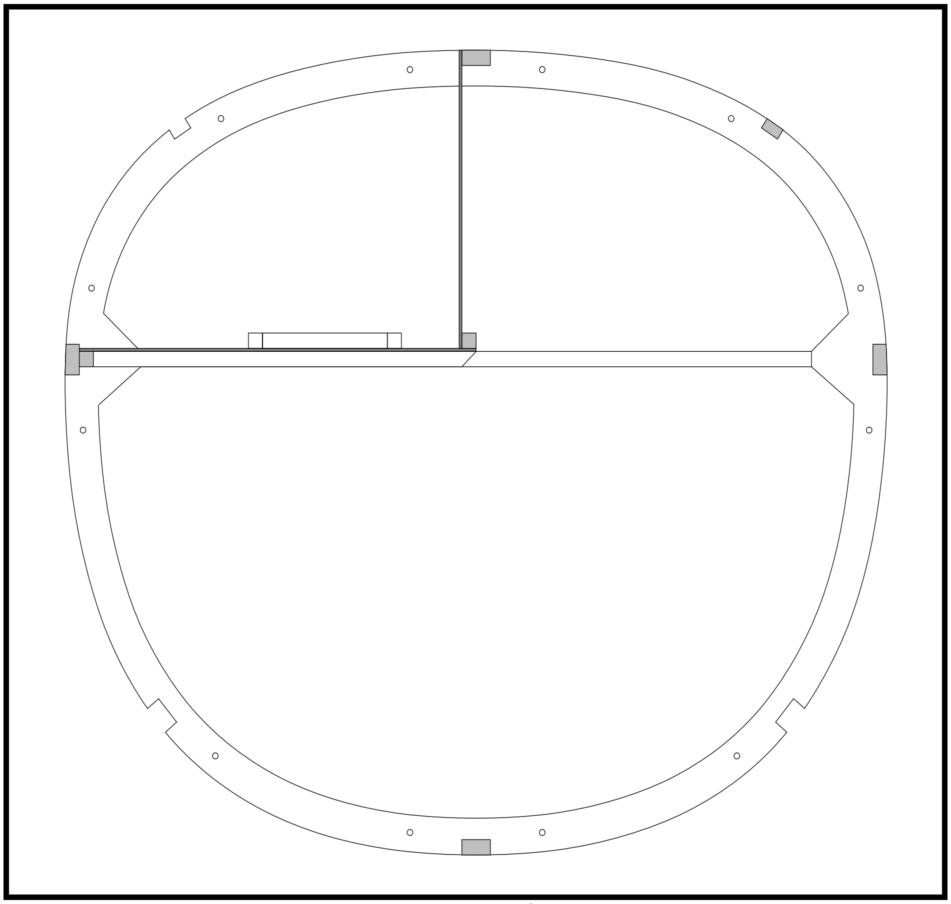


Figure 36

❑ Fit and install the center wall of the battery box. See Figure 36.

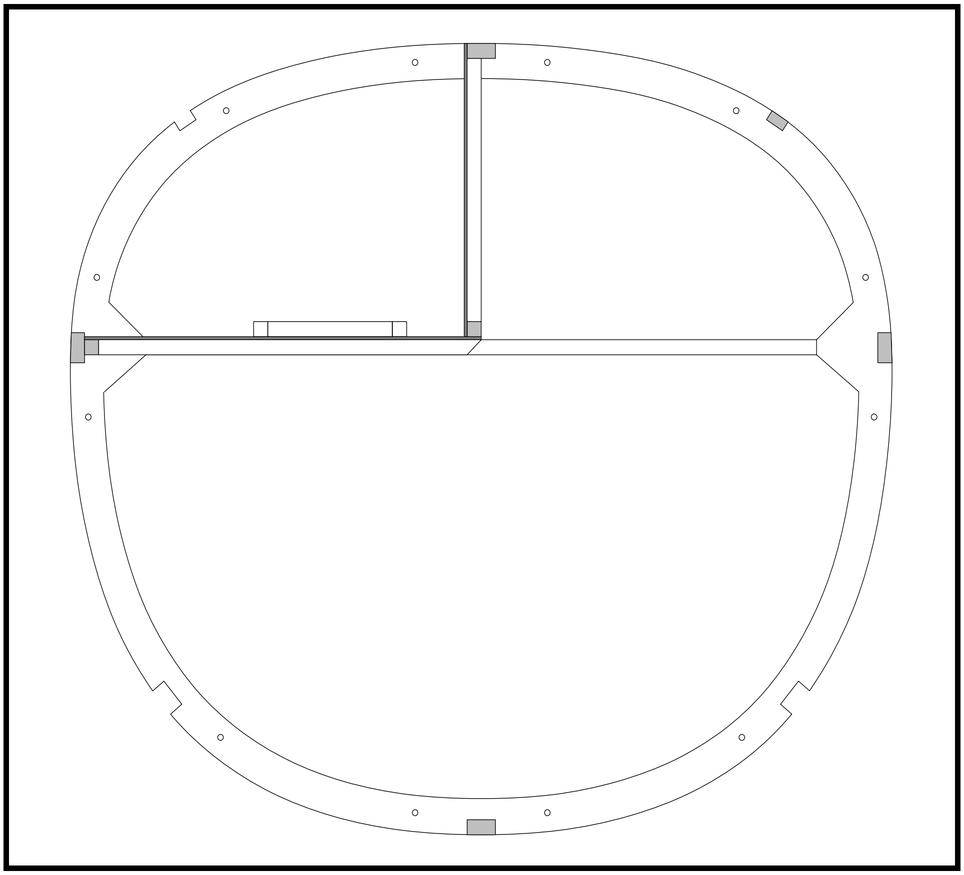


Figure 37

❏ Fit and install the 15x15 brace on the center wall of the battery box. See Figure 37.

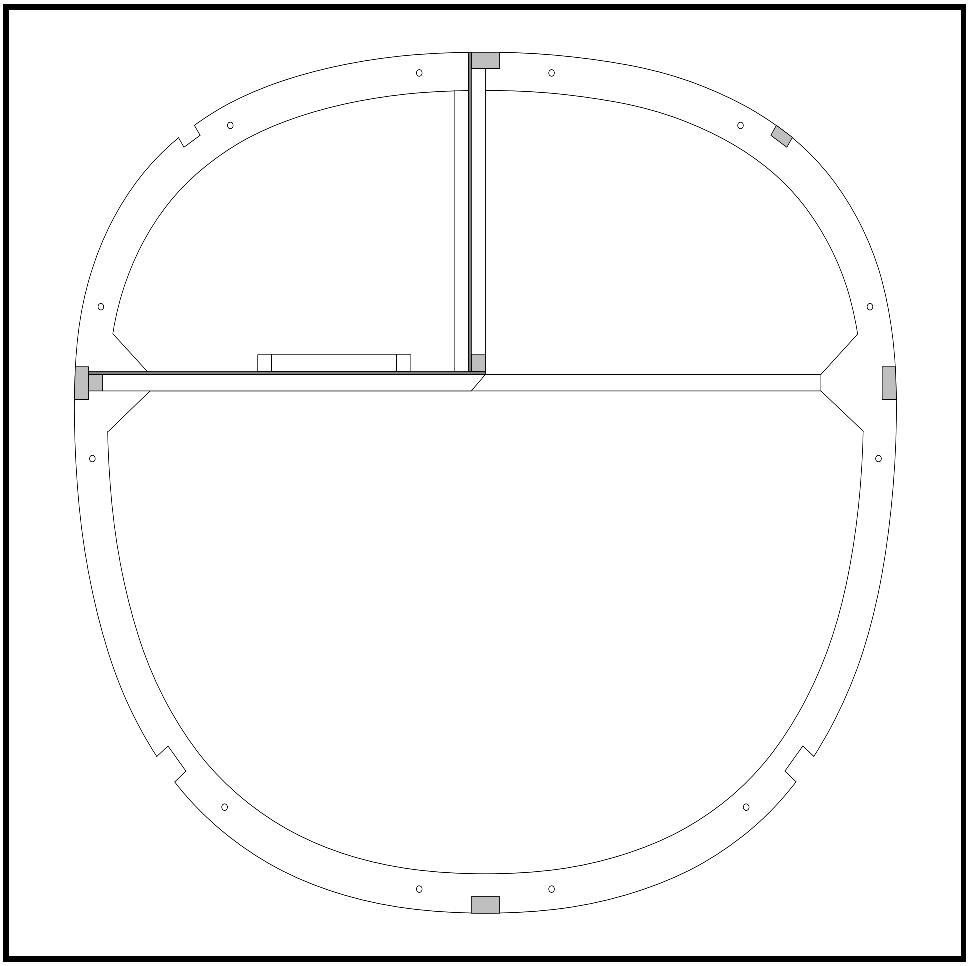


Figure 38

❏ Fit and install the 15x15 spruce brace on the center wall of the battery box at frame 8. See Figure 38.

❏ Fit and install the 15x15 spruce brace on the center wall of the battery box at frame 9.

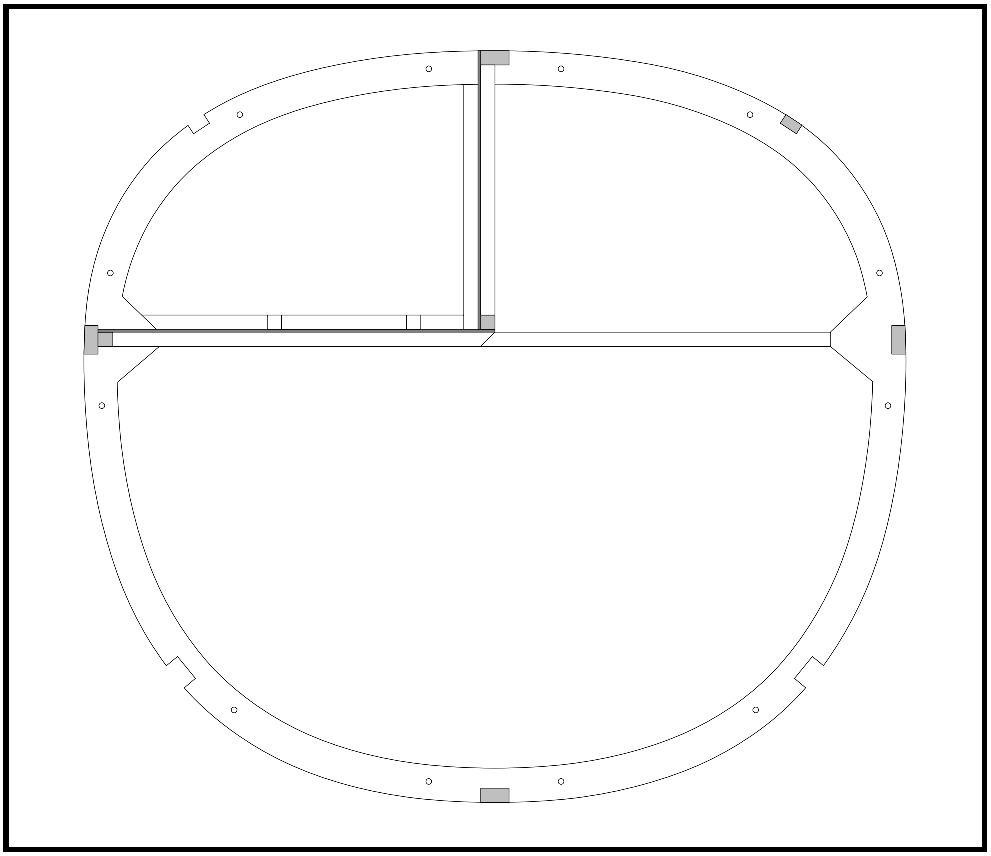


Figure 39

- ❏ Fit and install the 15x15 gluing strip on the battery box floor at frame 8. See Figure 39.
- ❏ Fit and install the 15x15 gluing strip on the battery box floor at frame 9.

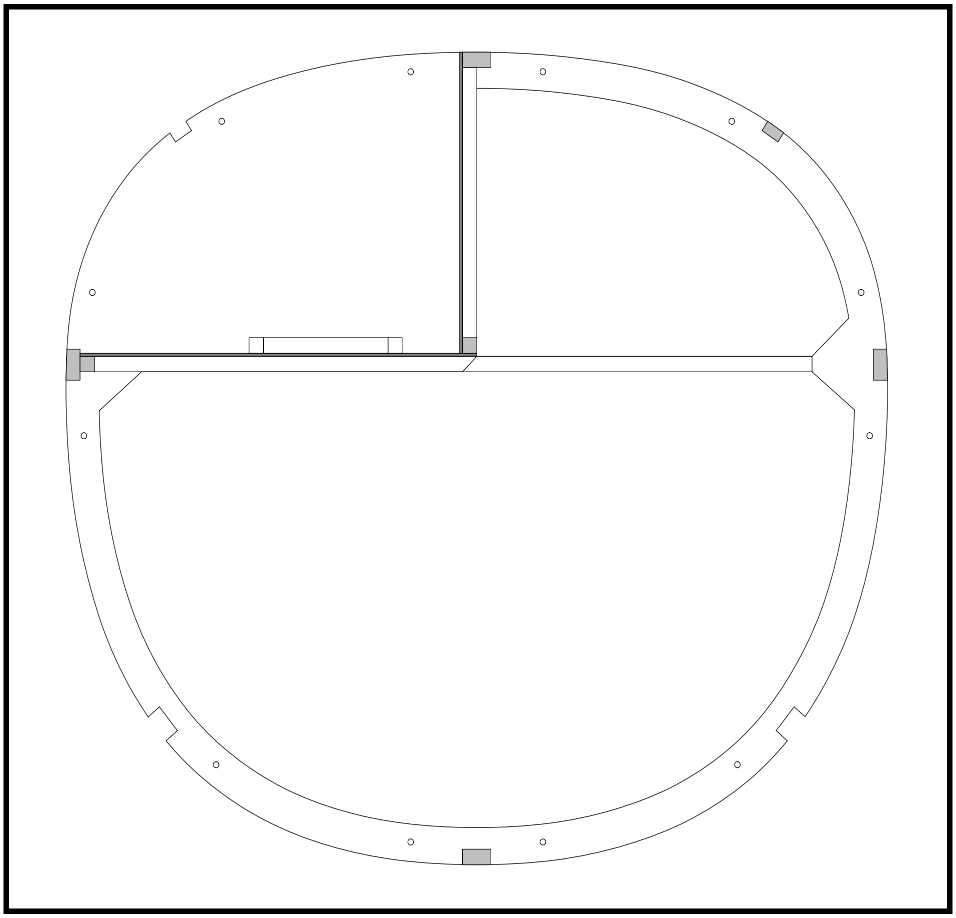


Figure 40

❑ Fit and install the forward wall of the battery box at frame 8. See Figure 40.

❑ Fit and install the aft wall of the battery box at frame 9.

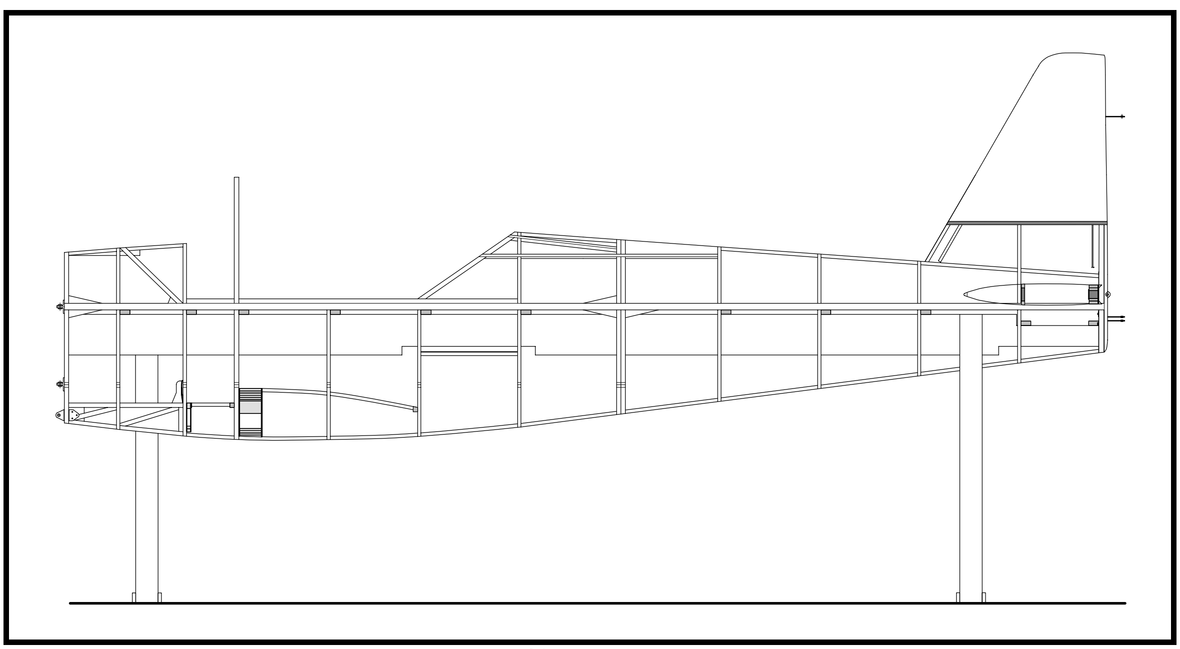


Figure 41

❏ Glue the left 20x10 stringer in place. See Figure 41.

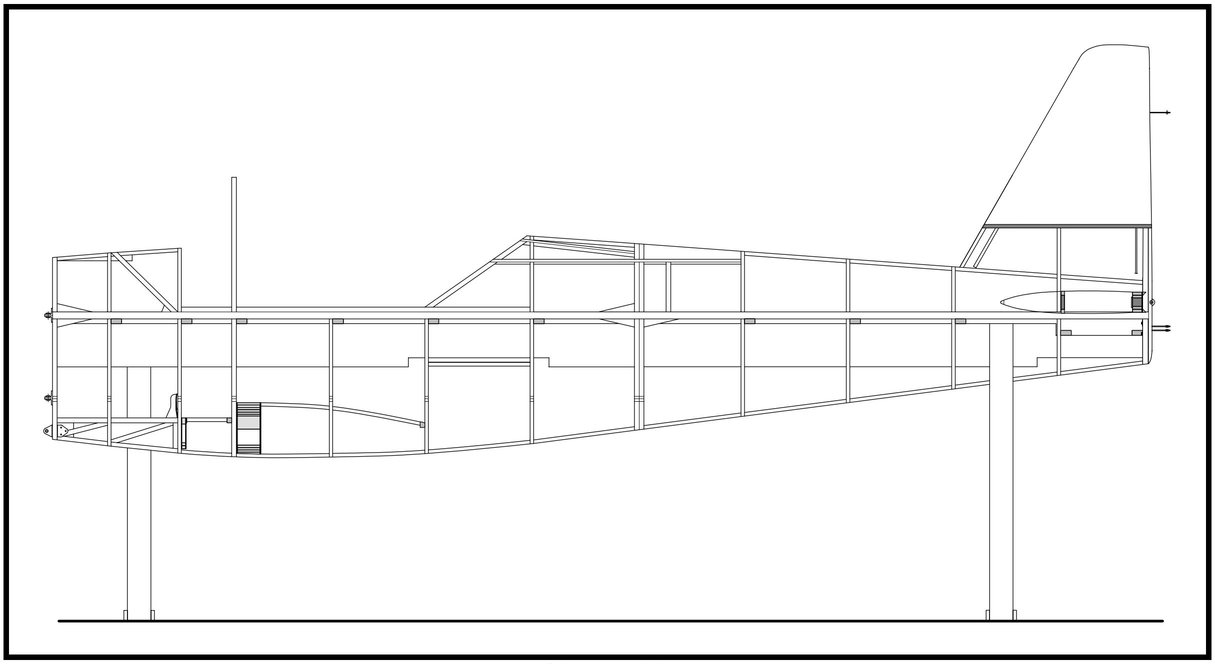


Figure 42

❏ Glue the laminated bow for the forward end of the battery compartment door in place. See Figure 42.

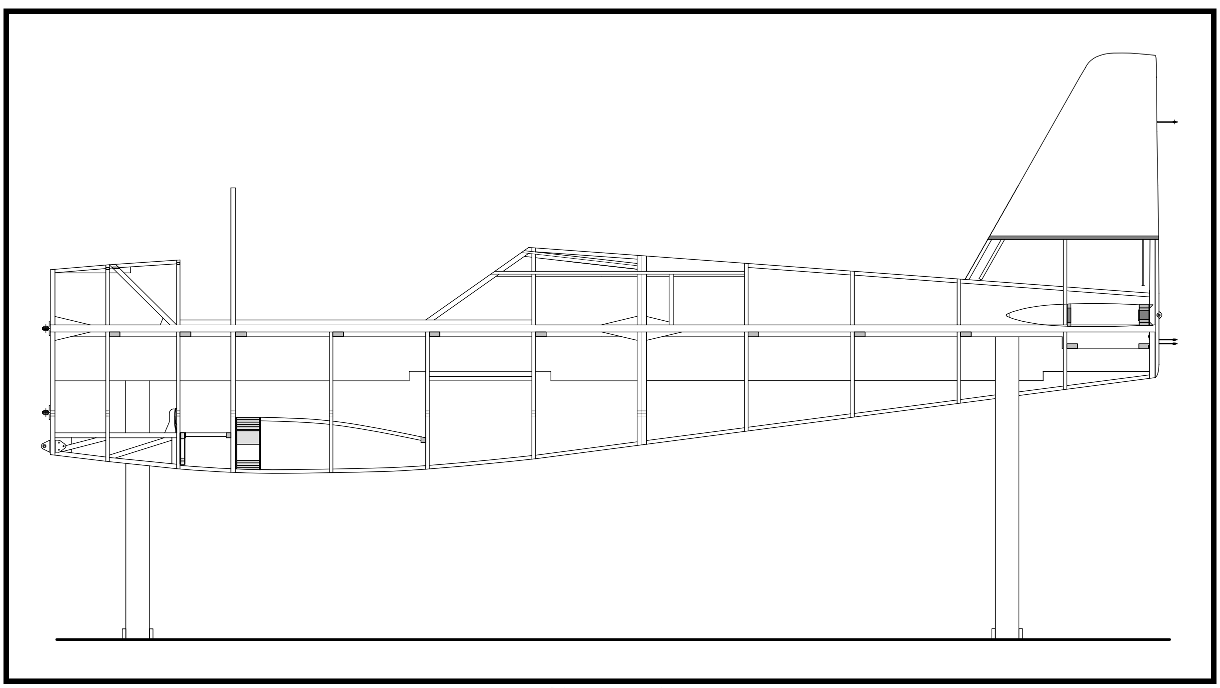


Figure 43

❏ Install the bob-tailed 35x150 corner block on the top of the side longeron. See Figure 43.

❏ Install the 35x150 corner block on the left side of the top center longeron at the aft face of frame No. 8.

- ❏ Install the corner blocks on the forward and aft face of frame No. 8 on the left and right 20x10 stringers. These blocks need only be 20x100. See Figure 43.

- ❏ Install the 20x20 corner blocks at the aft end of the left and right 20x10 stringers, reinforcing the butt joint with frame No. 9.

Exhaust Port Framing

The exhaust ports are not well-detailed in the drawings at this time, however the idea and construction is very simple. You will already have installed the framing on the aft face of frame No. 1 as shown in Chapter 25, Figure 21, and the framing on the forward face of 2 is shown in Chapter 25, Figure 29.

The 15x15 stringer on the outboard side of the exhaust port can be seen on Drawings No. 302, 303 and 304. This stringer extends all the way back to frame No. 3. The 15x15 stringer on the inboard side of the exhaust port can be seen on Drawings No. 302 and 303. This stringer extends only back to frame No. 2. These stringers and other views of the exhaust port framing can be seen on Drawing No. 201, Sheet 1 and Sheet 2.

Some builders have installed the inboard stringer all the way back to frame No. 3 and the stringer takes the same curve as its partner. There is no harm in this except for a few ounces of extra weight. The outboard stringer extend back to frame 3 to reinforce the fuselage skin since the wing leading edge strip attaches to the fuselage there.

The idea is to construct a simple box with 15x15 spruce and then cover it on the top and outer sides with 2 or 2.5mm birch plywood. The heavy plywood strengthens the front end by completing the "torsion box". Equally important, it will serve to keep the noise down. Much of the noise in the cockpit of a Falco comes through the exhaust ports.

By skinning the boxes on the top and outer sides, you create some air space between the plywood and the stainless steel exhaust port shield. In addition to letting noise through, the shield will become quite hot during flight, so the air space is needed for insulation against both heat and noise.

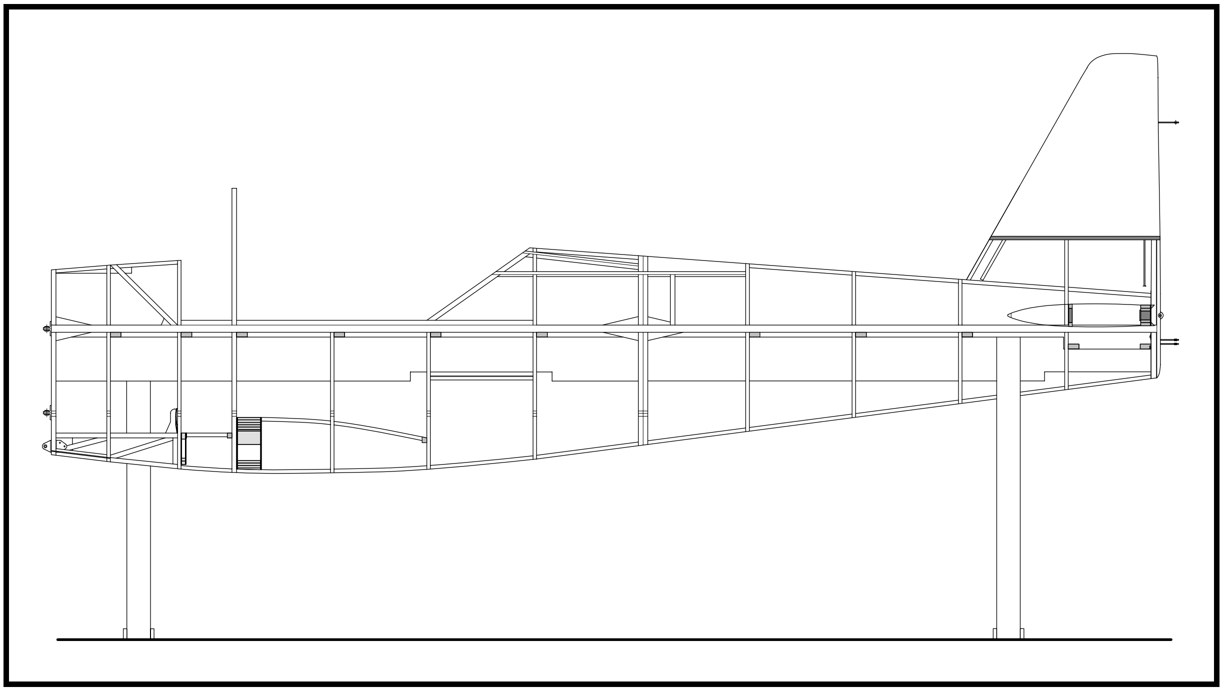


Figure 44

❏ Install the 15x15 stringers on the inboard side of the exhaust ports. The bottom of the fuselage has a slight convex shape, so you may bend the short stringers or make them a little oversized and sand to shape. In either case, you may use the curve of the nose gear bay as a pattern.

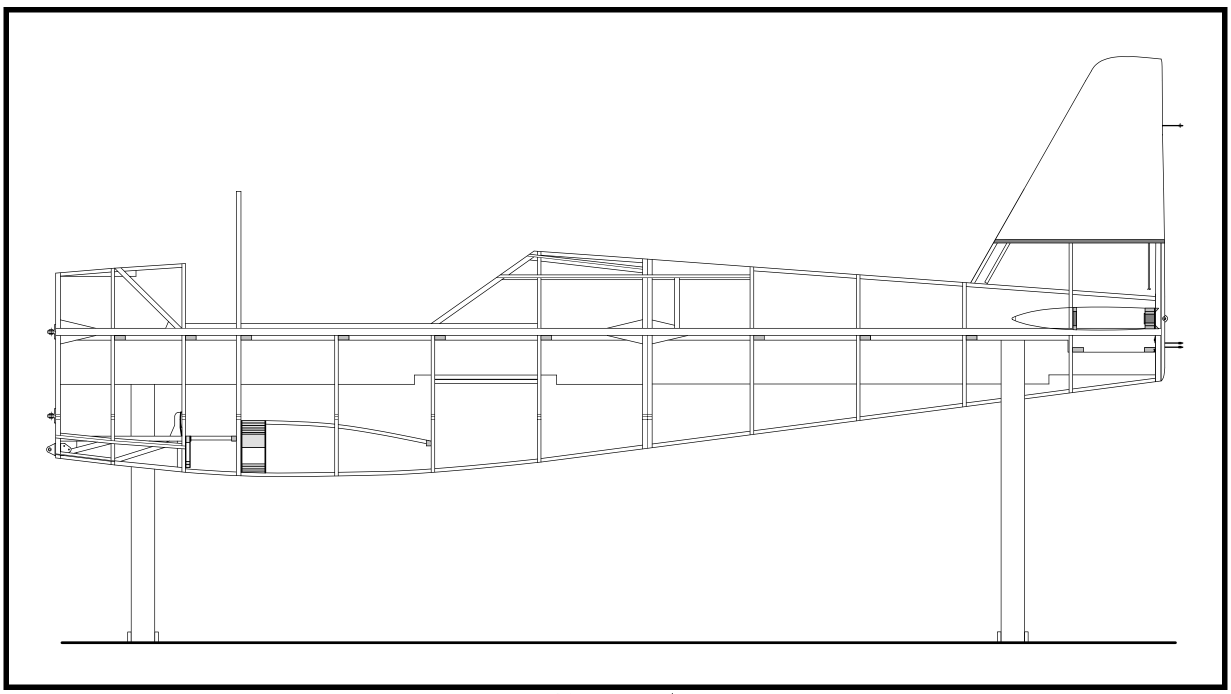


Figure 45

❏ Install the 15x15 stringers on the outboard side of the exhaust ports.

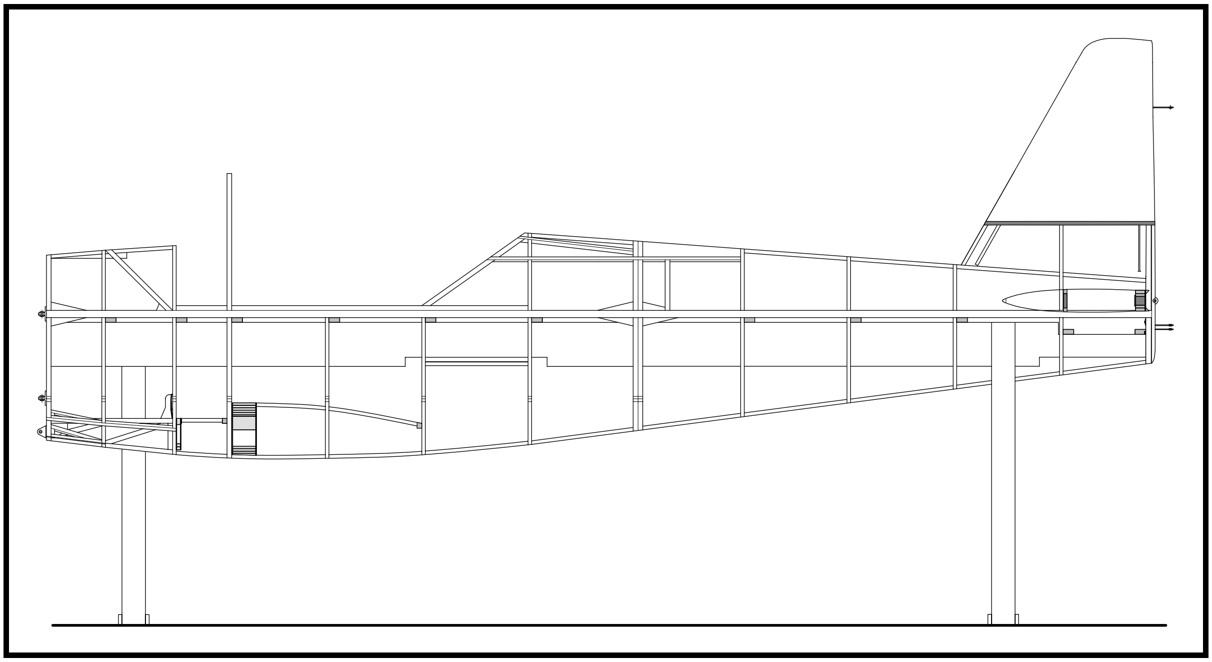


Figure 46

❑ Install the four 15x15 strips of spruce which form the upper corners of the box. These should be tapered on the bottom aft end so that the top of the box will fit against the strip on the forward face of frame No. 2.

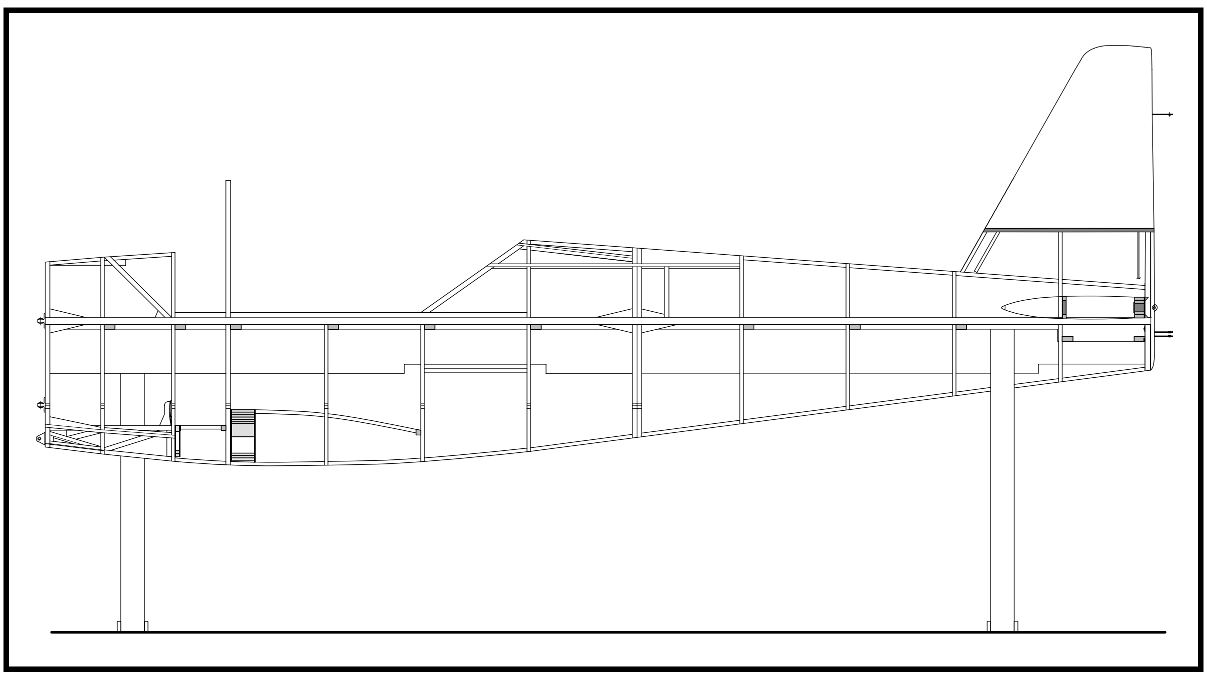


Figure 47

❑ Glue the plywood for the sides of the box in place.

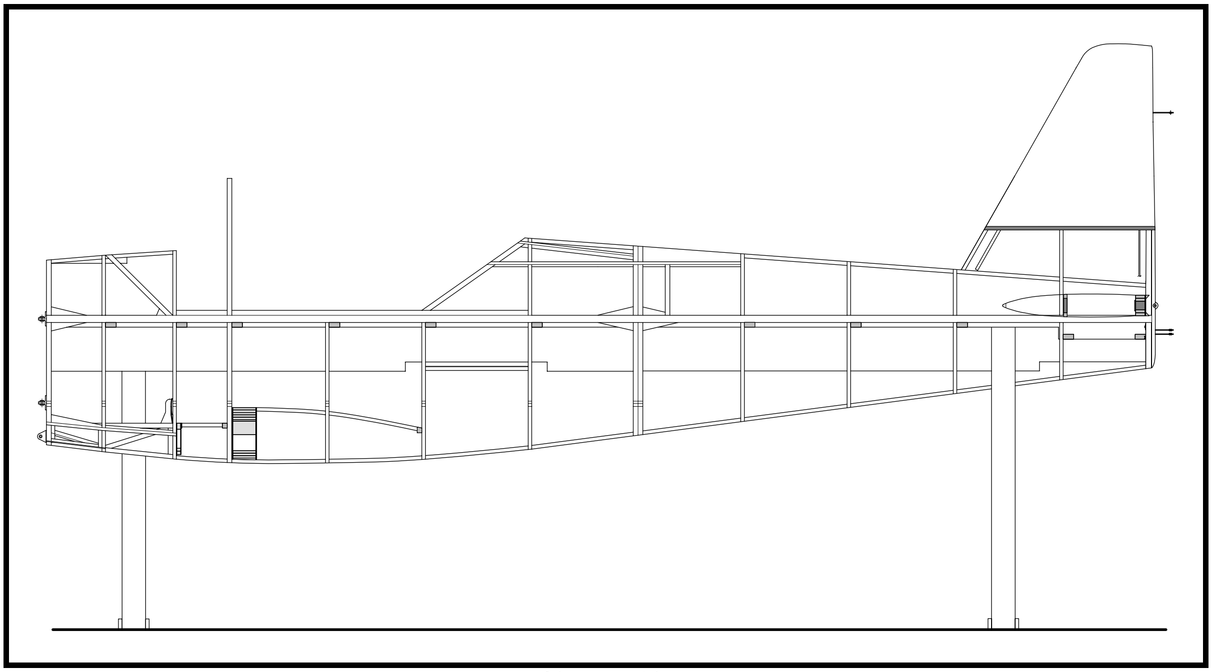


Figure 48

❏ Glue the plywood for the top of the box in place.

Now, resist all urges to overglorify the exhaust ports. By the time the airplane is finished, you will have stuffed the box with insulation and will have added additional insulation to the inside of the cockpit, but this is all the woodwork that is needed.

Nose Gear Screwjack Support Assembly

❏ Remove the nose gear screwjack support from the airplane and install the bearing and retainer. See Drawing No. 717-1. It's a good idea to put some wet zinc chromate between the two aluminum parts before riveting. This is a standard technique for seaplane construction since it not only protects the aluminum but also excludes any moisture.

❏ Mask off the bearing and paint the screwjack support assembly with zinc chromate primer.

There is really no point in putting the part back in the airplane until after you have varnished the wood under the fitting.

Chapter 28
Fuselage Assembly, Part 3

Kits on Hand

To do the work covered in this chapter, you should have the following:

Kit No. 807-1 Canopy Equipment (or 807-2)
Kit No. 809-1 Fuel Tanks and Equipment

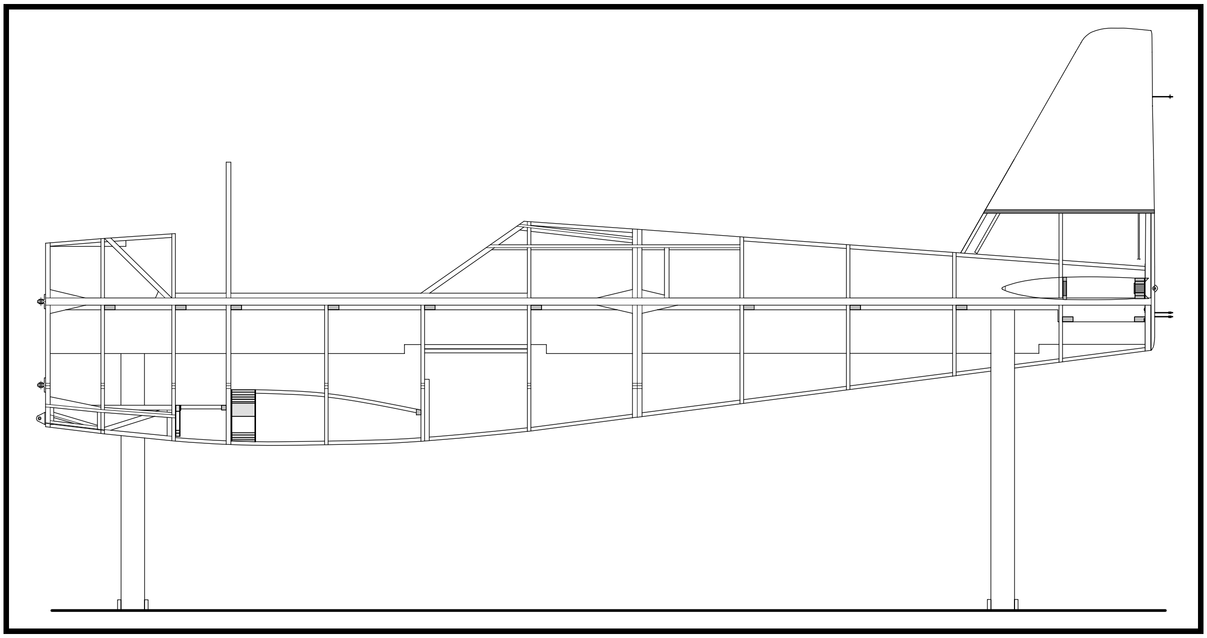


Figure 1

❏ Install the gluing strip on the bottom aft face of frame No. 6

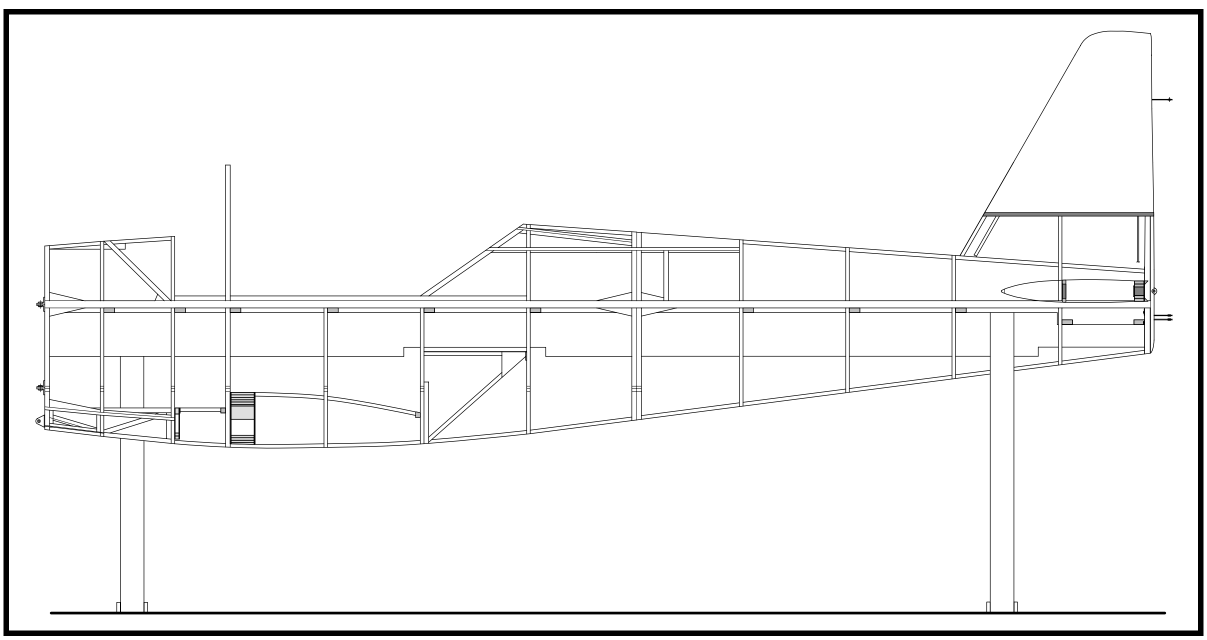


Figure 2

❏ Install the luggage compartment diagonal supports.

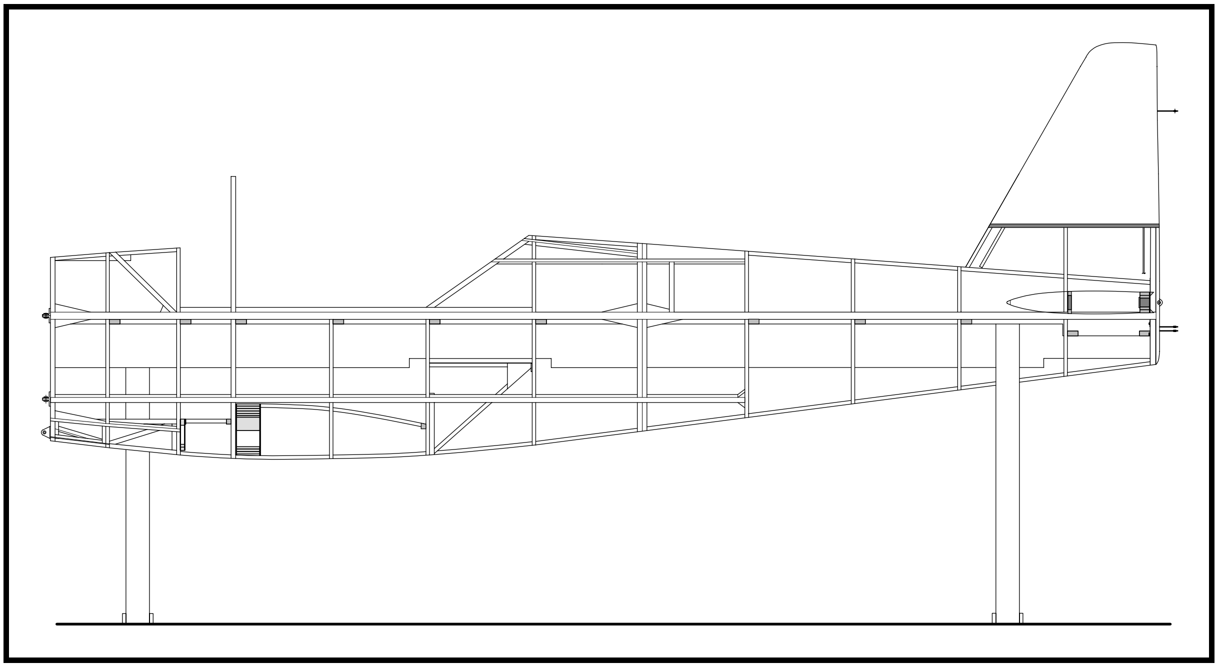


Figure 3

❏ Install the lower side longeron and corner block at station 9. At the aft end, the longeron requires a surprising amount of twisting and clamping to get it into place. Some builders have soaked the longeron and clamped it into place in advance. Others have glued blocking on the forward face of frame 9 and on the inside of frame 9 so that they could clamp the longeron in place, and later sanded this blocking off.

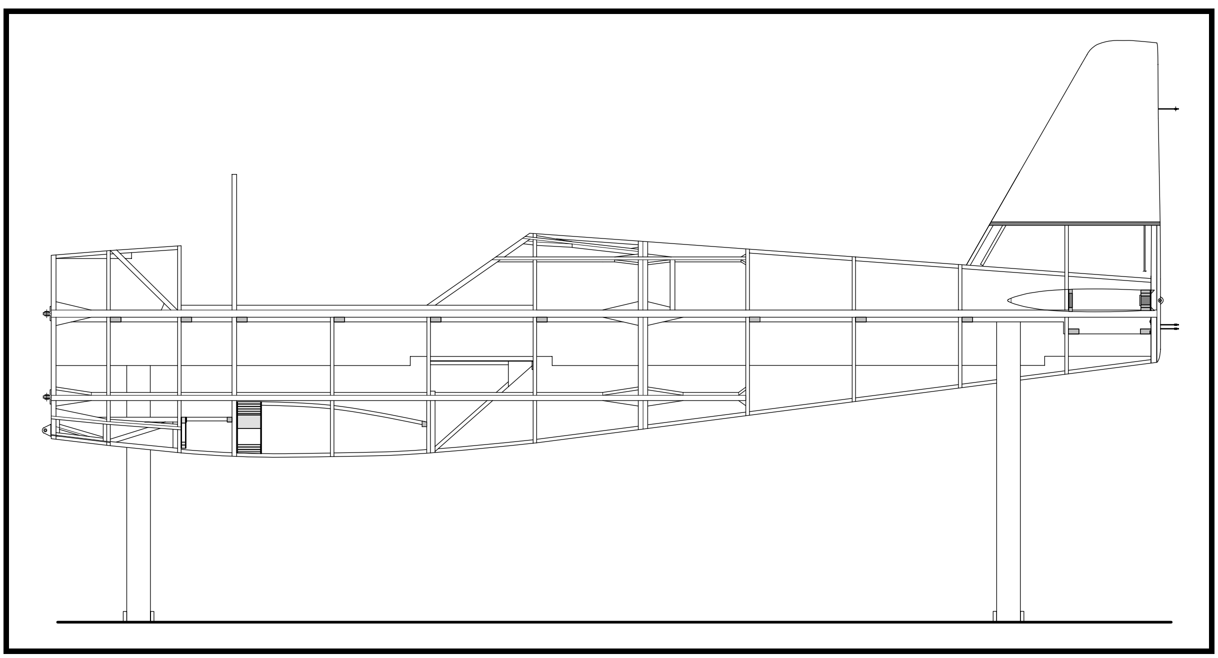


Figure 4

❏ Install the corner blocking for the lower side longerons.

❑ Install the corner blocking for the 10x20 stringers at the top of the battery compartment.

❑ Install the corner blocking for the 30x15 shoulder belt supports. To provide room for the fuel tank support, install the inboard corner block at frame 8 only.

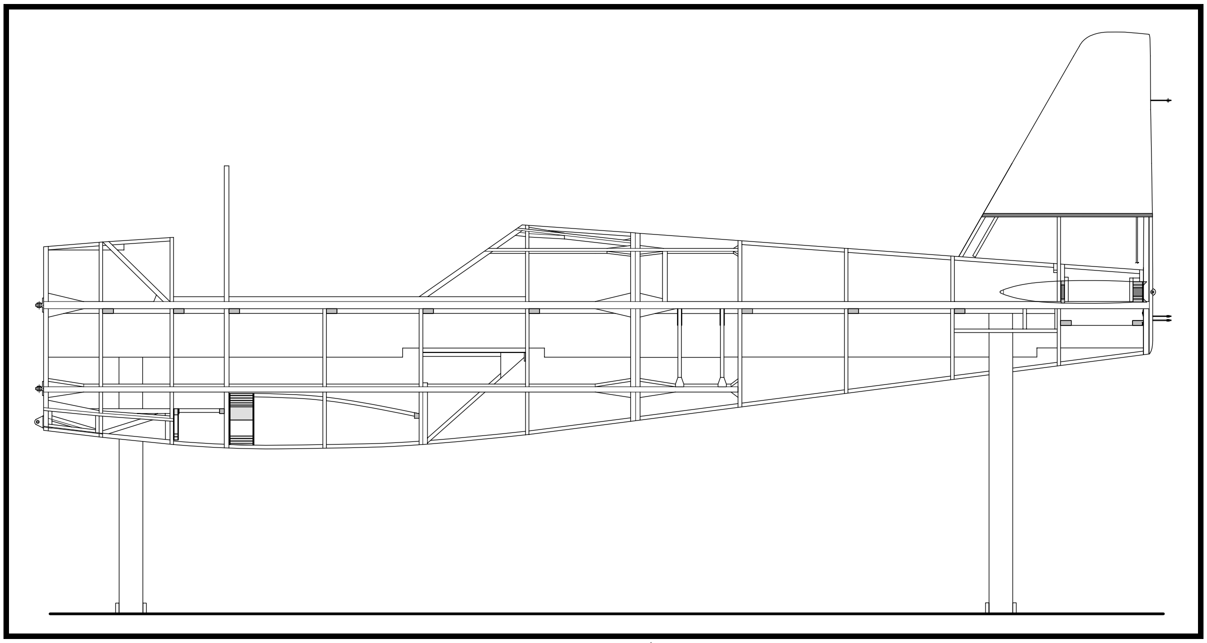


Figure 5

❑ Install the battery box diagonal supports.

❑ Install the framing for the access panel(s) for the rudder cable pulley. At a minimum, you need to install one access panel on the right side of the aircraft. Many builders install an additional access panel on the left side of the aircraft to make it easier to reach in and hook up wires. There is no harm in installing the additional access panel, so you should do as you please.

❑ Install the gluing blocks for the fuselage skin. These are installed on the main fin spar and forward fin spar. See Drawing No. 410.

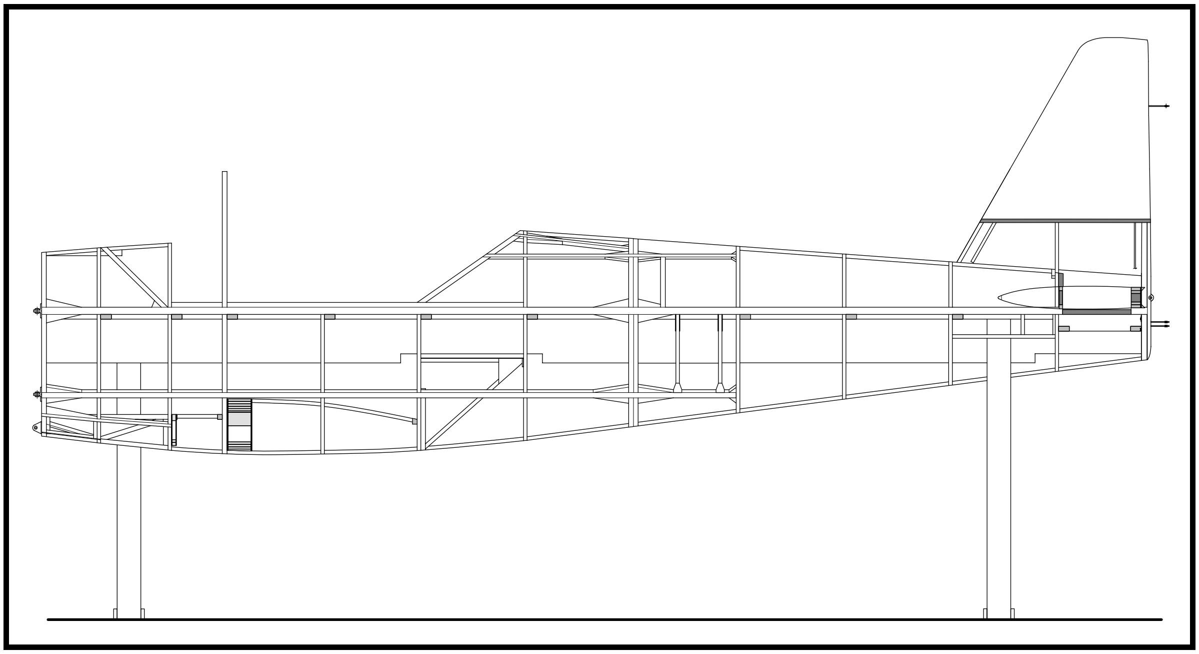


Figure 6

- ❏ Skin the top of the fuselage from Sta. 12 to 13.

Note: Although there is no requirement that you do so, the fuselage tail section is normally skinned in quadrants. That is, the skin is applied in four pieces, with scarf joints at the top center, bottom center and upper side longerons. An exception is the top skin from Sta. 12 to 13, which most builders do in one piece. It's quite easy to make a pattern for this piece from two pieces of cardboard. Cut and fit one piece to the front and another for the rear, then tape these together and use it as a template to cut out the plywood.

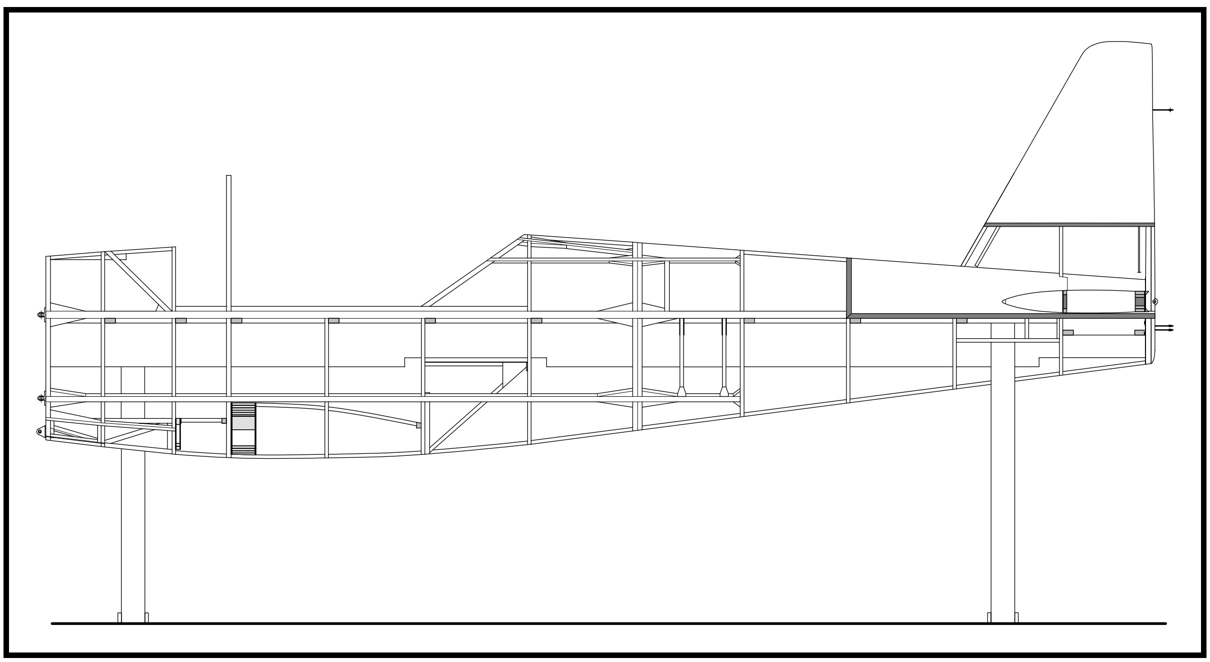


Figure 7

- ❏ Skin from frame 10 to 12 on the top of the fuselage.

Note: The skin is installed *under* the fin leading edge strip, and then you glue the leading edge strip to the skin. It's perfectly acceptable to cut the leading edge strip short and then insert a block.

There will be little areas directly below the stabilizer spars which will not be skinned. The best thing to do is to glue on little pieces of plywood to fill in these "missing teeth", and scarf these pieces so the next piece of skin will have a continuous scarfed area to glue to.

If you are using U.S. plywood (which is available in 4'x8' sheets), you can skin from Sta. 8 to 12 in one step.

The elevator trim tab cable and the aluminum tubing that is used as a conduit in the stabilizer is a little messy. What you have to do is to cut the aluminum tubing off so that you can install the skin and still have room to slip the rib in place. After the rib is glued in place, you fix the end of the aluminum tube in place with blocks of wood or epoxy-and-flox. It will not be pretty, but all that is necessary is that the conduit is functional. There is no requirement that the aluminum extend into the fuselage, only that the elevator have a conduit through which it can be passed. Who cares if the first inch or so is a block of wood?

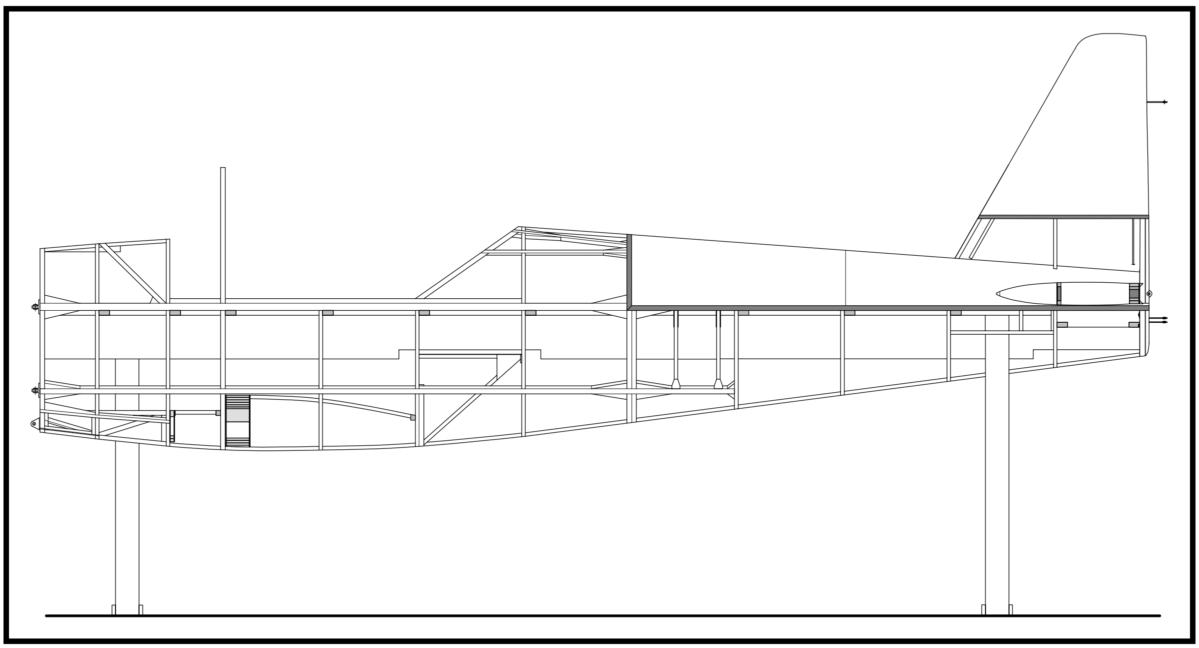


Figure 8

❑ Skin from Sta. 10 to 8. You should skin over the battery box and then cut the opening after the glue is dry. If you do not do this, the skin will tend to go 'flat' around the opening.

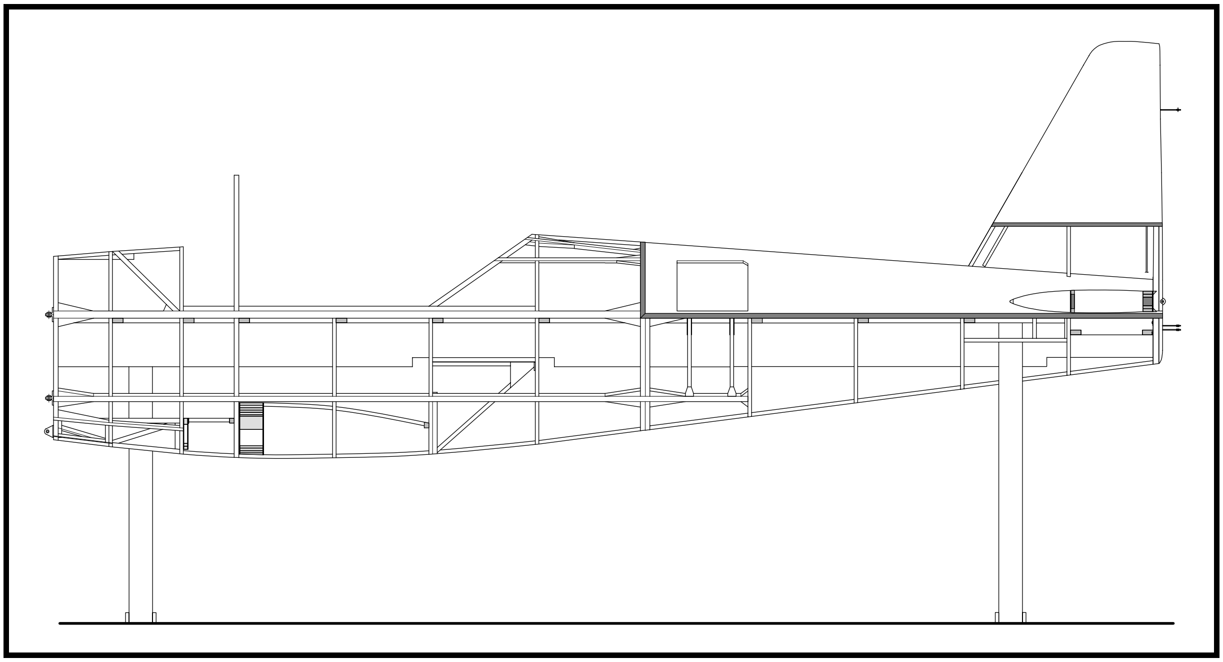


Figure 9

❏ Cut the battery box opening.

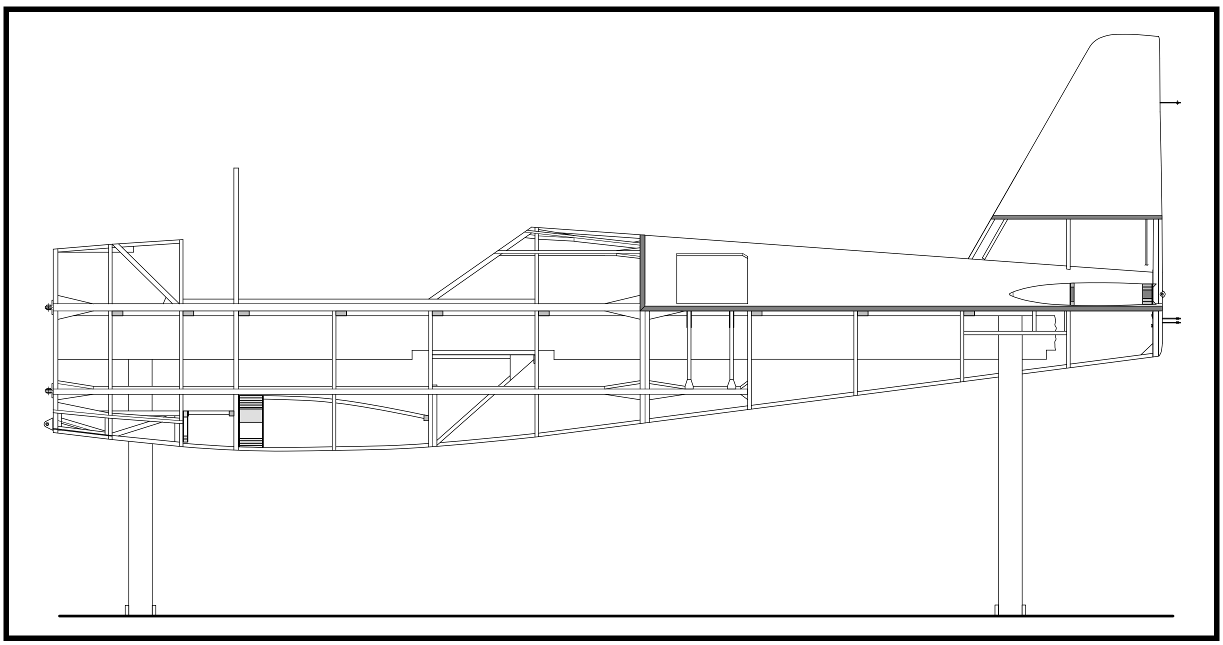


Figure 10

❏ Cut out the fuselage jig in front of the forward fin spar.

❏ Install the block for tail tie down. Measure and note the location of the center of the hole for the tail tie down.

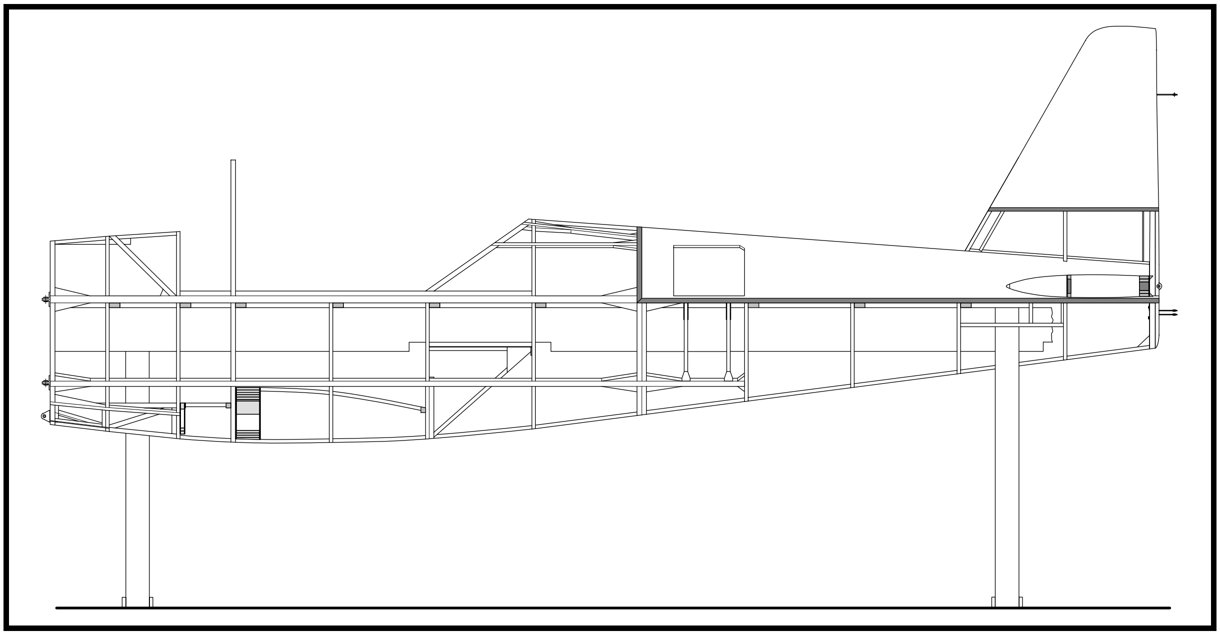


Figure 11

- ❏ Install fin rib 1.
- ❏ Drill the hole for the antenna wire and route it through the top of the fuselage and forward to the forward face of the forward fin spar.
- ❏ Drill the hole for the nylon tubing used as a conduit for the tail light wires. Epoxy the aft end of the tubing in place. The aft end of the tubing should be flush with the aft face of the main fin spar. See Drawing No. 402, Sheet 2, Section B-B. Because of the size of the wires, many builders have used 1/2” tubing.

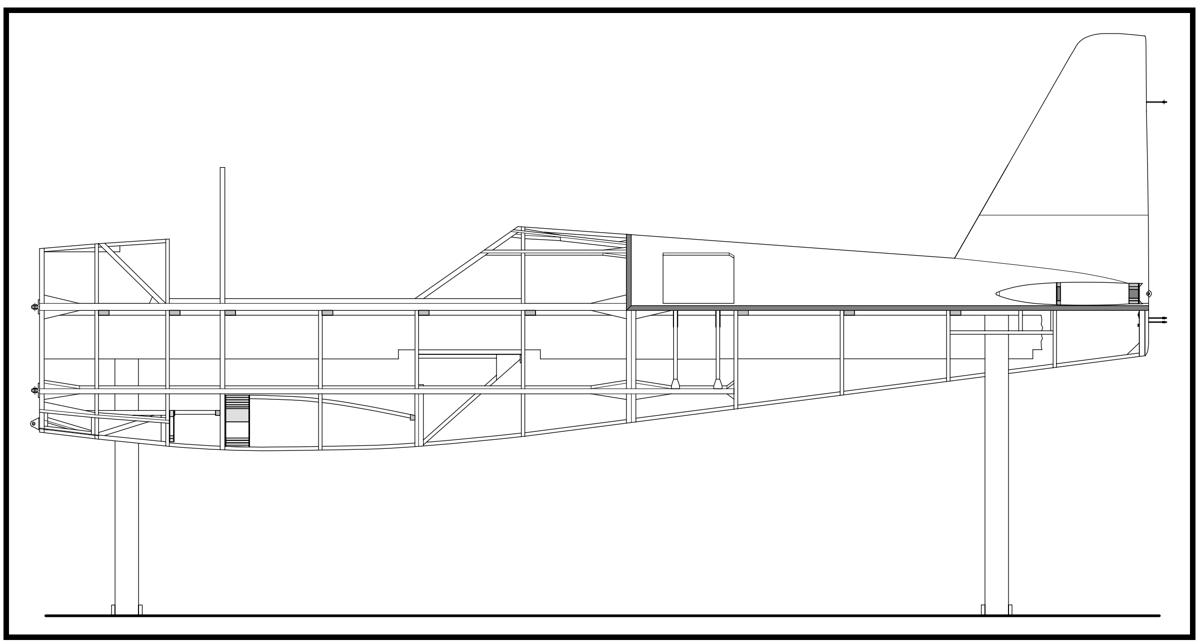


Figure 12

- ❏ Skin the fin at the bottom.

❏ Install the elevator and check the clearance for the control arm and balance weight. You will have to cut the upper center longeron at an angle for clearance with the elevator control arm, and you will need to cut the bottom of the slot in the main fin spar for the elevator balance weight arms at the bottom. See Drawing No. 402, Sheet 2, Section B-B.

❏ Install the upper elevator stop, or if you are going to install the piece of stainless steel at the bottom of the slot, do that now.

❏ Varnish the upper inside of the last section of the fuselage.

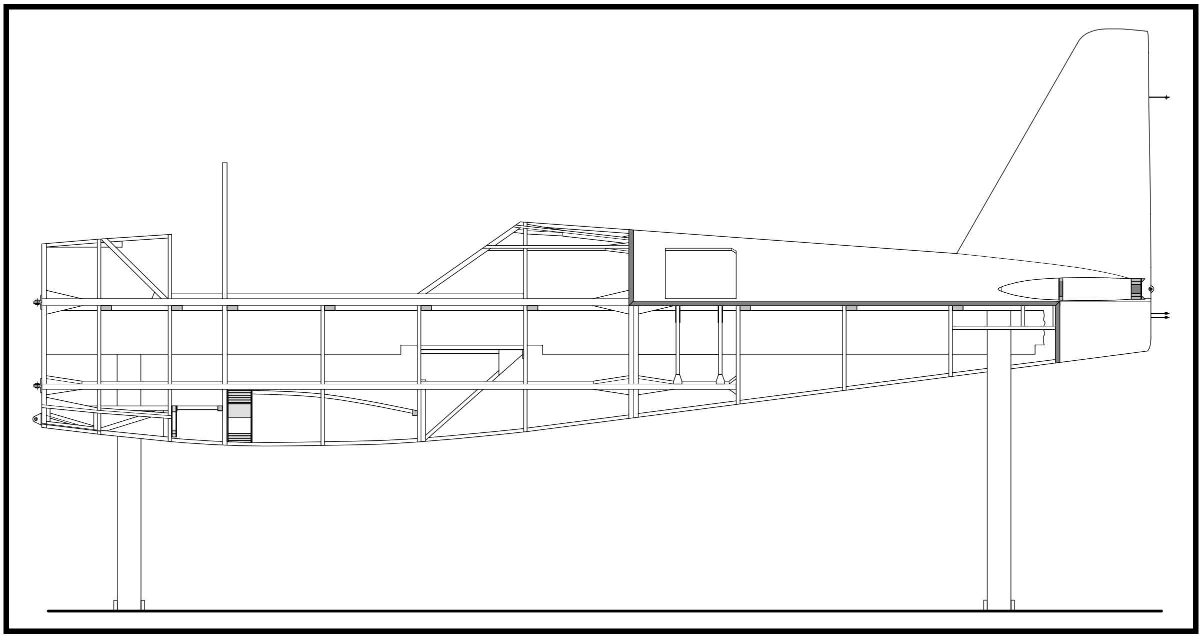


Figure 13

❏ Skin the bottom of the fuselage at the aft end on the left side of the airplane only.

❏ In anticipation for removing the fuselage jig, make a cradle to support the horizontal tail.

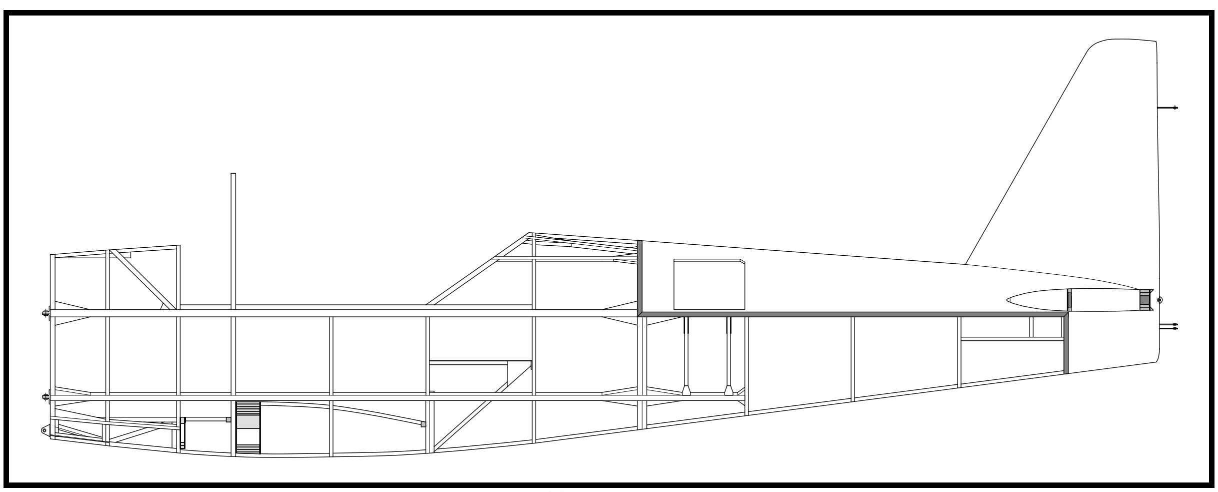


Figure 14

❑ Saw up and remove the fuselage jig.

❑ Varnish the inside of the last fuselage skin installed and also varnish the inside of all of the upper fuselage skins.

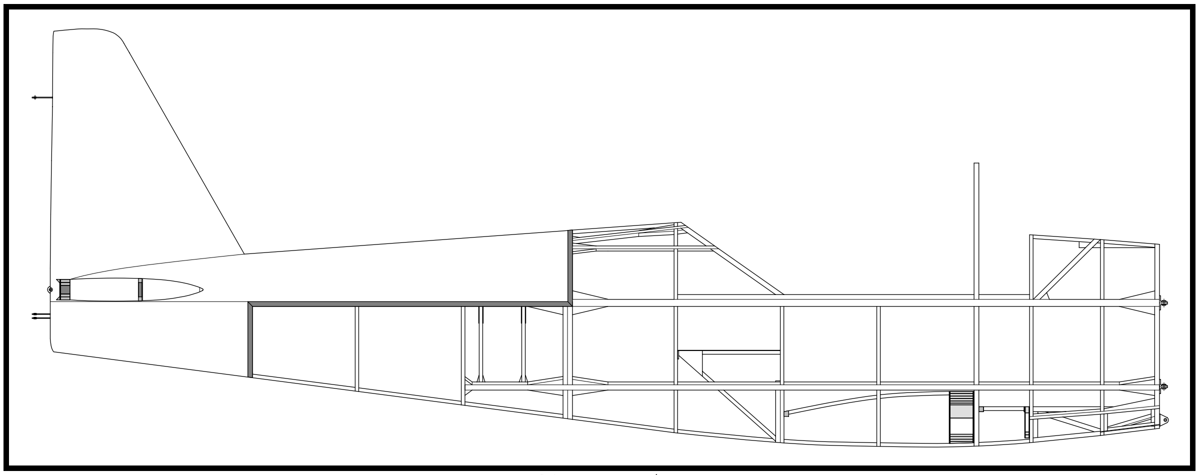


Figure 15

❑ Skin the right side of fuselage from Sta. 11 back. Skin over the access panel.

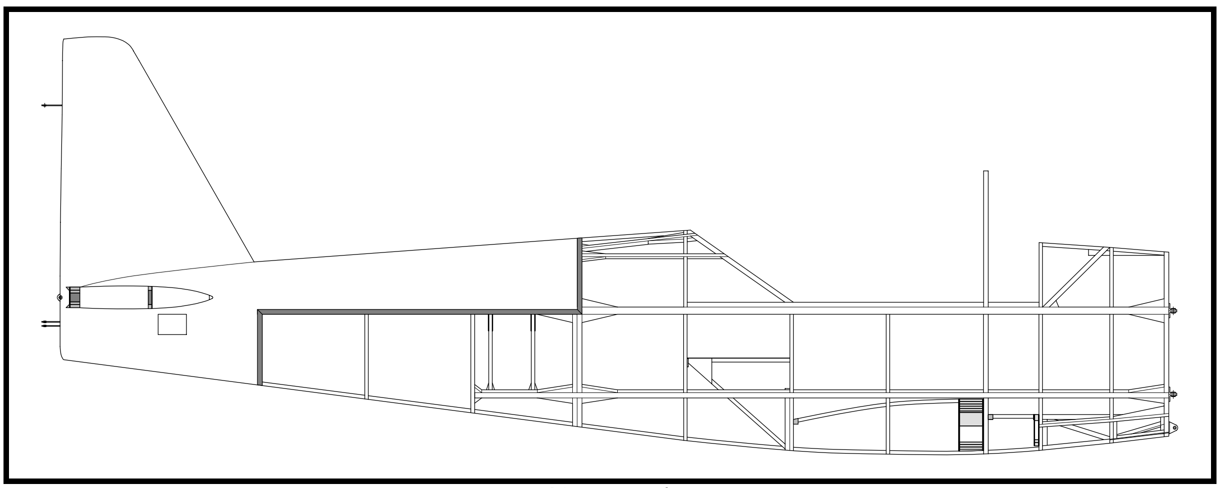


Figure 16

❑ Cut the opening for the rudder cable access panel on the right side of the aircraft. See Drawing No. 201, Detail J, and proceed at least through step 3, to provide room for maneuvering the router, (even so, you will find that not any router will work in such close quarters and you may have to use a laminate trimmer or a Dremel Moto-Tool).

❑ Cut the hole in the fuselage skin for the trim tab cable to pass through.

❑ Install the Sta. 0 stabilizer ribs on the right side of the aircraft.

❑ Secure the forward end of the elevator trim tab cable conduit at the forward end by blocking around it with wood blocks or by reinforcing it with epoxy and flox.

❑ Drill the hole for the tail tie-down fitting and epoxy it in place.

❏ Varnish the inside of the last fuselage skin installed.

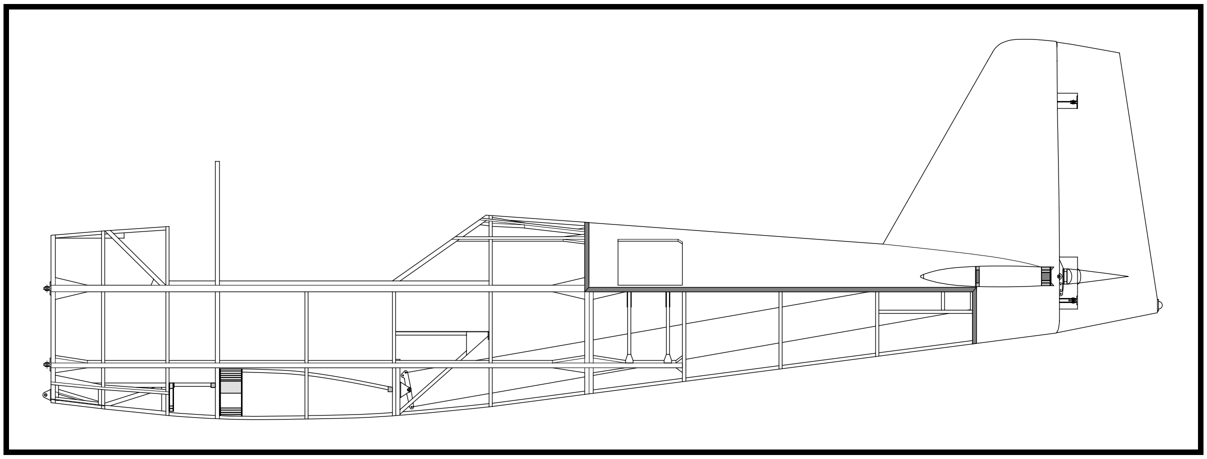


Figure 17

❏ Install the elevator.

❏ Install the elevator control bellcrank on the aft face of frame No. 6.

❏ Install the elevator control cables. Check to make sure that the upper cable goes through the hole provided in the forward stabilizer spar.

❏ Install the rudder on the airplane.

❏ Install the rudder cable pulley bracket assembly on the front face of the forward fin spar. This pulley is tilted so that the rudder cables cross each other aft of the pulley and the pulley is tilted slightly nose down for smoother action with the cables.

❏ Cut the holes in the sides of the fuselage where the rudder cables exit to check the position of the pulley.

❏ Install the hose clamps on the plastic tubing used as conduit for the tail light wires.

❏ If you have it, you should install a terminal block on the front face of the forward fin spar and hook up the tail lights on a trial basis. The tail light wires will not have standard ring terminals because this would make the wire bundle too large to pass though the tubing.

❏ If you have it, you should install the loran antenna coupler now.

❏ Drill the two holes in P/N 520 retraction gearbox housing for the installation of the elevator trim tab control cable. See Drawing No. 117.

❏ Install the P/N 520 housing in the airplane.

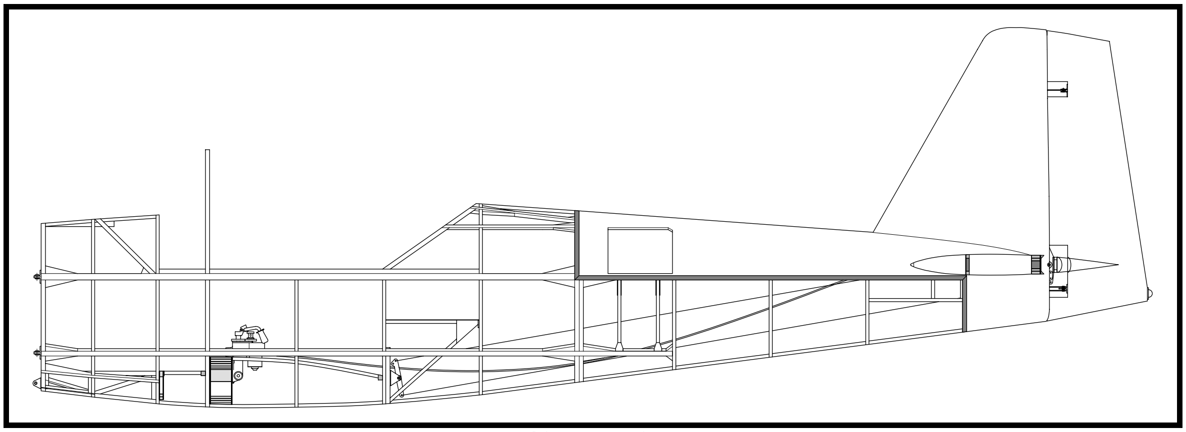


Figure 18

❏ Install the elevator trim tab control cable in the airplane. Hook up the aft end to the elevator trim tab and clamp the forward end to P/N 520. The trim tab control cable will spiral through the aft section of the fuselage and you will have to install clamps to secure the cable. This is one of those things that does not lend itself to precise dimensional layouts. You will simply have to install the clamps where the cable falls naturally and make blocks were required to position the clamps.

❏ Install the marker beacon antenna along the bottom center longeron. At this time, it is not necessary to hook up the antenna coax wire, but you should have the copper tape installed in the airplane.

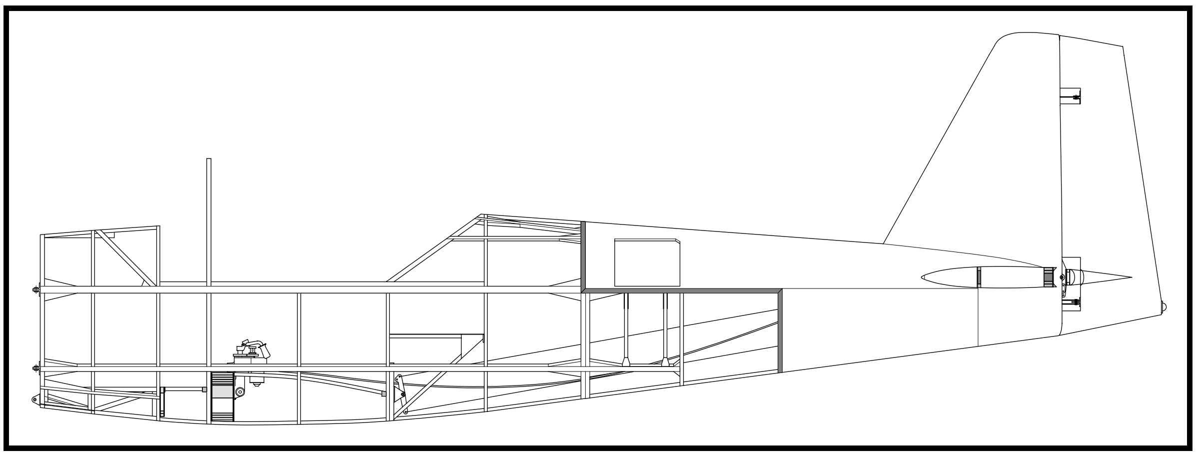


Figure 19

❏ Skin the left side of the airplane from Sta. 10 to 12.

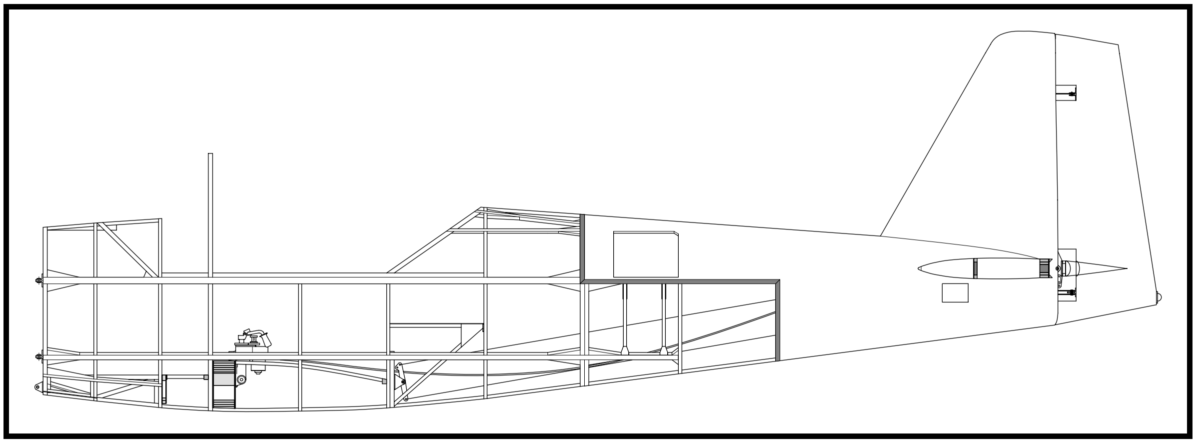


Figure 20

- ❏ Cut the opening for the rudder cable access panel (if you have installed one). See Drawing No. 201, Detail J, and proceed at least through step 3 to provide room for maneuvering the router, (even so, you will find that not any router will work in such close quarters and you may have to use a laminate trimmer or a Dremel Moto-Tool).

- ❏ Varnish the inside of the last fuselage skin installed.

- ❏ Install the stabilizer Sta. 0 ribs on the left side of the airplane. (The stabilizer may be skinned at any time now, although we will leave this for later.)

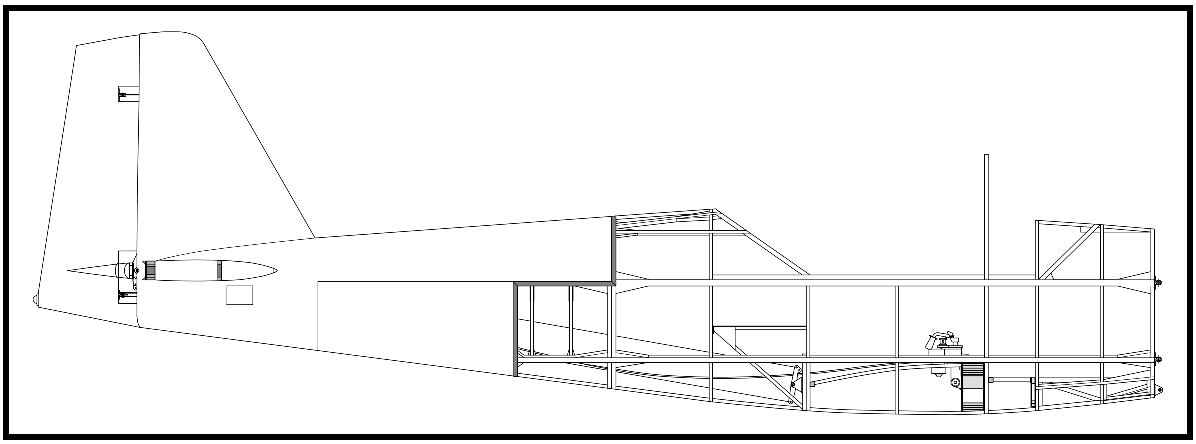


Figure 21

- ❏ Skin the right side from Sta. 9 to 11.

- ❏ Varnish the inside of this fuselage skin.

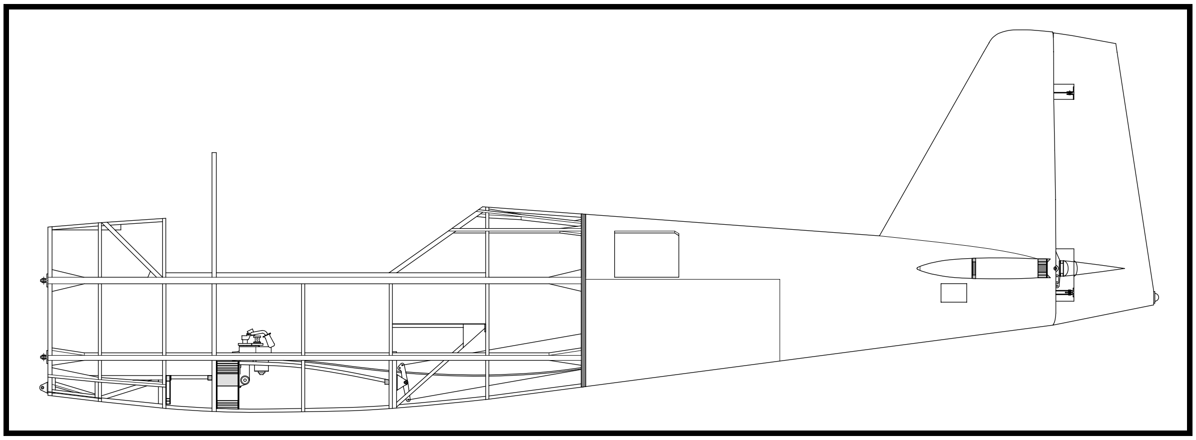


Figure 22

❏ Skin the fuselage on the left side from Sta. 8 to 10.

❏ Varnish the inside of this fuselage skin.

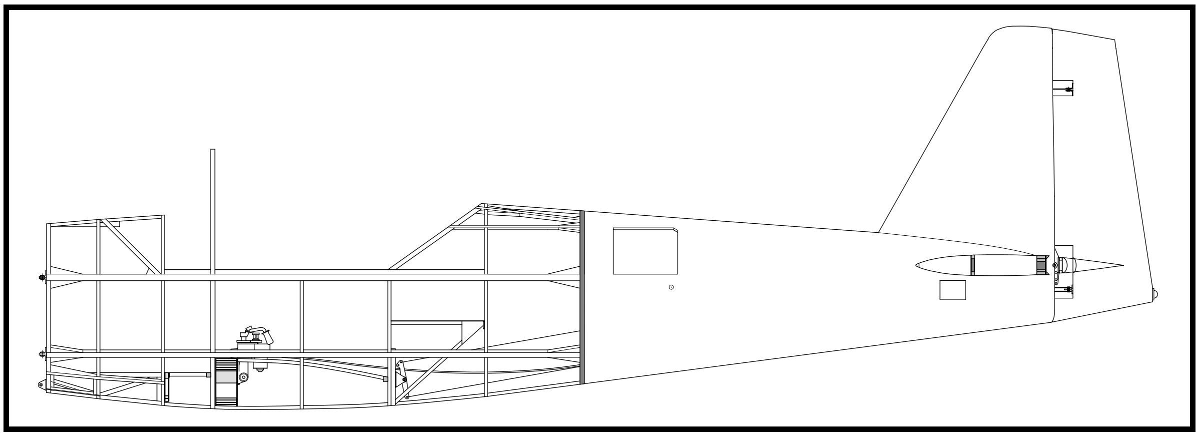


Figure 23

❏ Install the static port fitting on the left side of the airplane.

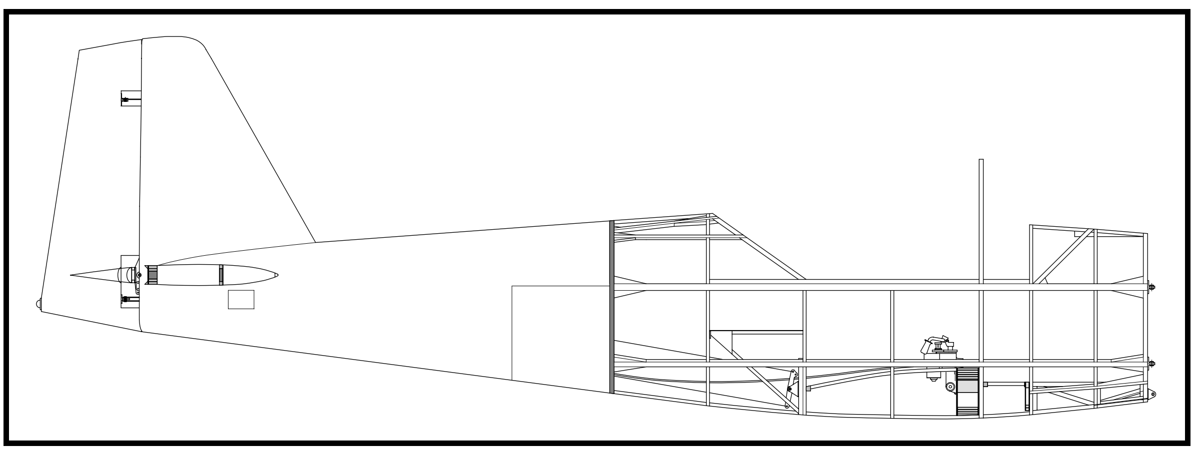


Figure 24

❏ Install skin from Sta. 8 to 9 on the right side of the airplane.

❏ Varnish the inside of this fuselage skin.

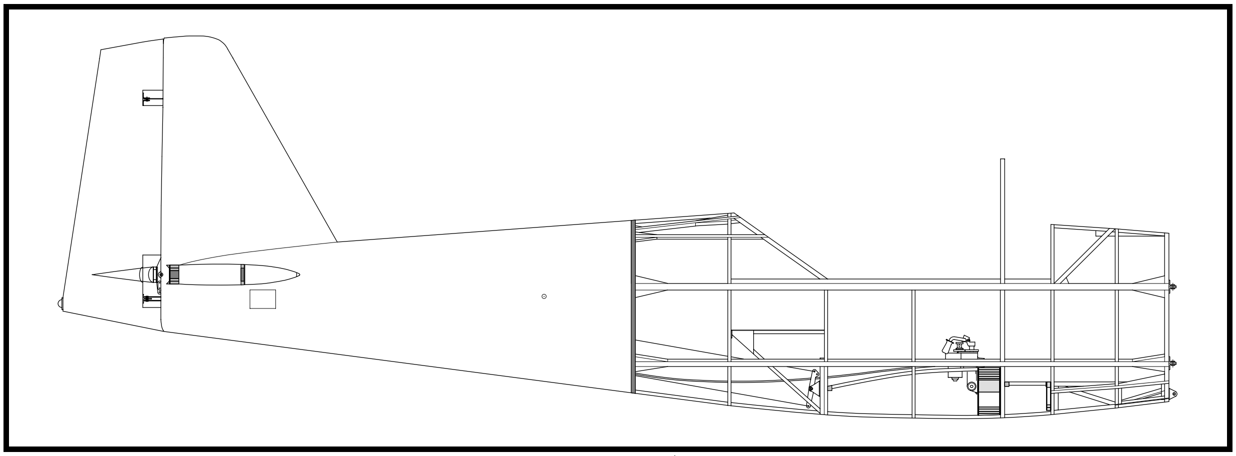


Figure 25

❏ Install the static port fitting on the right side of the airplane.

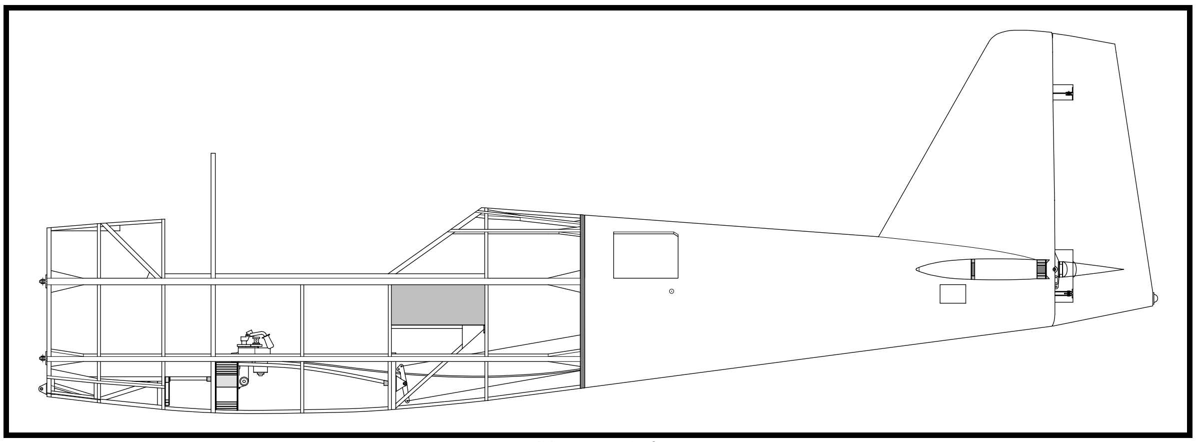


Figure 26

❏ Fit the interior cockpit skin between Sta. 6 and 7. Install corner blocks and trace the outlines of the frames for varnishing.

Note: Unless you are fond of self-flagilation, fitting the interior cockpit skins before installing the outside fuselage skins is the only sensible thing to do. With the framework still open, you can cut the interior skins, scarf them, and glue little blocks in the dorners to make the skins snap into exactly the right place. You can trace the outline of the fuselage frames for masking and varnishing, and you can do all of this at this early stage when everything is accessible. Then after you have glued on the outside skins, you can varnish the wall cavity and then pop the pre-fitted, pre-scarfed interior skins in place. Attempting to fit the interior cockpit skins at a later stage is a nightmare.

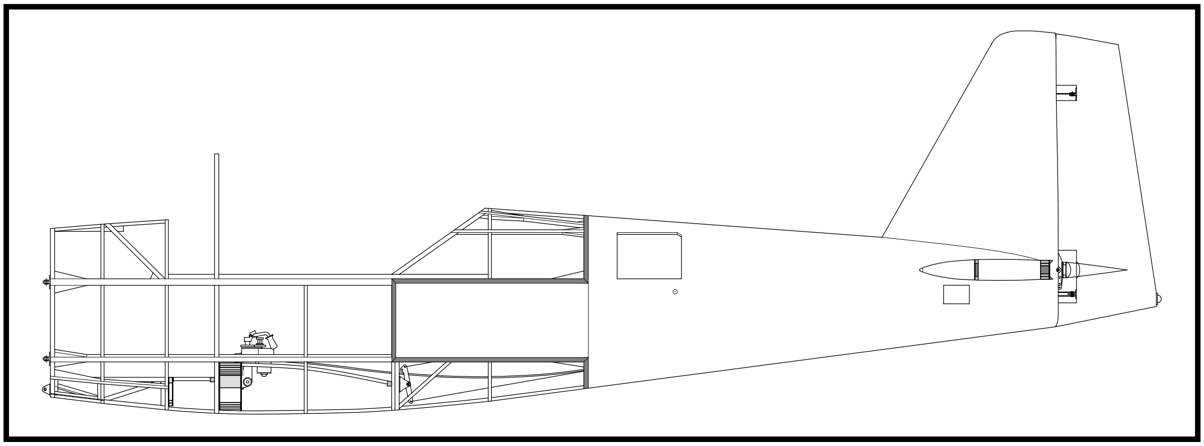


Figure 27

❏ Glue on the fuselage side skins from Sta. 6 to 8 on both sides of the aircraft. At the top of this skin, it works best if you cut the skin to fit along the upper side longeron and do not attempt to overlap the aft end of the coaming strip.

Note: The fuselage side skins have a slight compound bend, and there are three methods to bend the plywood. The first method is to wet the plywood and bend it over the frames. The production Falcos were built this way and most builders who have used this method have encountered problems. The plywood tends to take a sharp bend at the frames. About half of the builders that have used this method have scrapped the skins and done it again using another method.

A second method is to use a bending jig to bend the plywood before you install it on the airplane. (We have a drawing for this, can supply it on request, and intend to include this in future editions of the fuselage drawings.) You wet the plywood and then clamp it in the jig. This method has worked well for everyone who has tried it. It gives enough of a bend to the plywood so that it will pull into place.

The last method is to skin the fuselage with the plywood dry, and this requires a pneumatic staple gun. You simply apply glue and then staple the plywood in place, starting at the center of the panel at one of the longerons and working out in a fan-shaped pattern.

Builders who have installed the skin in one operation start in the center of the panel at the upper side longeron, then staple out along the longeron (usually for the full length of the panel), then down along the frame in the middle of the panel, then finally they staple along the bottom side longeron *and* the frame at the end of the panel. In the last operation, they work their way toward the corner. This whole operation is much like smoothing out a sheet on a bed—you work to smoothly pull the plywood down without allowing it to 'bunch' up or create a 'bubble'. In reality, you are compressing the plywood to create the bend—the object is to compress it evenly.

One builder reversed the process and installed each skin in three operations. He glued the skin to the bottom side longeron. Later after the glue dried, he glued and stapled the skin the frame in the middle. And finally he glued and stapled along the upper side longeron and frames on the end. He was working alone and wanted to break the work into three steps. By starting at the bottom, he was able to pour glue down into the space between the skin and framework.

Installing the skin dry works very well and is much easier than it sounds—in fact, many builders say these skins are the easiest skins to install. The curve of the skin is exceptionally smooth. The only complication is that upper wing skin makes it difficult to staple the skin to the lower side longeron. This is a very good reason to start at the bottom side longerons, where you can use small C-clamps, tilt the staple gun and shoot one-legged staples, and use small brass nails through nailing strips. You will then have all the heavy work of pushing and clamping to do at the top, where you can easily work on things.

You may want to consider bracing the centersection of the fuselage so that the sides don't bow inward when you bend the plywood. Most builders don't do this, but if you want to be extra careful, then you can just jam some cut-to-exact-width boards across each frame to ensure that nothing moves.

❏ Install the blocks required for the canopy track. See Drawing No. 107 or 107A. If you are going to install the left hand throttle modification, the forwardmost block should be solid to fuselage frame No. 4. See Drawing No. 157.

❏ If you are going to install the left hand throttle modification, install a 50x50 spruce triangle on the forward face of frame No. 4 on the left side of the airplane. See Drawing No. 157.

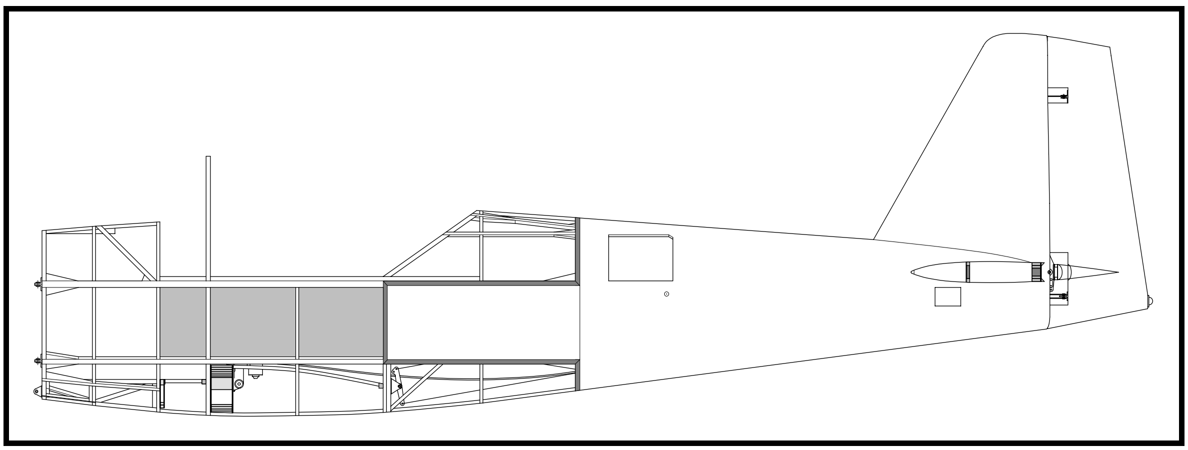


Figure 28

❏ Fit the interior cockpit skins between Sta. 3 and 6. This is ordinarily done in separate pieces with a scarf joint at each fuselage frame and so that the skins will be installed from the aft working forward. Install corner blocks and trace the outlines of the frames for varnishing.

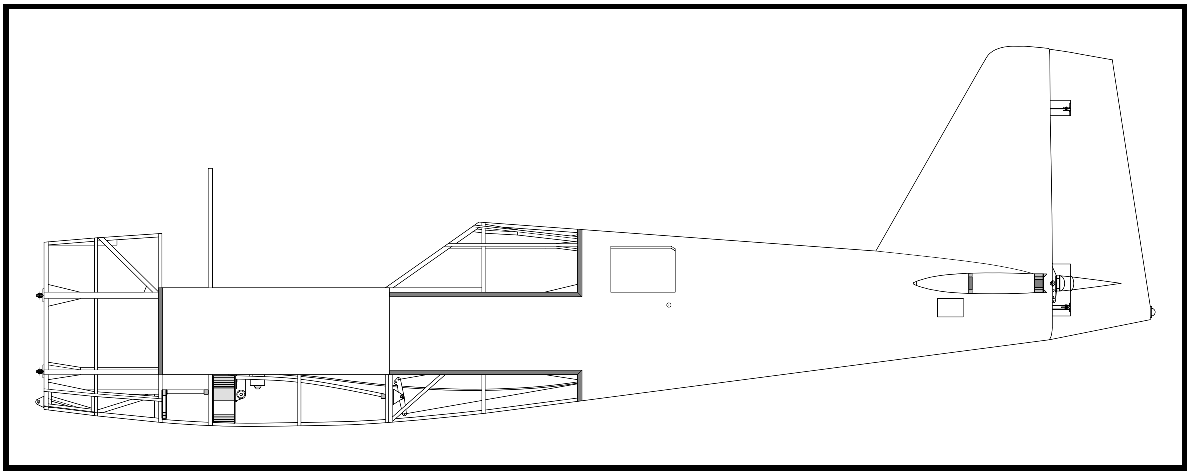


Figure 29

❑ Glue on the fuselage skin from Sta. 3 to 6 on both sides of the aircraft.

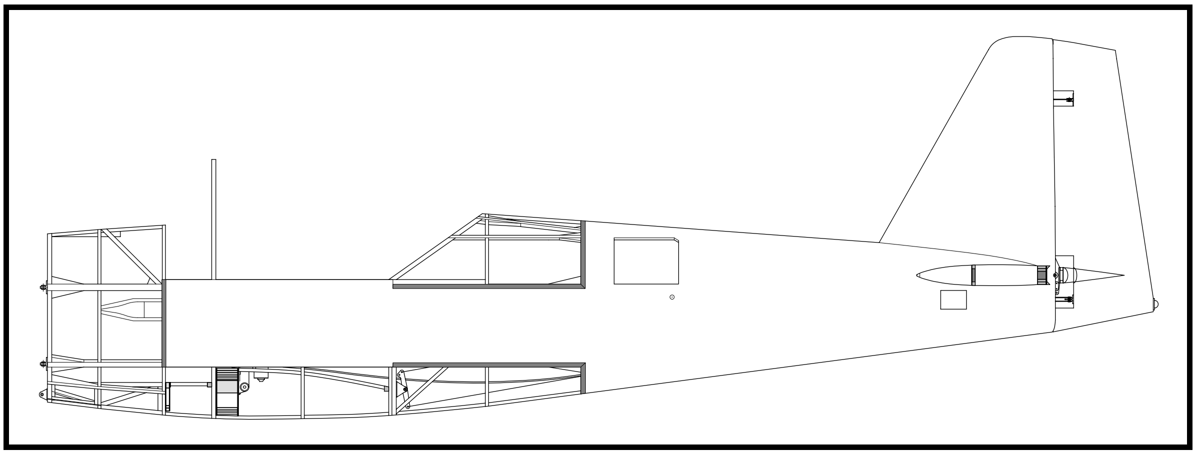


Figure 30

❑ Make the cabin fresh air inlet. (Install earlier?)

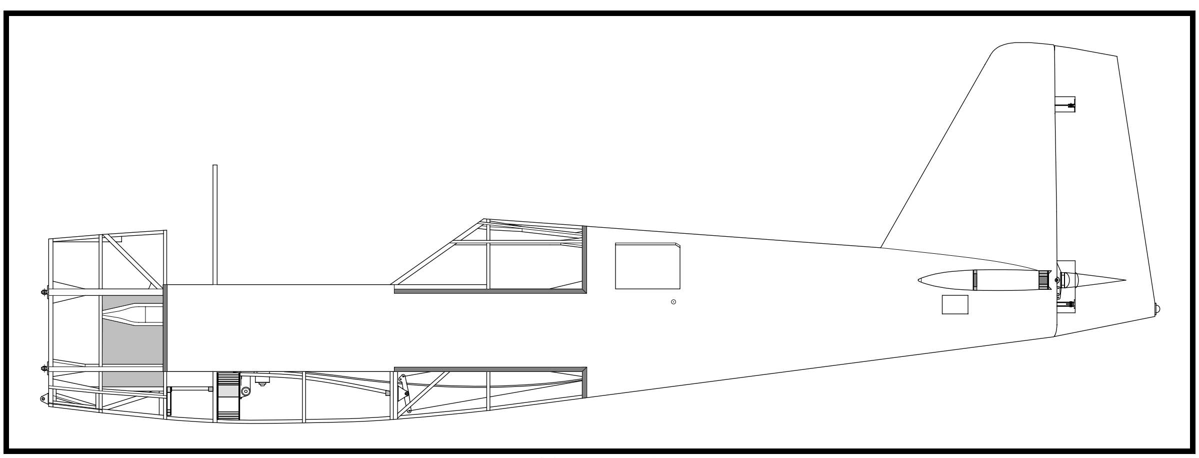


Figure 31

❑ Fit the interior cockpit skins between Sta. 2 and 3.

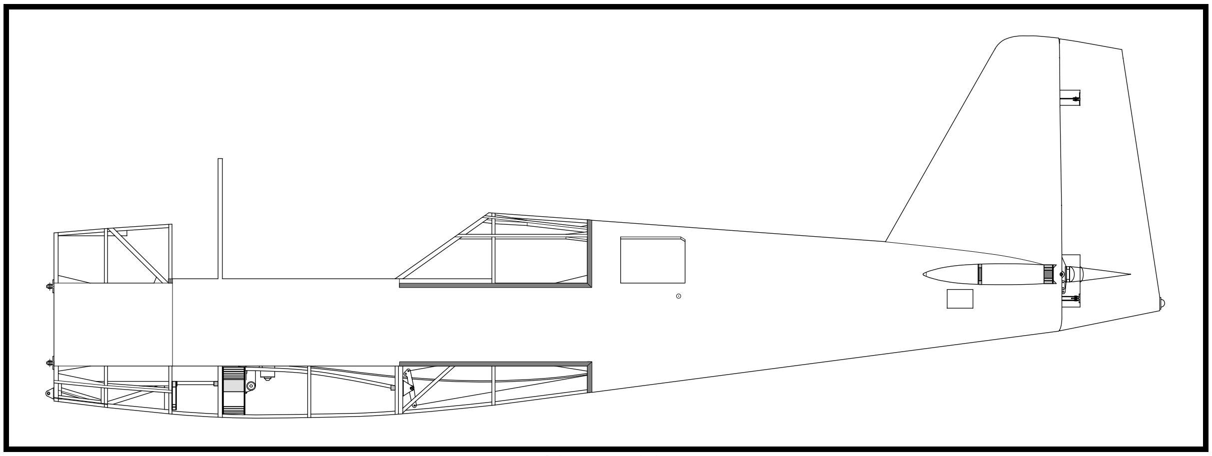


Figure 32

❏ Glue on the fuselage skin from Sta. 1 to 3 on both sides of the aircraft.

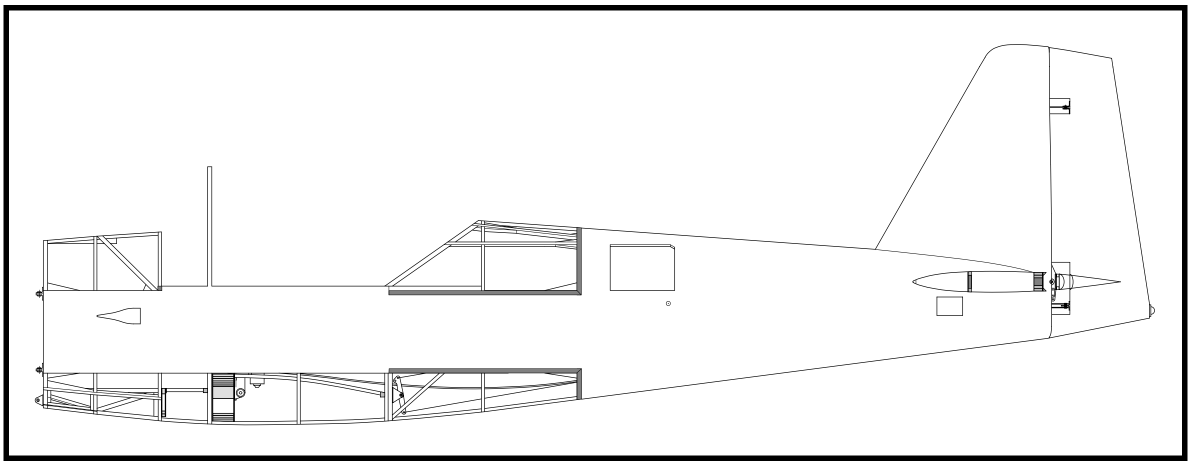


Figure 33

❏ Cut the opening for cabin fresh air inlet.

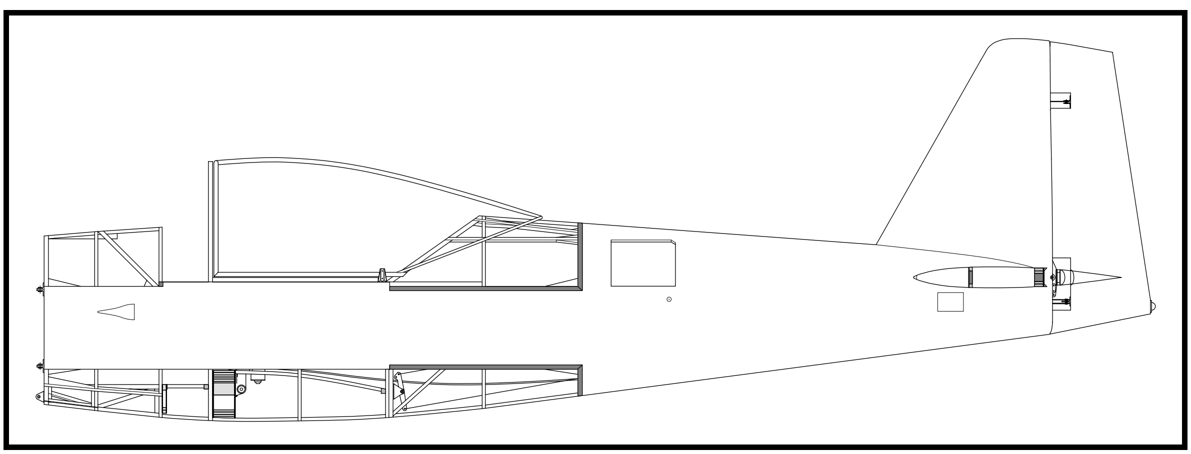


Figure 34

- ❑ Assemble the canopy frame, track and roller assemblies for the sides—not the rollers at the center aft end of the canopy—and place on the aircraft. See Drawing No. 107 or 107A. Cut the diagonal fuselage frame as required so that the canopy frame will clear it.

- ❑ When you have the canopy properly located, drill the holes for the screws that fasten the canopy track to the fuselage framework.

- ❑ Install the AN366-428 nutplates and screws. If you wish, you may epoxy these in place as well.

- ❑ Install the canopy roller mounts at the aft end of the canopy tracks.

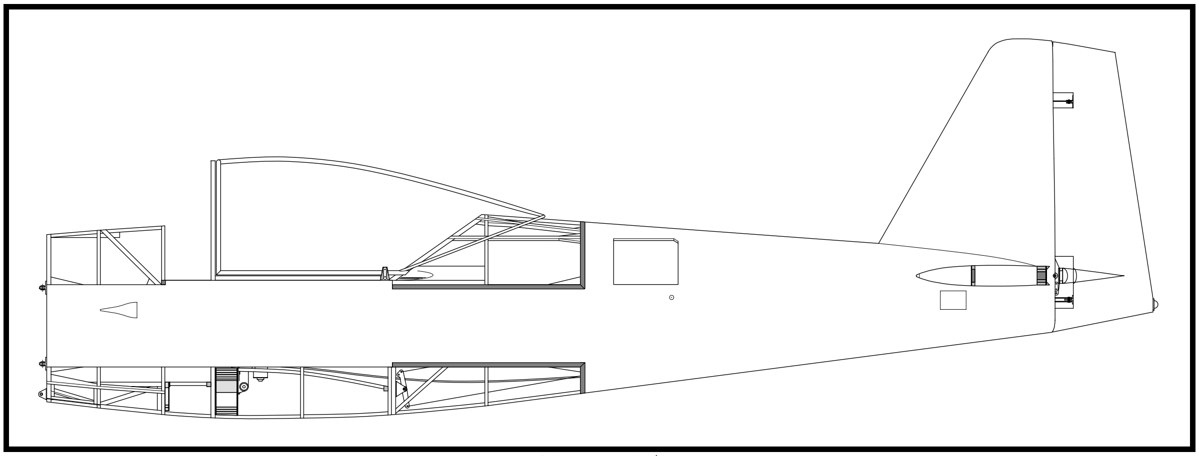


Figure 35

- ❑ Install the 65mm-tall spruce block aft of the diagonal frame. This block must continue the sculptured shape required to clear the canopy frame. You can save time by shaping the block to the approximate shape required, gluing the block in place and then sanding the block to the final shape. At the time that you fit the skin, you will do some additional shaping of this block.

- ❑ To prepare for installing the cockpit interior walls, varnish the interior surfaces of the fuselage side walls from Sta. 2 to 7.

- ❑ Install the interior cockpit skins from Sta. 2 to 7.

- ❑ Skin the stabilizer from Sta. 0 to 1.

You have now reached a stage in the construction where the construction sequence breaks down into a number of optional paths. Each is a block of tasks which must be done in a certain sequence, but the blocks themselves do not have to be done in any specific order, so feel free to bounce around among the blocks listed below.

Bottom Forward Fuselage Skin

- ❑ At this time you should break out your electrical kit manual and install the heavier wires in the airframe. In particular, you should pull the main battery wires through the forward part of the fuselage and out the firewall.

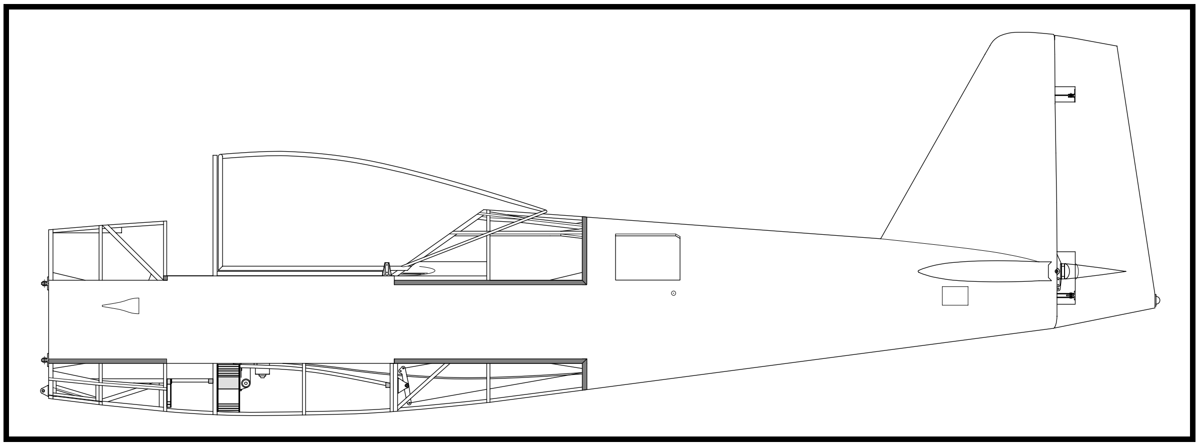


Figure 36

❏ Scarf the side skin from Sta. 1 to 3 in preparation for skinning.

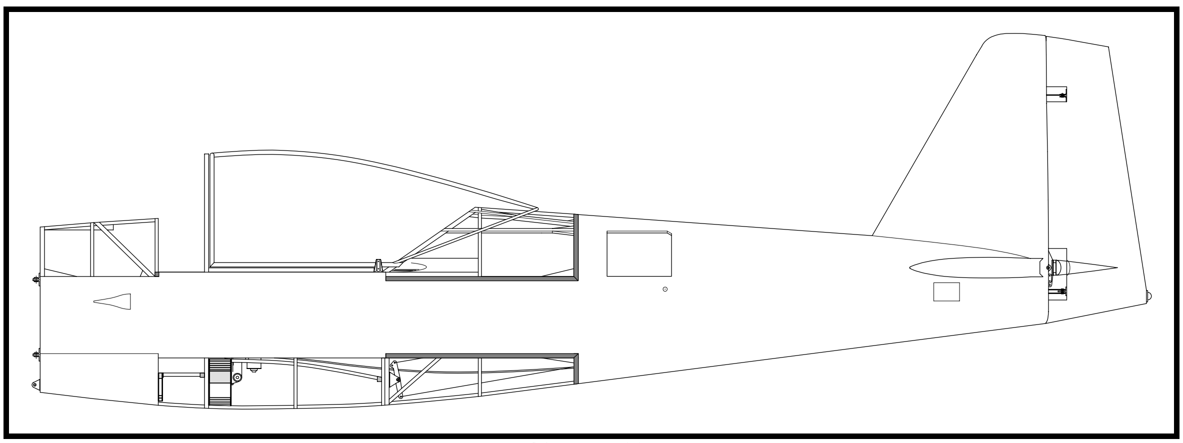


Figure 37

❏ Skin the bottom front of the fuselage from Sta. 1 to 3. Be sure to skin over the exhaust port openings.

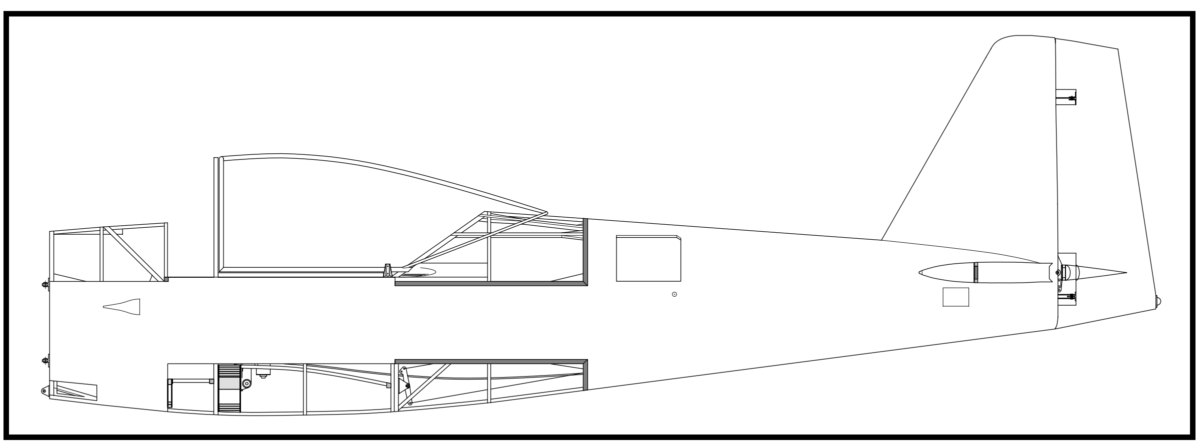


Figure 38

❏ Cut the openings in the skin for the exhaust ports.

Aft Top Fuselage Section

❏ Install the aft fuel tank support straps on frame 7 and 8.

❏ Install the aft fuel tank supports on the inside of the 10x20 stringers.

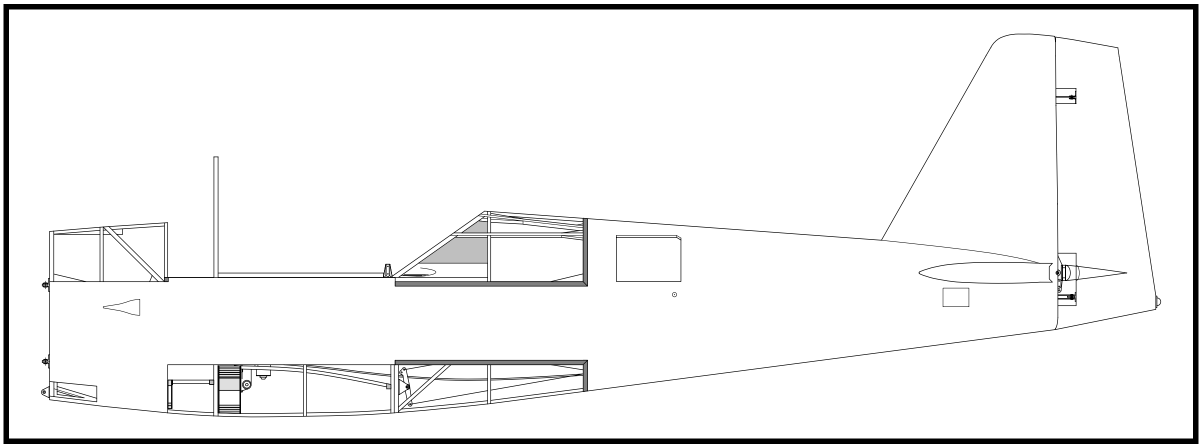


Figure 39

❏ Fit the interior cockpit skin for the upper part of the fuselage forward of frame 7. Install corner blocks and trace the outline of the frames for varnishing.

❏ Install the aft fuel tank.

❏ Install the framing for the aft fuel tank filler cap opening. At this time, we don't have a good drawing for you but the access door is installed with a piano hinge and a flush catch (required by the sliding canopy). The only thing you have to watch out for is the width of the door, which cannot be generous since the canopy fairing will encroach on it.

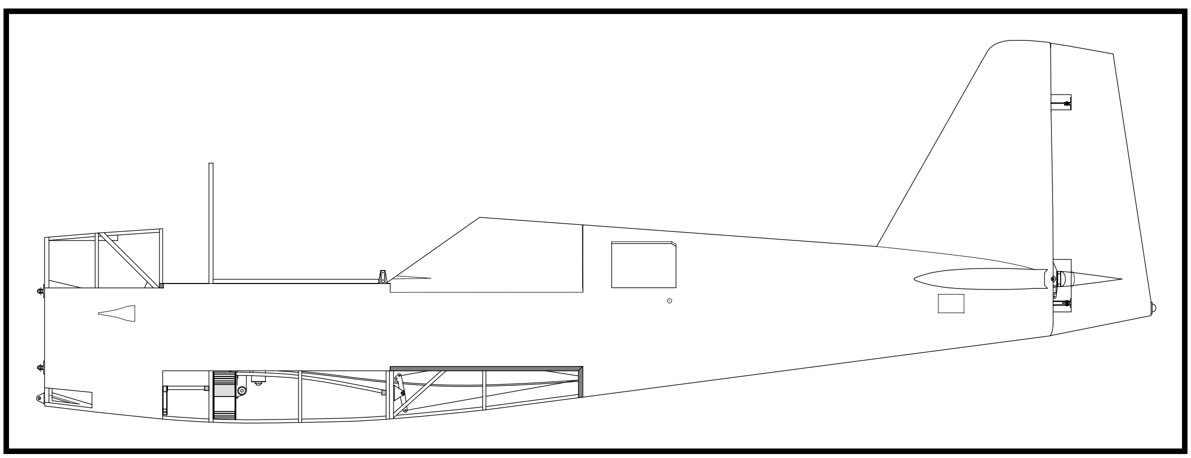


Figure 40

❏ Skin the top of the fuselage forward of Sta. 8. At the radiused indentation for the canopy frame, slit the plywood and staple it down.

❏ Varnish the inside of the skin just installed forward of frame 7.

❏ Varnish the inside cockpit skin for this area.

❑ Install the inside cockpit skin.

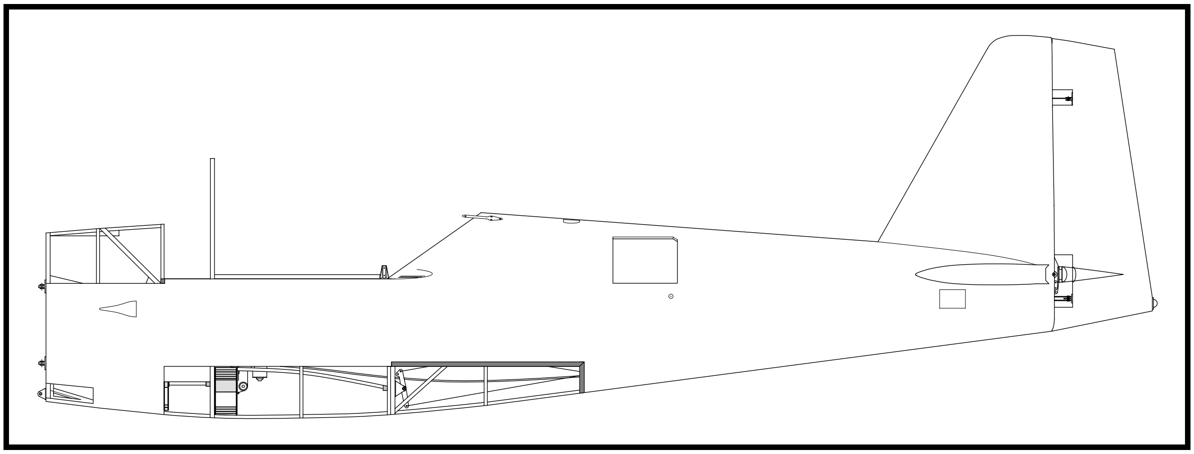


Figure 41

❑ After the glue is dry, feather out the plywood in the groove for the canopy frame. At the deepest part of the groove, you should see the spruce block, not plywood.

❑ (Assuming you have good drawings or know what you are doing) cut out the opening for the aft fuel tank filler cap and install the door.

❑ Install the shoulder belt mounts.

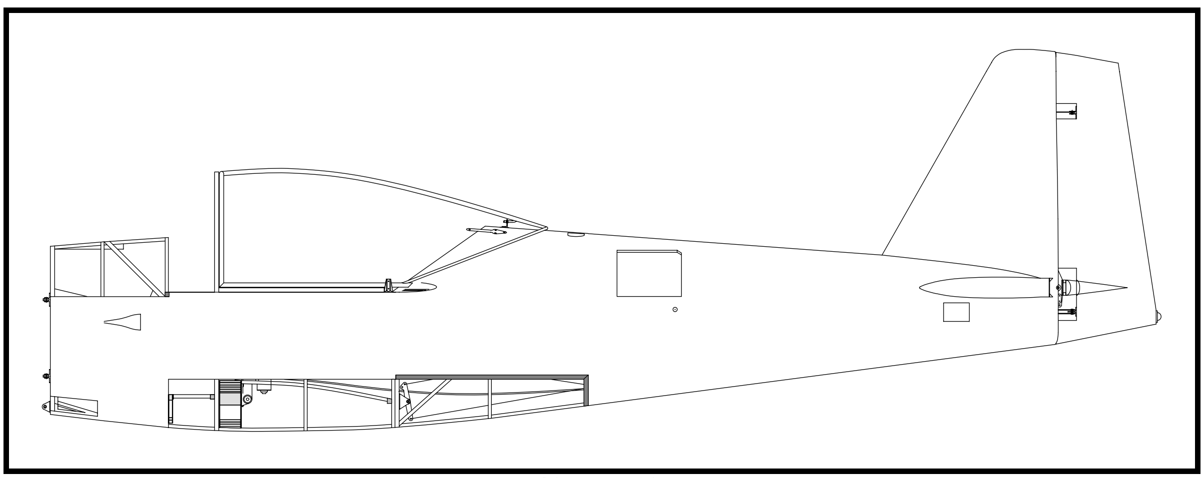


Figure 42

❑ Install P/N 823 canopy stop. See Drawing No. 107 or 107A.

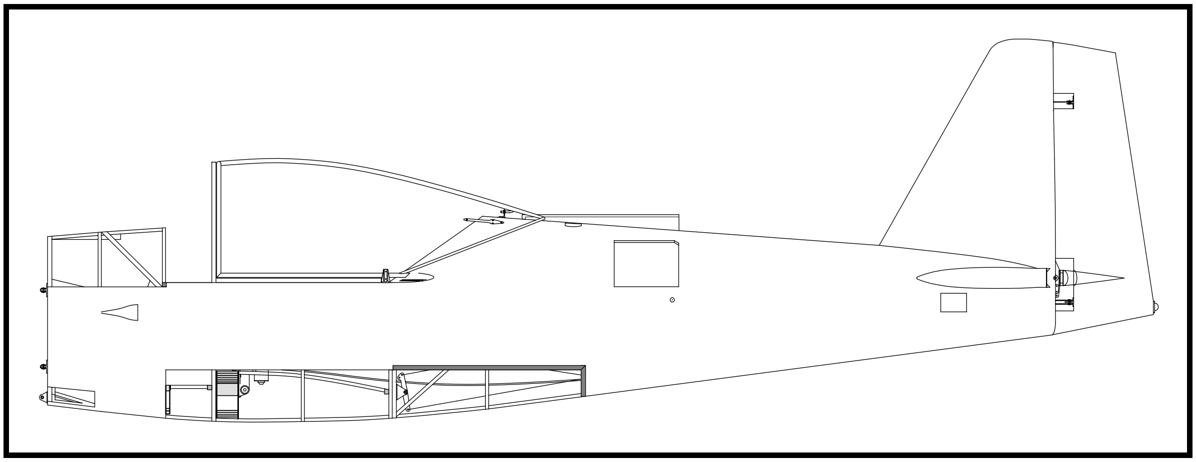


Figure 43

❏ Put the canopy slide tube in the solid spruce dorsal fin block and position it under the canopy. Try sliding the canopy and when you have the tube centered, glue the block in place.

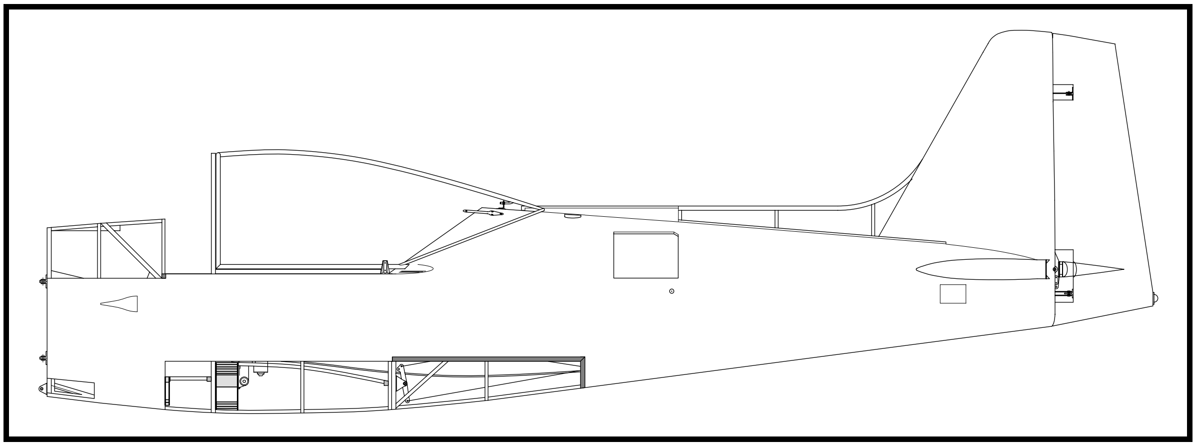


Figure 44

❏ Glue the framework for the dorsal fin in place.

❏ Fit the skins for the dorsal fin and varnish the inside of the dorsal fin.

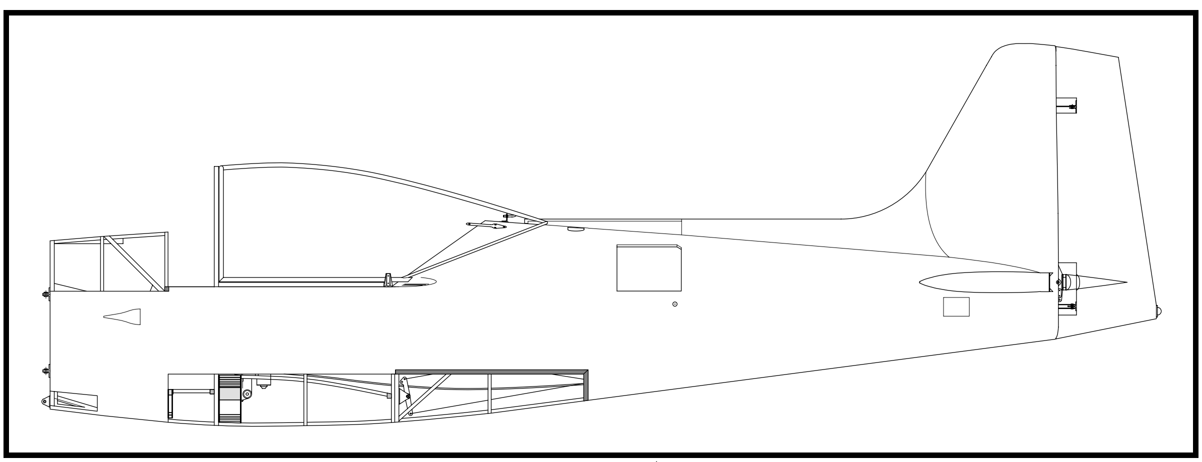


Figure 45

- ❏ Skin the dorsal fin.

- ❏ Complete the installation of the canopy slide tube by installing the fittings at each end.

Forward Top Fuselage Section

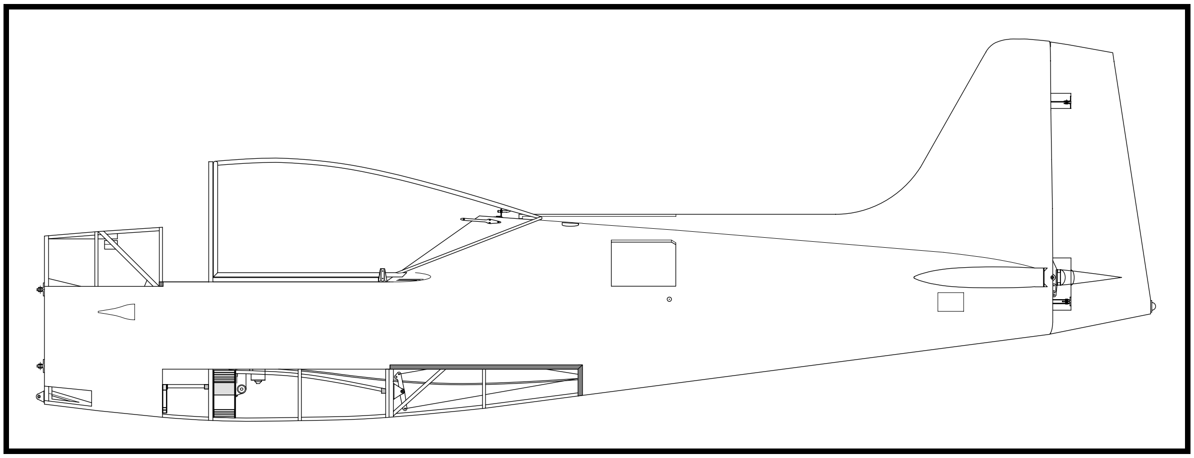


Figure 46

- ❏ Install the blocks of wood on diagonal frame No. 2 to support the forward fuel tank. See Drawing No. 121.

- ❏ Install the hanger straps for the forward fuel tank.

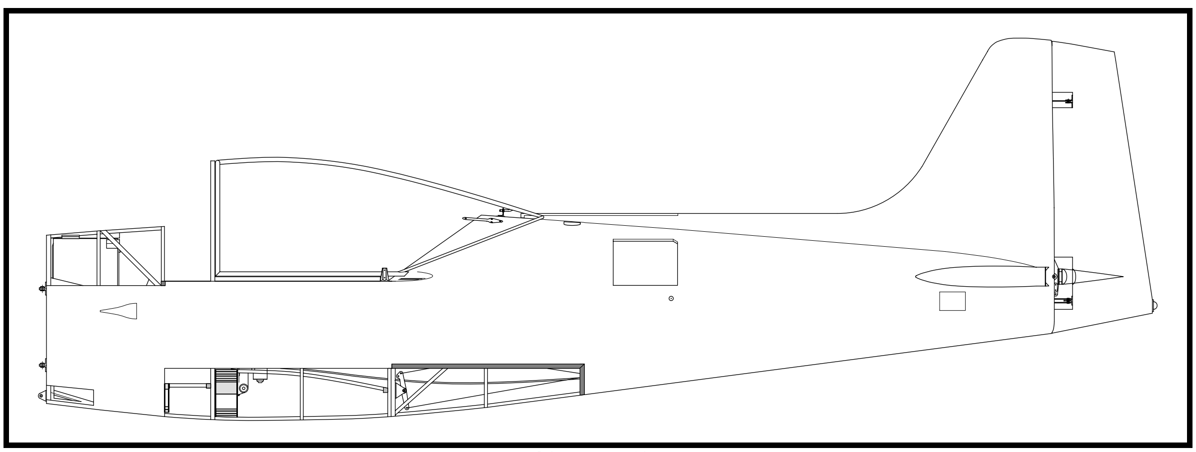


Figure 47

- ❏ Install the forward fuel tank.

- ❏ Install the framing for the forward fuel tank filler cap opening.

- ❏ Scarf the plywood on each side in preparation for skinning the top of the fuselage.

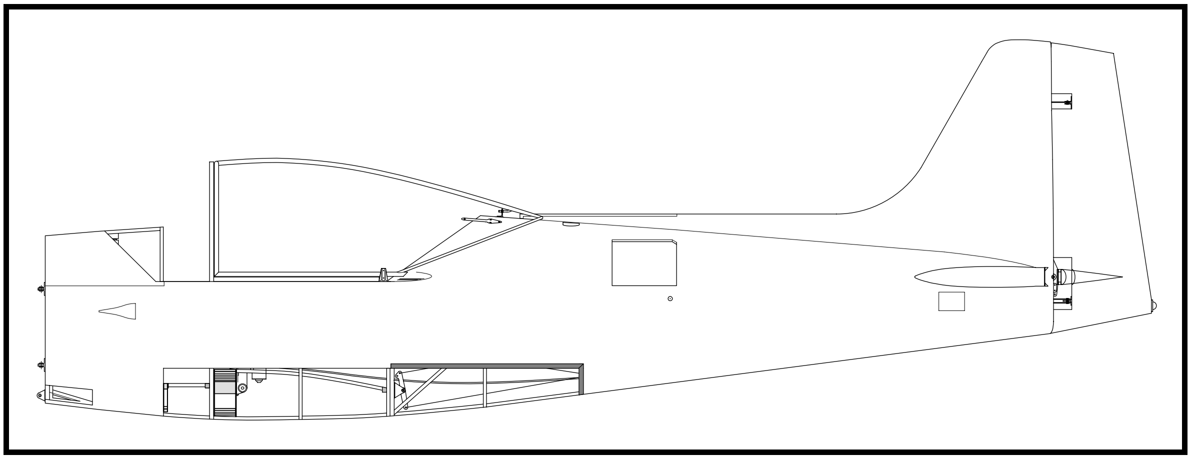


Figure 48

❑ Skin the fuselage between Sta. 1 and the Sta. 2 diagonal frame as shown in Figure 48.

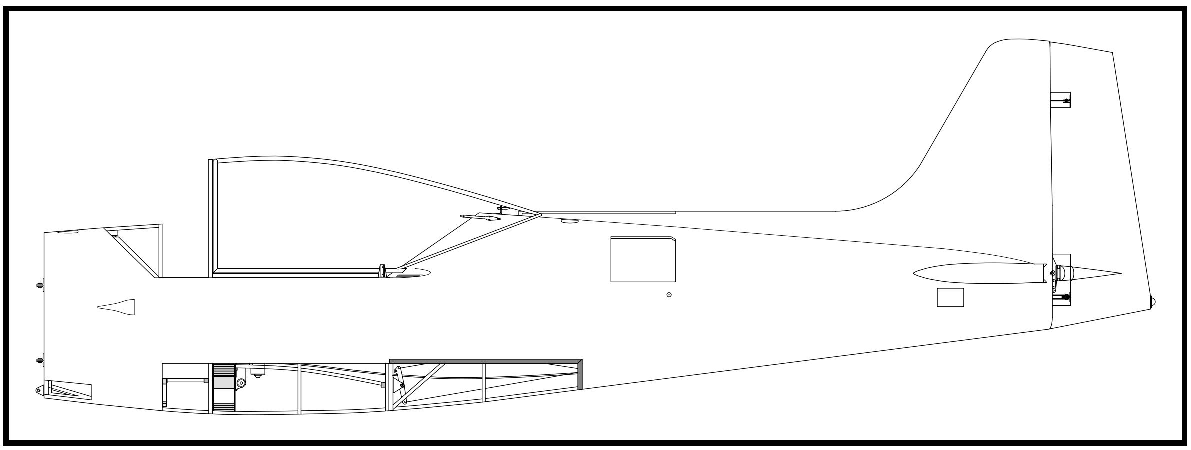


Figure 49

❑ Install the gluing strip on the aft face of the diagonal frame No. 2. This strip is to provide a gluing surface for the skin that will eventually cover the remaining area back to frame No. 3. At each side, this strip must be the same width (B.L. position) as the top lamination of frame No. 3, and then the strip is curved so that it joins the outer skin of the fuselage. This joining-up occurs approximately at the hanger block for the forward fuel tank. One view of these gluing strips is on Drawing No. 121. Until the instrument panel installation is complete, this skin will not be installed.

❑ Install the forward fuel tank access door.

Appendix A
Sources

Woodworking Tools

Gann Electronics, Inc., 12265 West Bayaud Avenue, Lakewood, Colorado 80225. Telephone: (303) 980-8484. Manufacturers of wood moisture meters. The LCD display is an interesting feature.

Lignomat USA Ltd., P. O. Box 30145, Portland, Oregon 97230. Telephone: (800) 227-2105 or (503) 257-8957. Manufacturers of wood moisture meters. www.lignomat.com

Delmhorst Instrument Company, P. O. Box 130, Boonton, N. J. 07005. Telephone: (800) 222-0638 or (201) 334-2557. Manufacturers of wood moisture meters. www.delmhorst.com

Jackson Wood Technology, 1616 Capital Avenue, Madison, Wisconsin 53705. Manufacturers of wood moisture meters. Kits also available.

Garrett Wade Company, 161 Avenue of the Americas, New York, N. Y. 10013. This company supplies an excellent line of woodworking tools and books. They have superior merchandise and give excellent service. Catalogue: $3.00. www.garrettwade.com

Woodcraft Supply Corporation, 41 Atlantic Avenue, Woburn, Massachusetts 01888. A mail order company supplying woodworking tools and books giving excellent service. Free catalogue. www.woodcraft.com

Adjustable Clamp Company, 431 No. Ashland Avenue, Chicago, Illinois 60622. This company specializes in clamps. Send for free literature or send $0.50 for 32 page "how-to-clamp-it" catalogue. www.adjustableclamp.com

Wetzler Clamp Co, P. O. Box 6, Scarsdale, N. Y. 10583. Telephone: (212) 784-2874. Manufacturer of broad line of clamps. Free catalogue. www.wetzler.com

The Rockledge Company, Box 56, Milwaukee, Wisconsin 53201. Manufacturer of wood clamp kit. The clamp is the Jorgensen-type hand wood screw clamp with 14" jaw length. Jaws open to 10". Kit included two 3/8"x1/2 Acme threaded rods, two tensions pins, four specially threaded pivot nuts and instructions on how to make your own jaws and handles from dowels. "Klamp Kit" is $9.95 postpaid. Visa/Mastercard accepted.

Grizzly Imports, P. O. Box 2069, Bellingham, Washington 98227. Telephone: (206) 647-0801. Importer of wood working tools—planers, jointers, saws, etc. www.grizzly.com

Aviation Industrial Supply, P. O. Box 38159, Denver, Colorado 80238. Telephone: (800) 525-0750 or (303) 355-2391. Discount mail order power tools. Carries Bosch, Hitachi, Makita, etc. www.aviation-industrial.com

Exaktor Tools (formerly J. Philip Humfrey Ltd), 3241 Kennedy Road, Unit 7, Scarborough, Ontario, Canada M1V 2J9. Telephone (800) 387-9789 Canadian retailer of power tools—tilting-arbor saws, band saws, wood lathes, etc. Catalogue: $1.00. www.exaktortools.com

Craftsman Wood Service Co, 1735 W. Cortland Ct., Addison Illinois 60101. Large supplier of wood veneers. Carries over 4000 items including books and tools. (800) 543-9367

The Xylophile's Co, 138 East Loudon Avenue, Lexington, Kentucky 40505. Telephone: (800) 354-9083 or (606) 254-9823. Mail order machinery and tools—Makita, Hitachi, Inca, Elektra, Hegner, Leigh, etc.

Gilliom Mfg, Inc, 1700 Scherer Parkway, St. Charles, Missouri 63303. Manufacturer of Gil-Bilt power tool kits. Band saws, tilt/arbor saw, combination drill press-lathe, 6 inch belt sander, 9 inch tilt table saw, spindle shaper, etc. Catalogue: $1.00. Used and recommended by a Falco builder.

Trend-Lines, Inc, 375A Beacham St., P. O. Box 6447A, Chelsea, MA 02150. Telephone: (800) 343-3248, (800) 322-6100, or (671) 884-8882. Discounter of power tools, clamps, sanding belts, etc. Carries Makita, Pony clamps, Jorgensen clamps, Milwaukee tools, Rockwell/Delta power tools, Freud saw blades, Hitachi power tools, etc. www.trend-lines.com

Highland Hardware, 1045 N. Highland Avenue, NE, Atlanta, Georgia 30306. Telephone: (800) 241-6748 or (404) 872-4466. Full line of woodworking tools and a very interesting catalogue. www.highland-hardware.com

Bridge City Tool Works, 2834 N. E. 39th, Portland, OR 97212. Telephone: (503) 282-6997. Wood working tools. www.bridgecitytools.com

Woodshop Specialties, Coal River Industrial Park, Quality Lane, Rutland, Vermont 05701. Dealers for Powermatic, Rockwell/Delta, DeWalt, SandRite, Acme, Hegner, etc. Telephone: (802) 773-3240

Woodmaster Tools, 2849 Terrace, Kansas City, Missouri 64108. 24-1/2 inch 3-speed band saw. www.woodmastertools.com

Bratton Machinery & Supply, 1015 Commercial Street, P. O. Box 20408, Tallahassee, Florida 32316. Discounter of power tools and hand tools. Carries Jorgensen, Norton, Greenlee, Hitachi, Black & Decker, Porter-Cable, Biesemeyer, DeWalt, Makita, Hegner, etc.

Shopsmith Inc, 3931 Image Drive, Dayton, Ohio 45414. Telephone: (800) 543-9396 or (800) 642-8778. Manufacturer of 5-in-1 woodworking tool. Combination table saw, vertical drill press, horizontal boring machine, lathe and disc sander. www.shopsmith.com

Kuster Woodworkers, P. O. Box 34, Skillman, N. J. 08558. Telephone: (201) 359-4680. Manufacturer of "Dynasand" thickness sander kit, clamp kits, etc. Free catalogue.

Brookstone Company, Vose Farm Road, Peterborough, N. H. 03458. Telephone: (603) 924-9511. Specialize in hard-to-find tools. www.brookstone.com

Seven Corners Ace Hardware, 216 West 7th St, St. Paul, Minnesota 55102. Telephone: (800) 328-0457 or (612) 224-4859. Complete line of power tools and clamps. www.7cornershdwe.com

Woodworkers Supply of New Mexico, 5604 Alameda N. E., Albuquerque, New Mexico 87113. Complete line of woodworking tools and supplies. Catalogue: $2.00.

D. G. Products, P.O. Box 292443, 3832 Marshall Road, Dayton, Ohio 45429. Telephone: (513) 294-1192. Manufacturers of Perma-Grit sanding tools, which are tools of various shapes with carbide grit brazed to steel. Buy one of each and at least two of each of the flat tools. These inexpensive tools remove wood far faster than sandpaper and have none of the problems associated with sandpaper.

Senco Products, Inc. 8485 Broadwell Road, Cincinnati, Ohio 45244. Telephone: (800) 543-4596 or in Ohio (800) 582-1405. Manufacturers of pneumatic staple guns. For the name of a local distributor, look for a listing in the telephone directory white pages or contact Senco direct at the telephone numbers listed. www.senco.com

Paslode Company, 2 Marriott Drive, Lincolnshire, Illinois 60015. Telephone: (800) 323-1303. Manufacturers of pneumatic staple guns. Contact for name of local distributor. www.paslode.com

General Tools, Metal & Wood

JET Equipment & Tools, 1901 Jefferson Avenue, Tacoma, Washington 98402. Telephone: (206) 572-5000. This company imports a line of inexpensive lathes and milling machines. Most are made in Taiwan, Korea, and are knockoffs of Bridgeport Mills and other famous brands. Not generally used by machine shops due to lack of precision and quality. www.jettools.com

Delta International Machinery Corp (formerly Rockwell Power Tool Division). Call (800) 438-2486 or (800) 438-2487 in PA for name of local distributor. Their Professional Power Tool Catalogue and Industrial Power Tool Catalogue is available from the local distributor. www.deltawoodworking.com

L. S. Starrett Company, Athol, Mass. Suppliers of calipers, rulers, protractors and other measuring tools. www.starrett.com

Brown & Sharp Manufacturing Co, Precision Park, North Kingston, Rhode Island 02852. A competitor of L. S. Starrett. Their catalogue, *The Shop Tool Manual*, is excellent. www.brownandsharpe.com

Fairgate Rule Co Inc, 22 Adams Avenue, Cold Spring, N.Y. 10516. Manufacturers of aluminum rulers. Free catalogue.

Cleveland Twist Drill Company, P. O. Box 6656, Cleveland, Ohio 44101. Manufacturer of drills and cutting tools. Their *Taps, Dies and Gages Catalogue* and *Cutting Tool Catalogue* are available from a local distributor.

Aircraft Tools

Aircraft Tool Supply Company, 5738 F 41, Oscoda, Michigan 48750. Telephone: (517) 739-1447. Good source of aircraft tools. Phone orders welcome and bank cards accepted. www.aircraft-tool.com

USATCO'S Air World, 1136 Arlington Avenue, Franklin Square, Long Island, New York 11010. An excellent source of aircraft tools. www.usatco.com

U. S. Industrial Tool & Supply, 15101 Cleat St, Plymouth, Michigan 48170. Telephone: (800) 521-7394, (800) 482-4167 (in Michigan), or (313) 455-3388. www.ustool.com

Aircraft Hardware & Materials

Western Aircraft Supply, Western Aircraft Supplies, P. O. Box 79, Slocan, BC V0G 2C0, Canada. Telephone: (250) 355-0003, Fax: (250) 350-0004 Western Aircraft supplies kits of spruce cut to size for the Falco.

Aircraft Spruce & Specialty Company, P. O. Box 424, Fullerton, California 92632. Telephone: (714) 870-7551. Aircraft Spruce is the Sears and Roebuck of homebuilt aircraft. They have a large, complete catalogue of hardware and materials. Their catalogue is an excellent reference book. www.aircraft-spruce.com

Wicks Aircraft Supply Co, 410 Pine Street, Highland, Illinois 62249. Telephone: (618) 654-7447. The quality homebuilt aircraft catalogue company. Wicks carries a broad list of building materials from spruce, plywood, Aerolite, T88 epoxy, 4130 steel tubing and sheet, covering materials, etc. In particular, Wicks has an excellent reputation for very prompt delivery. www.wicksaircraft.com

Wag-Aero, 1216 North Road, P. O. Box 181, Lyons, Wisconsin 53148. Telephone: (414) 763-9586. A good source of radios, strobes, and other parts. www.wagaero.com

Alexander Aeroplane Co., 900 S. Pine Hill Drive, Griffin, Georgia 30223. Telephone: (800) 831-2949 or (404) 228-3815. Good source for spruce, hardware and other homebuilder supplies.

San-Val Discount Aircraft Parts, 7520 Valjean, Van Nuys, California 91406. Telephone: (800) 423-3281 or (818) 786-8274. A mail order company specializing in brand name aircraft parts. A good source for intercoms, strobes, etc. www.san-val.com

Fibre-Glast Developments, 1944 Neva Drive, Dayton, Ohio 45414. Telephone: (513) 274-1159. Excellent source of all fiberglass, epoxy, polyester, Kevlar, and carbon fiber. They specialize in mail order and give excellent service. www.fibreglast.com

System Tyree Resins, Inc. P. O. Box 70436, Seattle, Washington 98107. Telephone (206) 782-7976. Manufacturers of T-88 epoxy adhesive and L-26 epoxy coating. 32 page manual is $2.50. One pint of T-88 is $9.50 for initial order only, post paid in U. S.

Gougeon Brothers, Inc, 706 Martin, Bay City, Michigan 48706. Manufacturers of WEST System epoxies for wood boats. Telephone: (517) 684-7286. www.gougeon.com

The Dillsburg Aeroplane Works, Rt. 3, Dillsburg, PA 17019. Telephone (717) 432-4589. A small company but Dillsburg has earned consistantly favorable comments from builders purchasing from them. They supply 4130 tubing and sheet, aluminum, hardware, etc. For their price list, send three first class stamps.

Aviation Products, 114 Bryant, Ojai, California 93023. Telephone: (805) 646-6042. A small company with a number of specialty products, among them a unique 1500 psi high pressure strut pump which boosts air pressure from a normal air compressor by a factor of ten—useful for those Falco builders who want to be able to pump up their main gear shock absorbers.

Engines & Accessories

Don George Aircraft Engines, Inc., 1325 W. Washington St., Bldg. B-8, Orlando, Florida 32805. Telephone: (407) 422-0188 or (813) 422-8087 (prop shop). Rebuilt Lycoming engines. Formerly Dick Waters, Inc., this company specializes in suppling homebuilders. www.dongeorgeaircraft.com

Aviat Inc., The Airport, P.O. Box 1149, South Washington Street, Afton, Wyoming 83110. Telephone: (307) 886-3151. Fax: (307) 886-9674. Manufacturers of inverted oil system. www.aviataircraft.com

Engine Components, 9503 Middlex, P. O. Box 17099, San Antonio, Texas 78286. Telephone: (512) 828-3131 or (800) 531-7398. Respected overhauler of aircraft engines. www.eci2fly.com

Appendix B
References

This appendix lists a number of books that you might want to purchase for additional reading. We have made an effort to steer you in the direction of the best books. There are a number of additional books that are inferior and which you might be tempted to buy. These are listed so that you can have an idea of the value of the book for your purposes.

You will find the name and address of the publisher listed for each book, however there are several principal sources. These are:

John Roby, 3703 Nassau Drive, San Diego, California 92115. John Roby offers a long list of out-of-print aviation books. Catalogue: $1.00.

Zenith Aviation Books, 729 Prospect Avenue, P.O. Box 1, Osceola, Wisconsin 54020. Telephone: (800) 826-6600. A major dealer in aviation books. Write for current catalogue.

Experimental Aircraft Association, Wittman Field, Oshkosh, Wisconsin 54903. www.eaa.org

Aviation Maintenance Foundation, P. O. Box 739, Basin, Wyoming 82410.

Aircraft Woodwork, The Best Books

ANC-18 Design of Wood Aircraft Structures
ANC-19 Wood Aircraft Inspection & Fabrication
Long out-of-print government bulletins. ANC-18 is the basic reference for wood aircraft designers, and it is full of graphs and formulas. Few Falco builders will profit from this book. ANC-19 is the "Bible" of aircraft woodwork. There isn't a builder who will not profit from reading it, but many of the most pertinent sections have been summarized in the *F.8L Falco Construction Manual*. Reproductions of these books can be obtained from John Roby.

Sportplane Construction Techniques
The Sportplane Builder
Firewall Forward
By Tony Bingelis. These excellent books are collections of articles on homebuilt aircraft construction methods. Every builder will find something of interest in these books which are written by a Falco builder! Highly recommended. Available from Experimental Aircraft Association.

Gluing & Clamping: A Woodworker's Handbook
By Pat Spielman. This excellent 255-page book covers nearly every conceivable glue and clamping situation. Lots of illustrations. Published by Stirling Publishing Co., Two Park Avenue, New York, N.Y. 10016. Available from Gougeon Brothers at $12.95 plus postage and shipping.

Wood Bending Manual
By W. C. Stevens & N. Turner. This excellent book covers the subject well, and much of what they have to say applies to aircraft work, although the book is not written specifically with aircraft in mind. Available from Woodcraft Supply Corporation, 41 Atlantic Avenue, Woburn, Mass. 01888.

Adhesive Bonding of Wood
By M. L. Selbo. Originally published by the Department of Agriculture as Technical Bulletin No. 1512, this excellent book covers the full range of glues for wood. While not specifically intended for aircraft work only, the book covers all of the glues used in aircraft. It is the best text available on the subject. The book is published by Sterling Publishers, Inc., 2 Park Avenue, New York, N. Y. 10016. (Reported out of print, probably available from Forest Products Laboratory, Madison, Wisconsin.)

Aircraft Woodwork, Other Books

Aircraft Spruce & Plywood MIL-S-6073
This is the basic military specification for aircraft wood, and Falco builders might find it interesting. Those builders who live in areas where Sitka spruce is available may want to purchase and select their own spruce. This specification gives all of the necessary information for grading the wood. Available from Aircraft Spruce & Specialty Company or John Roby.

Gluing Wood in Aircraft Manufacture
By T. R. Truax. This is the basic 1930s text on aircraft gluing as it existed at that time. Interesting reading, but better glues have been developed since that then. Available from John Roby.

Aircraft Woodwork
By Ruth Spencer. A very good little book that any Falco builder who wants to read all he can on wood aircraft construction will not want to miss. Many photos and construction techniques detailed. Available from Zenith Aviation Books.

Building the Custom Aircraft with Wood (Vol 1 & 2)
By the EAA. A collection of articles on wood aircraft construction from the EAA magazine. Some of the articles are quite good, but many are written by quasi-experts and suggest questionable practices. Available from the Experimental Aircraft Association.

Aircraft Construction—General, The Best Books

Airframe & Powerplant Mechanics General Handbook
Airframe & Powerplant Mechanics Powerplant Handbook
Airframe & Powerplant Mechanics Airframe Handbook
By Department of Transportation, Federal Aviation Administration. Reprinted by Aviation Maintenance Foundation. These books are required reading if you are not an A & P mechanic.

AC 43.13-1 Aircraft Inspection & Repair—Acceptable Methods
By the Federal Aviation Administration. This publication in a circular to advise anyone building or repairing an aircraft what the FAA inspectors will and will not accept. It is, in effect, the standard reference for what is acceptable and what is not. You should have this publication if you are planning to build an aircraft in the U.S.

Maintenance and Repair of Aerospace Vehicles
Electricity and Electronics for Aerospace Vehicles
Basic Science for Aerospace Vehicles
Powerplants for Aerospace Vehicles
By Northrop Institute of Technology. Available from Zenith Aviation Books. Excellent college level texts. The *Maintenance and Repair* book has an excellent section on wood aircraft construction and repair.

Standard Aircraft Handbook
By Leavell & Bungay. Available from Zenith Aviation Books. This is a valuable handbook.

Modern Welding
by Althouse, Turnquist & Bowditch. Available from Zenith Aviation Books.

Machinery's Handbook
By Erik Oberg, Franklin D. Jones and Holbrook L. Horton. Published by Industrial Press Inc., 200 Madison Avenue, New York, N. Y. 10016. This is a basic reference book for the mechanical engineer, draftsman, toolmaker and machinist. Order from your local bookstore.

Aircraft Construction—General, Other Books

Aircraft Hydraulic Systems
Aircraft Instrument Systems
Aircraft Oxygen Systems
Aircraft Fuel Metering Systems
Basic Electronics for A&P Mechanics
Aircraft Ignition Systems
By Aviation Maintenance Foundation. Good course in basic aircraft systems.

Sheet Metal Volume I
Sheet Metal Volume II
Available from Experimental Aircraft Association. Excellent Air Force manuals reprinted by the EAA. These are excellent manuals, but *Airframe & Powerplant Mechanics Airframe Handbook* is more complete and covers everything that is in these two books.

Aircraft Drafting & Detail Design (2 vol.)
Excellent course. Required reading if you have trouble reading plans. Possibly available from Zenith Aviation Books. Reportedly out-of-print and may be available from John Roby.

CAM *18 Maintenance, Repair & Alteration of Airframes, Powerplants, Propellers and Appliances*
By Federal Aviation Agency, 1959. This basic manual has been out of print for some time and has been reprinted by the EAA. Frankly, we can't see why they did it, since AC *43.13-1* is the current manual you should use. Available from Experimental Aircraft Association.

Light Airplane Construction for Amateur Builders
Pazmany PL-4A Construction Manual
By Ladislao Pazmany. Two excellent construction manuals. They are helpful reading for the inexperienced builder. The two Pazmany aircraft are aluminum sheet metal aircraft, and much of what is in these books will not apply to the Falco. Available from Pazmany Aircraft Corporation, P. O. Box 80051S, San Diego, California 92138.

Custom Built Sport Aircraft Handbook
This is a guide to dealing with FAA requirements and procedures. Available from Experimental Aircraft Association.

The Use and Care of Twist Drills
The Use and Care of Reamers
The Use and Care of Taps
By Cleveland Twist Drill Company, P. O. Box 91276, Cleveland, Ohio 44101. Available from local distributors.

Power Tool Know How
Good manual on the use of band saws, planers, miter boxes, sharpening tools, table saws, wood lathes and stationary sanders. Available from Sears Roebuck & Company.

EAA "How To" Series
The best of these books have already been specified. There are many helpful hints in these books as well as a lot of short cuts which should *not* be used on the Falco. Not highly recommended. Available from the Experimental Aircraft Association.

Basic Hand Tools, Vol I and II
Good primers on hand tools. Available from the Experimental Aircraft Association.

Complete Metalworking Manual
By R. H. Cooley. Available from Brookstone Company, 123 Vose Farm Road, Peterborough, New Hampshire 04358.

Aircraft Covering & Painting, The Best Books

DuPont Refinish Shop Manual
By E. I. DuPont de Nemours & Company. Excellent manual for the use of all of DuPont's paints. Available from local DuPont distributor.

Poly-Fiber Aircraft Covering Process
Refinishing Aircraft Fabric Surfaces
Painting Aircraft for Corrosion Control
By Ray Stits. Excellent manuals for the use of Stits paints and fabrics. Ray Stits is one of the few who backs up his claims for fabric coverings and coatings with tests. Available from Alexander Aeroplane, P. O. Box 909, Griffin, GA 30224-0909. Telephone: (404) 228-3815 or (800) 831-2949.

Aircraft Painting and Finishing Manual
By Randolph Products Company. This is an excellent reference on painting and surface preparation. Available from Aviation Maintenance Foundation, or Randolph Products Company, P. O. Box 67, Carlstad, New Jersey 07072.

Aircraft Engines

Lycoming Manuals
Available from Avco Lycoming, Williamsport, Pennsylvania.

Norm Bender's Handbook for Aircraft Powerplant Replacement
By Norm Bender. Norm Bender is a colorful individual who sells new Lycoming engines at discount prices. He is not a Lycoming dealer, but he buys Lycoming engines from other dealers and sells the trade-in engine for more than Lycoming gives for the core. He is praised by his customers and hated by his competitors. In this book, Mr. Bender covers the entire subject. The 132-page soft cover book is available for $28.87 from Norm Bender, Inc., P. O. Box 30343, Memphis International Airport, Memphis, Tennessee 38130.

Anatomy of an Overhaul
Available from *The Aviation Consumer*, 1111 East Putman Avenue, Riverside, Conn. 06878.

Aircraft Engineering

Design for Flying
Design for Safety
Homebuilt Aircraft
By David B. Thurston. Dave Thurston's *Design for Flying* is a superb book about aircraft design. You will find the book excellent reading, and it will answer many questions about why a plane is designed the way it is. It is easily understood by the non-engineer, and all formulas are in simple algebra. *Design for Safety* and *Homebuilt Aircraft* are interesting and valuable books, but do not approach *Design for Flying* in their value for the Falco builder. Dave Thurston is the consulting engineer who has approved all of the changes to the original Falco design. All three books are published by McGraw-Hill. Available from your local bookstore or Zenith Aviation Books.

Analysis & Design of Flight Vehicles Structures
By E. F. Bruhn. This is an extensive college text on the engineering of aircraft structural design. If you are not up on your calculus, you will find the math hard to follow, but you can get a good idea of what is involved, and you will have a better understanding of what each part of the aircraft does. This is an excellent engineering textbook, but you really don't need it. Available from Zenith Aviation Books.

Design & Analysis of Filimentary Composite Structures
By Lloyd E. Hackman. This is an excellent college level text on the design of fiberglass and other composite structures. It is an excellent text to convince you that the design of fiberglass aircraft is much more sophisticated than homebuilders are led to believe. Published by Tri-State Publishing Company. Order through your local bookstore.

Fluid-Dynamic Drag
Fluid-Dynamic Lift
By Sighard Hoener. Hoener's *Drag* is the classic work on aerodynamic drag, and if you are interested in the subject, this is the book to read. Available from Zenith Aviation Books.

Theory of Wing Sections
By Abbot & von Doenhoff. This is the best book on airfoils. Available from Zenith Aviation Books.

Publications

The Aviation Consumer
Light Plane Maintenance
Aviation Safety
These three magazines are published by the same company. They are among the best magazines in aviation today, evaluating products and covering maintenance and safety topics. They have a slight "Ralph Nader" consumer bias, and they are quick to set up a shout when they think they see a problem… but they are more often right than wrong. No one else in aviation is doing what they are doing. The magazines are highly recommended, but *Aviation Safety* will have less of interest to Falco builders than the other two. All are available from Belvoir Publications, 75 Holly Hill Drive, Box 2626, Greenwich, Conn. 06836-2626. Telephone: (203) 661-6111, Fax: (203) 661-4802. Subscriptions: (800) 829-9085. www.belvoir.com

Fine Woodworking
This superb magazine is devoted to "making beautiful things of wood". There is only an occasional article on aircraft construction, but each issue is crammed full of articles on woodworking techniques. Also, you will find tools advertised here that you will not see elsewhere. Subscriptions are $16.00/year. Canadian Subscriptions: $19.00/year. Other foreign: $20.00/year (U.S. funds). The Taunton Press, 52 Church Hill Road, Box 355, Newtown, Connecticut 06470. For credit card subscription orders, call (800) 243-7252 or (203) 426-8171. www.taunton.com

WoodenBoat
Nothing about aircraft, but this fine magazine is devoted exclusively to building wood boats. There is a wealth of information, particularly about the use of epoxy to protect wood boats. Published bimonthly. Subscription rate is $18.00. Canadian Subscription rate is $19.50 U.S. funds. Surface rate overseas: $21.00 U.S. funds. WoodenBoat, Subscription Department, P. O. Box 956, Farmingdale, New York 11737. Telephone: (800) 225-5205 or (800) 225-5800. www.woodenboat.com

Sport Aviation
Published by the Experimental Aircraft Association. A subscription to *Sport Aviation* is one of the main benefits of membership in the EAA. Experimental Aircraft Association, Wittman Field, Oshkosh, Wisconsin 54903. www.eaa.org

Trade-A-Plane
The best way to buy or sell anything. www.trade-a-plane.com

Hemmings Motor News
The "Trade-a-Plane" of antique automobiles. Nothing about airplanes, but a great source of information on suppliers of upholstery materials, leathers, etc. http://cars.hemmings.com

Wood Working
The English equivalent of *Fine Woodworking*. A superb publication for the serious craftsman. Wood Working, Quailcraft, Pankridge Street, Crondal, Farnham, Surrey, England.

Kitplanes
By the editors of *Private Pilot*. Subscription information at www.kitplanes.com

Appendix C
Paint Scheme Colors

Venezia & Palermo

	C1	C2	C3	C4	C5	C6
Imron:	*	99	75334	42811	5351	92095
	White	Black	Purple	Med Blue	Blue	Blue
Imron:	*	99	674	6282	60659	6561
	White	Black	Red	Red	Orange	Yellow
Stits:	*	215	187	182	142A	139A
	White	Black	Red	Dk Orange	Orange	Yellow
Imron:	*	7502	29607	3295	7863	218
	White	Brown	Brown	Brown	Yellow	Yellow
Imron:	*	7455	31	24316	54701	8550
	White	Orange	Orange	Yellow	Yellow	Yellow

Modena, Torino & Maranello

	C1	C2	C3	C4	C5
Imron:	78390	1021	44128	4992	99
	Beige	Orange	Red	Red	Black
Imron:	*	92095	5351	99	99
	White	Blue	Blue	Black	Black
Imron:	*	92095	5351	43459	99
	White	Blue	Blue	Met. Gray	Black
Imron:	*	92095	5351	6334	99
	White	Blue	Blue	Gray	Black
Imron:	*	6282	674	43459	99
	White	Red	Red	Met. Gray	Black
Imron:	*	6282	674	6334	99
	White	Red	Red	Gray	Black
Imron:	*	6561	60659	674	99
	White	Yellow	Orange	Red	Black
Imron:	*	6282	674	5321	99
	White	Red	Red	Red	Black
Imron:	*	92095	5351	2063	99
	White	Blue	Blue	Blue	Black

Imron:	78390 Beige	60659 Orange	674 Red	5321 Red	99 Black
Imron:	4296 White	78390 Beige	96704 Tan	7444 Brown	99 Black
Imron:	4296 White	78390 Beige	96704 Tan	7455 Orange	99 Black
Imron:	4296 White	24316 Yellow	60659 Orange	7455 Orange	99 Black
Imron:	* White	24316 Yellow	60659 Orange	7455 Orange	99 Black
Imron:	43938 Cream	24316 Yellow	60659 Orange	7455 Orange	99 Black
Imron:	5363 Lite Lime	43073 Green	7456 Green	99 Black	99 Black
Imron:	* White	43073 Green	7456 Green	99 Black	99 Black
Imron:	* White	71537 Gray	75334 Purple	99 Black	99 Black
Imron:	* White	43073 Green	7456 Green	99 Black	99 Black

San Marino & Monza

	C1	C2	C3	
Stits:	White	215 Black	189 Red	
Imron:	5027 Red	* White	* White	("Ferrari red")
Imron:	5027 Red	71537 Gray	99 Black	
Imron:	* White	71537 Gray	99 Black	
Imron:	* White	71537 Gray	6334 Gray	
Imron:	99 Black	5027 Red	6334 Gray	
Imron:	55137 Gray	5027 Red	99 Black	
Imron:	6334 Gray	5027 Red	99 Black	
Imron:	* White	5351 Blue	2063 Blue	
Imron:	43073 Green	* White	* White	
Imron:	4296 White	60659 Orange	96704 Tan	
Imron:	43938 Cream	60659 Orange	96704 Tan	
Imron:	4296 White	96704 Tan	7444 Brown	
Imron:	* White	60659 Orange	6282 Red	
Imron:	* White	60659 Orange	5027 Red	
Imron:	* White	43073 Green	7456 Green	

Imron:	*	5351	5027
	White	Blue	Red
Imron:	*	5027	2063
	White	Red	Blue

* Pure white. No color tint added to base white paint.

The following information is a reprint of Ciba-Geigy Instruction Sheet No. GR.3d of October 1982.

Aerolite 306
With the GB Hardeners

October 1982
Instruction Sheet No. GR.3d

Urea-Formaldehyde Adhesive. Aerolite 306 powder urea-formaldehyde resin, used with liquid Hardener GBP.X or GBQ.X by the separate application method, provides a gap-filling, water-resistant adhesive which is unaffected by moulds, fungi, etc. It conforms to BS 1204: Part 1 (Type MR)—also to Part 2 (Type MR) since this is included in the requirements of Part 1—and can be released in accordance with DCI and ARB regulations.

Aerolite 306 requires mixing with water before use but the as-supplied powder has considerably longer storage life than the equivalent liquid resin, Aerolite 300.

Hardeners. Choice of hardener depends on the prevailing temperature and on the user's preference in regard to the assembly and clamping times given below. In cold conditions the faster hardener should be used. Glue-line temperature should be at least:

10°C (50°F) using Hardener GBQ.X
15°C (59°F) using Hardener GBP.X

Instructions for Use

Preparation of Resin. Mix Aerolite 306 powder resin with water as follows:

	Parts by Weight	Parts by Volume
Aerolite 306	2	4
Water	1	1

Note
These are approximate values. Where the resin is required to have limited flow, e.g., on vertical surfaces or for filling gaps, less water is preferable (45 parts of water to 100 parts by weight of Aerolite 306).

Use a dry container (preferably non-metallic) and add the water to the powder gradually, stirring to ensure the powder is evenly dispersed. Continue to stir until the resin is free from lumps. The powder dissolves more readily if warm water (20-35°C or 70-95°F) is used. Before application, it is good practice to let the solution stand to allow dispersal of bubbles.

Surface Preparation. Thoroughly sand the surfaces to be joined. Ensure that all surfaces are free from dust or other deposits.

Application. To make application easier, resin and hardener may be transferred to small plastic or glass containers—not metal containers*. Aerolite 306 and hardener are applied by the following method:

1. Spread the resin, by means of a conventional glue spreader, wooden rod or clean brush*, on one of the surfaces to be joined. Leave until tacky.

2. Apply the hardener to the other surface, using a clean brush*, felt pad, sponge or similar iron-free applicator*.

3. Bring the surfaces together while the hardener-coated surface is still moist and maintain firm contact by any convenient method until the glue has set.

   * See note on avoidance of iron contaminations.

Coverage. The quantity of resin and hardener required for most joinery applications can be determined only by workshop tests but when gluing to flat surfaces the following figures may be taken as a guide:

Aerolite 306 resin solution	200 to 400 grammes per square metre (4 to 8 lb/100 sq ft) *Powder resin content of the solution:* *140 to 275 grammes per square metre (2-3/4 to 5-1/2 lb/sq ft)*
Hardener GBP.X or GBQ.X	100 to 150 grammes per square metre (2 to 3 lb/sq ft)

Assembly Times. From the moment at which contact is first made between the resin-coated and hardener-coated surfaces, the joint components must be assembled and firmly positioned within the following times:

	Glue-line Temperature				
Hardener	**10°C/50°F**	**15°C/59°F**	**20°C/68°F**	**25°C/77°F**	**30°C/86°F**
GBQ.X	30 min	20 min	10 min	5 min	—
GBP.X	—	25 min	15 min	10 min	5 min

Clamping Times. The following are the minimum periods during which the surfaces must be held in contact:

	Glue-line Temperature				
Hardener	**10°C/50°F**	**15°C/59°F**	**20°C/68°F**	**25°C/77°F**	**30°C/86°F**
GBQ.X	5 to 6 hrs	2-3/4 hrs	1-3/4 hrs	1-1/4 hrs	1 hr
GBP.X	—	3-1/2 hrs	2-1/4 hrs	1-1/2 hrs	1-1/4 hrs

These times should be at least doubled if the joint will be strained soon after removal from pressure—e.g. when making laminated bends. At the end of the above clamping periods, joints are sufficiently strong to withstand careful handling—but full strength and water resistance are not attained until several days later. The rate at which the glue-line matures to its ultimate strength greatly depends on the ambient temperature: because of this, destructive testing of glued joints should be deferred about 14 days.

Notes

Cleaning of Equipment. Mixers, spreaders, etc., should be cleaned by washing with warm water. The addition of isopropyl alcohol to the water will help to remove persistent residue. Equipment should be cleaned before the glue has time to set.

> **Note**
> Isopropyl alcohol and its vapours are highly inflammable. Due precautions must be taken against all possible fire risks.

Contact Between Hardener and Resin. Except where it is part of the prescribed gluing process, contact between hardener and resin must be carefully avoided. For example, if the applicator used to spread the hardener is dipped into the resin solution container, the resin immediately starts to thicken and set and become useless.

Avoidance of Iron Contamination. Care should be taken to avoid contact of resin or hardener with nails, etc., or with ferrous fitments (for example, on brushes or containers), since this can lead to staining on timber. Staining is caused by the formation—under acid conditions—of iron-tannin compounds (especially on woods with high tannin content, such as oak or ash).

Accidental discoloration—due, for example, to squeeze-out of the adhesive against a G-clamp—may be removed by wiping the affected area with an absorbent pad moistened with 10% citric acid solution. Since this acid may itself cause colour changes in certain types of wood, it is advisable first to test its effect on an off-cut.

Moisture Content of Wood. Wood that has been stored in an unheated shed or workshop may be cold and contain excessive moisture; this may cause poor bonding. It is therefore good practice to store the wood in reasonably warm and dry conditions for several days before gluing. For best results the moisture content of the surfaces to be bonded should be within the range 7 to 13%.

Storage. Close the resin and hardener containers tightly when not in use and store in a cool (ideally 5-20°C) dry place. Shelf life under these conditions is at least two years for Aerolite 306 powder and at least three years for the hardeners.

> **Caution**
> Aerolite resins and hardeners are generally quite harmless provided that certain precautions normally taken when handling chemicals are observed. These precautions amount simply to reasonable care and cleanliness. Keep the uncured materials (resins, hardeners, glue mixtures) away from foodstuffs. Cover any skin abrasions before starting work. Avoid contact with the skin as far as possible during work. Where contact does occur, clean the skin with a cotton pad (or similar absorbent material) moistened with water—ensure in particular that glue mixture is cleaned off before it has time to harden. At the end of each working period, wash the hands thoroughly with soap and water. Disposable paper towels should be used to dry the skin. Avoid inhaling powdered materials (certain resins and hardeners are supplied as powders). These precautions are described in greater detail in Ciba-Geigy Sheet No. AD.2 *Handling Precautions for Formaldehyde-based Products and Vinyl Emulsion Adhesives* which is available on request and should be referred to for fuller information.
>
> *The Aerolite GB Hardeners*. These materials contain formic acid—a corrosive chemical which is harmful if taken internally or allowed to come in contact with

the skin or eyes. If contact between hardener and eyes does occur, the eyelids—held open—should be thoroughly flushed with water, and medical attention should be obtained immediately. If skin or clothing comes in contact with the hardener, the affected skin area should be thoroughly washed with soap and warm water, and the contaminated clothing removed and washed before re-use.

All information is based on results gained from experience and tests and is believed to be accurate but is given without acceptance of liability for loss or damage attributable to reliance thereon as conditions of use lie outside our control. No statements shall be incorporated in any contract unless expressly agreed in writing nor construed as recommending the use of any product in conflict of any patent.

Plastics Division
Ciba-Geigy Plastics and Additives Company
Duxford
Cambridge CB2 4QA
England
Telephone: Cambridge (0223) 832121
Telex: 81101

The following information is a reprint of Koppers Technical Bulletin "Penacolite Adhesive G-1131" November 1982.

Koppers Adhesives
Penacolite Adhesive G-1131

A Room-Temperature Setting and Durable Resin Adhesive

Penacolite Adhesive G-1131 is a two component resorcinol-formaldehyde resin adhesive, capable of curing at room temperature and providing strong, water-proof bonds of utmost durability. Penacolite Adhesive G-1131 is especially effective as an assembly woodworking glue where strength and resistance against water, weathering, and dampness are required. These features are advantageous for general marine and aircraft use and other exterior service applications.

Essentially neutral and inert, and possessing resistance to deterioration or disintegration on aging, Penacolite Adhesive G-1131 will provide strong bonds between woods, treated woods, many plastics, natural and synthetic rubbers, primed metals, and porous materials such as paper, leather, textiles, fiber boards and asbestos boards.

The cured glue line is completely resistant to fresh or salt water, most acids and organic solvents, and lubricating oils and greases. However, alkaline solutions will act adversely on the glue line. The cured adhesive is thermoset so elevated temperatures do not affect the bond; conversely, no loss in bond strength is encountered at temperatures as low as –40°F.

Penacolite Adhesive G-1131 can be used advantageously in assemblies, such as laminated boat keels, arches, and trusses, or where it would not be economical or feasible to use heat for curing because of the size or shape or the number of glued assemblies being produced and where utmost durability with room temperature curing is desired.

As required by the Toxic Substance Control Act (TSCA) Penacolite Adhesive G-1131 is listed in the Chemical Substance Inventory. The CAS registry numbers for G-1131-A (resorcinol-formaldehyde polymer) and G-1131-B (paraformaldehyde) are [24969-11-7] and [30525-89-4].

Description

Penacolite Adhesive G-1131 consists of two parts, a liquid resin G-1131-A and a powdered hardener G-1131-B. Until mixed for use, each of these components has a shelf life of two years when stored at 70°F. The liquid resin G-1131-A is an alcohol-water solution of a partially condensed resorcinol-formaldehyde resin. The hardener G-1131-B is a tan powder formulated from paraformaldehyde and a suitable cellulosic filler.

Government and Industry Specifications

Penacolite Adhesive G-1131 meets the requirements of many Government and Industry specifications. Adhesive bonds produced in accordance with the recommendations n this bulletin and consistent with good wood bonding practice will meet the performance requirements of the following specifications and industry standards:

Federal Specification	MMM-A-181c
Military Specification	MIL-A-22397-1 (ships)
Military Specification	MIL-A-46051 (Ord)
N. B. S. Voluntary Product Standard	PS 56-73
AITC Inspection Manual	AITC-200-73
Product Fabrication Service	Quality Control System

American Society for Testing and Materials	ASTM D 2559-76
Canadian Standards Association	CSA-0112.7-1960

Storage Conditions

The liquid resin G-1131-A should preferably be stored at 70°F, or lower. Frozen resin need only to be thawed and stirred well before using. Containers should be tightly closed to prevent solvent loss. Resins thickened through loss of solvents may be thinned with denatured ethyl alcohol or water, or both, as required.

The hardener G-1131-B should be stored at temperatures below 80°F and kept dry. Continued exposure to higher temperatures will decrease the reactivity. The oldest inventory should be used first.

Mixing Instructions

G-1131-A. .... 5 parts by weight
G-1131-B.. 1 part by weight

It is essential that all mixing and spreading equipment be free of all traces of acids, alkalies and glue residue. Component "A" is charged to the mixer; Component "B" added slowly with agitation and mixing continued for 5 to 15 minutes, until the setting agent is thoroughly dispersed.

Working Life

Mix only that amount of adhesive that is expected to be used within one-half of the working life of the mixed adhesive. Table 1 indicated the relationship between useful working life and temperature of the mixed adhesive

Table 1

Adhesive Temperature	Useful Working Life
60°F	7-1/2 hours
70°F	3-3/4 hours
75°F	3 hours
80°F	2-1/2 hours
90°F	1-1/2 hours
100°F	1/2 hour

The working life of the adhesive is extremely sensitive to traces of acids and alkalies, so all mixing and spreading equipment should be kept clean. When the adhesive becomes too thick to spread, all the containers and spreading equipment should be immediately emptied and cleaned by the use of scrubbing brushes and cool or warm water.

Wood Bonding

Preparation of Stock to be Bonded. The wood to be joined should be of the correct moisture content and should be machined so as to provide smooth, clean and well-fitting surfaces. For best results, final surfacing should take place within the 24 hours preceding gluing. Moisture content of wood is most important and should be from 8 to 15%, preferably within the 10 to 12% range. The temperature of the wood should be 70°F or higher.

Spreading. Penacolite Adhesive G-1131 may be applied by a resilient rubber roll mechanical resin glue spreader, paint roller, or hand spread with a stiff bristled brush. The joints may be double or single spread. In double spreading, the glue is applied to both surfaces of the joint, the total amount of adhesive used being evenly divided between the two surfaces. Double spreading is recommended for dense species and where the time required for assembly approaches the maximum permissible.

Table 2
Recommended Spreads in Pounds Per 1,000 Sq. Ft., Single Glue Line

Low Density Wood..........	50 to 70
High Density Wood.........	50 to 60

The heavier spreads are required for rough surfaces or where long assembly periods are required

Assembly Time. The assembly period is the time elapsing between spreading a joint and applying pressure. "Open Assembly" is the time between spreading and assemblying the spread surfaces, while "Closed Assembly" is the time the spread surfaces are in intimate contact before pressure is applied. It is generally desirable to permit the adhesive to penetrate into the wood for 15 to 45 minutes (when at room temperature) before applying pressure. For certain dense woods and other non-porous material, it is advisable to allow part of the solvent to evaporate by providing a short open assembly time.

Table 3
Recommended Assembly Times

Temperature of room, wood, glue:	70°F	80°F	90°F	100°F
Maximum Permissible Open Assembly Time:	10 mins.	5 mins.	1 min.	0 mins.
Maximum Permissible Closed Assembly Time:	60 mins.	45 mins.	30 mins.	15 mins.

The times in this table are based on using either "open" or "closed" assembly, not both. When a combination of these two assemblies is desired, the maximum assembly times can be proportioned from the table. For example, if one-third of the maximum "open" assembly time is used, then only two-thirds of the maximum "closed" assembly time can be employed.

Curing Conditions

(a) Pressure—In general, sufficient pressure to reduce the glue line to a thickness of 0.002" to 0.007" is required. Thicker glue lines will result in an inferior bond. Pressures of 25-250 psi are generally used. In thick assemblies, slight excess pressure is desirable to compensate for shrinkage.

(b) Temperature—Penacolite Adhesive G-1131 is adaptable to accelerated curing at intermediate temperatures, as well as room temperature. Curing temperatures below 70°F should not be used.

For gluing flat stock at room temperature, minimum clamping pressure periods are shown in Table 4.

Table 4
Minimum Pressure Periods

Glue Line Temperature	Low Density Woods	Dense Woods
70°F	8 hours	10 hours
75°F	6 hours	8 hours
80°F	4 hours	6 hours
90°F	2-1/2 hours	3-1/2 hours
100°F	1-1/2 hours	2 hours

For curved stock the above times should be doubled.

When intermediate temperatures are used, the cure is speeded and penetration is improved. Table 5 is given as a guide for minimum safe clamping times at various glue line (not press) temperatures.

Table 5
Curing Period Under Heat Before Removal of Pressure

Glue Line Temperature	Pressing Time
110°F	55 minutes
120°F	40 minutes
130°F	25 minutes
140°F	18 minutes
150°F	12 minutes
160°F	9 minutes
170°F	5 minutes
180°F	3 minutes

Maturing Period. A complete cure does not take place for about 6 days at room temperature, so joints should not be tested for final strength or durability until after that time. Stock may frequently be machined with safety immediately after releasing from the clamps, though it is best to defer this for about 12 hours after removal of pressure. When intermediate temperature curing, i.e. above 100°F, is used a complete cure is attained quickly and machining may take place immediately after pressing.

Bonding of Other Materials

Penacolite Adhesive G-1131 will provide strong durable bonds to a large variety of material, other than wood. The following are illustrations:

A. Resin impregnated wood, molded and laminated phenolic plastics and many other plastics such as ureas, the cellulose plastics *(except cellulose nitrate)*, nylon, methacrylates, polyvinyl alcohol, polyvinyl acetate and foamed polystyrene, *(not polyvinyl chlorides, Saran, Polystyrene, polyethylene nor Teflon)*. Surfaces should be lightly sanded. If sanding is not feasible, the surfaces should be cleaned with a solvent.

Note
When gluing together two non-porous material, both surfaces should be spread and a ten minute open assembly should be used. In some cases it is advisable to precoat the surfaces with a dilute solution of Penacolite Adhesive G-1131 (such as 100 parts by weight of mixed adhesive plus 15 parts denatured alcohol). This priming coat should be allowed to thoroughly dry before spreading with the regular mix.

B. Natural Rubber, Styrene-Butadiene Rubber, Buna N, Neoprene, Thiokol and reclaimed rubber. Best results are obtained if the surfaces are cyclized by pretreatment with concentrated sulphuric acid prior to spreading. This treatment involves a five minute contact of the bonding surface with the acid followed immediately by a thorough rinse with cold water and drying. Neoprene requires a more severe cyclizing treatment with concentrated nitric acid.

C. Porous materials such as paper, leather, textiles, or fibers, plastic foam, plaster, cement, fiber boards such as “Masonite” or “Celotex,” asbestos or asbestos-cement boards.

Bonding of Treated Wood

Woods treated with preservatives can be bonded with Penacolite Adhesives. For recommendations on specific treatments and bonding conditions, contact Koppers Company, Inc., Chemical Division.

Precautions

The proper use of the mixed Penacolite Adhesive G-1131-A/G-1131-B should no create hazardous worker exposures, however, each use location will require specific hazard potential analysis. Material Safety Data Sheets describing the individual components of this adhesive should be consulted, keeping in mind that adhesive mixes will have the hazards of both components until the mixture cures. In every case, high standards of cleanliness should be maintained. To minimize the possibility of dermititis the use of gloves, protective creams and frequent washing is recommended. For household use, this product is classified as a hazardous substance.

Penacolite Resin G-1131-A contains denatured alcohol: Avoid contact with eyes and repeated or prolonged contact with skin. Wash thoroughly after handling. Wash clothing before reuse. Avoid breathing vapor or mist. Local or area exhaust ventilation is adequate volume and pattern may be required to control vapors below OSHA regulations. Flash point is between 73°F and 100°F. Keep away from heat, sparks and open flame. Keep container closed when not in use.

Penacolite Hardener G-1131-B contains paraformaldehyde: May cause allergic reaction. Avoid contact with eyes, skin and clothing. Wash thoroughly after handling. Avoid breathing dust or prolonged breathing of formaldehyde vapor. Local or area exhaust ventilation in adequate volume and pattern may be required to control vapors and dust below OSHA regulations. Keep container closed when not in use.

KEEP OUT OF REACH OF CHILDREN
For first aid treatment, see container label or Material Safety Data Sheet.

Koppers Company, Inc.
Chemical Division, Pittsburg, PA 15219

Important

All technical advice, recommendations and services are rendered by the Seller gratis. While they are based on technical data which the Seller believes to be reliable, they are intended for use by persons having skill and know-how, at their discretion and risk, and are rendered and accepted at Buyer's risk. Seller shall not be responsible or liable therefore for results obtained or damages incurred from their use as set forth herein or otherwise. Such recommendations, technical advice or services are not to be taken as a license to operate under or intended to suggest infringement of any existing patent.

Bulletin No. OM-645-Nov. 1982

The following information is a reprint of Weldwood Product Date Sheet WC-1680-677

Product Data
Weldwood Waterproof Resorcinol Glue

Weldwood Waterproof Resorcinol Glue is a high performance, chemically curing, wood laminating adhesive. Once fully cured, Resorcinol withstands continuous salt or fresh water immersion, outdoor exposures, tropical and sub-zero temperatures; is not softened by paint or lacquer solvents, oils, grease or mild acids or alkalis; is chemically inert and thus highly resistant to degradation by molds, fungi, bacteria and insects.

Resorcinol Glue is a two-component adhesive (separate catalyst) to provide maximum shelf life and room and intermediate curing capabilities. When the best techniques (outlined below) are used in bonding wood Resorcinol Glue provides the strongest, most everything-proof bond of any of the Weldwood adhesives.

Physical Properties

Base:	Resorcinol Resin	Flash Point:	Resin—100°F
Color:	Brown to Dark Purple	Weight/gallon:	Resin—9.6 lbs.
Solids:	Resin—66%		Catalyst—3.5 lbs.
	Catalyst—100%	Shelf Life:	One Year (see Notice to Purchaser)
Viscosity:	Resin—Thick Liquid	Odor:	Resin—Denatured Alcohol
	Catalyst—Fine Powder		Catalyst—Paraformaldehyde
Carrier:	Resin—Ethanol	pH:	3.5 (Mixed)

Uses

General. Weldwood Waterproof Resorcinol Glue is especially recommended for exterior structural application where maximum durability is required under severe service conditions, temperature extreme, cyclic or constant salt or fresh water immersion, tropical exposures of high temperature and humidities, arctic exposures of low temperatures and humidities, and exposure to biological attack. (In such severe exposures the wood requires protection, use Weldwood water repellents and/or preservatives.)

Resorcinol may also be used as an interior adhesive for severe or normal exposures of conditions or stress. Here it also supplies superior durability and bond strength.

Materials. Resorcinol Glue is designed specifically for the lamination of structural wood beams for severe exposure. It also will provide extremely durable and resistant bonds on a variety of other porous and semi-porous materials such as wood, particle boards, flake boards, fiber boards, leather, cork, phenolic plastics (sanded), concrete (thoroughly cured), unglazed crockery and to the sanded side of high pressure decorative plastic laminates.

Resorcinol is a brown to purple adhesive with characteristic staining properties which may show at the glue line, through a surface or bleed through some materials such as wood and similar, marble, unglazed crockery and some plastics. It should not be used where any such stain might be undesirable.

Preparation

General. Resorcinol is a two-component adhesive. The resorcinol resin and its catalyst are packaged separately to provide a room temperature curing adhesive with a reasonable shelf life.

The proportions of resin to catalyst mix are:

	Weight	Volume
Resin (liquid):	1 lb.	4 units
Catalyst (powder):	0.25 lb.	3 units

For critical assemblies and where uniformity of results are required, the mix of resin and catalyst should be by weight measure. When mixing by volume measure, the catalyst must be shaken in the container to "re-fluff" the powder from its shipping and storage "packed down" condition. Mixing by estimated proportions or to consistency is not recommended since these methods often result in proportion mistakes and inferior adhesive performance.

Place the measured, desired quantity of resin in any standard type mixing equipment. This may be made of iron, steel, enamel or glass but not copper or copper-bearing allows since these tend to react with the adhesive and produce inferior results. Add the catalyst slowly while stirring and continue for 5 to 10 minutes until a uniform dispersion is obtained. The adhesive is now ready to use.

Working ("Pot") Life. The working ("pot") life, that is, the time between preparing the mix for use to when it becomes too thick to be spread of Resorcinol is very sensitive to temperature since it is a chemical reaction. The working life of Resorcinol will vary with the quantity but is approximately:

Temperature:	70°F	80°F	90°F	100°F
Working Life:	4 hours	2-1/2 hours	1-1/2 hours	3/4 hour

Batch sizes should be limited to the quantities of adhesive that will be used during the working life of the adhesive, based upon temperature. When the working room temperatures are high the working life of the batch may be prolonged by keeping the container in a water-jacketed container with cool water circulation or an ice water bath. With such cooling, care should be taken that the applied adhesive warms to the substrate temperature before clamping.

As the working life is ending the adhesive will become thick fairly quickly. Don not attempt to dilute the product at this point for further use since it will cause inferior bonds.

Temperature. Resorcinol is a room temperature (75-95°F) curing adhesive and is capable of being more quickly cured at intermediate (95-190°F) temperatures. High (190-300°F) temperatures are not generally recommended since the cure is almost immediate at intermediate temperatures.

The temperature of gluing and curing rooms, materials and adhesive must be no lower than 70°F, and materials to be used should be preconditioned at the bonding and curing conditions.

In no instance should Resorcinol be used at temperatures below 70°F since poor bonds are almost always the result.

Humidity. The relative humidity is also an important factor, especially when bonding woods. As closely as possible the materials to be bonded should be pre-conditioned, bonded and cured in the conditions (temperature and relative humidity) of the intended end use. Such stability of conditions reduces internal bond stresses during cure and in service, providing superior performance.

If such exact condition control is impossible, the next best results are obtained by preconditioning, bonding and curing the wood with a moisture content of 8 to 12%. This may usually be achieved by storing and maintaining the materials at a temperature of 70-80°F at a relative humidity of 60-70%. Bonds on woods with moisture contents below 5% and above 15% are usually inadequate.

Bonding Surfaces. The bonding surfaces should be more than normally clean, dry and free of any foreign materials, especially previous finishes and stains, oil, water, grease, dirt, etc. Resorcinol will bond in the presence of certain wood treatments but whenever possible treatments should wait until after bonding and curing (once cured Resorcinol is unaffected by treatment). Machining the surfaces shortly before spreading the glue (within 3 to 16 hours and immediately for treated woods) removes materials from the surface that might interfere with the bond strength as well as helping to assure proper and tight fit of the bonding surfaces; this is especially critical on joints of any type.

Application

Tools. Resorcinol Glue may be applied with a variety of tools. Small to moderate areas may be spread with Resorcinol by brush, small notched trowel or paint roller. Large surfaces or industrial applications normally require a glue gun application or finely grooved rubber metal roll mechanical glue spreaders.

Application. Spreading both bonding surfaces is recommended, and is especially advisable for dense wood specie and where the time required for assembly approaches the maximum allowed. This provides maximum wetting of the surfaces assuring better bonds. The spreading of only one surface is allowed when the time between application is minimal (5 to 10 minutes).

Open Time. After Resorcinol Glue has been spread on the surfaces, some delay in assembly (open time) should be allowed to permit some absorption into the wood and "flash off" some of the solvents; especially important for bonding high density woods where high pressure will be used. The reduces the chance of "starving" the glue line under high pressure. Under no circumstances should the adhesive spread be allowed to become "tacky" or "skin over" before the surfaces are mated. Since the rate of dry is dependent on the porosity of the wood, its moisture content, the temperature and the relative humidity of the air, and these factors vary considerably, "good judgement" must be used in following the below recommended open time table of temperatures.

Temperature of Wood and Area:	70°F	80°F	90°F	100°F
Maximum Open Time:	80 mins.	20 mins.	15 mins.	10 mins.

Post Application

Mating. The surfaces should be mated uniformly and squarely, bringing them into full surface contact overall, with a minimum of sliding and repositioning. Mating the surfaces from one to the other may cause excessive loss of adhesive from one area and create nonuniform glue spread and thus bond strength.

After mating, the surface pressure should be applied as soon as possible, however some time is allowable for the spreading of other adhesive surfaces, the arrangement of pressure jigs and clamps and the mating of other bonds.

Again, the allowable closed assembly time before pressure is applied is very dependent upon the conditions of the wood and environment and the following table is given as a guide to be used with "good judgement."

Temperature of Wood and Area:	70°F	80°F	90°F	100°F
Maximum Open Time:	75 mins.	45 mins.	30 mins.	20 mins.

Pressure. In general, for the best results, sufficient pressure should be used to reduce the glue line thickness to 0.005 inches. In all cases the pressure should be adequate to provide thin glue lines and close contact of the surfaces being joined. However, high pressure must never be substituted for well machined, accurately fitted joints.

When all other requirements are met, pressures of 25-75 psi should be sufficient. Multiple glue lines between thick or dense wood laminates may require pressure of 150-200 psi, or more.

In all cases, sufficient adhesive should be applied to provide squeeze-out when pressure is applied to insure uniform adhesive contact and eliminate voids.

Set Time. The length of time that this pressure must be maintained is determined by the texture of the wood, the stresses present in the construction and the temperature at which the assembly is maintained during the initial curing period. The recommended minimum time under pressure for stress-free joints is shown in the following table:

Minimum Time Under Pressure at Various Glue Line Temperatures

Temperature:	70°F	75°F	80°F	90°F	100°F
Low Density Woods:	8 hours	6 hours	4 hours	2-1/2 hours	1-1/2 hours
High Density Woods:	10 hours	8 hours	6 hours	3-1/2 hours	2 hours

The rate of cure of Resorcinol is accelerated when raised to intermediate (95-190°F) temperatures. The following schedule is furnished as a guide only and may require modification, depending upon the bonding circumstances (e.g., increase the time if the joint in under stress). Also, there are glue line temperatures which may vary from the temperature of the room or press assembly.

Recommended Curing Periods For Glue Lines at Elevated Temperatures

Temperature:	110°F	120°F	130°F	140°F	160°F	170°F	130°F
Time:	60 mins.	50 mins.	35 mins.	22 mins.	12 mins.	9 mins.	7 mins.

Cleanup. Weldwood Waterproof Resorcinol Glue cures to an insoluble substance which cannot be easily removed from clothing, tools, working surfaces or other unwanted areas. Thus, Resorcinol must be used with care against spills and spatters, and should not be allowed to contact surfaces where its presence would be objectionable. There are no satisfactory solvents for softening a cured Resorcinol glue line.

Mixing equipment, glue spreaders, glue brushes and all containers should be cleaned thoroughly and immediately after use, with scrub brushes and cool or warm (but not hot) water. Faster cleaning may be obtained by using caustic soda solution (Caution: caustic may cause burns; do not use on hands or skin) but caution should be observed and followed by a thorough clean water rinse.

Since Resorcinol is difficult to impossible to remove once cured, cleanliness of the working area and personal cleanliness of the operators while mixing and using the adhesive is required, and especially to prevent dermatitis and respiratory irritations. The wearing of face masks, rubber gloves and other protective clothing is strongly recommended.

Performance

Coverage. The coverage of Weldwood Resorcinol Glue depends greatly upon the wood texture, moisture contend and the glue line thickness. Coverage of between 100 and 150 square feet per gallon of glue line may be expected depending upon the precision of technique.

Cure Rate. Resorcinol reaches ultimate strength and complete waterproofness after room temperature aging for one week. Therefore, no test for joint strength, waterproofness or durability should be performed until after this curing period.

Resorcinol glued stock may be lightly machined upon release from pressure, but heavy machining, shaping or undue rough handling should be postponed until after a tempering period of from 12 to 24 hours above 70°F.

Bond Strength. The bond strength of properly prepared glue joints with Weldwood Waterproof Resorcinol Glue are usually in excess of the strength of the wood bonded.

When tested on hard maple in block shear (re: ASTM D905) Resorcinol bonds have a compression shear strength in excess of 2,800 psi.

Heat and Water Resistance. Three ply, yellow birch, 3/16-inch plywood laminates boiled in water for 3 hours and cooled in water for 1/2 hour still have an average tension shear strength of at least 400 psi.

Durability. Weldwood Resorcinol glued joints, when properly prepared per manufacturer's recommendations and sound, standard commercial practices, are among the most durable bonds available for wood, and usually in excess of the substrate life.

Storage and Handling

Temperature. Weldwood Waterproof Resorcinol Glue should be stored at temperatures of 70°F or below for best storage stability. Storage at temperatures above 70°F may reduce expected shelf life due to solvent and catalyst evaporation.

If the liquid resin becomes frozen from prolonged storage or shipping at low temperatures, the adhesive must be allowed to return to room temperatures and stirred before use.

Shelf Life. Weldwood Resorcinol Glue is packaged in two containers per unit, in all sizes; the liquid resin is in one and the powdered catalyst in the other. These components remain usable for a reasonable length of time under normal storage condition in the original tightly closed containers. These containers should be kept tightly closed as much as possible to prevent solvent loss.

The resin portion may thicken due to solvent loss but may be returned to a usable state by thinning with equal parts of denatured alcohol and water but to no more than 10% by weight of the resin.

In the liquid resin has gelled, this indicated overage or storage under improper conditions and such resin should be discarded since it will not form bonds of adequate strength.

Caution

Powder Catalyst. CAUTION! Toxic, strong sensitizer. Contains Paraformaldehyde. Avoid frequent or prolonged contact with skin. First Aid: In case of contact with skin, wash thoroughly with soap and water. If eye contact occurs, flush with water. Call a physician immediately. KEEP OUT OF REACH OF CHILDREN!

Liquid Resin. CAUTION! Combustible mixture. Contains ethanol and resorcinol resin. Do not use or store near heat or open flame. Avoid prolonged contact with skin and breathing of vapor. First Aid: In case of contact with skin, wash thoroughly with soap and water. If eye contact occurs, flush with water. Call a physician immediately. KEEP OUT OF REACH OF CHILDREN!

Additional Information

Specification. Weldwood Waterproof Resorcinol Glue conforms to the requirements of:

Federal Specifications: MMM-A-1811b (Type I, Grade A)
MIL-A-46051 (Type I, Grade A) (Type I, Grade C)
MIL-A-22397

Important Notice to Purchaser. Buyer assumes all risk of use, handling and storage of product not in strict accordance with label directions. No expressed warranties are given. ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS OR PARTICULAR USE IS LIMITED TO ONE YEAR FROM DATE OF PURCHASE. LIABILITY FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGE OR LOSS IS SPECIFICALLY EXCLUDED AT ALL TIMES. If used for other than personal, family or household purposes, any implied warranty of MERCHANTABILITY or FITNESS FOR PARTICULAR USE is excluded.

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The following information is a reprint of Ciba-Geigy Instruction Sheet No. GW.10k of May 1981.

Aerodux 500
With Hardener 501

May 1981
Instruction Sheet No. GW.10k

Resorcinol-Phenol-Formaldehyde Adhesive. Aerodux 500 is supplied in three grades: 500.F (Fast), 500.M (Medium) and 500.S (Slow). Hardener 501 is used with each grade.

Aerodux 500 liquid resins mixed with Hardener 501, a resinous liquid containing filler, provide a range of resorcinol-phenol-formaldehyde adhesives which are fully weatherproof and gap-filling, and are expecially suited to the manufacture of large laminated timber structures. Aerodux 500 adhesives are also suitable for use in the production of heat-resistant composite structures, e.g., fire-check doors. They are resistant to acids, weak alkalis, solvents and boiling water.

Aerodux 500 adhesives are simple to prepare. Both resin and hardener are liquids, and are mixed in a 1:1 ratio.

Aerodux 500 resins with Hardener 501 meet the requirements of BS 1204: Parts 1 and 2 (Type WBP), BS 1203 (Type WBP) and DIN 68 705 (AW 100) and can be released in accordance with DCI and ARB regulations.

The three adhesives are highly suitable for bonding a wide range of materials to porous substrates. These materials include:

Wood, improved or densified woods, e.g., 'Hydulignum'.
Asbestos-based boards, brick, concrete, unglazed porcelains.
Rigid expanded plastics, e.g., expanded ebonite, polystyrene, polyurethane and PVC.
Industrial and decorative laminated plastics (phenolic resin-based or phenolic resin-backed).
Leather, cork, linoleum, nylon.

Typical Properties of Aerodux 500 at Manufacturer

Appearance:	Reddish-brown liquid
Viscosity:	0.35-1.1 Pa s (3.5-11 poises) at 25°C/77°F
Specific gravity:	1.2-1.4 at 25°C/77°F
Solids content:	52-58%
Flash point*:	31°C

* Hardener 501, which is also inflammable, has a flash point of 38°C/100°F.

Instructions for Use

Mixture. Mixing proportions are the same for each of the three resins.

Aerodux 500 (Fast, Medium or Slow):	100 parts by weight or volume*
Hardener 501:	100 parts by weight or volume*

* Since resin and hardener have slightly different densities, but are supplied by weight, mixing by volume will result in uneven consumption of the components.

Viscosity of Mixture. Viscosity, 15-20 minutes after mixing, is similar for each grade of resin used:

Viscosity: 1.5-2 Pa s (15-20 poises) at 25°C/77°F

Extension. Wood flour or mineral filler may be added to increase the viscosity and reduce glue costs. Typical mixtures are:

Lightly-Filled Mix		Heavily-Filled Mix	
Aerodux 500:	100 parts by weight	Aerodux 500:	100 parts by weight
Hardener 501:	100 parts by weight	Hardener 501:	100 parts by weight
China clay:	40 parts by weight	China clay:	200 parts by weight

The lightly-filled mix still complies with the requirements of BS 1204: Part 1 (Type WBP). It may be necessary to adjust the viscosity of the heavily-filled mix with water but the water addition should be kept to a minimum. This mix is suitable for bonding uneven-surfaced boards, such as asbestos-based boards, where maximum strength and full weatherproof properties are not required

Mixing. Hardener 501 must be well stirred before removal from the container. Add the required amount of Hardener 501 to the Aerodux 500 and mix thoroughly. Addition may be measured by weight or volume.

Pot Life. Pot life of resin-hardener mixture in relation to temperature:

	Temperature of Resin-Hardener Mixture (°C/°F)						
Resin	5°/41°	10°/50°	15°/59°	20°/68°	25°/77°	30°/86°	35°/95°
500.F (fast)	9-10 hrs	6-7 hrs	4-5 hrs	1.5-2 hrs	—	—	—
500.M (med)	—	—	5.5-6.5 hrs	3-3.5 hrs	2-2.5 hrs	1-1.5 hrs	—
500.S (slow)	—	—	—	—	3.5-4 hrs	2.5-3 hrs	1.5-2 hrs

Surface Preparation. The surfaces to be bonded should be free from dust and other deposits. Wood, panels, laminates, etc., should be of uniform thickness. Solid timber should be freshly machined, but does not usually require sanding. Smooth dense surfaces to be bonded—except expanded plastics and asbestos-based boards—should also be thoroughly sanded.

Metal surfaces should be abraded and coated with Primer L.62 before bonding to porous materials (such as wood). Directions are given in Ciba-Geigy Instruction Sheet No. AD.4.

Moisture Content. Satisfactory results may be obtained when the moisture content of the surfaces to be bonded is within the range 6-25%, but for best results, 12-16% is preferred. Artificial drying will be required to reduce the moisture content to 16% or lower. Adjacent surfaces should not differ by more than 3% moisture content.

Application. Whenever practicable it is advisable to spread the resin-hardener mixture evenly on both of the bonding surfaces. For coverage see "Control of Spread to Counteract Drying-Out" below.

Closed Assembly. Joints must be assembled and pressure finally applied within the following times:

	Glue-Line Temperature (°C/°F)					
Resin	10°/50°	15°/59°	20°/68°	25°/77°	30°/86°	35°/95°
500.F (fast)	3 hrs	1.25 hrs	1 hr	—	—	—
500.M (med)	—	2.75 hrs	2 hrs	1.5 hrs	1 hr	—
500.S (slow)	—	—	—	2 hrs	1.5 hrs	1 hr

Since the adhesive has gap-filling properties, only enough pressure is needed to give firm contact. It is essential that the joint should be "made" before the adhesive gels.

RF Heating. Resorcinol adhesives heat up more slowly under glue-line or stray-field heating than UF adhesives but curing may be accelerated by the addition of common salt (sodium chloride) at a rate of 1-2 parts by weight of salt to 100 parts by weight of resin. Precautions should be taken against arcing which may lead to tracking and burning in the glue-line. Arcing can be avoided by low spread, low moisture content and good jig design to ensure no air gaps between electrode and glue-line and sufficient and even pressure on the joint during curing.

Pressing or Clamping. The following table gives the minimum time for application of pressure:

	Glue-Line Temperature (°C/°F)						
Resin	10°/50°	15°/59°	20°/68°	25°/77°	30°/86°	35°/95°	40°/104°
500.F (fast)	14 hrs	4 hrs	3 hrs	1.5 hrs	1 hr	40 min	30 min
500.M (med)	—	8.5 hrs	5 hrs	4 hrs	2 hrs	1.25 hrs	45 min
500.S (slow)	—	—	10 hrs	5.5 hrs	4 hrs	3 hrs	2 hrs

Note. Minimum pressing or clamping times stated are those required to give 1.33 kN/300 psi dry shear strength on close joints conforming to BS 1204: Part 2. For dense or high moisture content timbers, where a component is impermeable, or if the joint is liable to be strained immediately after removal of pressure (e.g., as in the manufacture of laminated bends), the above times should be increased. Aerodux glues will continue to gain strength until, after several days, full water-resistant properties are developed.

Hot Pressing. The press should be loaded and closed as quickly as possible in order to avoid pre-curing. Basic setting times in minutes:

	Glue-Line Temperature (°C/°F)					
Resin	50°/122°	60°/140°	70°/158°	80°/176°	90°/194°	100°/212°
500.M (Medium)	30 min	12 min	6 min	3 min	2 min	1.5 min
500.S (Slow)	50 min	25 min	12 min	7 min	4 min	2.5 min

Heat Penetration. The basic setting times stated refer to glue-line temperatures only and allowance must be made for the heat to travel from the heat source. Heat penetration time will vary according to density of the wood, moisture content and distance to the farthest glue-line. The following table is a guide to the additional time required:

Up to 5mm	1 minute per millimeter of distance to the farthest glue-line
5-8mm	1.25 minute per millimeter of distance to the farthest glue-line
8-12 mm	1.5 minute per millimeter of distance to the farthest glue-line`

Notes

Accelerator for use with Aerodux 500. An accelerator is available which will speed curing at low ambient temperatures and accelerate the rate of cure with radio frequency or warm pressing. Our technical Department would be pleased to discuss this further in detail, if required.

Control of Spread to Counteract Drying-Out. The defect known as drying-out is influenced mainly by relative humidity, temperature and thickness of glue spread. In conditions of high ambient temperature and low relative humidity, higher spreads may be necessary to limit drying-out. Under average conditions (65% relative humidity and 18°C/65°F), a spread of about 225 grammes per square meter (4.5 lbs/100 sq ft) to each face of a joint is sufficient.

Gluing Preservative-Treated Timber. Before gluing timber that has been treated with a preservative, it is generally necessary to machine or vigorously sand the surfaces to be bonded. Also the timber should be checked for moisture content, since this can be increased beyond acceptable level by water-borne preservatives and may need to be reduced before gluing. Further advice on the gluing of preservative-treated timber is available on request.

Preservative Treatment after Gluing. Beams and components should be allowed to stand for at least 7 days after gluing before being subjected to water-borne preservative treatment in pressure cylinders.

Staining on Absorbent Boards. Light-coloured absorbent boards, e.g., cement-asbestos boards, bonded with resorcinol or resorcinol-phenol-formaldehyde adhesives may tend to show signs of staining when subjected to exposure to weather or very wet conditions. This is because certain soluble materials in the uncured resin are absorbed and retained by the board and may subsequently be leached out by soaking. These materials appear as dark stains on the surface of the board, but disappear with further weathering.

Cleaning of Equipment. Mixers, spreaders, etc., should be cleaned by washing with warm water. The use of a warm dilute washing-soda solution will help to remove persistent residue. Equipment should be cleaned before the glue has time to set.

Storage. Aerodux resins and hardeners should be stored firmly sealed in their original containers in a cool (ideally 5-20°C) dry place. Shelf life under these conditions is at least 1 year for both Aerodux 500 and Hardener 501.

Containers. Aerodux 500 and Hardener 501 are available packed as follows:
Aerodux 500: 225 kg/495 lb and 25 kg/55 lb Tighthead plain drum. 5 kg/11 lb and 1 kg/2.2 lb tins.
Hardener 501: 75 kg/165 lb and 25 kg/55 lb Openhead plain drum. 5 kg/11 lb and 1 kg/2.2 lb tins.

> **Caution**. Aerodux resins and hardeners are generally quite harmless to handle provided that certain precautions normally taken when handling chemical are observed. These precautions amount simply to reasonable care and cleanliness. Keep the uncured materials (resins, hardeners, glue mixtures) away from foodstuffs. Cover any skin abrasions before starting work. Avoid contact with the skin as far as possible during work. Where contact does occur, clean the skin with a cotton pad (or similar absorbent material) moistened with water—ensure in particular that glue misture is cleaned off before it has time to harden. At the end of each working period, wash the hands thoroughly with soap and warm water. Disposable paper towels should be used to dry the skin. These precautions are described in

greater detail in Ciba-Geigy Sheet No. AD.2 *Handling Precautions for Formaldehyde-Based Products* and in Ciba-Geigy Product Safety Information Sheet for Aerodux 500 which are available on request and should be referred to for fuller information.

Aerodux 500 and Hardener 501. Avoid breathing the vapour from Aerodux 500 or Hardener 501—good ventilation of the working area is recommended. Aerodux 500 and Hardener 501 (and their vapours) are inflammable. Due precaution should be taken against all possible fire risks. Keep the uncured materials (resin, hardener and resin-hardener mixture) away from open flames, electrical elements, etc., and firmly seal the containers when not in use. If the materials catch fire, either a water fog or a carbon dioxide or dry powder extinquisher should be used—drenching with water is best avoided because Hardener 501 is water-immiscible.

All information is based on results gained from experience and tests and is believed to be accurate but is given without acceptance of liability for loss or damage attributable to reliance thereon as conditions for use lie outside our control. No statements shall be incorporated in any contract unless expressly agreed in writing nor construed as recommending the use of any product in conflict of any patent.