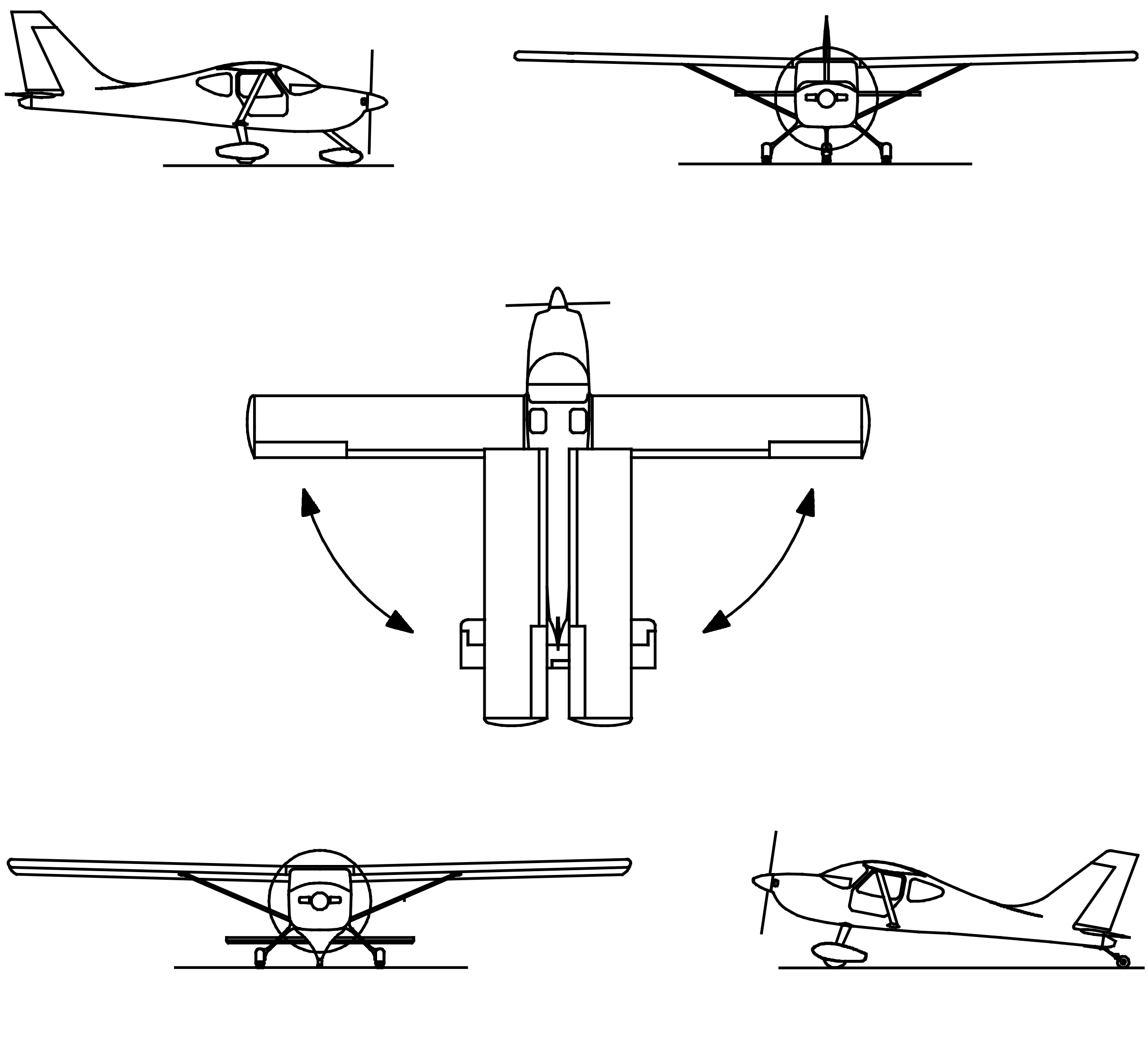
GlaStar

ASSEMBLY MANUAL

GlaStar Assembly Manual

vol. 1



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ALWAYS CONSULT THE MANUAL PROVIDED WITH YOUR KIT AND ALL RELEVANT ADVISORY PUBLICATIONS:
http://www.glasairaviation.com/advisglastar.html

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SECTION I: INTRODUCTION

WELCOME!

Welcome to the GlaStar family! We are confident that building your GlaStar aircraft will be a satisfying, enjoyable and fun project. We have done as much as possible to simplify construction of the GlaStar and to eliminate the need for expensive or exotic tools, for complicated jigging procedures and for specialized skills. The purpose of this *Assembly Manual* is to describe every assembly procedure clearly and concisely in a step-by-step manner.

Before beginning construction of your GlaStar, **we strongly urge you to read this section and the following "SECTION II: TOOLS AND TECHNIQUES" thoroughly. Pay particular attention to the "SAFETY PRECAUTIONS" in this section. Our experience of nearly twenty years in the kitplane industry has shown that time invested in studying the manual before starting work is richly repaid in increased efficiency and greater enjoyment down the road.**

AIRCRAFT DESCRIPTION

The GlaStar is a two-place, high-wing, tractor-engine airplane that is designed to provide the highest possible utility and versatility. It can be built with either tricycle or conventional (taildragger) landing gear and was designed from the outset to accept floats, either straight or amphibious. The GlaStar features folding wings and an easily removable horizontal stabilizer that allow the airplane to be trailered home, reducing or eliminating hangar costs.

The GlaStar has a simple, rugged airframe of mixed construction. The wing, the horizontal stabilizer, and all control surfaces are made of sheet aluminum to minimize both weight and cost and to provide the fastest possible construction. All ribs and spars are pre-formed, as are leading and trailing edge bends. Pilot holes for rivets are pre-punched in the aluminum structure wherever possible to minimize the amount of measurement and lay-out needed to assemble the airframe.

The fuselage is a fiberglass composite shell with an internal steel tube cage around the passenger compartment. Most of the major components (the wings, the landing gear, and the engine) attach directly to the steel tube cage, which eliminates the need to fabricate load-bearing structure for these components in the fiberglass shell. Being able to bolt these components directly to a pre-welded structure also greatly reduces the requirements for tedious and exacting jigging procedures. Attach points are provided in the steel tube cage for both conventional and tricycle gear as well as for floats, so the airplane is easily converted among gear types.

The fuselage shell consists of left and right halves and a cabin roof, joined together by seam laminates. The forward part of the fuselage is essentially a fairing, providing smooth contours to reduce parasite drag; the aft fuselage is a structural member that carries the aerodynamic loads from the empennage. Loads are transferred between the steel tube cage and the fuselage shell by an array of reinforced areas in the shell and attach tabs on the cage.

The control system in the GlaStar is conventional. Dual sticks provide pitch and roll control, rudder pedals for both the pilot and the passenger provide yaw control, and a centrally-mounted lever actuates the large Fowler flaps. All of the primary controls are actuated by a system of cables and pushrods. A large elevator trim tab provides pitch trim.

TECHNICAL SUPPORT

With any project of this size, questions will almost certainly arise, and we want to assure you at the start that we will provide the best support possible. Our reputation for supporting our builders and standing behind our products is unequaled in the industry. If a question arises, please call our dedicated **Technical Support Line**, where a technician who has experience constructing the GlaStar airframe, as well as a wide range of aviation experience in general, will be available to help you. Refer to your purchase confirmation documentation for specifics of our technical support policy.

USING THE *ASSEMBLY MANUAL*

The *GlaStar Assembly Manual* begins with two general, introductory sections (this section and the following "SECTION II: TOOLS AND TECHNIQUES"). Sections describing the various sub-assemblies of the airplane follow the introductory sections in the recommended order of completion. All detailed descriptions of fabrication and assembly techniques appear in "SECTION II: TOOLS AND TECHNIQUES;" later sections will assume that you already know how to accomplish specific procedures.

Dimensions and Tolerances

Many dimensions are given throughout the *Assembly Manual.* All dimensions are in inches, mostly in fractional form as these are the easiest to measure using standard, English-system measuring tools. There are a few instances where we specify decimal dimensions; for these, use a rule graduated in 1/50ths of an inch. The fractional dimensions given have a tolerance of no more than ± 1/32". All decimal dimensions given have a tolerance of no more than ± .030".

For GlaStar builders in countries that use the metric system, we recommend procuring a set of English-system measuring tools (tapes and rules) and becoming familiar with their use rather than converting from English to metric measurements. Since English-size hardware is supplied in the GlaStar kit, and since you will be using English-size drill bits to drill all the holes, we feel that it is better to maintain consistency and use the English system throughout. Converting between systems is an unnecessary, time-consuming step that introduces one more opportunity for errors to occur.

Parts Lists, Tool Lists and Workspace Requirements

At the beginning of each assembly section is a list of parts used in the assembly. The parts in the parts list are assigned a key number by which they are referenced in the illustrations and the text. The key number is circled in the illustrations and enclosed in brackets in the text. Key numbers are for reference within the manual **only**. The complete, ten-digit part number is the number you should refer to when contacting the Order Desk to inquire about orders, order replacement parts, etc.

Note These lists have two main purposes. First, they give you an idea of which parts are required for a particular sub-assembly of the aircraft. Second, they allow us to omit ten-digit part numbers from the text and illustrations, resulting in more easily readable instructions and clearer illustrations. What the manual parts lists are **not** intended for is taking inventory of your kit shipment(s). Special Kit Contents Lists included with each shipment are intended for this purpose. Due to different revision schedules, the manual parts lists and the Kit Contents Lists may not always agree, but any discrepancies will either be explained in Advance Notices of Revision (see below) or will be made good by supplemental parts shipments called "Addenda." **Please do not inventory your kit based on the manual parts lists.**

Note Purchasers of any of our pre-finished steel part options will receive parts with part numbers such as "101-05000**P**03," where the "P" substitutes for the usual hyphen and indicates that the part is primed, plated or powder coated. The parts lists in the manual, however, will only list the standard, untreated part numbers. Construction procedures are identical in all cases.

The parts list is followed by lists of tools and additional materials not provided in the kit (such as scrap wood for simple jigs, household glue, anti-corrosion primer, etc.) needed to complete the assembly and a description of the workspace required for the assembly.

Illustrations

The *GlaStar Assembly Manual* makes extensive use of isometric line drawings of the various assemblies and exploded views of assembly details. As mentioned previously, parts shown in the illustrations are referenced by the key number that appears in the parts list at the beginning of the section. Detail drawings include a thumbnail sketch of the entire assembly with the location of the detail marked with an arrow.

Pre-punched holes in the parts are shown as holes in the illustrations. The locations of holes to be drilled by the builder are shown by small crosses.

Location References

Throughout the GlaStar Assembly Manual we make frequent use of terms that specify the location or orientation of a part or an assembly. Following is an alphabetical list of such terms with their definitions as used in this Assembly Manual:

AFT — used to denote a position or a direction relative to a reference point; means closer to the tail of the aircraft.

BOTTOM — used to denote a location; the lowest point.

FORWARD — used to denote a position or a direction relative to a reference point; means closer to the nose of the aircraft.

INBOARD — used to denote a position or direction relative to a reference plane; means closer to the longitudinal centerline of the aircraft.

LEFT — used to denote a position or direction relative to a reference point; corresponds to the pilot's left side when seated in the aircraft facing forward.

LOWER — used to denote a position relative to a reference point; means closer to the bottom of the aircraft when the aircraft is upright; often used as an adjective to differentiate between two similar objects.

OUTBOARD — used to denote a position or direction relative to a reference plane; means farther from the longitudinal centerline of the aircraft.

RIGHT — used to denote a position or direction relative to a reference point; corresponds to the pilot's right side when seated in the aircraft facing forward.

TOP — used to denote a location; the highest point.

UPPER — used to denote a position relative to a reference point; means closer to the top of the aircraft when the aircraft is upright; often used as an adjective to differentiate between two similar objects.

Warnings, Cautions, Notes and Hints

The following definitions apply to the **Warnings**, **Cautions**, **Notes** and **Hints** used throughout this Assembly Manual. **Warnings**, **Cautions**, **Notes** and **Hints** appear in the format shown here.

Warning A warning is used to alert you to a procedure, a practice or a situation that may result in personal injury or loss of life if not carefully followed or strictly observed.

Caution A caution alerts you to a procedure, a practice or a situation that, if not carefully followed or strictly observed, may result in damage to or destruction of a part.

Note A note alerts you to a step, a procedure, or an instruction that is considered important to emphasize.

Hint A hint is a recommendation for an easy way to accomplish a certain procedure.

Assembly Manual Revisions and Advisory Publications

ADVANCE NOTICES OF REVISION AND FORMAL REVISIONS

In order to keep you advised of pending *GlaStar Assembly Manual* changes in as timely a manner as possible, we will publish periodic **Advance Notices of Revision** (ANORs) for the manual. An ANOR consists of a simple list of items indicating places in the manual where changes will occur, with brief descriptions of the changes. When you receive an ANOR, we recommend that you pencil the outlined changes into your manual in order to insure that you are building according to the most current instructions.

ANORs are essentially a stop-gap measure to keep you informed between formal **revisions** to the manual. A formal revision consists of a set of replacement pages for the manual in which changes briefly outlined in the ANORs are fully developed with appropriate text and illustrations. When you receive a revision, discard the affected pages from your manual and replace them with the revised pages provided.

Any revision to the manual will be noted in the "LIST OF REVISIONS," which appears directly after the title page of this volume. The revision will be designated by a revision letter and date. The revised page will show the most current revision letter and date in the footer at the bottom of the page. Any page that shows no revision letter and date in the footer has never been revised and is the most current page available. A vertical revision bar in the outside margin indicates the area where each latest revision was made.

ADVISORY PUBLICATIONS

In addition to the *Assembly Manual* and its revisions, Stoddard-Hamilton utilizes a variety of **advisory publications** to keep GlaStar builders and pilots apprised of important information. The publications include **service bulletins** and **service letters**; the specific definitions of these types of publications are discussed below. Any advisory publication that you receive should be read carefully and immediately, as it may contain vital information pertinent to construction you are currently undertaking or to operation of the completed aircraft. All advisory publications received should be retained in an organized fashion as part of the permanent record of the aircraft.

Advisory publications are numbered sequentially as they are issued. An important point, however, is that not all advisory publications apply to all kits. In order to avoid burdening you with irrelevant material, we will send you only those advisory publications that may pertain to your kit. Therefore, few builders will end up with complete sets of service bulletins or letters.

Service Bulletins

A service bulletin is a publication designed to alert builders and pilots to changes, recommendations, problems, or other information of a critical nature pertaining to either the construction of the kit or the operation of the completed aircraft. Service bulletins often prescribe actions to be undertaken by the builder or pilot.

Mandatory service bulletins concern problems with or changes in parts, assembly procedures or aircraft operations that are **directly related to the safety of flight**. Actions prescribed in mandatory service bulletins are **compulsory**, even if they affect an already completed aircraft or assembly.

Non-mandatory service bulletins concern non-flight-critical changes in parts, assembly procedures or aircraft operations. Undertaking the actions prescribed in non-mandatory service bulletins is **strongly recommended** to enhance ease of kit assembly and/or serviceability of the completed aircraft, but compliance remains at the builder's or pilot's discretion.

Service Letters

Service Letters are advisory publications of a non-critical nature concerning company policies, recommended operating procedures, aircraft systems, maintenance issues and so on. Any actions suggested in Service Letters are to be undertaken solely at the builder's or pilot's discretion.

Revisions to Advisory Publications

Revisions to advisory publications will be designated with a letter in the box marked "Revision" at the bottom of the page. The revised service bulletin/letter will supersede the previous service bulletin/letter of that number. Additional information on a subject covered in a previous service bulletin/letter will be published in a **service bulletin/letter supplement**. For example, "Service Bulletin 3, Supplement A," supplements the information published in "Service Bulletin 3."

Index of Advisory Publications

For your reference, we will periodically send out a list of service bulletins and service letters under the title **Index of GlaStar Advisory Publications**. This index also lists current ANORs and manual revisions. We recommend keeping a 3-ring Advisory Publications notebook in which you can organize service bulletins, service letters and the index.

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RECOMMENDED READING

Although "SECTION II: TOOLS AND TECHNIQUES" provides a fairly complete description of the various aircraft construction procedures needed to assemble the GlaStar, we recommend supplementing the information provided in that section with readings from the following list of books, which address the subject of airplane construction in greater detail. The handbooks listed are especially good for the amount of information they condense into a small package. We also recommend the various homebuilt airplane periodicals—especially *Sport Aviation* (which is sent to EAA members) and *Kitplanes.* In addition, browsing through some of the aircraft tool and supply catalogs, such as the Aircraft Spruce and Specialty catalog (800-824-1930), can provide a lot of insight into aircraft construction practices.

Bent, Ralph D., and James L. McKinley. *Aircraft Maintenance and Repair,* 4th ed. New York: McGraw-Hill Book Company.

———. *Maintenance and Repair of Aerospace Vehicles.* New York: McGraw-Hill Book Company.

———. *Powerplants for Aerospace Vehicles.* New York: McGraw-Hill Book Company.

Bingelis, Tony. *Firewall Forward: Engine Installation Methods.* Oshkosh, WI: EAA Aviation Foundation, Inc.

———. *The Sportplane Builder: Aircraft Construction Methods.* Oshkosh, WI: EAA Aviation Foundation, Inc.

———. *Sportplane Construction Techniques: A Builder's Handbook.* Oshkosh, WI: EAA Aviation Foundation, Inc.

Reithmaier, Larry, ed. *Standard Aircraft Handbook.* Blue Ridge Summit, PA: Tab Aero Books.

Standard Aviation Maintenance Handbook. Casper, WY: IAP, Inc.

U.S. Department of Transportation, Federal Aviation Administration. *Airframe & Powerplant Mechanics: Airframe Handbook.* Washington, D.C.: U.S. Government Printing Office.

———. *Airframe & Powerplant Mechanics: Powerplant Handbook.* Washington, D.C.: U.S. Government Printing Office.

———. *EA-AC 43.13-1A & 2A, Acceptable Methods, Techniques, and Practices: Aircraft Inspection and Repair—Aircraft Alterations.* Washington, D.C.: U.S. Government Printing Office.

Parts Not Supplied in the GlaStar Kit

The GlaStar kit supplies most parts necessary to build the airframe but not all parts needed to build the entire airplane. Additional parts and components you will need include an engine and its accessories, a propeller, cowling, avionics, and flight and engine instruments. Many of these, as well as various optional components that you might choose to configure your airplane just the way you want it, are available from Stoddard-Hamilton. If you choose not to install components and options offered and supported by Stoddard-Hamilton, you are responsible for finding sources of the components and working out the details of their installation.

Material Substitution

All the metal parts and raw metal stock supplied with your GlaStar kit are certified, aircraft-grade alloys—4130 chromium-molybdenum steel and 2024-T3 or 6061-T6 aluminum. **Substitution of materials with different grades or dimensions than those specified in the design and provided in the kit is strictly forbidden.** Additionally, in some applications, 6061-T6 aluminum stock is **not** an acceptable substitute for the 2024-T3 stock specified.

Similar restrictions apply to the composite fabrication materials. The fiberglass cloth supplied with your GlaStar kit has been treated with a chemical, called "sizing," to enhance its compatibility with the GlaStar's vinyl ester resin system. Fiberglass material obtained elsewhere, even though identical in all other respects, might be treated with a different sizing, making it difficult to achieve well-saturated laminates and resulting in structures with reduced strength. Substituting different resin for the supplied vinyl ester resin could also lead to construction difficulties and inadequate strength.

If you need to replace any parts or raw materials—either because of mistakes during construction or wear or breakage during service—we **strongly recommend** that you procure replacements directly from Stoddard-Hamilton. If you insist on procuring raw materials from an alternative source, contact us first to confirm the material specifications.

GENERAL CONSIDERATIONS

Before beginning any construction, consider the following general instructions:

1. We suggest studying each of the individual assembly sections before beginning work on that assembly. By acquiring a thorough understanding of what is to be accomplished before beginning work, you will avoid surprises and help prevent costly and time-consuming mistakes. Often, questions that arise in reading any given step will be answered in subsequent steps.

2. Make sure all the tools and materials required are on hand.

3. Proceed in a stepwise manner paying close attention to the **Warnings**, **Cautions** and **Notes**.

4. After completing each step in the individual assembly sections, check the space marked "Completed." Also, when you have completed each major sequence of steps, sign and date the appropriate line on the Assembly Log pages at the end of this section. If you do this, you will always know where you are in the construction sequence and where you ended your previous work session. This will also provide some of the documentation required by the FAA (or other national authority) that you, yourself, accomplished the major portion of the work to assemble the GlaStar airframe. (Refer to the "FAA INSPECTION AND DOCUMENTATION REQUIREMENTS" information that appears later in this section.)

Suggestions for Kit Storage

Because most builders can work on just one part of the GlaStar airframe at any one time, the other parts must be stored until they are needed. Sheet metal, fiberglass and acrylic plastic (Plexiglas) components are subject to damage or deterioration if stored improperly. Heed the following suggestions for storing these parts.

Sheet Metal Parts

The sheet metal airframe components, such as the spars, ribs and skins, are subject to damage by deformation, by scratching and by corrosion. Take care, when storing these parts, not to pile heavier parts on top of them that might deform them, rendering them unusable. Store pre-bent skins on top of other components, for example, so that heavier parts do not tend to change the radius of the bends. Leave small components in their boxes or other packaging to protect them until needed. If a protective **plastic** coating is present on sheet aluminum parts, leave it on until the parts are needed. Any protective **paper** used during shipment should be removed for storage, however, since it can retain moisture next to the metal.

Caution Be very careful and take your time when removing the protective covering from aluminum sheets. If you pull too hard in the wrong direction, you could permanently crease or kink the sheet. To remove the covering, start from one end and then hold that end down while pulling the covering low and parallel to the surface. Do not pull the covering up perpendicular to the surface. Additionally, take care when picking up large pieces of sheet metal (like the elevator skins, for example) that have a joggle or a bend in one edge. If you allow the sheet to flex perpendicular to the bent edge, you will crease it, and such creases are difficult or impossible to remove.

When aluminum is alloyed with various other metals, its stiffness and strength is increased dramatically but its corrosion resistance is reduced. So, a thin coat or "cladding" of pure aluminum (which is much more corrosion-resistant than aluminum alloy) is often applied to the surface of aluminum alloy sheets. All of the sheet metal skins in the GlaStar are made from this "Alclad" aluminum alloy. Because pure aluminum is very soft, the surfaces of Alclad sheets are easily scratched. Scratches that penetrate just the protective cladding have little effect on the strength of the sheet, but they do reduce its corrosion-resistance.

Deeper scratches on sheet metal components provide places where stresses concentrate, which can reduce the strength of the parts and their tolerance to fatigue. Be very careful, therefore, to prevent scratches on sheet metal parts. If small scratches occur, remove them with a non-metallic scrub pad like Scotch Brite. Deeper scratches can be removed with wet, aluminum oxide sandpaper. Use 400 grit, followed by 600 grit, and final polish with Scotch Brite. To prevent scratches, store the parts in an out-of-the-way place where they are not subject to routine contact from other parts or from tools while you are working in your shop.

Caution In sanding aluminum parts, be certain to **avoid carborundum grit sandpaper**. This type of paper will imbed tiny carbon particles in the aluminum surface, which can cause dissimilar metals corrosion. For the same reason, **steel wool should never be used** on aluminum parts. We recommend only aluminum oxide sandpaper, and even that should be followed with Scotch Brite.

Keep sheet metal components in a dry place to help prevent corrosion. Aluminum parts that are continuously damp, especially if in contact with dissimilar metals, can be ruined by corrosion in a very short time. Do not store metal parts in close proximity to corrosive chemicals, such as battery electrolyte or powerful cleaning compounds. Even the vapors from such chemicals, if confined to a closed space, can induce corrosion of metal parts.

The same storage and handling precautions apply to finished aluminum airframe components. Once you have finished the empennage components and the wings, for example, find a place to store them where they are safe from damage while you are working on the fuselage.

Fiberglass and Composite Parts

Fiberglass airframe components, individually, do not have the structural integrity of a completed assembly. Until bonded together into an integral structure, fiberglass parts are free to bend and adapt to any shape to which they are subjected. If stored for an extended period in a deformed condition (especially at higher temperatures), "sets" can occur in the fuselage halves and other fiberglass parts, which will complicate assembly of the parts. Proper storage is mandatory, therefore, to keep the parts from warping or taking on sets.

The best place to store the parts is in the shipping crate itself. All the parts are held in place with nylon strapping. Cut these straps to relieve any tension or pressure on the parts. If the parts cannot be stored in the crate, make sure the parts are stored in an un-deformed condition.

> **Note** If parts do become warped they can be corrected by applying pressure over a period of time in a direction opposite the set. Careful application of heat is also helpful.

Also, protect the unfinished interior surfaces of fiberglass components from long-term exposure to direct sunlight. Over time, the ultraviolet light in sunlight can cause the plastic resin in unprotected fiberglass parts to deteriorate, which can seriously weaken the parts. The exterior surfaces of all fiberglass components supplied for the GlaStar kit are finished with a durable white gel coat, which provides excellent protection from the harmful effects of ultraviolet light. After the airframe has been completed, therefore, and the interior surfaces of airframe components are no longer exposed, the potential for damage from sunlight is greatly reduced.

Acrylic Plastic Components

Protect acrylic plastic parts (the windshield and the cabin windows) from contact with sharp metal or fiberglass parts that could scratch them. Leave as much as possible of the protective covering on these parts until airframe assembly is complete. If the parts cannot be left in their original packaging, protect them from damage with sheets of corrugated cardboard, sheets of soft plastic foam, or clean old blankets. Acrylic plastic components can become warped if stored in a deformed condition, especially if subjected to elevated temperatures.

Fiberglass and Resin Storage

Store raw fiberglass cloth in such a way that it will be kept clean and free of water absorption. Moisture can easily damage the sizing of the cloth, which will affect the strength of the finished laminate. Glass cloth that is dirty or that has absorbed moisture will retard resin saturation, resulting in a defective laminate. Do not use fiberglass products that have been wet or are dirty.

We recommend storing fiberglass products in a closed package in a clean environment. Also, to reduce exposure of fiberglass cloth to possible contaminants, set up a separate cloth-cutting table in a clean area of your shop and restrict its use to handling fiberglass products only.

The estimated shelf life of the vinyl ester resin used in the GlaStar is approximately three months. Because of the limited shelf life, we do not ship the resin and other chemicals until you request them. Contact our order desk when you are ready to begin fuselage construction, and we will ship the chemicals to you. Once you receive the resin and other chemicals, store them in a cool, dry, dark, well-ventilated place.

Warning Because all of the chemicals used in the GlaStar are toxic to some degree (some worse than others), store them out of the reach of children. Refer to the "SAFETY INFORMATION," which appears later in this section, for additional precautions in storing and handling chemicals.

KIT BUILDING SEQUENCE

We recommend building the aircraft in the sequence outlined in this manual, starting with the rudder and then proceeding to the horizontal stabilizer and elevator assemblies. Then, fabricate the wing panels, the flaps and the ailerons. Once all of the flying and control surfaces have been completed, proceed to fuselage construction and then to final assembly. This sequence is not mandatory, but it is usually easier to store the completed tail surfaces and wing panels while working on the fuselage than vice versa. The other advantage to using the recommended sequence, especially if you are an inexperienced builder, is that you start on the smaller, less expensive components and proceed to larger components only after your skill level has increased. If you are an experienced builder, or lucky enough to have unrestricted shop space or a hangar you can move completed components to, you can devise your own schedule for component completion and even work on several sub-assemblies concurrently. Within a given sub-assembly, however, we **strongly urge** you to follow the prescribed assembly sequence. It is all too easy to skip ahead without fully appreciating what difficulties you may encounter later.

SAFETY PRECAUTIONS

Warning For personal safety, please read and heed the following safety precautions. Some of the materials and processes discussed below may be unfamiliar to you, but we believe it's important that you acquaint yourself with potential hazards before you encounter them. All the materials and processes discussed here will be fully explained in "SECTION II: TOOLS AND TECHNIQUES." Refer back to this "SAFETY PRECAUTIONS" section when you begin working with a new material or process.

Eye and Skin Contamination

Because of the corrosive nature of the chemicals used in the GlaStar airframe, care must be taken with them, especially with the MEKP catalyst. The MEKP catalyst is a strong oxidizing agent.

MEKP CATALYST

MEKP (methyl-ethyl ketone peroxide) is harmful or fatal if swallowed and harmful if inhaled. MEKP is a severe eye irritant. One drop of MEKP splashed in the eye **will cause blindness** unless the eye is washed within **four seconds** after contamination. Use of safety glasses is **strongly** recommended when catalyzing resin. Keep an eyewash bottle filled with clean water close at hand. In case of eye contact with MEKP, immediately flush the eye with plenty of clear water and see a physician.

MEKP is flammable. Keep MEKP catalyst away from fire and protect from direct sunlight, heat and sparks. Do not add MEKP to hot materials. Prevent contamination with foreign materials, especially readily oxidizable materials, accelerator (DMA) or promoter (cobalt).

Store MEKP in the original closed container in a cool location. When the container is emptied, it must be destroyed and not be reused for any purpose. Failure to observe these precautions may result in explosive decomposition.

Catalyzed Resin

Contact with fingers and hands poses no serious problem, but avoid prolonged contact. Tight-fitting latex medical gloves can be used to avoid any contact with the skin.

Vapors and Dust Particles

Avoid breathing the fiberglass particles while sanding or filing fiberglass. Use a good quality particle mask, available at most hardware stores.

The strong vapor smell of the resin before it cures is from the styrene in the resin as it evaporates away. Always laminate in a well-ventilated area. High concentrations of styrene in small, enclosed areas may cause nausea. Avoid breathing these vapors when high concentrations exist. We recommend wearing a vapor respirator (available at most hardware stores) for protection. We also recommend that you complete the fiberglass work on your airplane in an area separate from your living quarters because of the vapors present. A small fan is useful to carry styrene vapors away when working in a confined space, such as the tail cone. Because styrene vapors are heavier than air, try to work on an elevated bench or table; use a fan to move the air along the floor, away from the work space.

Flammability

The materials used in fiberglass construction are highly flammable, especially the acetone and catalyst. Keep them away from direct sunlight, heat, sparks and open flame. Keep track of all materials and store them in a cool, clean, well-ventilated area. Make sure all containers are sealed when not in use.

When resin gels and then exotherms, enough heat may be generated to cause a fire. None of the lay ups on the GlaStar pose a problem because they are not thick enough. The only time this could be a problem is when a large batch of resin is used in a container, coupled with high temperatures and a high catalyst percentage.

Do not throw away catalyzed resin before it has gelled, exothermed and cooled. If you have a pot of uncured resin left over after a laminating procedure, let it gel in its container on a concrete floor before discarding.

Proper Resin Mixing Sequence

Never mix cobalt directly with MEKP catalyst. A violent reaction will occur which may result in fire or explosion. Resin is first promoted with cobalt and then DMA. This forms a master batch of promoted resin from which smaller quantities may be taken as needed. Just prior to use, the promoted resin is catalyzed with MEKP catalyst. The proper resin promotion procedures are explained in "SECTION II: TOOLS AND TECHNIQUES."

Lead Toxicity

Lead is used for the control surface counterweights in the GlaStar. Lead is a poison that can enter the body either through inhalation or ingestion. Repeated exposures to lead over time can result in accumulation in the body. The effects of exposure to lead include loss of appetite, weakness and tiredness, insomnia, muscle and joint pain, frequent headaches, tremors, numbness, dizziness, vomiting, poor memory, irritability, and seizures. Overexposure to lead can damage the reproductive systems of both men and women. Birth defects, miscarriages, or stillbirth can occur if either the mother or the father were overexposed to lead.

Although it is highly unlikely that fabricating the control surface counterweights will result in overexposure to lead, it is wise to observe the following precautions: After handling lead, scrub your hands thoroughly before eating, drinking, or smoking. Clean your work area thoroughly after working with lead, carefully bagging any shavings or filings for disposal. Brush your clothing and shoes to remove lead shavings before going into your home from your workshop. Since lead poses a special risk to children (whose nervous systems are still developing), banish children and pregnant women from your workshop when working with lead. Store lead in an out-of-the-way place (preferably in a sealed and marked container) where you won't come into routine contact with it. Keep lead out of the reach of children.

A Final Word About Safety

We feel it's vitally important that you be aware of the potential hazards associated with aircraft construction from the beginning. However, the preceding catalog of dangers can sound rather overwhelming, and it's worth emphasizing that the experience of building your GlaStar will be safe and enjoyable as long as you follow the few, simple precautions outlined above. Like flying itself, building an airplane can be extremely safe as long as safety isn't taken for granted.

Note The following three sections outline inspection, documentation, registration and certification requirements for amateur-built experimental aircraft in the United States according to the regulations of the Federal Aviation Administration. Although national regulations in countries other than the United States are often very similar to the U.S. rules, there are also significant differences. It is the builder's responsibility to acquaint him/herself with these regulations, and we strongly recommend that this be done **early** in the construction process, if not prior to kit delivery.

FAA Inspection and Documentation Requirements

The FAA requires that certain documents and records be kept, including records of pre-cover inspection, during construction of a homebuilt aircraft. These requirements are detailed in FAA Advisory Circular 20-27D, which is available (free of charge) from:

U.S. Department of Transportation
Utilization and Storage Section M-443.2
Washington, D.C. 20590

This is a brief outline of the major points covered in AC 20-27D, but we strongly encourage you to procure and review a copy of the circular early in your construction schedule. First, the builder must keep copies of invoices, receipts and shipping documents for materials and kits used in construction of the aircraft. The FAA inspector will want to see these documents when inspecting the finished aircraft prior to issuance of an airworthiness certificate.

The builder must also keep a log of the construction and inspection of the aircraft as it is built. The Assembly Log at the end of this section is designed to help satisfy this requirement, but you should carefully study AC 20-27D to ensure that you meet all FAA logging requirements.

The FAA no longer performs so-called "pre-cover inspections" of the interior structure of homebuilts. However, pre-cover inspections performed by some knowledgeable person (such as the builder himself or an EAA designee) are still required and must be recorded in the construction log. As additional evidence of pre-cover inspection, many builders photograph the construction process as they build, and we strongly endorse this practice.

The FAA will perform a final inspection of the aircraft before flight. In addition to inspecting the aircraft itself, the FAA will inspect the above-mentioned documents and records. If the aircraft passes the inspection, and the necessary documents and records are in order, the inspector will issue a limited airworthiness certificate for a specific test period and area.

The flight history of the aircraft during the specified test period must be recorded in a flight log. Record the length of each flight, the tests performed and the outcome of the tests. Document any problems encountered during test flights and the steps taken to resolve the problems.

After the flight test period has been flown off, the builder should present the construction and flight logs and the old limited airworthiness certificate to the FAA for issuance of an unlimited airworthiness certificate. If all the records are in order, the FAA will not inspect the aircraft at this time.

If you have any questions concerning registration and certification we suggest contacting the local FAA General Aviation District Office (GADO) or Flight Standards District Office (FSDO).

AIRCRAFT REGISTRATION PROCEDURES

The Federal Aviation Regulations (FAR) require that all U.S. civil aircraft be registered before an airworthiness certificate can be issued. FAR Part 47, Aircraft Registration, prescribes the requirements for registering civil aircraft. The basic procedures are as follows:

1. Before an amateur-built aircraft can be registered, the builder must first obtain an identification number that will eventually be displayed on the aircraft. About six months before you anticipated first flight, request assignment of an identification number by writing to:

   FAA Aircraft Registration Branch
   Attn.: Central Records
   Department of Transportation
   P.O. Box 25504
   Oklahoma City, OK 73125

   Your request must include the following information: the manufacturer of the airplane (**your** name!), the make (GlaStar), the model number (GS-1), the serial number (your GlaStar kit number), your name, address, telephone number and signature. You must also enclose a check for the $10.00 fee.

   If you want a personalized "N" number assigned to your aircraft, specify five choices in order of preference. Alternatively, you can telephone the FAA in Oklahoma City at (405) 954-3116 to find out if a particular number is available. A personalized identification number costs an additional $10.00, so a check for this amount must be included with your letter of request. There is no extra charge for a random identification number. Within a few weeks of receiving your application, the Aircraft Registry will send you a form letter giving your assigned number, a blank Aircraft Registration Application (AC Form 8050-1) and other registration information.

2. Before you can get an Airworthiness Certificate, you must have an Aircraft Registration Certificate. So, about four months before your first flight, send the following information to the Aircraft Registry:

   a) The letter you received with your identification number assignment.

   b) A completed Aircraft Registration Application, FAA Form 8050-1.

   c) A completed Affidavit of Ownership—Amateur-Built Aircraft, FAA Form 8050-88.

   d) A completed Eligibility Statement for Amateur-Built Aircraft, FAA Form 8130-12.

AIRWORTHINESS CERTIFICATION

After one hour of taxi testing has been logged on the finished aircraft, it is time to submit your Application for Airworthiness Certificate and to request an inspection by the FAA. Contact your local FSDO to request an inspection.

So as not to waste the FAA inspector's time (and possibly evoke his or her ire!), you should be absolutely certain that the airplane is ready when you call for the inspection. We recommend having an independent inspection performed by a knowledgeable person, such as an EAA designee, before calling for the FAA inspector. Often, builders are so close to their projects that they inadvertently overlook deficiencies that are obvious to an unbiased observer.

Remedy any deficiencies uncovered by your independent inspector before the FAA inspector arrives, or else the Airworthiness Certificate could be denied. **Keep in mind that the primary objective of the inspections is not just to verify compliance with the law, but to ensure safety**.

In addition to inspecting for acceptable workmanship and construction practices, the FAA inspector will check the airplane for the minimum required instrumentation (see FAR 91.33), instrument range markings, ELT installation, pilot and passenger restraints, properly marked "N" number and the appropriate, permanently installed placards.

The placards required for certification of an experimental, amateur-built aircraft are:

1. The word "**EXPERIMENTAL**," in 2" high block letters, displayed near each entrance to the cabin.

2. A permanently installed, fireproof **identification plate** that is indelibly stamped or engraved with the information required by FAR 45.13. The data plate must be located on the exterior of the aircraft, either just aft of the entry door or on the fuselage near the tail surfaces, and must be legible to a person standing on the ground.

3. A Passenger Warning Placard, permanently installed in the cockpit in full view of all the occupants with the words:

   PASSENGER WARNING—THIS AIRCRAFT IS AMATEUR BUILT AND DOES NOT COMPLY WITH FEDERAL SAFETY REGULATIONS FOR "STANDARD AIRCRAFT"

Also, have the following documents ready for the inspector:

1. An Application for Airworthiness Certificate, FAA Form 8130-6.

2. Enough data (such as photographs or a three-view drawing) to identify the aircraft type. (The three-view drawings at the beginning of this Assembly Manual would suffice.)

3. An Aircraft Registration Certificate, AC Form 8050-3, or the pink copy of the Aircraft Registration Application, AC Form 8050-1.

4. A statement setting forth the purpose for which the aircraft is to be used. In "governmentese," your purpose is most likely to be: "Operating an amateur-built aircraft." (Other possibilities include "Exhibition" and "Air Racing.") The statement should also state the estimated duration of the test period and the areas over which the test will take place. Call your GADO or FSDO for guidance.

5. A notarized statement that the applicant, a) fabricated and assembled the major portion of the aircraft for educational or recreational purposes and, b) has evidence to support the statement available to the FAA upon request. This is where photographs of construction in progress will provide a good supplement to your Assembly Log.

6. Weight and balance data on the finished aircraft.

7. An aircraft log book with evidence of inspections, such as log book entries signed by the builder, describing all inspections conducted during construction of the aircraft. This will substantiate that the construction has been accomplished in accordance with acceptable workmanship methods, techniques, and practices. The GlaStar Assembly Manual with completion of each section signed off in the Assembly Log will suffice.

If no deficiencies are found in the aircraft, and if all the documents are in order, you will be issued a Limited Duration Experimental Airworthiness Certificate and Operating Limitations that will permit you to begin flight testing.

The regulations and paperwork required to get your GlaStar airborne can be daunting in their number and complexity. In general, we would advise you to establish a relationship with your local FSDO early in the construction process and to maintain it through final airworthiness certification. Things are likely to go much more smoothly if you do.

GOING FOR THE GOLD

Anyone willing to undertake the rewarding experience of constructing his or her own airplane will strive to do the very best job possible. This is important for many reasons, such as function, integrity, cosmetic appearance and safety.

For those aspiring to be considered for one of the prestigious workmanship awards presented at major EAA events, air shows and fly-ins, we've included, on the following page, a reproduction of a typical custom-built judge's evaluation sheet, which was provided by EAA headquarters. Knowing in advance what the judges look for and how they score an aircraft may give you a better idea of where to concentrate your efforts.

Not every GlaStar builder needs to compete for an award. The extra work required to produce an award winner compared to just a nice airplane may not be worth the effort for many builders and has little effect on the flight characteristics or utility of the airplane. If you choose to "go for the gold," however, we wish to arm you with as much ammunition—and as much encouragement—as possible.

CUSTOM BUILT JUDGING **FORM A**

REGISTRATION NO.__________________ **CATEGORY**: PLANS____________
DESIGN NAME______________________ KITS____________
CLASSIC____________

OPTIONAL INFORMATION: **ENGINE**:
OWNER'S NAME ______________________ MAKE ____________
ADDRESS ____________________________ HP RATING ____________
____

1. OVERALL APPEARANCE .... 1-10 |___|
   Quality of workmanship, neatness, consistency
2. FUSELAGE .... 1-10 |___|
   Quality of workmanship, sound construction practice, innovation and improvements, access for maintenance
3. MAIN LIFTING SURFACES .... 1-10 |___|
   Quality of workmanship, fit and finish, sound construction practice, innovation and improvements
4. EMPENNAGE/PITCH & YAW SURFACES .... 1-10 |___|
   Quality of workmanship, sound construction practices, innovation and improvements, neatness, consistency, fit and finish
5. LANDING GEAR AND BRAKES .... 1-10 |___|
   Quality of workmanship, sound construction practice, innovation and improvements, safety provisions
6. COCKPIT OR CABIN .... 1-10 |___|
   Utilization of instruments and controls, evidence of forethought and planning, safety provisions, neatness, consistency, innovations and improvements, workmanship
7. POWER PLANT AND PROP .... 1-10 |___|
   Safety provisions, sound practice, workmanship, access for maintenance and preflight, innovations, improvements
8. FINISH .... 1-10 |___|
   Consistency and attention to detail
9. PRESENTATION .... 1-10 |___|
   Documentation, builder's log, photo presentation
10. EXECUTION AND INNOVATION .... 1-10 |___|
    Difficulty, theme, judges discretion
11. DOCUMENTATION AND COMPLIANCE WITH FARs YES_____ NO_____

TOTAL .... |___|

POINTS:						
10	Perfect	6	Definitely Above Average	3	Functional
9	Excellent	5	Slightly Above Average	2	Crude
8	Very Good	4	Average	1	Unairworthy
7	Good				

Judge's Remarks: Judge No._______

THE ADVENTURE BEGINS!

Enough preliminaries—let's roll up our sleeves and get to work! Your GlaStar awaits . . .

GLOSSARY

ACCELERATOR —a chemical added to resin along with the catalyst to accelerate catalysis; not needed when working at higher ambient temperatures; in the case of the vinyl ester resin used in the GlaStar, this chemical is dimethylaniline (DMA). See also "CATALYSIS" and "RESIN."

ACID ETCH — a conversion coating process in which an acidic solution is wiped or sprayed on the surface and then washed off with sprayed water. See also "ALODINE TREATMENT" and "CONVERSION COATING."

AFT — toward the tail of the aircraft. See also "FORWARD."

ALCLAD — a type of sheet aluminum in which an alloy core is clad in a thin layer of pure aluminum to enhance corrosion resistance; used for all GlaStar wing and control surface skins.

ALODINE TREATMENT — a metal preparatory treatment that can be applied after acid etching for increased corrosion resistance and enhanced primer adhesion. See also "ACID ETCH."

BIAS — the orientation of the weave pattern of fiberglass cloth to load paths, measured in degrees from the longitudinal axis of the piece.

BIDIRECTIONAL CLOTH — fiberglass cloth in which the proportion of warp fibers to fill fibers in nearly equal. See also "FILL," "UNIDIRECTIONAL CLOTH," and "WARP."

BLIND RIVET — a rivet that can be both inserted and peened from one side of the work surface; commonly called a "Pop" rivet, after the popular brand manufactured by USM Corporation.

BUCKING — the process of peening the interior end of a standard rivet. See also "BUCKING BAR."

BUCKING BAR — a metal die used in driving bucked rivets. See also "BUCKING."

BUTT LINE — a reference line left or right of and parallel to the aircraft centerline; also called a "BUTTOCK LINE."

CABLE CLAMP — a nut-tightened clamping device that is used to hold components temporarily in desired locations on control cables.

CATALYSIS — the chemical process by which resin cures. See also "CURE."

CATALYST — the chemical that causes resin to cure; this is methyl ethyl ketone peroxide (MEKP) in the case of the vinyl ester resin used in the GlaStar. See also "CURE" and "RESIN."

CHAMFER — a slight bevel in the edge of a part.

CHORD — a straight line from the leading edge to the trailing edge of an airfoil section.

CHORDWISE — in a direction parallel to the chord line of an airfoil.

CLECO — a pin fastener or sheet fastener, which is a type of clamp used in sheet metal work that holds two or more sheets together temporarily by means of a spring-loaded, expandable shank inserted through holes in each piece; "Cleco" is a trade name of the Aerospace Fastener Division of Monogram Industries, but it has become virtually a generic term industry-wide and has therefore been used throughout the text.

CLECO SIDE-GRIP CLAMP — a clamp that temporarily holds two or more sheets together at the edges by means of two spring-loaded, parallel jaws; "Cleco" is a trade name of the Aerospace Fastener Division of Monogram Industries, but it has become virtually a generic term industry-wide and has therefore been used throughout the text.

COBALT – see "PROMOTER."

CONAP – see "PROMOTER."

CONVERSION COATING — a process for preparing a metal surface to enhance primer adhesion.

COUNTERSINKING — the process of drilling out a hole with a beveled bit so that a rivet or screw head can fit flush with a surface.

COVE — the interior of a C-sectioned spar, that is, the area between the flanges. See also "FLANGE" and "SPAR."

CURE — the chemical state of catalyzed resin in which it reaches its full hardness and strength. See also "RESIN."

DBM (DOUBLE-BIAS MAT) CLOTH — a fiberglass cloth made of two uni-directional layers oriented on opposite 45° biases and a so-called 'mat' backing of multi-directional fibers. DBM produces stronger secondary bonds than standard bi-directional cloth and is therefore used in seaming the GlaStar fuselage shells together, as well as in other applications.

DEBURRING — the process of removing the sharp burrs of metal left behind after drilling or shearing.

DIMPLING — the process of introducing a slight inward deflection around the edges of a hole drilled in thin aluminum sheet; functionally equivalent to COUNTERSINKING.

DMA — see "ACCELERATOR."

EXOTHERMIC REACTION — a chemical reaction (e.g., the curing of resin) that releases energy in the form of heat.

FIBERGLASS — the trade name for glass fibers (consisting mainly of silicon, calcium and aluminum dioxides) woven into various types of cloth. See also "BIDIRECTIONAL CLOTH" and "UNIDIRECTIONAL CLOTH."

FILL — the direction on a piece of fiberglass cloth with the lesser percentage of fibers and, therefore, of strength. See also "WARP."

FLANGE — with regard to ribs and spars, the surfaces that are parallel to the skins they support. See also "WEB."

FOAM CORE — plastic foam used as a substrate onto which fiberglass laminates are applied to produce stiff, lightweight structures; also used to refer to the construction method using such foam cores. See also "LAMINATE."

FORWARD — toward the nose of the aircraft. See also "AFT."

GEL COAT — a durable, opaque, pigmented finish on the exterior surface of fiberglass parts. The white gel coat used on all of the GlaStar's fiberglass components is a two-part, catalyzed material that is applied to the mold before the part is laid up to become an integral part of the laminate.

GEL TIME — the time it takes a batch of resin to begin gelation. See also "GELATION."

GELATION — the chemical process by which resin begins to solidify after catalysis. See also "CATALYSIS" and "RESIN."

GREEN CURE — the point at which a laminate becomes hard enough to be cut with a knife; usually reached from 15—45 minutes after gelation, depending on temperature. See also "CATALYSIS" and "CURE."

HAT SECTION — an informal term used throughout the manual for the skin stiffeners used in the GlaStar wing, so called because of their cross-sectional shape. See also "STIFFENER."

HOLLOW-SHANK RIVET — see "BLIND RIVET."

INBOARD — toward the center of the aircraft in a spanwise direction. See also "OUTBOARD" and "SPANWISE."

JIG — a temporary structure built to hold parts of an assembly in the proper position during fabrication.

JOGGLE — an offset flange bent into the edge of a sheet (as, for example, on the trailing edges of the elevator skins) to add torsional stiffness and to provide a riveting surface.

LAMINATE — one or more layers of fiberglass cloth impregnated with cured resin; or the process of producing such a laminate. See also "FIBERGLASS" and "RESIN."

LAY-UP — one or more layers of fiberglass cloth being saturated with resin; or a synonym for the verb laminate. See also "LAMINATE" and "RESIN."

LEADING EDGE — specifically, the skin around the forward edge of the wing and tail surfaces; generally, the edge of a part nearest the nose of the aircraft. See also "TRAILING EDGE."

LEFT — the position or direction relative to the centerline of the aircraft corresponding to the pilot's left when seated facing the nose of the aircraft. See also "LEFT-SIDE."

LEFT-SIDE — left; used occasionally in the manual when the term "left" alone might be confusing. See also "LEFT."

MANUFACTURED HEAD — the head of a rivet (usually round or flush) that retains its original shape throughout the riveting process.

MILL FIBERS — very short, chopped strands of fiberglass resembling grayish lint. See also "FIBERGLASS."

NICOPRESS — a tool manufactured by the National Telephone Supply Company that allows full-strength cable splices to be made without complex manual splicing or swaging procedures. See also "SWAGING."

OUTBOARD — away from the center of the aircraft in a spanwise direction. See also "INBOARD" and "SPANWISE."

PASS DRILLING — the process of drilling a hole to final diameter through two or more contiguous pieces of material. See also "PILOT HOLE."

PILOT HOLE — an undersized hole drilled or punched through a piece of material for use as a drill guide for later drilling to final diameter.

PIN FASTENER — see "CLECO."

PLUMB — precisely aligned relative to one or more reference axes, most often the vertical axis.

POP RIVET — see "BLIND RIVET."

PROMOTER — a chemical added to resin before the catalyst to promote catalysis; necessary for resin to cure properly; in the case of the vinyl ester resin used in the GlaStar, this chemical is cobalt naphthenate (CoNap or cobalt). See also "ACCELERATOR."

PULL RIVET — see "BLIND RIVET."

PVA — polyvinyl alcohol; a green, water-based coating used as a mold release agent; may be found on the outer surface of factory-molded parts; can be easily removed with water.

Q-CELL — an inorganic micro-sphere (glass bubble); mixed with resin to form a lightweight, sandable sealing or filling paste for foam panels, cracks, etc. See also "RESIN."

REAMING — the process of deburring the interior circumference of a hole by means of a special hand or power tool. See also "DEBURRING."

RESIN — a chemical used to impregnate fiberglass cloth to produce laminates; in the GlaStar, vinyl ester resin is used. See also "FIBERGLASS" and "LAMINATE."

RIB — a structural member of a wing or tail surface that extends in a chordwise direction.

RIGHT — the position or direction relative to the centerline of the aircraft corresponding to the pilot's right when seated facing the nose of the aircraft. See also "RIGHT-SIDE."

RIGHT-SIDE — right; used occasionally in the manual when the term "right" alone might be confusing. See also "RIGHT."

RIVET SET — a die used with a rivet gun to drive rivets; each set is designed for a particular shape and size of rivet head.

ROOT — the location where a wing or tail surface meets the fuselage. See also "TIP."

SAFETYING — the process of securing aircraft fasteners (such as nuts, pins, turnbuckles, etc.) against unintended loosening, usually accomplished with wire or specially designed safety pins.

SHEAR — mechanical stress in a direction so as to cause two parts or two layers of a material to slide relative to each other; for example, a shear load on a bolt holding two sheets together is perpendicular to the longitudinal axis of the bolt See also "TENSION."

SHEET FASTENER — see "CLECO."

SHOP HEAD — the head of a rivet that is "upset," that is, the head that is deformed in the riveting process to secure the rivet.

SPANWISE — in a direction parallel to the span of the wing.

SPAR — a structural member of a wing or tail surface that extends in a spanwise direction.

SPRING CLAMP — see "CLECO SIDE-GRIP CLAMP."

STATION — a location reference specified by a distance from a datum point; on the GlaStar, wing stations are measured spanwise from the aircraft centerline, and fuselage stations are measured from an imaginary plane 58" forward of the cowling mounting flange joggle.

STIFFENER — a structural part that, when riveted to a sheet metal surface, provides increased torsional rigidity to that surface. See also "TORSION."

SWAGING — a process for attaching terminals to cable ends in which a sleeve on the terminal is compressed around the cable in a special press under such high pressure that the metal of the sleeve infiltrates among the strands of the cable, producing a splice as strong as the cable itself. See also "TERMINAL" and "TERMINAL SPLICE."

TENSION — mechanical stress in a direction so as to elongate a part; for example, a tension load on a bolt is parallel to the longitudinal axis of the bolt See also "SHEAR."

TERMINAL — a piece of hardware (such as an eye, clevis or turnbuckle shank) attached to a cable end to allow fastening the cable to another piece of hardware (such as a bellcrank, turnbuckle barrel or another terminal).

TERMINAL SPLICE — the attachment of a terminal to a cable end, usually either by NicoPressing or swaging. See also "NICOPRESS" and "SWAGING."

THIMBLE — a metal channel formed in the shape of a closed horseshoe, around which a cable end is wrapped to form a NicoPressed terminal eye splice. See also "NICOPRESS" and "TERMINAL SPLICE."

TIP — the end of a wing or tail surface furthest from the fuselage. See also "ROOT."

TORSION — motion in a twisting direction.

TRAILING EDGE — the edge of a part nearest the tail of the aircraft. See also "LEADING EDGE."

UNIDIRECTIONAL CLOTH — fiberglass cloth in which the ratio of warp fibers to fill fibers is very large. See also "FILL," "BIDIRECTIONAL CLOTH," and "WARP."

WARP — the direction on a piece of fiberglass cloth with the greater percentage of fibers and, therefore, of strength. See also "FILL."

WATERLINE — a horizontal reference plane running longitudinally through the fuselage.

WEB — with regard to ribs and spars, the surfaces that are perpendicular to the skins they support. See also "FLANGE."

WORKING TIME — the time after a resin is catalyzed but before it begins to gel, i.e., the time during which it can be applied successfully. See also "CATALYSIS," "GELATION," and "RESIN."

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ASSEMBLY LOG

Sign and date the appropriate line below as you complete each section.

Rudder Assembly

Preparing the Parts—Completed: (Steps 1 and 2)

Signature: ______________________________ Date: ________

Fabricating the Rudder Jig—Completed: (Steps 3 —5)

Signature : ______________________________ Date: ________

Preliminary Assembly of the Structural Framework—Completed: (Steps 6 — 10)

Signature: ______________________________ Date: ________

Preliminary Assembly of the Skins to the Structural Framework—Completed: (Steps 11 — 14)

Signature: ______________________________ Date: ________

Pre-Closeout Inspection Performed:

Signature: ______________________________ Date: ________

Final Rudder Assembly—Completed: (Steps 15 — 22)

Signature: ______________________________ Date: ________

Horizontal Stabilizer Assembly

Positioning and Drilling—Completed: (Steps 1 — 19)

Signature: ____________________ Date: ______

Pre-Cover Inspection Performed:

Signature: ____________________ Date: ______

Final Assembly–Completed: (Steps 20 —32)

Signature: ____________________ Date: ______

Elevator Assembly

Preliminary Assembly—Completed: (Steps 1 — 20)

Signature: Date:

Main Structure—Completed: (Steps 21 — 44)

Signature: Date:

Pre-Cover Inspection Performed:

Signature: Date:

Main Structure Riveting–Completed: (Steps 45 —60)

Signature: Date:

Trim Tab–Completed: (Steps 61 —71)

Signature: Date:

Pre-Cover Inspection Performed:

Signature: Date:

Trim Tab Riveting–Completed: (Steps 72 —77)

Signature: Date:

Elevator Hinges–Completed: (Steps 78 —84)

Signature: Date:

Elevator Assembly (continued)

Trim Tab Hinge—Completed: (Steps 85 —88)

Signature: ____________________ Date: ______

Hinge Riveting—Completed: (Steps 89 —92)

Signature: ____________________ Date: ______

Wing Assembly

Fabricate the Wing Jig—Completed: (Steps 1 — 3)

Signature: ______________________________ Date: ________

Assemble the Wing Spars—Completed: (Steps 4 —14)

Signature: ______________________________ Date: ________

Fabricate the Wing Jig—Completed: (Steps 1 — 3)

Signature: ______________________________ Date: ________

Assemble the Wing Spars—Completed: (Steps 4 —14)

Signature: ______________________________ Date: ________

Mount the Spars in the Jig—Completed: (Steps 15 — 16)

Signature: ______________________________ Date: ________

Mount the Ribs and Strut Beam Assembly to the Spars—Completed: (Steps 17 —22)

Signature: ______________________________ Date: ________

Fit Up and Drill the Wing Skins—Completed: (Steps 23 — 33)

Signature: ______________________________ Date: ________

Install the Hat Section Stiffeners, Forward Spar Cap Strips and Lower Center Skin Stiffeners—Completed: (Steps 34 —40)

Signature: ______________________________ Date: ________

Dimple the Skins and Countersink the Forward Spar Flanges—Completed: (Steps 41 — 43)

Signature: ______________________________ Date: ______

Assemble the Aileron Hinges—Completed: (Steps 44 — 45)

Signature: ______________________________ Date: ______

Assemble the Aileron Bellcrank and Mount the Hinges and the Bellcrank—Completed: (Steps 46 — 50)

Signature: ______________________________ Date: ______

Fabricate and Mount the Aileron Pulley Brackets—Completed: (Steps 51 — 52)

Signature: ______________________________ Date: ______

Assemble and Mount the Flap Tracks—Completed: (Steps 53 — 54)

Signature: ______________________________ Date: ______

Assemble and Mount the Flap Bellcrank—Completed: (Steps 55 — 58)

Signature: ______________________________ Date: ______

Fabricate and Install the Flap Pulley Brackets—Completed: (Step 59)

Signature: ______________________________ Date: ______

Rivet the Ribs and the Leading-Edge and Lower Skins—Completed: (Steps 60 — 66)

Signature: ______________________________ Date: ______

Aileron and Flap Assemblies

Aileron Positioning and Drilling—Completed: (Steps 1 — 21)

Signature: ______________________________ Date: ________

Aileron Pre-Cover Inspection Performed :

Signature: ______________________________ Date: ________

Aileron Riveting—Completed: (Steps 22 — 35)

Signature : ______________________________ Date: ________

Flap Component Preparation—Completed: (Steps 36 —40)

Signature : ______________________________ Date: ________

Flap-Track and Deployment Arm Installation—Completed: (Steps 41 — 47)

Signature: ______________________________ Date: ________

Flap Skin Positioning and Drilling—Completed: (Steps 48 — 57)

Signature: ______________________________ Date: ________

Flap Pre-Cover Inspection Performed:

Signature: ______________________________ Date: ________

Flap Main Structure Riveting—Completed: (Steps 58 — 65)

Signature: ______________________________ Date: ________

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Fuselage Assembly

Component Preparation—Completed: (Steps 1 — 7)

Signature: ________________________________ Date: ________

Fitting Fabrication—Completed: (Steps 8 —12)

Signature: ________________________________ Date: ________

External Structure—Completed: (Steps 13 — 32)

Signature: ________________________________ Date: ________

Internal Structure—Completed: (Steps 33 —85)

Signature: ________________________________ Date: ________

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Systems Installation

Rudder Control Assemblies Installation—Completed: (Steps 1 — 8)

Signature: _______________________________________ Date: ______

Control Stick Assembly Installation—Completed: (Steps 9 —10)

Signature: _______________________________________ Date: ______

Flap Handle Assembly Installation—Completed: (Steps 11 — 12)

Signature: _______________________________________ Date: ______

Fuselage Control System Pulleys Installation—Completed: (Steps 13 — 20)

Signature: _______________________________________ Date: ______

Rudder Control Cables Installation—Completed: (Steps 21 — 22)

Signature: _______________________________________ Date: ______

Elevator Pushrod and Control Cables Installation—Completed: (Steps 23 — 25)

Signature: _______________________________________ Date: ______

Mounting the Wings to the Fuselage—Completed: (Steps 26 — 35)

Signature: _______________________________________ Date: ______

Mounting the Flaps to the Wing—Completed: (Steps 36 — 37)

Signature: _______________________________________ Date: ______

Mounting the Ailerons to the Wing—Completed: (Steps 38 — 39)

Signature: _______________________________________ Date: ______

Flap Control Cables Installation—Completed: (Steps 40 — 43)

Signature: Date:

Aileron Control Cables Installation—Completed: (Steps 44 — 46)

Signature: Date:

Control Cable Retainers Fabrication and Installation—Completed:
(Steps 47 —48)

Signature: Date:

Preliminary Fuel Tank Installation—Completed: (Steps 49 — 58)

Signature: Date:

Wing Plumbing, Wiring and Other Miscellaneous Stuff—Completed:
(Steps 59 —65)

Signature: Date:

Main Gear Leg Installation—Completed: (Steps 66 — 68)

Signature: Date:

Main Gear Wheel and Brake Installation—Completed: (Steps 69 —75)

Signature: Date:

Nose Gear Installation (Optional)—Completed: (Steps 76 — 89)

Signature: Date:

Tailwheel Installation (Optional)—Completed: (Steps 90 —102)

Signature: Date:

Brake System Plumbing—Completed: (Steps 103 — 106)

Signature: ______________________________ Date: ________

Fuselage Fuel System Plumbing—Completed: (Steps 107 —112)

Signature: ______________________________ Date: ________

Manual Elevator Trim System Installation (Optional)—Completed:
(Steps 113 — 118)

Signature: ______________________________ Date: ________

Miscellaneous Fuselage Plumbing and Wiring—Completed: (Steps 119 —123)

Signature: ______________________________ Date: ________

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Final Assembly

Firewall Installation—Completed: (Steps 1 — 6)

Signature: Date:

Firewall Forward—Completed: (Step 7)

Signature: Date:

Interior Installation—Completed: (Steps 8 — 28)

Signature: Date:

Fuselage Fairing Installation—Completed: (Steps 29 — 46)

Signature: Date:

Gear Fairing Installation—Completed: (Steps 47 — 73)

Signature: Date:

Wing Pre-Closure Inspection Performed:

Signature: Date:

Final Wing Assembly—Completed: (Steps 74 — 102)

Signature: Date:

Door Installation—Completed: (Steps 103 — 128)

Signature: Date:

Top Deck Installation—Completed: (Steps 129 — 146)

Signature: Date:

Instrument Panel Installation—Completed: (Steps 147 — 158)

Signature: ______________________________ Date: ________

Window Installation—Completed: (Steps 159 — 163)

Signature: ______________________________ Date: ________

Control Surface Balancing and Fairing Installation—Completed: (Steps 164 — 176)

Signature: ______________________________ Date: ________

Final Control System Rigging—Completed: (Steps 177 — 186)

Signature: ______________________________ Date: ________

Miscellaneous Final Assembly Details—Completed: (Steps 187 — 194)

Signature: ______________________________ Date: ________

Systems Check-Out—Completed: (Steps 195 — 202

Signature: ______________________________ Date: ________

Fastener Inspection and Safetying—Completed: (Steps 203— 216

Signature: ______________________________ Date: ________

Weight and Balance—Completed: (Steps 217 — 222)

Signature: ______________________________ Date: ________

SECTION II: TOOLS AND TECHNIQUES

This section of the *Assembly Manual* describes the tools and construction techniques required to build the GlaStar. It describes metal fabrication, riveting, fiberglass laminating and other fabrication procedures. Refer to this section frequently when fabricating the individual assemblies described later.

None of the procedures described here is difficult to learn, especially if you have some experience using basic hand and power tools. If a particular procedure is new to you, however, practice on scrap material to develop your skill before risking damage to the airframe components. To help you with this, we have supplied a **sheet metal practice kit** (P/N 075-00001-01) in your GlaStar kit. The kit consists of small pieces of aluminum sheet of various thickness so you can practice procedures such as riveting, dimpling and countersinking.

Besides studying the techniques described here, also refer to the publications listed under "RECOMMENDED READING" in "SECTION I: INTRODUCTION." This is your opportunity to learn as much as possible about aircraft fabrication in order to build the best GlaStar that you can. If nothing else, studying the various aviation mechanic's handbooks and shop manuals will give you an appreciation of how much of the GlaStar assembly work has already been done for you!

TOOLS REQUIRED TO BUILD THE GLASTAR

This tool list is not meant to be exhaustive; as you work on your GlaStar, you will undoubtedly think of other useful tools to procure. You may already have some favorite tools not listed here that you find indispensable. If you live in a normal household, you will probably already have many of the tools on the "*General Purpose Tools*" list; if you are an experienced airplane homebuilder, some of the more specialized tools will also be familiar. Brief descriptions of the less common or less familiar tools needed to assemble the GlaStar are provided here; for more detailed descriptions of the tools and their proper use, refer to the various Techniques sections, which follow the tool list.

Some, if not most, of the tools on the "*Sheet Metal Tools*" and "*Special Tools*" list will be unavailable at your local hardware store. We will be stocking some of these tools; for the rest, contact the suppliers listed below to order catalogs.

Sources for Special Tools

Options Catalog, Stoddard-Hamilton Aircraft, Inc.
18701 - 58th Ave., N.E.
Arlington, WA 98223
(360) 435-8533
Fax (360) 435-9525

Aircraft Spruce and Specialty
Box 424
Fullerton, CA 92632
(800) 824-1930
Fax (714) 871-7289

U.S. Industrial Tool and Supply
15101 Cleat St.
Plymouth, MI 48170
(800) 521-7394/4800
Fax (313) 455-3256

Wicks Aircraft Supply
410 Pine St.
Highland, IL 62249
(800) 221-9425
Fax (618) 654-6253

Clinton Aircraft Tool & Supply, Inc.
3399-3405 Harrison Rd.
East Point, GA 30344
(404) 766-3222
Fax (404) 766-3809

Avery Enterprises, Inc.
Hicks Airfield
2290 W. Hicks Road
Hangar 54-1
Fort Worth, TX 76131
(800) 652-8379
Fax (817) 439-8402

Cleaveland Aircraft Tool and Material
1804 First St.
Boone, IA 50036-4417
(515) 432-6794
Fax (515) 432-7804

General Purpose Tools

1. Tape measure, 16' (both decimal and fractional graduations recommended)
2. 12" steel decimal/fractional ruler
3. Dial or vernier caliper (optional)
4. Digital level, accurate to 1/2° (strongly recommended) or carpenter's level (acceptable)
5. Carpenter's framing square
6. Try square
7. Protractor
8. Straightedges of various lengths up to 10' (ruler, level and squares will work for shorter straightedges)
9. Plumb bob
10. Fine-point felt-tip marking pens ("Sharpie" brand works well)
11. 3/8" electric drill (cordless with a keyless chuck recommended) or air drill (high speed: 3000+ rpm). An air drill is best for drilling aluminum because of its high speed.
12. Small drill bit set (see also "*Sheet Metal Tools*")
13. Die grinder (recommended). This is a small, hand-held, air-powered tool that turns at a very high speed. It has a special chuck to hold rotary files, drum sanders or cut-off wheels and is very useful for a variety of grinding, sanding or cutting operations, especially in fiberglass construction.
14. Rotary files, drum sanders and fiber cut-off wheels for drill motor or die grinder (recommended)
15. Scroll saw (optional). Useful for cutting out small, intricately-shaped parts.
16. Assorted files

General Purpose Tools (Continued)

17. Assorted clamps: C-clamps, spring clamps, etc.
18. Portable work light. A fluorescent light is preferred because it generates less heat and is therefore less likely to burn fiberglass laminates (or you!).
19. Flashlight
20. Common hand tools: wrenches, screwdrivers, pliers, hammers, etc.

Sheet Metal Tools

1. Drill bits in the following sizes: #10, 11, 19, 21, 27, 30 and 40; letters D, F, O, U and V; and standard twist drills of 1/16", 11/64", 3/16", 1/4", 11/32", 3/8", 13/32", 7/16", 1/2" and 9/16". The number 30 and 40 bits (both 3" and 6" lengths) are most frequently used because they are the correct size to drill rivet holes for 1/8" and 3/32" rivets, respectively.
2. 3/32" diameter Clecos, 250 minimum. Clecos—also called “sheet fasteners,” “pin fasteners” or “sheet holders”—are small, spring-loaded clamps that engage holes drilled in two or more parts to fasten the parts together temporarily. Special pliers that compress the spring are used to insert a Cleco into the hole. Our experience is that “Cleko-loc” or “Kwik-loc” brand Clecos work best.
3. 1/8" diameter Clecos, 200 minimum
4. 5/32" and 3/16" Clecos, about 15 of each

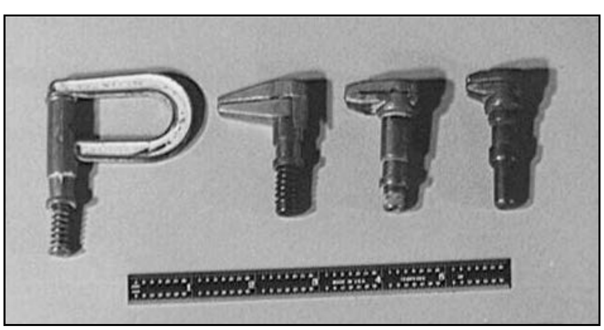

Figure 0.05: Assorted Side Grip Clamps

5. Cleco side-grip clamp fasteners, assorted grip lengths. These are small, spring loaded clamps that are operated by Cleco pliers and used to hold parts together before any rivet holes have been drilled. Ten to twenty of these should be enough.

Sheet Metal Tools (Continued)

6. Cleco pliers

7. Straight reamers in the following sizes: .4375", .5400", .5625", .6000" and .6255". Reamers are, unfortunately, quite expensive, and each size is used only once or twice. You may wish to consider having the necessary reaming done at a local machine shop.

8. Metal-cutting hole saws in the following sizes: 1", 1-1/4", 2-5/8", 3" and 3-5/8"; or an adjustable fly-cutter

9. Machine stop countersink tool with 1/8", 3/32" and 5/32" pilots and 100° countersink bits. This tool holds a piloted countersink bit and has an adjustable, telescoping sleeve that controls the depth of the cut.

10. A 120° countersink cutter with a 1/8" or #30 pilot for installing flush-head blind rivets. This tool is available from Stoddard-Hamilton; order P/N 081-02001-01.

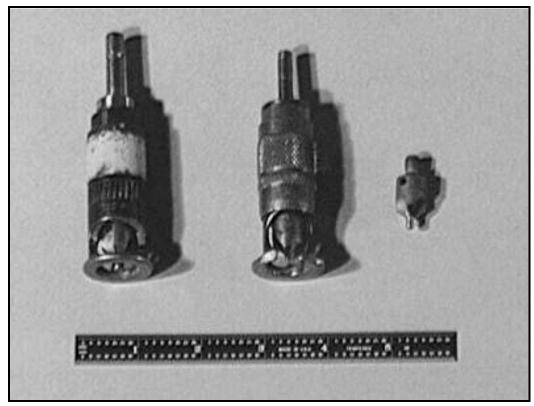

Figure 0.10: Stop Countersink Tools with Bit

> **Warning** The 120°countersink cutter should be used **only** for the flush-head blind rivets used in installing the flap skin doublers in "SECTION VII: AILERON AND FLAP ASSEMBLIES." Use of this cutter for countersinking holes for standard, 100° flush-head rivets will compromise the strength of these rivets.

11. Rivet shaver (recommended). This is a bit that fits in a microstop cage and is typically used for shaving the heads of poorly set flush rivets but is also very useful for removing the broken mandrel ends that often remain protruding above the heads of Cherry AAPQ blind rivets after they have been pulled. A fine-tooth file will do the same job but requires more care and time.

Sheet Metal Tools (Continued)

12. Center punch. A hardened steel tool with a cone-shaped point, used to make a small divot in a piece of metal at the location where a hole is to be drilled. The divot keeps the drill bit from wandering when the hole is started. The simplest center punch is held in position with one hand and struck with a hammer. Also available are automatic center punches which have an internal spring-loaded hammer; the point of the tool is pressed against the work with one hand, which compresses the spring to cock the hammer mechanism. When the pressure reaches a certain point, the hammer is released to drive the point into the work.

13. 3/32", 1/8" and 3/16" pin punches. Used mostly for removing defective rivets.

14. Air compressor. Choose a compressor capable of generating at least 75 psi. A large air storage tank is preferable, especially if you are using an air-powered drill or a die grinder, as this will minimize the amount of time that the compressor is running while you are working.

15. 2X rivet gun. This size gun is appropriate for driving **all** the rivets used in the GlaStar, and we do not recommend the use of any other size gun.

16. 3/32" and 1/8" universal head rivet sets. One end fits the rounded, manufactured head of a universal head rivet; the other end is inserted into a rivet gun for driving the rivet.

17. Flush rivet set for countersunk rivets. Used in a rivet gun like the universal head sets, the flush rivet set has a large flat end to fit against the flat head of countersunk rivets.

18. Fluting pliers (optional). This is a useful tool for straightening ribs.

19. Rivnut installation tool, size 8-32. Rivnuts are female-threaded fasteners installed like a blind rivet—the installation tool mushrooms the interior portion of the rivnut collar against the inside surface of the skin, locking the collar securely in place. Required for installing the rudder base fairing, this tool is available from Stoddard-Hamilton; order P/N 081-01001-01.

Sheet Metal Tools (Continued)

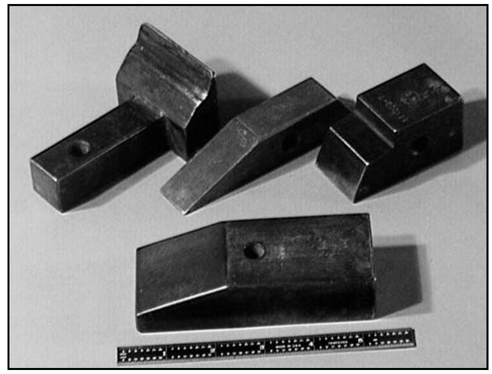

Figure 0.15: Bucking Bars

20. Assorted bucking bars. A bucking bar is simply a heavy, smooth piece of steel that fits against the tail of a rivet when the head is being driven with a gun-mounted set. The vibrations of the rivet against the bucking bar cause the tail to spread out and flatten, forming the "shop head" of the rivet. Bucking bars are made in a variety of sizes and shapes to fit the various locations where rivets are to be driven. Our experience shows that three different styles of bucking bars are sufficient to complete all riveting on the GlaStar. Sources of these three styles are given below. However, the choice of an appropriate bucking bar for a particular riveting situation is not an exact science; individual riveters will find different styles most useful in different situations. That having been said, we recommend either of the following sets of three (or their equivalents):

    From Aircraft Spruce & Specialty, bar numbers TP-638, AT-721 or TP-647, and TP-760B-1.
    From U.S. Industrial Tool and Supply Co., bar numbers TP-638, TP-721 and TP-760B-1.

21. Blind rivet puller. A pliers-like tool used to form "blind" or "pull" rivets. Sometimes called a "Pop" rivet puller.

22. Sheet metal snips ("Prosnip" type aviation **offset** snips recommended); straight, left and right cutting. Choose snips with smooth rather than serrated blades as these require less work to smooth the edge after the cut has been made.

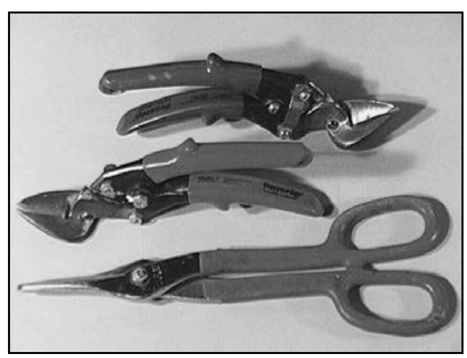

Figure 0.20: Offset and Straight Snips

Sheet Metal Tools (Continued)

23. (This tool deleted by Revision C.)

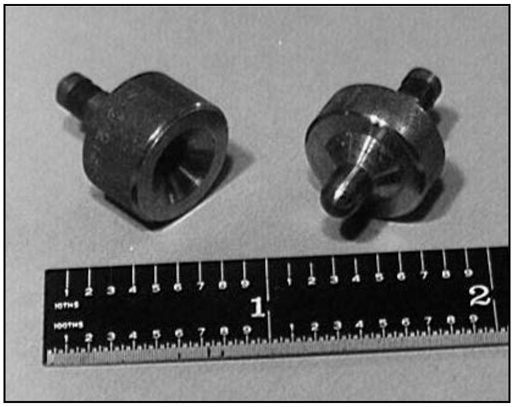

Figure 0.25: Dimple Dies

24. 3/32" and 1/8" dimple dies. These tools, consisting of matched male and female dies, are used to form thin sheet metal to accommodate countersunk rivets. The male die or punch is cone shaped to match the shape of the rivet head and has a small concentric pilot shaft that fits into the female die and matches the diameter of the rivet hole. The female die has a corresponding degree of countersink into which the male die fits. The sheet to be dimpled fits between the two dies; the dimple is formed by pressing the male die into the female die using either a rivet gun, a rivet squeezer or a bench-mounted riveting frame.

25. Chip chaser. This is a thin, hooked blade mounted in a handle. It is used to remove metal chips or shavings from between metal sheets that cannot be disassembled for cleaning.

26. Duck bill pliers (with the jaws taped to prevent damage to aluminum parts). Pliers with wide, flat jaws, used to straighten flanges on ribs and spars or to adjust bends in other metal parts.

27. Rivet squeezer (highly recommended). This is a pliers-like tool used to set rivets near the edges of sheets. It has a pair of sets that fit into the jaws of the tool, between which the rivet is compressed to form the shop head. A rivet squeezer is easier to use than a rivet gun and bucking bar and produces more consistent results.

Sheet Metal Tools (Continued)

28. #30 and 40 drill stops (optional). A device which fastens to a drill bit with a set screw to limit the penetration of the bit into the material. Helps prevent both damage to underlying structure and broken drill bits.

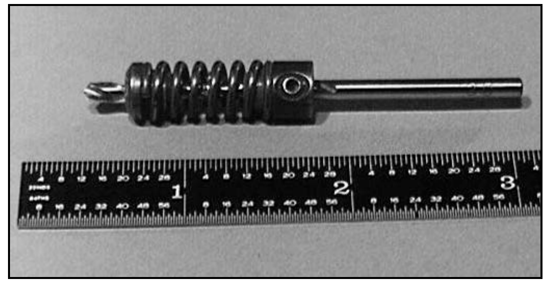

Figure 0.30: Drill Stop

29. Rivet cutter (optional). This is like a heavy-duty wire cutter and is used to shorten longer rivets to the correct length for a particular application. Usually has an adjustable stop to control the finished length of the rivet.

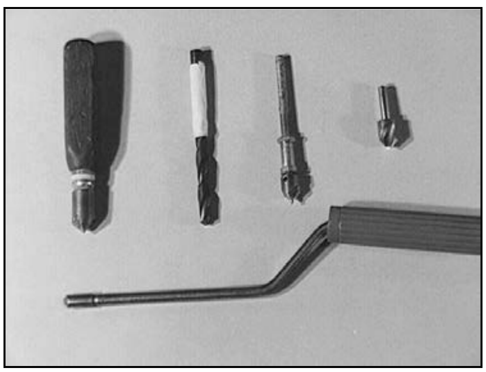

Figure 0.35: Hole Deburring Tools

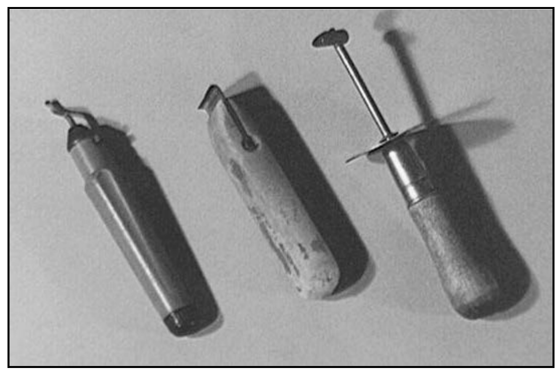

Figure 0.40: Edge Deburring Tools

30. Deburring tools for both edges and holes. An edge deburring tool is a hardened steel blade set in a handle and is used to remove the sharp burrs from the edges of metal sheets. A hole deburring tool removes the burr from holes drilled in aluminum. You can use a large drill bit or a countersink bit to deburr holes, but it is nice to have the tool mounted in a handle to expedite the operation.

Sheet Metal Tools (Continued)

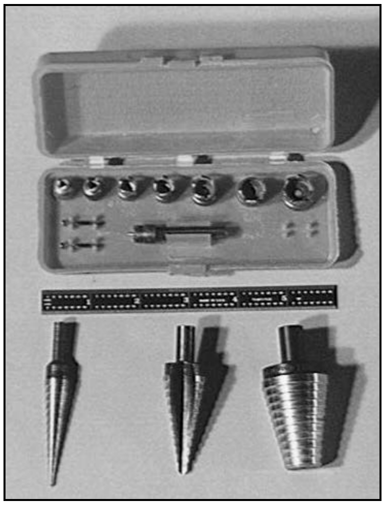

Figure 0.45: Blair Hole Cutter Set and Unibits

31. Blair hole cutter or Unibits (optional). A Blair hole cutter is a miniature hole saw; Unibits are special drill bits. Both tools make it easy to drill round, clean holes in thin aluminum sheet (a process that is difficult with standard drill bits for holes over about 1/4" diameter). The Unibits incorporate cutting steps of progressively larger diameter, so you can drill a number of different size holes with a single bit. We recommend a #1 Unibit (for holes from 1/8" through 1/2" diameters in 1/32" steps) and a #3 Unibit (for holes from 1/4" through 3/4" in 1/8" steps).

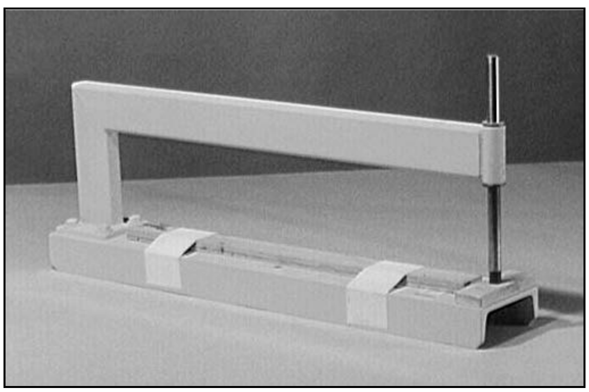

Figure 0.50: Riveting Frame

32. Riveting/dimpling frame (optional). This is a large, bench-mounted, C-shaped frame designed to hold rivet squeezer sets and dimple dies; the rivet is set or the dimple is formed by hitting the tool holder with a hammer. Since the sets and dies are held rigidly in the correct relationship to each other, it is relatively easy to achieve consistent, high-quality results. The frame has a throat depth of approximately 18" so, unlike the rivet squeezer, it can be used a considerable distance from the edge of a part.

Fiberglass Tools

1. Gram scale, 0-500 grams. Used to measure resin for laminating.

2. 5cc syringe, without needle. With the hole plugged, used like a graduated cylinder to measure promoters and catalyst.

3. Rubber squeegee. Used for laminating large flat surfaces.

4. 1" and 2" wide varnish brushes. Used for laminating smaller surfaces and convoluted shapes where a squeegee will not work.

5. Unwaxed mixing cups and mixing sticks (tongue depressors). Unwaxed cups are required to prevent contamination of the resin.

6. Heavy-duty scissors for cutting fiberglass materials.

7. Razor trim knife. This is just the standard utility knife or "box cutter." Used to trim fiberglass cloth in the "green cure" condition.

8. 50, 60, 80, 180, 220, 320, 400, and 600 grit sandpaper and sanding blocks

9. Rotary cloth cutter (optional). Similar to a pizza cutter—a sharp, circular, steel blade that is rolled across fiberglass cloth. Since the cloth remains flat on the table (it should be on a wood or soft plastic surface to prevent damage to the blade), the cut is made without distorting or fraying the cloth. A rotary cloth cutter makes especially good curved cuts.

Special Tools

1. Paint spray gun

2. Right angle drill motor or adapter with bits for drilling in tight spaces where access with a regular drill is difficult or impossible

3. NicoPress crimping tool. The control cables in the GlaStar are secured at their ends by doubling the cable back on itself and crimping a copper sleeve over the doubled cable to form an eye. The NicoPress tool crimps the copper sleeves.

4. Cable tensiometer. Used to adjust control cables to the proper tension. (This is a very expensive tool; we recommend trying to borrow one from a local A&P or EAA chapter.)

5. Tubing cutter

6. Crimping tool for insulated electrical wiring connectors

7. Wire strippers

8. Soldering pencil. Use a low-wattage type ($\leq$30W) to prevent damage to delicate electronic components. Avoid heavy soldering irons or guns.

9. Heat gun (hair dryer) for shrinking heat-shrink tubing in the electrical system and (optionally) on the control cables. Can also be used (carefully) to expedite curing of fiberglass laminates.

Safety Equipment

1. Fire extinguisher

2. Hearing protectors. Strongly recommended when riveting with a rivet gun.

3. Safety goggles or eye shield. Eye protection is needed when grinding metal on a bench grinder, when using a die grinder and when handling the MEKP catalyst for vinyl ester resin

4. Particle masks for protection from dust generated by sanding or grinding.

5. Paint spray respirator mask for protection from chemical vapors and solvent fumes.

6. Ventilation fan

Recommended Optional Tools

1. Bench grinder. In addition to its many other uses, a bench grinder with a Scotch Brite wheel can be used to deburr the edges of small parts.

2. Combination belt and disc sander. This is a very handy tool for finishing the edges of small metal parts.

3. Drill press

4. Band saw

5. Hot-melt glue gun. Used to temporarily hold parts together, especially for fiberglass lamination, in areas where they cannot be clamped. Hot glue can be removed easily using a heat gun; acetone will take care of any remaining residue.

6. Vise

Aluminum Sheet Metal Work

Since the entire wing, the horizontal stabilizer and all of the control surfaces are made from sheet aluminum (with some aluminum angle for reinforcement), aluminum sheet metal work obviously forms a major part of the GlaStar assembly project. If you have never worked on a sheet aluminum airplane before, you will find that it involves a relatively small number of easily learned skills performed repetitively. We provide a detailed description of the necessary metalworking skills in this section of the *Assembly Manual*; we will not repeat the detailed descriptions in later parts of the manual, but instead will assume you already know how to perform the procedures. Until you develop some facility with the various procedures, refer to this section often for review. We also recommend further study, using the publications listed in "Recommended Reading" in "Section I: Introduction."

Rivet Terminology

Before describing sheet-metal aircraft construction, here is a brief discussion of the various terms used to describe rivets. Most of the rivets used in the GlaStar are the round-headed variety known as "universal-head rivets." Some flat-headed, "countersunk" or "flush-head rivets" are also used. The end of the rivet formed by the factory during manufacture—the round head of universal-head rivets and the flat head of flush-head rivets—is called the "manufactured head" or, simply, the "head." The long, cylindrical part of the rivet is called the "shank." The end of the shank opposite the head is called the "tail." Driving a rivet, either with a rivet gun and bucking bar or with a rivet squeezer, causes the tail to spread out and flatten, forming the "shop head" of the rivet. The shop head, even after forming, can still be referred to as the "tail."

A special type of rivet is used in areas that are accessible from only one side for installation. These are called "blind" rivets—because the shop head is not visible during or after forming—or "pull" rivets—because the shop head is formed by pulling a solid "mandrel" or "stem" into the hollow rivet shank from the accessible side. These rivets are also frequently called "Pop" rivets, which is actually a proprietary trade name of a particular brand.

Warning All driven rivets used in the GlaStar must be the high tensile-strength "AD"-series rivets rather than the soft "A"-series rivets. Since we cannot always catch the mistake if our vendor ships the wrong rivets, it is your responsibility to verify that you are installing the proper, AD-series rivets. The two series of rivets can be distinguished by the head: the proper, AD-series rivets have a small dimple in the center of the head; the soft, A-series rivets have plain heads without dimples.

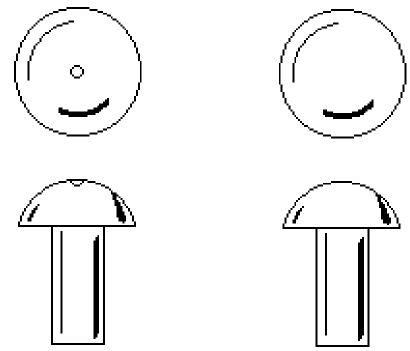

Figure 0.55: Rivet Markings

Summary of Riveting Procedures

The following list provides a general summary of the steps used to rivet together two sheet aluminum components:

1. Straighten and deburr the parts, as necessary.
2. Mark centerlines on rib and spar flanges.
3. Align the parts and clamp them together.
4. Drill the rivet holes to size, installing Clecos as you go.
5. Disassemble the parts, deburr the rivet holes and remove drill chips and shavings.
6. Corrosion-proof parts that will be inaccessible after assembly.
7. Reassemble and clamp the parts together with Clecos.
8. Rivet the parts together.
9. Inspect your work and replace defective rivets, if necessary.

The rest of this section describes these procedures in detail.

Straightening and Deburring Parts

Most of the components of the GlaStar airframe are supplied in a fully formed condition ready for assembly. Some parts may require some minor adjustments and clean-up, however. Taking the time at this stage to accomplish minor adjustments will simplify assembly as work progresses.

STRAIGHTENING

Use a try square to check the flanges of ribs for squareness to the webs. If the flanges are not quite square, use duck bill pliers (with the jaws taped to prevent damage to the flanges) to gently increase or decrease the angles of the flanges. It doesn't take much to accomplish this, so be careful and check your work frequently as you go.

Note Some of the flanged parts in the GlaStar do not have their flanges perpendicular to their webs. The flanges on the rudder ribs, for example, must match the taper of the rudder, so you shouldn't expect them to be square.

DEBURRING

Use a deburring tool (recommended) or small, fine-toothed files to remove any burrs remaining on the parts from the manufacturing process. Use flat files on straight or convex edges; use half-round or round files on concave edges, such as the perimeters of lightening holes. Deburring the parts will make them more comfortable to handle, as well as eliminating stress risers which might lead to cracking from metal fatigue. Don't go overboard with this; a few strokes with a file or one pass with the deburring tool is all you need. This is where the advantages of the deburring tool become obvious; filing parts can be tedious.

Marking Rivet Lines on Rib and Spar Flanges

Before beginning to assemble the structural framework of major assemblies, rivet lines must be marked on rib and spar flanges. When the skins are positioned on the framework in preparation for drilling the rivet holes, these marked lines will be visible through the pre-punched pilot holes in the skins and can be used as guides to align the skins on the underlying framework. Such lines are often centered on the rib or spar flange and are thus most often called "centerlines" in later sections of the manual; however, in a few places the lines must be drawn slightly off-center at a specified distance from the flange edge.

> **!** **Warning A sharp instrument**, such as a scribe, an awl or an electric engraving pencil, **must never be used for marking metal parts**. Stresses will concentrate in the scratches or indentations made by such tools, leading to cracking of the part over time. Also, **do not use pencil** for marking aluminum. The graphite in pencil lead is a form of carbon, which will promote dissimilar metals corrosion.

Use a fine-point felt tip marker to mark the lines. (Our mechanics prefer the "Sharpie" brand pen.) It's not necessary to take great pains to measure the exact centerline of the flange and then use a straightedge for marking. You can just "eyeball" the location of the centerline and mark it freehand. To do this, hold the pen as you normally would between your thumb and forefinger. Place the point of the pen on the centerline at the far end of the flange while resting your middle, ring and little fingertips against the edge of the flange, as shown in Figure 0.60. Hold your hand in this position and draw the pen toward you along the flange; your fingers sliding along the edge of the flange keep the pen point on the flange centerline as you mark the line.

Figure 0.60: Marking a Centerline on a Rib

You can also use a marking pen mounted in a compass (the kind for drawing circles, not the magnetic kind!). Set the distance between the legs of the compass equal to the distance from the edge to the center of the flange. Slide the leg with the point along the edge of the flange while marking the centerline with the pen; the compass keeps the pen on the flange centerline while marking.

Clamping Parts Together

It is very important to hold sheet aluminum parts together tightly during the riveting process. If the parts are not held tightly together, the rivet will tend to expand between the parts, leaving a gap that reduces the strength of the riveted joint.

The usual method of clamping sheet metal parts in which holes have already been drilled is to use sheet holders, or "Clecos." If holes are not available in the parts being joined, use small C-clamps or spring-loaded, side-grip clamps (Cleco clamps) to hold the parts together while riveting.

A Cleco consists of a small, cylindrical steel body which contains a plunger, a coil spring, a pair of locking wires and a spreader. When the plunger is depressed with a pair of Cleco pliers, the locking wires extend beyond the spreader, reducing the distance between the wires, which reduces the combined diameter of the two wires. The Cleco can then be inserted into the rivet hole. When the pliers are released, the spring pulls the locking wires back over the spreader, which expands the combined diameter of the locking wires to the diameter of the rivet hole. The Cleco's internal spring holds the parts tightly together by compressing them between the body of the Cleco and the hooks on the locking wires. Removing a Cleco is accomplished by reversing the installation process.

Caution To avoid enlarging the rivet hole, be careful to compress the Cleco fully so that the diameter of the locking wires is reduced to a minimum. Also, refrain from twisting the pliers to install and remove the Cleco; twisting can deform the hole.

Cleco fasteners are available in all common rivet sizes and are color-coded according to the following table:

Fastener Size:	Cleco Color Code:	Drill Size:
3/32"	Silver	#40
1/8"	Copper	#30
5/32"	Black	#21
3/16"	Brass	#11

Table 1: Cleco Sizes

When clamping skins to a structural framework in preparation for drilling the rivet holes to their final size, the rib and spar flanges in the framework must be centered under the pilot holes in the skins, using the lines marked on the flanges as references for alignment. A handy tool for aligning the ribs is a "rib alignment probe," which you can make yourself. The probe is simply a length of aluminum or copper tubing with a small, 90° hook bent in one end (or you could use a wooden dowel with a hook screwed into the end). The probe can be inserted into the structure spanwise through the lightening holes in the ribs to push or pull the ribs into alignment, as necessary. The probe must be long enough to reach all the ribs in an assembly from a location that has not yet had the skins installed; usually about 4-5' long is sufficient.

Preparation of Rivet Holes

On the GlaStar, the sheet metal skins of the wing, the empennage and the control surfaces have undersized pilot holes already punched in them. After the internal structural framework (the spars and ribs) has been assembled and jigged, the skins are positioned and clamped to the structure. The pilot holes in the skin are then used as guides to drill the rivet holes to the final size.

It is very important that the rivet holes be of the correct size and shape and free from burrs. If a hole is too small, the protective coating will be scratched from the rivet when the rivet is driven through the hole; if a hole is too large, the rivet will not fill the hole completely. When such a rivet is bucked, the joint will not develop its full strength and structural failure may occur at that spot.

If flush-head rivets are specified, consider the thickness of the metal and adopt the method—either countersinking or dimpling—recommended for that thickness. (the section on "COUNTERSINKING AND DIMPLING," below, provides guidelines for choosing the correct method.) If the metal thickness requires dimpling, keep hammer blows or dimpling pressures to a minimum so that no undue work-hardening occurs in the surrounding areas.

DRILLING

Standard drill sizes for common rivets are shown in Table 2:

Rivet Diameter:	Drill Number:	Drill Diameter:
3/32"	40	0.098"
1/8"	30	0.129"
5/32"	21	0.159"
3/16"	11	0.191"

Table 2: Drill vs. Rivet Sizes

As mentioned previously, most of the aluminum skins for the GlaStar airframe have undersized pilot holes already punched in them. These holes are used as guides for drilling the rivet holes to their finished size. When drilling holes that do not have an existing pilot hole for guidance, lightly center punch the locations for the rivet holes before beginning the actual drilling. The center punch mark acts as a guide and lets the drill bit grip or bite into the metal with greater ease. Make the center punch mark large enough to prevent the drill from slipping out of position, but punch lightly enough not to dent the surrounding material. To prevent deforming thin sheets when making a center punch mark, back up the material with a thick sheet of metal or a bucking bar.

In order to drill accurately-sized rivet holes, it is essential to use sharp drill bits. Worn bits not only tend to make enlarged, out-of-round holes, but also are more likely to "walk" across the surface being drilled. Either discard or sharpen worn drill bits. Also, before beginning to drill, always test the drill bit for trueness by running the drill freely and watching the end of the bit. If the bit wobbles, it may be because of burrs on its shank or because it is bent or incorrectly chucked. Do not use a drill bit that wobbles or is bent; such a bit causes enlarged holes. **This cannot be over-emphasized: use straight, sharp drill bits**; don't attempt to hand sharpen them.

When drilling, hold the drill motor firmly with both hands. Always hold the drill at right angles to the work, regardless of the position of the hole or the curvature of the surface. Extend the index and middle fingers of the left hand against the metal to act as a guide in starting a hole, and as a snubber or brake for when the drill goes through the material. You can also use special drill stops that fasten to the drill bit to limit the bit's penetration through the material. Another technique for starting a hole is to use a long drill bit and pinch the smooth shank of the bit between your fingers, initially, to act as a guide.

Hint When drilling holes in sheet metal, you can position the drill bit at a right angle to the surface by aligning the bit with its own reflection in the material. Check from two different directions because this method cannot detect misalignments that are in the plane defined by the drill bit and your eye.

Use a right-angle drill or drill extensions and adapters when access is difficult with a straight drill. Never tip the drill sideways when drilling or when withdrawing the drill from the material because this causes elongation of the hole.

Edge Margins for Rivet Holes

For **universal-head** rivets in aluminum sheet, the **center** of the rivet hole must be at least **two rivet diameters** from the edges of all parts in the assembly. For **flush-head** rivets, the **center** of the rivet hole must be at least **2-1/2 rivet diameters** from the edges of all parts. For example, edge margins must be 1/4" for 1/8" universal-head rivets and 5/16" for 1/8" flush-head rivets.

Drilling a Line of Rivet Holes

When drilling a line of rivet holes in an assembly, it's best to first drill holes at the ends of the line and at several places along the line, while making sure that the parts are held in correct alignment. Insert Clecos into each of these first holes after drilling to "tack" the parts together and maintain alignment between them. Then go back and drill the intervening holes. This practice will help prevent warped assemblies caused by slight misalignments.

DEBURRING

When holes are drilled through sheet metal, small burrs are formed around the edges of the hole. The holes must be deburred before riveting. This can be done by hand using a drill bit larger than the hole by placing the point of the larger bit into the hole and twisting the bit through several revolutions between your fingers. (If you use this method, wrap the drill bit with tape to protect your fingers.) You can also use a countersink bit in an electric drill, using very light pressure.

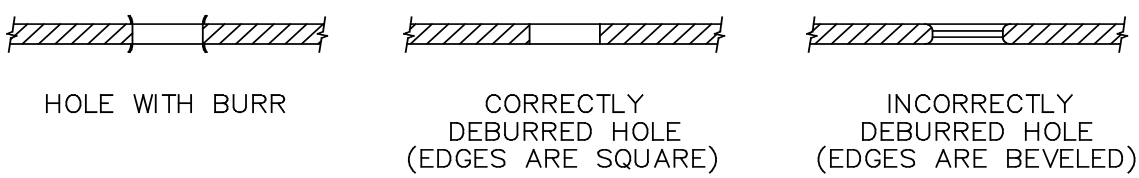

Figure 1: Deburring Rivet Holes

> **Note** Be careful to remove just the burr; do not enlarge the hole or bevel the edges of the hole. See Figure 1.

The usual sequence is to drill all of the holes at once and then disassemble the parts so that **both** sides of all holes can be deburred.

Note While the parts are disassembled, thoroughly clean away all chips that have accumulated between the parts. If drill chips or shavings prevent good contact between the parts, the rivet joint will not achieve its full strength.

Use an air nozzle or the exhaust from the air drill to blow the drilling chips off the surface; brushing the chips with your hand or a rag tends to scratch the aluminum cladding. A special tool, called a "chip chaser", can be used to remove drill chips from between parts that can no longer be disassembled.

Hint Before deburring rivet holes in exterior aluminum skins, remove narrow strips of the plastic covering along the rivet lines, leaving the major portion of the plastic for protection during construction. To remove the strips, run a hot soldering iron down both sides of the rivet line to melt through the plastic. Then you can peel off the plastic between the melted lines.

Caution Do **not** use any kind of knife or razor blade to score the plastic covering for removal along the rivet lines. Such tools will scratch the skin, possibly leading to later cracking.

COUNTERSINKING AND DIMPLING

To use flush rivets in sheet-metal aircraft construction, the surface must be either countersunk or dimpled to accept the rivet head. The proper method for any particular application depends mostly on the thickness of the parts being riveted and the height of the rivet head. As a general rule, use the machine or drill countersink method when the thickness of the material is greater than the thickness of the rivet head; use the dimpling method on thinner material. Dimpling works best in material no more than .040" thick. Refer to Figure 2 and Table 3.

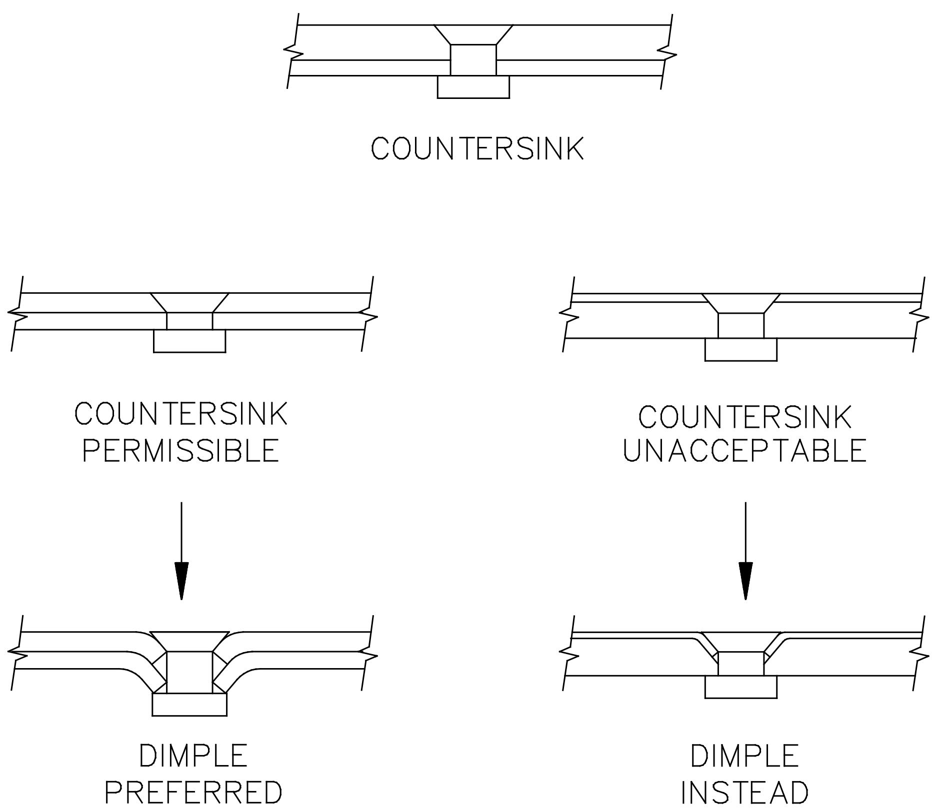

Figure 2: Countersinking and Dimpling

PREFERRED METHOD	3/32" Rivet	1/8" Rivet
Dimple	.032" material	.040" material
Countersink	.040" material	.050" material

Table 3: Material Thickness for Countersinking vs. Dimpling

Note Table 3 gives the preferred method for **structural** applications. For other applications, you have greater leeway in deciding between countersinking and dimpling. For instance, when using 3/32" rivets to mount nutplates to .032" thick aluminum, it is normal and acceptable to countersink rather than to dimple the rivet holes.

Warning Flush-head (countersunk) rivets are specified only in locations on the GlaStar where they are desirable for drag reduction or, in some cases, for the clearance they provide for other parts. However, flush-head rivets do not offer the tensile strength of universal-head rivets of comparable size. Where flush-head rivets are called for, this relative lack of strength is compensated for by the number and size of the rivets specified, but **under no circumstances** should you substitute flush-head rivets when universal-head rivets are specified.

Countersinking

To countersink sheet metal for flush-head rivets, use a machine stop countersink tool, which cuts away the edge of the rivet hole to form a recess —called the “well” or the “nest”—for the rivet head. The countersink tool’s cutter has a pilot that fits into the drilled hole to accurately position the cutter. It also has an adjustable stop to help ensure that the depth of the countersink will be accurate. Adjust the stop to the proper depth by practicing with a rivet on a piece of scrap material. (The head of the rivet must not extend more than 0.006" either above or below the surface of the metal, in most cases. A barely visible ring of cut metal around the rivet head is just right.) You can use the sheet metal supplied in the sheet metal practice kit for adjusting the countersink depth. (If you are countersinking .032" material for installing nutplates, use a thicker sheet for practice to get a true indication of the countersink adjustment.)

To cut accurate countersinks, hold the countersink tool at right angles to the material. Do not tip it. Tipping elongates the well and prevents the rivet head from seating properly. Oversized rivet holes, undersized countersink pilots, chattering caused by improper use of the countersink or by a countersink in poor condition, and a countersink not running true in the chuck of the drill motor are some causes of elongated wells.

Dimpling

To install flush rivets in thinner sheet aluminum (0.040" thick or less), the material must be dimpled to form the well for the rivet head. This is accomplished by using male and female die sets to press the metal immediately surrounding the rivet hole into the proper shape to fit the rivet head. The rivet must fit the well snugly enough to obtain maximum strength. The number of sheets which can be dimpled simultaneously is limited by the capacity of the equipment used, but generally two sheets of relatively thin material, such as the 0.020" GlaStar tail surface skins, can be dimpled simultaneously.

Note For thicker sheets that cannot be dimpled simultaneously, simply dimple each sheet separately. The resulting dimples will nest together properly for final riveting.

Both male and female dimple dies are machined accurately and have highly polished surfaces. The male die or punch is cone shaped to match the rivet head and has a small concentric pilot pin that fits into the female die and matches the diameter of the rivet hole. The female die has a corresponding degree of countersink into which the male die fits. The dimpling dies available from some sources (Cleaveland Aircraft Tool and Material, listed in the "*Sources for Special Tools*" section, is one) are made so that their included angle is about 5° less than that of the rivet. This arrangement allows for spring-back of the metal and works especially well.

To dimple a hole, rest the female die on a solid surface, place the material on the female die, insert the male die into the hole to be dimpled, and then hammer the male die. Strike with several solid blows until the dimple is formed. Since the metal is stretched slightly during the dimpling process, the pilot hole of the female die should be smaller than the diameter of the rivet. After dimpling, the hole may be reamed to the exact diameter, using the appropriate drill bit, so that the rivet fits snugly. We recommend the use of a dimpling frame or a rivet squeezer to hold the dies.

Fitting a Dimpled Skin to a Countersunk Part

There are several places in the GlaStar where thin aluminum sheet is flush-riveted to an underlying thicker part; one example is the attachment of the wing skins to the forward spar flanges. In these instances, the thin sheet must be dimpled and the underlying thicker part must be countersunk. To achieve the maximum structural strength of each of these rivets, the countersink must be carefully adjusted to the proper depth of cut.

Use **scrap pieces** of aluminum to adjust your countersink, as follows:

A) Choose a piece of scrap aluminum the same thickness as the thin sheet you're working with. Drill an appropriately sized hole (#30 for 1/8" rivets; #40 for 3/32" rivets) through this piece and dimple the hole.

B) Drill the same size hole in another piece of thicker scrap (1/16" minimum), and countersink the hole. This piece simulates the underlying thicker part.

C) Fit the dimple formed in Step A into the countersink formed in Step B, and check the fit. If, when the dimple is pressed tightly into the countersink, the two pieces are held apart so that a gap exists between them, the countersink is too shallow. Refer to Figure 2.1. If the pieces fit tightly together without gaps but the dimple is loose in the countersink so that the pieces can shift laterally relative to each other, the countersink is too deep. If the dimple fits snugly in the countersink and the parts fit tightly together without gaps, the countersink depth is just right.

D) Adjust the depth of the countersink, if necessary, and repeat Steps B and C until you have achieved the proper countersink depth.

Now that your countersink tool is adjusted properly, you can use it to cut the countersinks in the rivet holes in the thicker part.

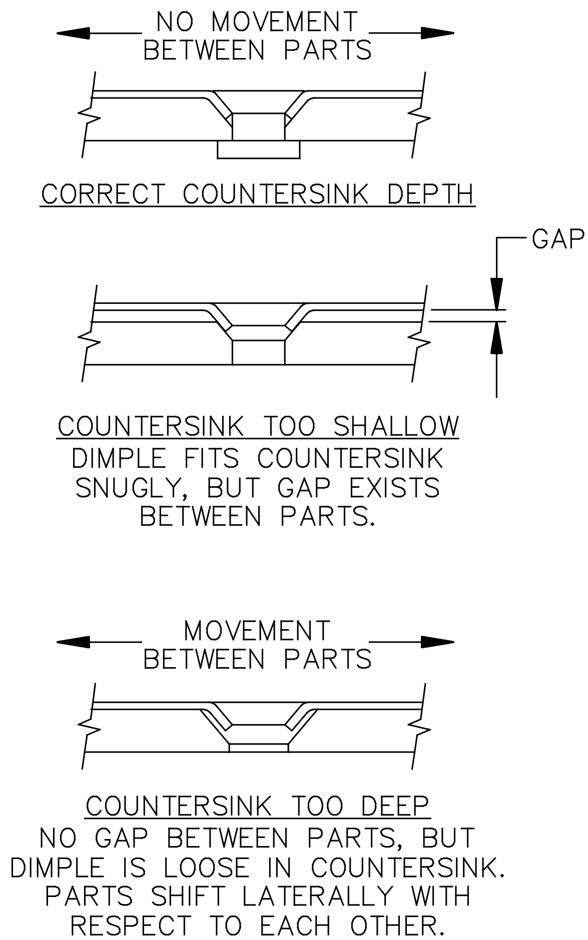

Figure 2.1: Countersink Adjustment

Note Since aluminum sheet of various thicknesses may be fastened to the same underlying part (as when fastening the various wing skins to the spar flanges), you must readjust your countersink tool, following the procedures described above, for each different sheet thickness. For example, you can use the same countersink adjustment for the rivet holes for the inboard leading edge wing skin and the inboard main wing skins, which are all .032" thick, but you must change the adjustment for the center leading edge wing skin, which is .025" thick.

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Determining the Proper Size of a Rivet

DIAMETER

Rivets used on the GlaStar range from 3/32" to 5/32" in diameter, with 3/32" and 1/8" being by far the most common sizes. The diameter of rivet to use in any particular application will always be specified in the manual.

LENGTH

The manual does not specify the length of rivets for particular applications, and so it is very important that you develop the ability to determine the proper length yourself. Rivets that are too long or too short for a given situation will not produce joints of full strength. The reason we do not call out specific rivet lengths is that small variations in material thickness, type of corrosion-proofing applied, parts fit, etc., can all produce differences in the optimal rivet length.

To determine the proper length of a rivet for any given application, the combined thickness of the material to be joined, or the "stack-up," must be known. This measurement is known as grip length. The total length of the required rivet is equal to the grip length plus the amount of rivet shank necessary to form a proper shop head, which is 1-1/2 times the diameter of the rivet shank . Referring to Figure 3 and the above information, use the formula A = B + C to determine the correct length of a rivet. (A is the total rivet length; B is the grip length; C is the material needed to form a shop head.)

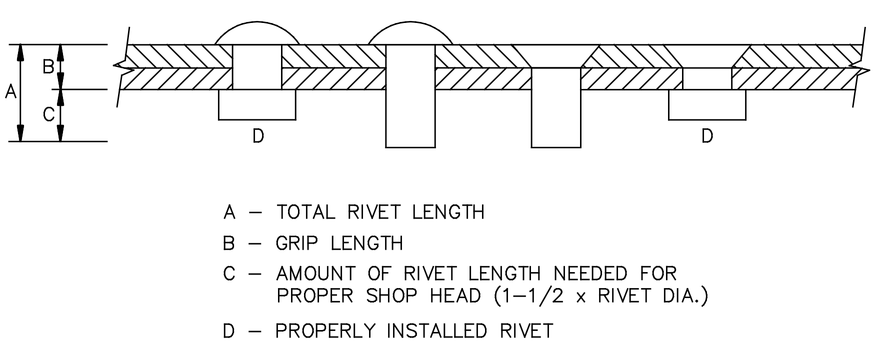

Figure 3: Determining the Proper Length of a Rivet

Note The length of a universal-head rivet is measured from the underside of the head; the length of a flush-head (countersunk) rivet is measured from the upper surface of the head. Refer to Figure 3.

A slightly longer or shorter rivet may be used if, after driving, the shop head conforms to the specifications given in the next section. As a general rule, a rivet within 0.020" of the optimal length is acceptable. A rivet of the correct size can be obtained by trimming a longer rivet with a rivet cutter.

If the combined thickness of the material to be joined is not known, and the location of the hole is such that the thickness cannot be measured directly, you can easily determine the grip length of a rivet by using a homemade tool. Simply bend a tiny 90° hook into the end of a stiff piece of wire. Insert the wire into the rivet hole and pull the hook back against the metal around the lower side of the hole. Mark the wire at the upper surface of the hole (either use a pen or simply hold your thumbnail against the wire), then withdraw the wire from the hole and measure the distance from the hook to the mark. Remember, this just gives you the needed grip length; you must add 1-1/2 times the rivet diameter to the grip length to determine the required total length of the rivet.

Note Lengths of blind rivets will be specified in the text.

Specifications for Properly Driven Rivets

After driving, the shop head should be a minimum of 1-1/2 times the diameter of the rivet shank in width and about 2/3 the diameter of the rivet shank in height. The minimum acceptable height of the shop head is 1/2 the shank diameter. See Figure 4 for examples of properly and improperly driven rivets.

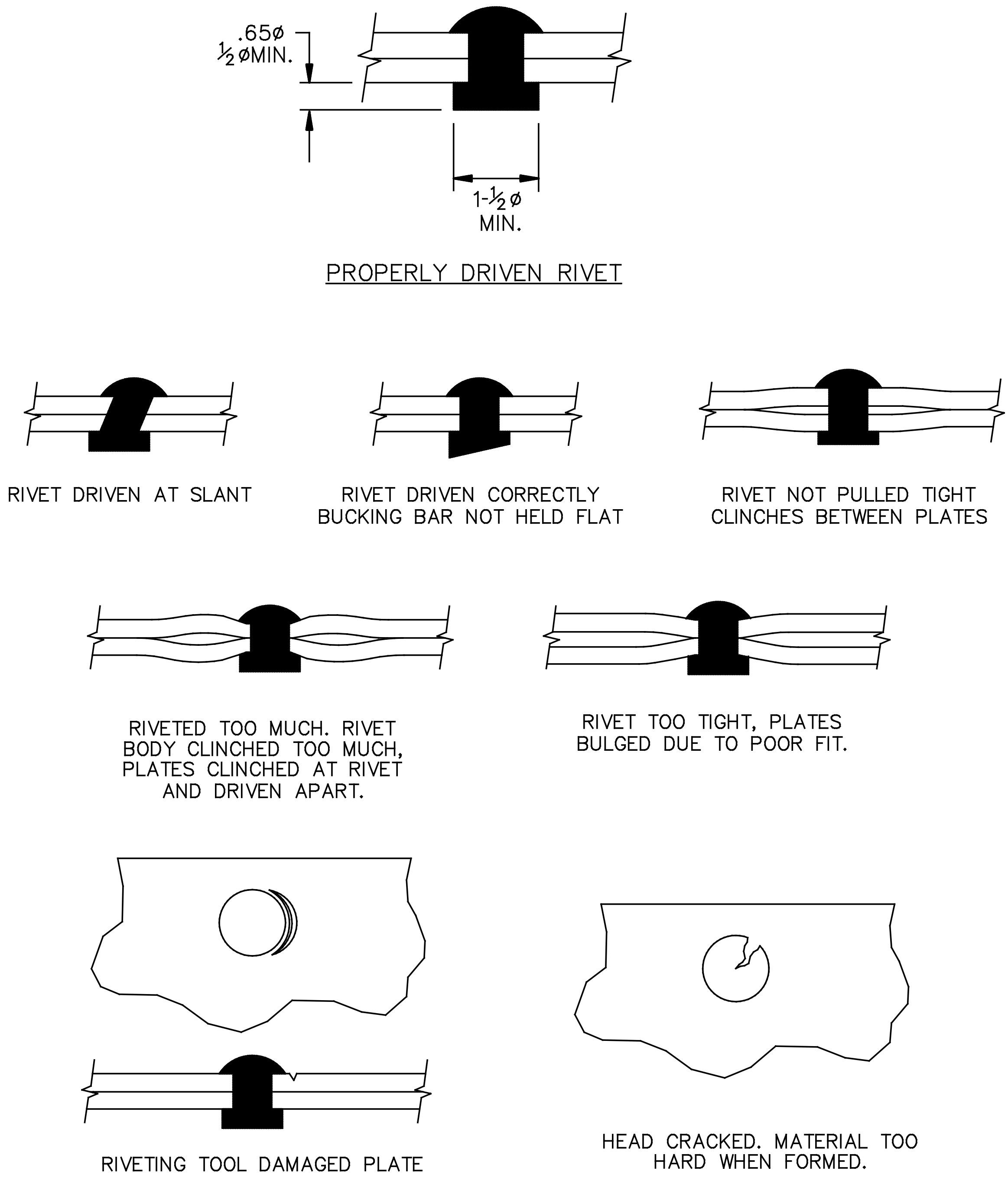

Figure 4: Properly and Improperly Driven Rivets

Installing a Line of Rivets

When driving a line of rivets in an assembly, start by driving a rivet at the center of the line and then one at each end. Then drive a rivet halfway between the center and the end on each side. Continue in this fashion, driving rivets at the centers of unriveted areas, until the entire line is finished. This practice tends to distribute any expansion of the material or any slight misalignments between the two parts along the entire length of the rivet line, resulting in a straighter assembly. If, on the other hand, you were to start at one end of the line and work your way to the other end, any slight misalignments or expansion would tend to be pushed along and to accumulate as you progressed. In this situation, you could force a curve into the assembly in order to get the rivet holes to line up as you go along, or you might be left with a bulge in the skin between the last two rivets.

The same principle applies to riveting the skins of the wings and control surfaces to their underlying structural frameworks. Begin with a rivet in one corner, then a rivet in the opposite corner, then a rivet somewhere in the middle. Establish a pattern in which you are always riveting approximately in the middle of the remaining unriveted area.

Driving Rivets

The essential tools for driving standard, solid-shank rivets are a compressor, a rivet gun, rivet sets and bucking bars. The rivet gun is used to deliver rapid, hammer-like blows that quickly drive the rivet when it is backed by a suitable bucking bar. Three basic types of rivets are used in building the GlaStar: universal round-head, countersunk flush-head and the blind pull type. For each type of rivet, different techniques and tools are required. The universal-head and flush-head rivets obviously require different rivet sets. The blind rivets require only a pull riveter to install them. When using pneumatic rivet guns, hearing protectors are highly recommended. A rivet squeezer may be used for forming the standard, solid-shank rivets in accessible areas, but accessibility is limited by the jaw depth of the squeezer. Installing rivets with a squeezer is much easier than with a pneumatic gun.

When riveting together material of different thicknesses, place the manufactured head against the thinner material wherever possible and form the shop head against the thicker material. This practice will minimize deformation of the material caused by riveting.

> **Note** Before driving any rivets, make sure that all holes line up perfectly, all shavings and burrs have been removed, and that all the parts to be riveted are securely fastened together.

BUCKING

Two people, a "gunner" and a "bucker," usually work as a team when driving rivets. On some jobs, however, the riveter can hold a bucking bar with one hand and operate the rivet gun with the other.

Follow these general guidelines for bucking rivets:

1. Make sure the bucking bar has a flat, square face; otherwise, the rivet head will deform.
2. For the least distortion of the surrounding material, use as heavy a bar as practical.
3. Always hold the face of the bucking bar at right angles to the rivet shank. Failure to do this will cause the rivet shank to bend with the first blows of the rivet gun and will cause the material to be marred by the final blows.
4. The bucker must hold the bucking bar in place until the rivet is completely driven. If the bucking bar is moved while the gun is in operation, the rivet set may be driven into the surface of the material.
5. Position the bucking bar so that it clears surrounding obstructions, allowing the bucking surface to rest squarely against the tip of the rivet shank. Pad the bar with masking tape where it may contact the structure.
6. Avoid having the point of contact with the rivet too close to the edge of the bucking bar or it may slip off.

7. Do not bear down too heavily on the shank of the rivet. Allow the weight of the bucking bar to do most of the work. The hands merely guide the bar and supply the necessary tension and rebound action.

Failure to hold the bucking bar at right angles to the rivet can cause defective rivet heads. A rivet going "clubhead" (malforming), can be corrected by rapidly moving the bucking bar across the rivet in a direction opposite that of clubhead travel. This corrective action can be accomplished only while the gun is in action and the rivet is partially driven. If a rivet shank bends at the beginning of the bucking operation, place the bar in the corrective position only long enough to straighten the shank.

Pneumatic Driving

In pneumatic riveting, the pressure for forming the shop head of the rivet is applied with a rivet set and an air-driven hammer or gun. A rivet gun should be large enough to drive rivets in a reasonable length of time without distorting the structure. We have found that a 2X size rivet gun works well for all of the work on the GlaStar. Be sure to choose the proper rivet set to match the type and size of the rivet you are driving.

Always use a regulator on your rivet gun and adjust it for the minimum pressure needed to drive the rivet. Adjust the speed of the gun (strokes per minute) before starting to drive rivets. To do this, press the rivet set against a block of wood before pressing the trigger.

Caution Never operate the gun without resistance to the set; the vibrating action may cause the retaining spring to break, allowing the set to fly out of the gun. Also, free vibration may flare or mushroom the gun end of the set, causing it to bind in the barrel of the gun.

Hold the rivet set at right angles to the work to prevent damage to the rivet head or the surrounding material. Avoid using too many strokes without enough force because this may cause the rivet to work-harden and crack.

Hint Use masking tape on the rivet set and on the bucking bar. The tape on the set protects the rivet head from marring; the tape on the bar helps to keep the bar from slipping off the rivet.

Remove the bucking bar and check the shop head of the rivet; it must conform to the standards described above in "SPECIFICATIONS FOR COMPLETED RIVETS." If the rivet needs further driving, repeat the necessary procedures to complete the job. If the rivet has been driven too far (the shop head is less than 1/2 times the shank diameter in height), it must be removed and replaced. (See "REMOVING RIVETS" below.) In some cases, however, you may be better off leaving a rivet that has been driven too far rather than risk elongating the hole when removing the rivet.

We recommend practicing riveting on scrap material to get a feel for the proper techniques before attempting to drive rivets in any of the airframe components.

BACK RIVETING

For some assemblies in the GlaStar, especially where thick stack-ups of heavy material are joined by long rivets, it may be easier to "back rivet" instead of driving rivets in the conventional manner. In back riveting, the shank end of the rivet is driven with a flush set and a rivet gun, and the manufactured head is bucked. A bucking bar is used to buck flush-head rivets; universal-head rivets are bucked with a universal-head set held in a vise or a bottle bar (a special bucking bar recessed to hold a rivet set).

Hint For such thick joints, it helps to C-clamp the assembly tightly together while riveting.

SQUEEZE RIVETING

The squeeze method of setting a rivet produces the most uniform and balanced type of shop head. Each rivet is upset in a single operation; all rivets are formed with uniform pressure; and each rivet shank is sufficiently and uniformly expanded to completely fill each rivet hole. Squeeze riveters come equipped with pairs of end sets, each pair being designed for a particular type of rivet. Once the correct end set is selected and the squeezer is adjusted for a particular application, all the rivets will be driven uniformly, thus providing an efficient method of riveting. Access for squeeze riveting is limited by the jaw depth of the riveter, so this method can be used only near the edges of components.

The procedures for installing rivets by squeezing will vary depending on the type of rivet squeezer you are using, but, in general, follow these steps:

1. Carefully select and insert suitable sets to match the rivet being used. This is very important; it is impossible to buck the rivet properly unless the correct pair of sets is used.

2. Adjust the gap to conform to the length of the rivet being installed. The gap adjustment method varies with the type of squeezer: usually either a gap regulator controls the stroke of the jaw (adjusted by rotating the plunger that holds the moving set) or shims adjust the spacing between the sets.

3. Before using the squeezer on the work, test the accuracy of the gap adjustments on a piece of scrap material. The scrap must be the same thickness as the work to be riveted, and the rivets must be the same length and diameter.

4. If the parts to be riveted are small and easily handled, mount the rivet squeezer in a bench vise or a special clamp and hold the parts to be riveted in your hand.

Consult the instructions included with your rivet squeezer for specific details.

BLIND RIVETING

Blind rivets are used in areas of the GlaStar airframe that are accessible from only one side (the joint between the stabilizer skin and the leading edge ribs, for instance). These rivets are called "blind rivets" because the shop head is not visible during or after forming. They are also called "pull rivets" because the shop head is formed by pulling a solid mandrel into the hollow rivet shank from the accessible side.

Although the blind rivets supplied with the GlaStar kit may resemble the Pop rivets available at your neighborhood hardware store, there are important differences. All of the 1/8" pull rivets used on the GlaStar are aircraft-quality Cherry "Q" rivets, in which the stem fills the hollow shank of the rivet after pulling, providing much greater shear strength. On common Pop rivets, by contrast, the stem breaks off short during installation, leaving a structurally weak empty shank. There are a few places on the GlaStar where 3/32" pull rivets are specified. The rivets supplied for these applications are Cherry "N" rivets, in which the stem breaks off below the surface when pulling, leaving a partially hollow shank. Although these lack the shear strength of the Cherry "Q" rivets, they are still superior to common Pop rivets in that they are designed to positively retain the broken stem after installation.

! **Warning Do not** use standard, hardware-store Pop rivets in the GlaStar airframe. Use **only** the rivets supplied with the kit.

Installing blind rivets is pretty straightforward. Holes are drilled and deburred in the same manner as for standard rivets except that greater care must be taken not to enlarge or elongate the hole. This is because a blind rivet will not expand as much as a solid shank rivet. Use the correct pulling tool and make sure that the proper pulling head is installed on the tool for the size of rivet being used. After the hole is drilled and the parts are clean and clamped securely together, insert the rivet fully into the hole, position the head of the pulling tool on the rivet stem (mandrel) and pull the rivet stem until it snaps. After pulling, the head must fit tightly against the metal. When a blind rivet is installed in an assembly with a thickness in the middle of the rivet's grip range, the mandrel will break off flush with the head. Otherwise, the mandrel will break off either above or below the head, depending on the thickness of the assembly. If the mandrel breaks off above the rivet head, simply file it down flush with the head.

Note In some places in the GlaStar where Cherry AAPQ-42 blind rivets are specified, the stack-up is technically too small for the optimal grip length range of the -42 rivets. -41 rivets are unavailable, however, so -42s must be used. This is not a problem; the rivet will develop full strength since the broken-off stem will fill the shank solidly after pulling. The only problem is that the stem will break off above the rivet head and will have to be shaved or filed down, as described above.

Replacing Defective Rivets

The design of riveted joints is based on the theory that the total joint strength is simply the sum of the individual strengths of each of a whole group of rivets. It is obvious that if any one rivet fails, its load must immediately be carried by others of the group; if they are unable to carry this added load, progressive joint failure then occurs. Consequently, an inspection must be made of **all** rivets before an assembly is put into service. This inspection consists of examining both the shop and manufactured heads and the surrounding skin and structural parts for deformities. A machinist's scale or a special rivet gauge can be used to check the condition of the shop head to see that it conforms to the specifications. The eye alone can detect deformities in the manufactured head. Use a straightedge to check that flush head rivets are neither protruding above the skin surface nor recessed too deeply below the surface.

Some common causes of defective rivets are improper bucking, rivet set slipping off or being held at the wrong angle, and rivet holes or rivets of the wrong size. Additional causes of unsatisfactory rivets are countersunk rivets not flush with the well; work not properly fastened together during riveting; the presence of burrs; and too much or too little driving. Whatever the cause, defective rivets must be removed and replaced.

Note Stop and inspect your work at important milestones before proceeding with further work that will make defective rivets inaccessible for replacement. When riveting the horizontal stabilizer skins, for example, inspect all rivets (and replace rivets as needed) after riveting the skins to the ribs and front spar, but before riveting the aft spar to the skins.

REMOVING RIVETS

When removing a rivet for replacement, be very careful to maintain the original size and shape of the rivet hole so that replacement with a larger size rivet will not be necessary. If the rivet is not removed properly, the strength of the joint may be weakened and replacement of rivets made more difficult.

When removing a rivet, work on the manufactured head. It is more symmetrical about the shank than the shop head, and there will be less chance of damaging the rivet hole or the material around it. The preferred method on the relatively light structure of the GlaStar is to drill through the rivet head and then to pull the tail out with a pair of flush cutting diagonal cutters, or to simply drill all the way through. On heavier structure, drill through the head and then drive out the remainder of the rivet with a pin punch. The dimple in universal and flush head rivets usually eliminates the need to center punch the rivet head, but you may center punch the head anyway to reduce the tendency of the drill bit to walk off the head. For blind rivets, use a small pin punch to drive the remains of the stem down into the rivet; the hole in the middle of the head then centers the bit for drilling.

Note On thin sheet metal, back up the rivet on the shop head side to avoid depressing the surrounding metal when center punching a bucked rivet or driving out the mandrel of a blind rivet.

Select a drill one size smaller than the rivet shank and drill out the rivet head. When using a drill motor, set the drill bit on the rivet head and rotate the chuck several revolutions by hand before pulling the trigger. This procedure helps the drill cut a good starting spot and reduces the chance of the drill slipping off and tracking across the metal. Drill the rivet to the depth of its head, while holding the drill at a 90° angle. Be careful not to drill too deeply because the rivet shank will turn with the drill and elongate the hole. The rivet head will often break away and climb the drill bit, which is a good signal to withdraw the drill. If the rivet head does not come loose of its own accord, insert a pin punch of the proper size into the drilled hole and rock it back and forth slightly until the head comes off.

Drive out the shank of the rivet with a pin punch slightly smaller than the diameter of the shank. On thin metal or unsupported structures, support the sheet with a bucking bar or a block of wood while driving out the shank, or pull out the shank from the back side with a pair of diagonal cutters. If the shank is exceptionally tight after the rivet head is removed, drill the rivet about two-thirds of the way through the thickness of the material and then drive out the remainder of the rivet with a pin punch.

The procedure for removing flush rivets is the same as just described. Be very careful to avoid elongation of the dimpled or countersunk holes. Drill the rivet head to approximately one-half the thickness of the top sheet.

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NUTPLATE INSTALLATION

Nutplates (also called “anchor nuts”) are used in numerous places in the GlaStar in inaccessible areas where a regular nut cannot be used. As shown in Figure 5, installing nutplates is simple but requires following a specific sequence:

1. Drill the bolt hole through both parts.
2. Insert a bolt through the hole from the top side and thread the nutplate partially onto the bolt.
3. While the bolt holds the nutplate in alignment, use one of the rivet holes in the nutplate as a guide to drill the first rivet hole.
4. Insert a Cleco or a rivet through the first rivet hole to maintain alignment.
5. Drill the second rivet hole.
6. Remove the nutplate, deburr the rivet holes and countersink or dimple the holes on the top side. (If you dimple, as you should on thin material, then you will also have to dimple the flanges of the nutplate, or else it will not lie flat against the part when riveted.
7. Rivet the nutplate in place.

Note If the nut plate is to be mounted in a location that is inaccessible for drilling from the bottom side, insert the bolt through the hole from the bottom, thread the nut plate onto the bolt and drill the rivet holes from the top side.

Hint Special **nut plate jig** tools are available to simplify the installation of nut plates. The tools have a pin that fits into the bolt hole and two drill guides of the correct size and spacing for drilling the rivet holes. A different tool is needed for each size of nut plate.

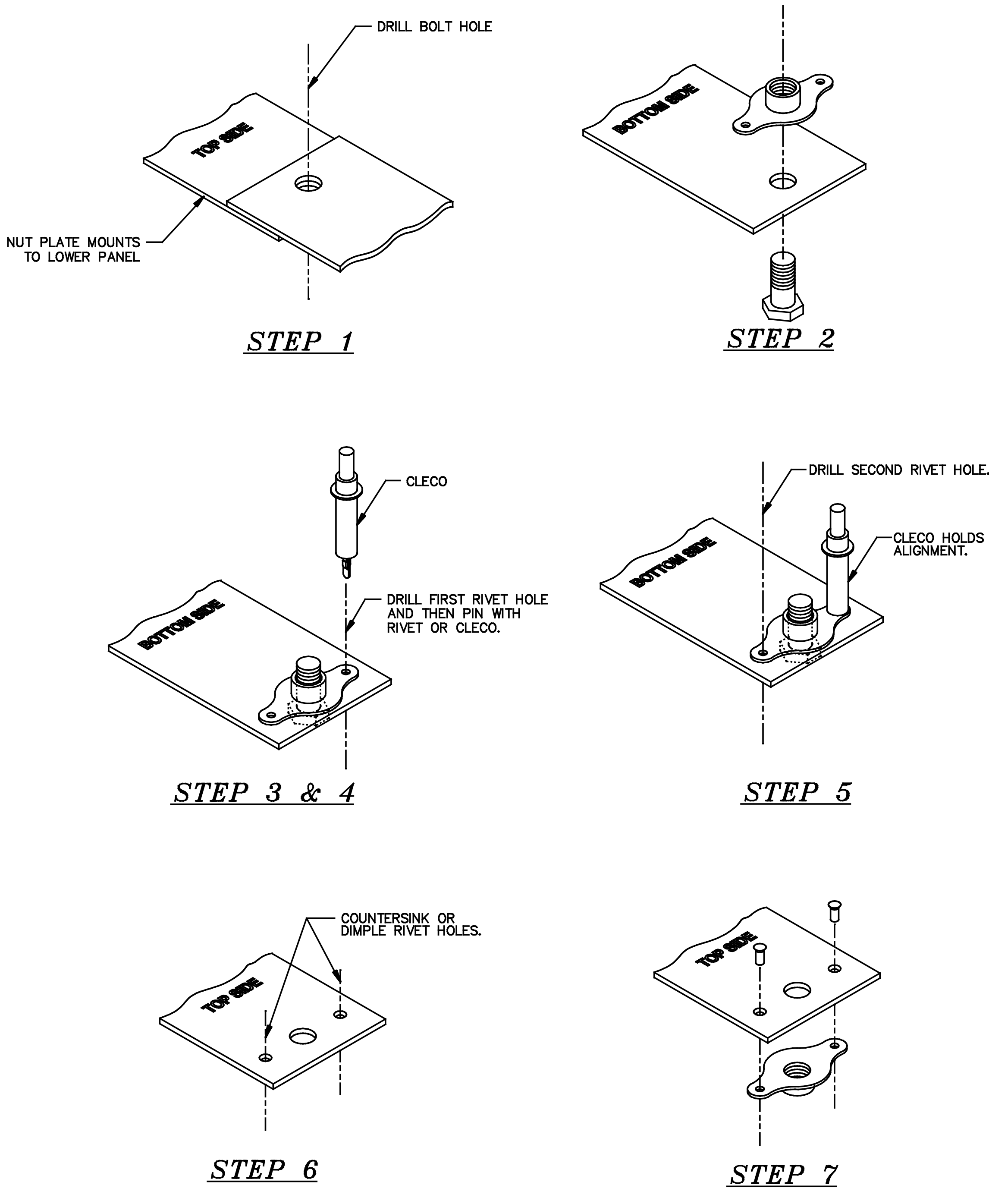

Figure 5: Nutplate Installation Procedures

Fiberglass Laminating

What Is Fiberglass?

Glass fiber is produced by drawing single fibers of special glass (largely silicon, calcium and aluminum dioxides) into very small-diameter strands. The glass itself has very high tensile strength, little corrosion resistance and is vulnerable to attack by both acids and alkalis. When the properties of glass fibers are properly complemented with the corrosion-resistance and toughness of resin, however, the end product is a strong, lightweight, corrosion-resistant material known by the generic name "fiberglass reinforced plastic" (FRP).

Fiberglass Construction in the GlaStar

The GlaStar fuselage halves are manufactured by laminating layers of bi-directional cloth on both sides of a foam core in a female mold. The foam sandwich construction combines exceptional stiffness with low weight. To assemble the GlaStar fuselage, you will seam the fuselage halves together (around the welded, steel-tube cage) using laminates of fiberglass seam tape. The cockpit cage will then be fastened to the fuselage with bolts and machine screws. You will also fabricate structural bulkheads and stiffeners at the aft end of the fuselage using pre-cure plastic foam-and-fiberglass laminate sheets and fiberglass cloth, both to reinforce the fuselage and to provide attach points for the horizontal stabilizer.

The resin supplied with your GlaStar kit is Dow Derakane 411-45 vinyl ester resin. This resin is well regarded for its high corrosion resistance (it is used to make underground fuel storage tanks), its ease of use and its low toxicity. A variety of other vinyl ester resins are used in the manufacture of the pre-molded parts of the GlaStar, but these are **not** recommended for use by the builder.

The majority of the fiberglass cloth supplied with the kit is 7781 9.5 oz. bi-directional E-glass (Mil. Spec. MIL-F-9084) with a CS-472 finish optimized for use with vinyl ester resin. This is the **only** bi-directional cloth recommended for use with the supplied resin. Substitution of any other cloth **cannot** be assumed to produce laminates of sufficient strength.

The DBM cloth supplied with the kit consists of 17 oz. double uni-directional cloth on the 45° bias with a 3/4 oz. mat backing.

Warning Because of the careful match between the resin and the fiberglass cloth used in the GlaStar, **do not** substitute unapproved materials from other sources. Use only the materials supplied with your kit.

Before the vinyl ester resin can be used for fiberglass lamination, it must be promoted with cobalt naphthenate (cobalt) promoter and dimethylaniline (DMA) accelerator. Resin is promoted in one-gallon quantities, and then smaller quantities are taken as needed from the one-gallon batches of promoted resin. Finally, the resin is catalyzed with methyl-ethyl-ketone-peroxide (MEKP) catalyst just prior to use.

Warning **Never** mix cobalt directly with MEKP catalyst. A violent reaction will occur that may result in fire or explosion. Store cobalt separately from the catalyst.

The estimated shelf life of unpromoted vinyl ester resin is approximately three months. Once promoted with cobalt and DMA, the shelf life decreases to 1–2 months. Because of the limited shelf life, we do not ship the resin and other chemicals until you request them. Contact our order desk when you are ready to begin fuselage construction, and we will ship the chemicals to you.

Summary of Fiberglass Laminating Procedures

The following list provides a general summary of the steps used to apply a fiberglass laminate:

1. Promote the resin, if you don't already have a quantity of promoted resin on hand.

2. Prepare the surface where the laminate will be applied by sanding, if necessary, and cleaning with acetone.

3. Cut the cloth for the laminate.

4. Measure a sufficient quantity of promoted resin and catalyze it.

5. Saturate the cloth with the catalyzed resin, adhering it to the underlying structure and working out air bubbles.

6. Clean up and dispose of excess resin.

7. Trim the laminate in the green cure condition, if necessary.

8. Let the laminate cure.

The rest of this section describes these steps in detail.

Promoting Vinyl Ester Resin

Before vinyl ester resin can be catalyzed for lamination, it must be promoted. No noticeable change will occur in the resin upon promotion except for a change of color. Resin is promoted first with the cobalt promoter and then with the DMA accelerator. At high temperatures (80°-100° F), DMA is not required to cure the standard vinyl ester resin and may be left out of the promotion step to provide a longer working life for the resin.

If necessary, transfer the resin to a wide-mouth container so the promoters can be easily mixed into the resin. Use a clean plastic container that can be sealed, preferably with a closable spout. The amount of promoters used depends on the ambient temperature while you're working. See Table 4:

Chemical Component:	65-85° F	80-100° F
RESIN:	1 gallon	1 gallon
COBALT (purple in color):	5cc	3.6cc
DMA (orange-yellow in color):	3cc	0cc

Table 4: Resin Promotion

Use a graduated cylinder with metric markings or a plastic syringe without the needle to measure the cobalt and DMA. **Add the cobalt first** and mix thoroughly, scraping the sides and bottom of the mixing vessel. Then add the DMA, if needed, and mix again. You can use a paint stirrer on a drill motor to mix the promoters into the resin. This method introduces air bubbles into the resin, however, so you will want to wait until the bubbles have risen out of the resin before catalyzing it for use.

The minimum quantity of cobalt that can be used for promotion is 0.1% by weight. Since 1 gallon is approximately 3,600 grams, the minimum quantity of cobalt for a 1 gallon batch of resin is 3.6g. (You can assume that 1cc is equivalent to 1g.)

Note Be accurate when measuring the promoting agents. A small error will significantly alter the gel time.

The shelf life of promoted resin is 1 to 2 months, depending on storage conditions. Re-promotion with up to 100% of the original amount of cobalt and DMA, as listed in Table 4, is authorized if gelation is too slow.

Catalyzing Resin

Gel Time

"Gel time" or "pot life" is the time it takes the resin to set up in the container after proper and thorough mixing with cobalt promoter, DMA accelerator and MEKP catalyst. Gel times can be adjusted significantly by varying the amounts of these materials. Gel times also will vary significantly with changes in ambient temperature and humidity.

"Working time" is the time after catalysis and before the start of gelation, when the resin can be applied successfully to the fiberglass cloth. Due to many variables affecting gel time, the working life can vary considerably from the gel time. The working life of the resin is shortened by high ambient temperatures, by warm resin temperatures and by direct sunlight. Large batches of resin and thicker laminates will also have a shorter working life, because a larger volume, due to its smaller ratio of surface area to mass, tends to retain rather than to radiate excess heat from the chemical reaction. High humidity will lengthen the resin's working life, as will brisk wind, unless the wind carries styrene fumes away from the surface of the resin, in which case wind will shorten the working life. Table 5 shows approximate gel times for promoted resin at various catalyst ratios and different ambient temperatures:

% Catalyst	Resin Amount	Catalyst Amount	50° F	60° F	70° F	80° F
.75%	100g	.8cc	1-1.5 hr.	50-60 min.	20-40 min.	15-20 min.
1.00%	100g	1.1cc	45 min.	30 min.	20 min.	10-15 min.
2.00%	100g	2.1cc	30-40 min.	20 min.	15 min.	10 min. or less

Table 5: Gel Times

Note Catalyst weighs approximately 1 gram per cubic centimeter; this is a useful conversion when catalyzing resin. For example, 1cc of catalyst (the approximate equivalent of 1g) is required for a 100g batch of resin catalyzed at 100%.

MIXING RESIN

Batch Size

Before mixing resin, the necessary batch size has to be determined, which depends on the size of the lay-up.

We recommend using resin in small quantities of 50, 100 or 200 grams. This is especially helpful when first becoming familiar with gel times and laminating techniques. Unless otherwise specified, start with a 50 gram batch to get a feel for how much resin will be needed for each step. Once this is determined, mix only enough resin in small amounts to complete the step. In time you will acquire a feel for how much resin to mix for a laminate, depending on the temperature, the size of the laminate and the number of layers.

There are several reasons for using small quantities of resin. If a large area is laid up all at once, the whole laminate will begin to gel at once. By using small batch sizes to divide the laminate into sections, the laminate will also gel in sections; after one area is saturated, the next area can be worked even if the previous area starts to gel. Small batch sizes allow enough time to do a good job before the resin begins to gel. Large batches of resin tend to cure faster than small ones because of the heat concentration of the larger mass of resin. Also, because less resin is left to gel in the container, smaller batches minimize the amount of resin wasted.

Determining the Mixing Ratio

Use the gel times information, the ambient temperature and the size of the laminate to determine the ratio of catalyst for each batch of resin. If temperatures are high, use the minimum amount of catalyst. If temperatures are low and the lay-up is small, use the maximum amount of catalyst. When the conditions are indeterminate, always use the minimum amount of catalyst, allowing the slowest gel time and longest working life. As you gain experience with the particular conditions of your working environment and as your facility with laminating procedures increases, your judgment for determining the mixing ratio will improve. We have found that the most commonly used mixing ratio is a 1% catalyst ratio. This ratio works for most situations, but there are exceptions that will be up to you to determine.

Warning Do not under any circumstances use more than 2.0% catalyst in the mixture. Also, do not use less than the recommended minimum amount of catalyst (.75%) or the resin may never completely cure, resulting in reduced strength.

Measuring the Catalyst

Be accurate when measuring the catalyst. Small deviations will greatly alter gel time. Use a gram scale (available from Stoddard-Hamilton) to weigh the resin and a small plastic syringe, or graduated cylinder, to measure the catalyst. (Plastic syringes without needles are also available from Stoddard-Hamilton.) Syringes with a capacity of 3-5cc graduated in 0.1cc increments work fine for measuring the catalyst.

For small batches of resin, an alternative is to use a small plastic squeeze bottle (available from Stoddard-Hamilton) for dispensing the catalyst drop-by-drop. Included with the squeeze bottle is a calibration chart which displays the number of drops necessary to catalyze different size batches of resin at different percentages.

Warning Be **extremely** careful with the MEKP catalyst. Contact with the eyes must be prevented. Refer to the "SAFETY PRECAUTIONS" in "SECTION I: INTRODUCTION."

Mixing the Resin

Mix thoroughly and scrape the sides and bottom of the mixing vessel while mixing the catalyst into the resin. This mixing step should take approximately 30-60 seconds. Mix in such a way as to entrap the least possible amount of air. After mixing let the resin sit a couple of minutes to de-air. Use **unwaxed** paper mixing cups and wooden tongue depressors for mixing the resin. Any clean container will work for a mixing vessel. Do not reuse containers until the resin in them has cured because the leftover uncured resin in the containers will upset the gel time of the current batch.

Gelation Versus Cure

Upon mixing the promoted resin with MEKP catalyst, an exothermic reaction takes place—that is, a reaction in which thermal energy (heat) is released. The catalyzed resin will go through five sequential stages of hardness: gel, exotherm, cool, green cure, initial cure and cure. There are no rapid hardness changes except at the gel stage, when the resin begins to change from a liquid to a solid. Depending on the mixing ratio, temperature, batch size, etc., the gel time can vary anywhere from 10 minutes to 1-1/2 hours. To gain approximately 75% strength, the resin must cure for 16-24 hours. This is called "initial cure". To gain full strength, the resin must cure for 3-14 days at 74° F. "Green cure" is the stage at which the resin is hard or stiff enough to allow trimming excess cloth with a knife. Green cure is reached in anywhere from 15-45 minutes after gelation, depending upon temperature.

When resin begins to gel in a container, it will "curdle," developing a consistency similar to strawberry jam for approximately 2-3 minutes and then quickly solidifying. Just before the resin begins to gel, it will be unworkable on cloth, but there will still be enough time to save the brush with acetone solvent. When gelation begins, acetone loses its effectiveness to dissolve the resin, so be sure clean-up is accomplished before the resin gels.

While laminating, pay special attention to the elapsed time (i.e., the time from initial resin catalysis to the present). "Working time" is the time after catalysis and before the start of gelation. "Pot life" is the time specified in the "GEL TIMES" section under "*Catalyzing the Resin,*" above. Due to the many variables affecting gel time, working time will not always agree with quoted pot life times. A cooking timer is helpful to keep track of elapsed time.

Fiberglass Lamination

Fiberglass lamination is the process of impregnating the fibers of the fiberglass cloth reinforcement material with catalyzed plastic resin. While easily learned, fiberglass lamination is an art that requires some practice. The idea is to saturate the cloth with resin while removing any air bubbles present (which detract from the strength and corrosion-resistance of the laminate) without using so much resin that an unnecessarily heavy, resin-rich laminate results.

Hint The best guide for proper lamination is to compare the appearance of the cured laminate with the laminates in small factory-molded parts, such as the fairings or the wheel pants. Don't compare your laminates to the inside of the fuselage halves; they were manufactured with a special process that is difficult for you to duplicate in your workshop.

Standard Laminating Procedures

SURFACE PREPARATION

Secondary bonds are formed whenever a new fiberglass laminate is applied to a previously cured laminate (such as seam laminates applied to join pre-fabricated panels). To achieve satisfactory secondary bonds, proper surface preparation is required.

An independent engineering analysis has shown that prep sanding is the most important factor in ensuring adequate secondary bonding to laminates that have cured for longer than eight months. Joints made where no prep sanding was done sometimes failed at the new-to-old adhesive interface. Joints with prep sanding did not fail in the adhesive interface, but instead failed in the pre-cured piece or in the new lay-up. This indicates the joint overlap was stronger (in shear) than the pieces being joined (in tension).

Surface preparation by wiping with acetone also produced good results (joint stronger than pieces being joined). Dow Chemical literature warns that this practice should not be necessary, however, and can actually cause poor secondary bonding if the wiping rag itself contains any oil or contaminants.

Outside Surfaces of Molded Parts

Any surface that is smooth from being next to the mold must be sanded with 80 grit sandpaper when bonding is required. Primer or gel coat, when present, must be completely removed with sandpaper.

Note Be careful to restrict sanding to the surface only; do not sand through any of the fiberglass layers.

A green-colored coating called PVA may be present on the outside of the molded parts supplied in the kit. PVA is used to keep parts from sticking to the molds when new molds are being broken in. PVA may be barely visible, so check closely and remove any PVA with water and paper towels prior to sanding. Dry thoroughly.

Inside Surfaces of Molded Parts

When bonding to the inside surface of the composite shells (those surfaces not against the mold) or to other previously cured laminates, sanding preparation may or may not be required. For the vinyl ester resin system used in the GlaStar, exposure to air actually inhibits chemical curing of the exposed surfaces. Consequently, resin at the surface of a part that was exposed to the air while curing will remain slightly gummy for a period of time. Eventually (after approximately 8-12 months) the surfaces of such parts will cure completely, even when exposed to air. Soft, gummy surfaces do not require prep sanding, but hard, fully cured surfaces do.

To test whether the surface needs preparation, sand a small portion of the surface. If the sandpaper gums up quickly, preparation is not needed. If the sandpaper does not gum up, preparation is needed. Preparation entails sanding the entire area to be laminated with coarse sandpaper (60-80 grit) until it is dull or has no shine. Again, restrict your sanding to the surface only. Do not sand into fiberglass layers below the surface, thereby weakening the structure.

During manufacture of the GlaStar's main fuselage halves, a material called "peel-ply," which is a light dacron cloth, is laminated to the interior surfaces as the final layer. The panels are then vacuum-bagged and allowed to cure. This results in completely cured surfaces, since they are not exposed to the air. After the parts have cured, the peel-ply is removed, leaving a rough surface that is ready for secondary bonding. If your fuselage panels are less than a few months old, therefore, you can safely dispense with sanding before laminating to them; if your fuselage panels are more than a few months old, test them and prep sand, if necessary, as described above.

After the surface has been prepared properly, it must be kept clean and dry until laminating can begin. Dust, moisture, wax, fingerprints, traces of oil or other foreign material that comes in contact with the surface may prevent a good bond. If there is any chance the surface has been contaminated, wipe it with acetone (applied with a clean cloth) as a last step before laminating.

CUTTING THE CLOTH

Fiberglass cloth, like any other fabric, is woven from bundles of fibers. "Warp" is defined as the direction of the cloth weave with the greater percentage of fibers and the greatest strength. "Fill" is the direction of the cloth weave with the lesser percentage of fibers and less strength. The standard, bi-directional fiberglass cloth used in the GlaStar airframe has approximately the same percentage of warp and fill fibers, so it has roughly equal strength in both directions. To gain full structural advantage of fiberglass cloth, the orientation of its weave to load paths in the structure is important. Orientation to load paths is called "bias", which is measured in degrees from the longitudinal axis of the pattern.

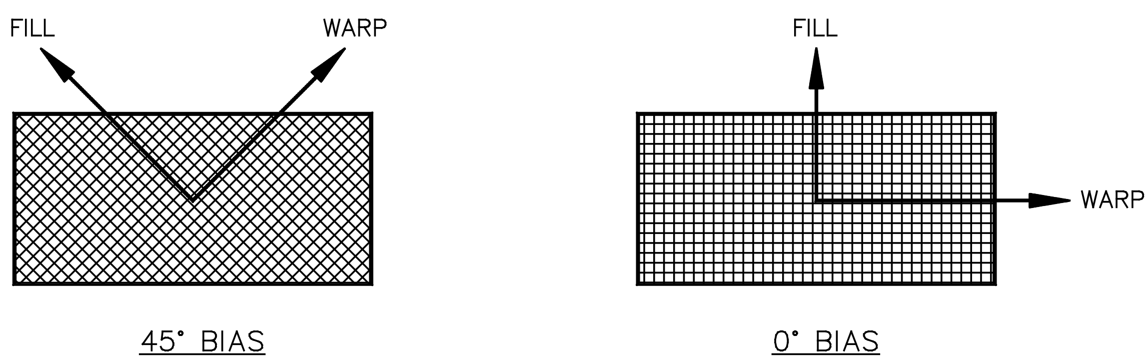

Figure 6: Cloth Bias

All bi-directional cloth used in the GlaStar airframe is cut on either the 45° or the 0° bias (see Figure 6). Cutting bi-directional cloth on the 45° bias has certain advantages related not only to strength. The edges of a piece of cloth cut on the 0° bias tend to unravel, making laminating more difficult, while cutting cloth on the 45° bias alleviates this problem. Also, cloth cut on the 45° bias conforms much more readily to the contours of compound curves. The instructions for particular steps in the Manual will tell you at what bias to cut the cloth.

To cut the bi-directional cloth supplied with the GlaStar kit, unroll a length and lay it on a clean, flat table, being careful not to distort the cloth by pulling it diagonally. Use a marking pen to lay out the pattern on the cloth while observing the specified bias. If a 45° bias is called for, lay out the pieces with their longitudinal axes at a 45° angle to the "selvage" edge—that is, the sewn edge—of the cloth. If a 0° bias is specified, lay out the pieces parallel to the selvage edge. Most of the long, narrow seams in the GlaStar fuselage are laminated with fiberglass seam tape, for which bias is not a consideration. Simply cut pieces of seam tape to the lengths specified.

Cut the cloth either with a pair of heavy-duty scissors or with a rotary cloth cutter ("pizza cutter"). The latter tool (available from Stoddard-Hamilton Aircraft) has a sharp, circular blade that is rolled across the cloth, which is supported on a wood or soft plastic surface to prevent damage to the blade. The rotary cutter works especially well for making curved cuts in fiberglass cloth; it also reduces fraying of the edges and helps reduce stretching of the cloth. If you are striving for a show-quality airplane, and if the laminate will be visible when the airplane is completed, cut the cloth in such a way as to remove any pen marks; the final laminate will be much more appealing to a judge.

Caution Be very careful to keep fiberglass cloth clean and dry during storage and handling. Any moisture or contaminants on the cloth—especially grease or oil—can inhibit adequate saturation of resin into the cloth, greatly reducing the strength of the laminate.

We recommend storing fiberglass products in a closed package in a clean environment. Also, to reduce exposure of fiberglass cloth to possible contaminants, set up a separate cloth-cutting table in a clean area of your shop and restrict its use to fiberglass work only.

SATURATING THE CLOTH

Proper Cloth Saturation

When fiberglass cloth is properly saturated with resin, the cloth looks wet and rich in color but is without puddles. The cloth pattern should still be visible on the surface and not glazed over. White or pale dry areas need more resin.

Note Once the laminate begins to cure, it is too late to add or remove resin to "touch it up."

Minimizing Air Bubbles

Air bubbles in a laminate detract from its strength and corrosion-resistant properties. Air bubbles may be minimized by the following practices:

1. First, apply a thin coat of resin to the surface to be laminated. Then lay the cloth down, rolling the cloth into the resin. Application of cloth to dry surfaces tends to cause air bubbles.
2. When laying up a cloth layer, start in the middle of the piece and work to the outer edges. Use firm but not excessive pressure when brushing or squeegeeing the resin into the cloth. Excessive pressures may fragment existing air bubbles and make them more difficult to remove.
3. Always eliminate all air bubbles from one ply before proceeding to the next ply.

Saturation Techniques

On large, flat surfaces, use the squeegee technique. To start, apply a thin layer of resin to the area to be laminated. This will help saturate the first layer of cloth with resin. Lay the cloth down as neatly as possible, making sure it is centered on the seam or part with no wrinkles or folds present. Then brush on more resin, getting the entire lay-up wet. With a rubber squeegee, spread the resin out using medium pressure, raking across the surface of the cloth to remove any bubbles, air pockets, or excess resin. Be sure not to add too much resin, causing the laminate to float. Also, be careful not to shift the laminate on the part when raking, but still apply enough pressure to remove any excess resin.

On surfaces where the use of a squeegee is impossible, use a varnish brush. The majority of the surfaces on the GlaStar will use the varnish brush technique for saturating the cloth. To saturate the cloth using a brush, use a dabbing or stippling motion with the brush. First, wet the area to be laminated and apply the fiberglass cloth. Then apply the resin with the brush, being careful not to use too much because excess resin is difficult to remove with a brush. Once the cloth is wet, start removing the air bubbles using a rapid stabbing (same as dabbing or stippling) technique with the tip of the brush. The air will bleed through the cloth eliminating the bubbles in this manner.

Hint A standard varnish brush is more effective for laminating if you cut the bristles off to about a 1" to 1-1/4" length.

For large laminates consisting of long narrow strips (especially in inaccessible areas, such as the main fuselage seams), we recommend saturating the cloth on a smooth, clean table top, rolling or folding it as you go. Then, carry the saturated cloth to the seam and, starting at one end, unfold it into position. Use your fingers (protected by rubber gloves) to stick the cloth to the fuselage panels and to work out any air bubbles under the cloth.

When working on difficult or inaccessible laminates, let each layer become tacky to the touch before applying the next layer. For these difficult laminates, applying a new layer before the underlying layer becomes tacky can cause the underlying layer to shift position, introducing large air bubbles or wrinkles.

For most laminates, layers can be placed while the underlying layers are still wet. With this technique, there is no need to wet the area again because the surface will still be wet from the previous layer of cloth. This results in a lighter, less resin-rich laminate. If the previous layer has dried and cured, wet the area again to aid in cloth saturation.

Practice Laminate

If you are not experienced (or not current) with fiberglass laminating, we recommend practicing before starting work on the actual airframe parts. Even if you are experienced with fiberglass construction, it is helpful to practice with the actual materials used in the GlaStar to become familiar with their mixing procedures, gel times, saturation techniques that may differ from other resin systems, etc. Refer to previous topics in this section for detailed descriptions of the procedures discussed below.

Wax a 3'-square area of a Formica table top or an aluminum sheet on a flat workbench. Use a special mold release wax (available from Stoddard-Hamilton; order P/N 270-0205-001) or a good quality automotive paste wax. Apply at least two layers of wax, buffing between layers.

Note Avoid any silicon-based wax. Traces of silicon are extremely difficult to remove from the finished laminate and will inhibit the adhesion of secondary laminates, paint, etc.

Cut two 2'-square pieces of bi-directional cloth on the 45° bias and lay one of these pieces in the center of the waxed area, being careful not to stretch the cloth. Mix a 200 gram batch of resin and pour it onto the cloth. Use a brush or squeegee to spread the resin and then use a squeegee to work the resin into the cloth and to remove excess resin and any air bubbles. Be careful not to stretch the cloth when squeegeeing. Remove as much of the excess resin as possible without drying the laminate out excessively; there should be no white, dry areas in the laminate. Mix extra resin if necessary. When the first layer is saturated satisfactorily, lay the second piece of cloth over the first. Apply more resin and saturate as before.

Before the laminate has cured, compare its surface to the interior surface of the manufactured airframe components; the entire laminate should be evenly and thoroughly saturated with no excess resin pooled on the surface and no white areas of unsaturated cloth. Let cure.

When cured, peel the laminate off the work surface (it should release easily) and save it for use during kit construction. Small pieces will be cut from the laminate for use as supports to which other laminates will be applied to form such components as attach brackets or panel flanges. For use in these applications, the smooth side of the laminate, which was down against the waxed surface, must be thoroughly roughened with sandpaper to prepare a good surface for bonding.

Q-Cell and Mill Fiber Mixtures

"Q-cells" are very tiny, hollow glass spheres that resemble a fine, white powder. Q-cell mixtures are made up of Q-cells mixed into catalyzed resin. Q-cell mixtures are used primarily for sealing the porous surfaces of foam panels, filling holes and radiusing corners.

When mixing to use as a sealant for foam panels, add Q-cells to a batch of catalyzed resin until a **thin**, milkshake-like consistency is achieved. This is called a "wet mix". To seal foam bulkheads and the like, apply a thin layer of wet Q-cell mixture to the foam. Apply only enough to seal the foam. Use a squeegee to rake the mixture over the foam when applying.

To make a Q-cell mixture to use as filler, add Q-cells to a batch of catalyzed resin until a **thick** milkshake-like consistency is achieved. This is called a "thick mix". The consistency should be such that the mixture will hang on a tongue depressor held vertically; a real milkshake of this consistency would have to be eaten with a spoon.

"Mill fibers" are very short fiberglass strands. A mill fiber mixture consists of an appropriate quantity of fiberglass mill fibers mixed into catalyzed resin. These mixtures are used when strong adhesion bonding is required. To mix, add mill fibers to catalyzed resin until you achieve a consistency just slightly more liquid than paste. The mixture should be thick enough to stay on a wooden tongue depressor without running off, while still being fully saturated with resin.

Clean-Up and Disposal of Wastes

The best solvent to use with resin is acetone, which is available at most hardware stores. As noted in the "*Gelation Versus Cure*" section, acetone loses its effectiveness as a solvent when the resin and gel coat begin to gel, so be careful to start clean-up before the resin starts to gel. Use acetone for cleaning resin from brushes, squeegees, etc.

Note If the resin begins to gel while still on the brush, the brush will be ruined unless immediately immersed in acetone.

Warning Acetone is highly flammable. It is harmful to the eyes and skin. Avoid inhalation. It is also poisonous if swallowed. Carefully read all safety precautions on the outside of the container.

Take care when disposing of catalyzed resin. An exothermic reaction is set in motion when catalyst is mixed into resin. Enough heat can be generated in this reaction to cause a fire, depending upon the depth of the resin in the mixing vessel and the amount of catalyst used.

Warning Do not throw away catalyzed resin until after it has gelled, exothermed and cooled. This will help prevent fires from starting in trash cans or waste bins.

We suggest letting the resin cure in its mixing cup on a concrete floor or some other place where it is not in contact with flammable materials and cannot be knocked over. After the mixture gels, exotherms and cools, discard the container.

Trimming and Drilling Fiberglass

Often a fresh laminate must be trimmed to meet the edge of the underlying structure. This is easiest to accomplish when the laminate is in the green cure condition, which is reached about 15-45 minutes after the resin begins to gel, depending on the temperature. In the green cure condition the resin has begun to cure but is still somewhat rubbery, and the laminate can easily be trimmed with a sharp utility knife. If you wait until the resin has reached initial cure (from 16-24 hours after gelation, or even just overnight), you will have to use a hacksaw blade, a cut-off wheel in a die grinder or sheet metal snips to trim the laminate. Trimming the laminate by any of these methods leaves a ragged edge that will then have to be smoothed with sandpaper. If you use a band saw or a saber saw to trim cured fiberglass laminates, the abrasive-type blades work the best and last the longest.

Drilling and countersinking holes in fiberglass structure is done using the same procedures used for other materials, except that the glass fibers tend to fray and intrude into the hole as it is drilled, reducing the hole diameter. This can be minimized by using a very sharp drill bit, but you may need to drill with a slightly oversize bit to allow easy insertion of the fastener.

AIRCRAFT FASTENERS

The following discussion is a brief description of the most common fasteners used in assembling the GlaStar. This information is intended to assist the builder in identifying the different hardware supplied with the kit and to provide some general guidelines for its proper use. If you are a first-time builder or an amateur mechanic, we strongly recommend procuring an aviation mechanic's general handbook for a more detailed discussion of this subject.

Bolts

With very few exceptions, the bolts used in the GlaStar are standard, general-purpose, aircraft-grade bolts designated AN3 through AN8. The "AN" number refers to the diameter of the bolt in sixteenths of an inch. The "AN" number is followed by a "dash number" that specifies the bolt's length. For bolts less than 1" long, the dash number is a single digit that indicates the length in eighths of an inch. Dash numbers for bolts 1" long and longer consist of 2 digits, in which the first digit specifies the whole inch portion of the length and the second digit specifies the fractional portion in eighths of an inch. An "H" between the "AN" number and the dash number indicates that the head of the bolt is drilled for safety wire; an "A" after the dash number indicates that the shank is undrilled; and no letter after the dash number indicates that the shank is drilled for use with a castle nut and a cotter pin. For example: an AN3H10A is a 3/16" diameter, 1" long bolt with a drilled head and an undrilled shank; an AN4-16 is a 1/4" diameter, 1-3/4" long bolt with a drilled shank.

A good tool to keep handy is a bolt gauge (available from aircraft hardware suppliers), which is designed to measure the most common sizes of AN bolts.

Nuts

Most of the nuts used in the GlaStar are of the self-locking variety, which uses a nylon insert as a means of safetying the nuts. These can be used in any low-temperature application where there is no rotation in the components being fastened, which might tend to loosen the nut. In general, self-locking nuts used in high-temperature applications (such as in the engine compartment) are an all metal type (AN363). A letter "A" after the dash number indicates a non-metallic insert.

The nylon self-locking nuts used in the GlaStar are of two types: shear nuts and tension nuts. The shear nuts are designated AN364, are thinner, and may be used only when the only loads on the bolt are shear loads (that is, loads that are perpendicular to the length of the bolt). Tension nuts are designated AN365, are thicker, and may be used when tension loads (parallel to or in line with the length of the bolt) are applied to the bolt.

Other nuts used in the GlaStar (primarily on the control system components) are of the non-self-locking variety. These are either AN310 or AN320 castle nuts for use with drilled-shank bolts and cotter pins or AN316 nuts, which are plain nuts used as jam nuts to lock components such as threaded rod end bearings. Of the castle nuts, the AN310 are tension nuts and the AN320 are shear nuts. AN355 nuts are another type of castle nut used primarily on the engine installation.

Nuts are designated with a dash number which specifies the shank diameter (for bolts 1/4" diameter and larger) or the shank diameter and thread pitch (for bolts or screws smaller than 1/4") of the fastener on which the nut will fit. For example, an AN320-4 is a shear-type castle nut that fits a 1/4" bolt, and an AN365-1032A is a tension-type, self-locking nut that fits a #10 (3/16") bolt with 32 threads per inch.

Washers

Most of the washers supplied with the GlaStar kit are plain washers for use under hex nuts to provide a smooth bearing surface and to act as shims for obtaining the correct grip length of a nut and bolt assembly. AN960 washers are standard-diameter washers; AN970 washers have a larger diameter to provide a greater bearing area in some installations to prevent crushing the structure that the bolt passes through.

Washers are designated with a dash number that corresponds to the diameter of the bolt shank they fit. In addition, a letter "D" before the dash number indicates the washer is made of aluminum alloy rather than steel. Steel washers have no letter designation before the dash number. Use aluminum alloy washers under bolt heads and nuts on aluminum or fiberglass components. For AN960 washers, a letter "L" after the dash number indicates a thin washer. For example, an AN960-416 is a plain steel washer that fits a 1/4" (4/16") bolt, an AN970-3 is a large diameter steel washer for an AN3 (3/16" or #10) bolt, and an AN960D10L is a plain, thin aluminum washer to fit a #10 (3/16") bolt.

Installation Practices

AN bolts have a round "washer" surface machined on the underside of the head, which eliminates the need for a washer under the head when the bolt head contacts a steel surface. A washer under the nut on all types of surfaces guards against mechanical damage to the structure when the nut is tightened. On aluminum alloy structure, use aluminum alloy washers under both the head of the bolt and the nut unless their omission is specified. By observing this practice, any corrosion due to the contact of the dissimilar metals will attack the washer rather than the structure. Use steel washers when joining steel structure with steel bolts.

Be certain that the bolt grip length is correct. Grip length is the length of the unthreaded portion of the bolt shank. Generally speaking, the grip length should equal the thickness of the material being bolted together. Bolts of slightly greater grip length may be used, however, if extra washers are placed under the nut and/or the bolt head. Washers may also be used to adjust the position of castellated nuts with respect to drilled cotter pin holes in bolts. When using self-locking nuts, a **minimum** of 1-1/2 bolt threads must show beyond the nut when the installation is complete.

Torque Values

Use Table 6 as a guide in tightening nuts, studs, bolts and screws whenever specific torque values are not called out. The following rules apply when using the table:

1. To obtain values in foot-pounds, divide inch-pounds by 12.

2. Do not lubricate nuts or bolts except where specifically instructed to do so.

3. Always tighten by rotating the nut, if possible. When space considerations make it necessary to tighten by rotating the bolt head, approach the high side of the indicated torque range. Do not exceed the maximum allowable torque value.

4. Use maximum torque values only when materials and surfaces being joined are of sufficient thickness, area and strength to resist breaking, warpage or other damage.

BOLT, STUD OR SCREW SIZE		TORQUE VALUES IN INCH-POUNDS	
Coarse Thread	Fine Thread	Shear Nuts (AN 320, AN364)	Tension Nuts (AN310, AN365)
8-32	8-36	7-9	12-15
10-24	10-32	12-15	20-25
1/4-20		25-30	40-50
	1/4-28	30-40	50-70
5/16-18		48-55	80-90
	5/16-24	60-85	100-140
3/8-16		95-110	160-185
	3/8-24	95-110	160-190
7/16-14		140-155	235-255
	7/16-20	270-300	450-500
1/2-13		240-290	400-480
	1/2-20	290-410	480-690

Table 6: Torque Values

On all 3/16" and 1/4" bolts, over-torquing is the most common mistake. It is very easy to stretch or strip the threads on 3/16" bolts. A torque wrench is not a requirement for assembling the GlaStar but is recommended if you are not familiar with the approximate feel of the proper torque for the smaller hardware.

Hint To avoid over-torquing small fasteners, use short-handled tools and “choke up” on the handle. This minimizes the amount of torque you can apply.

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CONTROL CABLES

Cables are used throughout the GlaStar's flight control system. You'll need to master the following fairly simple splicing, tensioning and safetying procedures.

NicoPress Sleeve Installation

The prettiest connections between control cables and terminal hardware are swaged splices, but unless you have special access to a very expensive swaging press, you'll probably want to make do with the NicoPress splices supplied with the GlaStar kit. This is no sacrifice in any but aesthetic terms—NicoPress splices are every bit as strong as swaged joints, which is to say as strong as the cable itself.

Figure 7 illustrates the process of making a NicoPress splice. The first step is to run the cable through the sleeve, loop it around the thimble, and feed the end back through the sleeve. Be sure to leave sufficient length extending beyond the sleeve—an inch or more is fine. If you're careful, it's easier to cut off excess when the splice is finished than it is to start over if you come up short. Also, before crimping the sleeve, remind yourself what kind of hardware will ultimately be connected to the terminal you're working on; if it's an eye or a particularly tight shackle, for example, it has to go through the thimble **before** you make the splice! You can save yourself a little cable and a lot of frustration by thinking ahead at this point.

With the thimble in place, slide a cable clamp over the loose end of the cable and push it tightly up against the sleeve. When you have pulled the loose end as tightly as you can around the thimble, tighten the cable clamp to hold the cable in place. Use the NicoPress pliers to make the first of three crimps in the center of the sleeve. Before you squeeze, make sure you've seated the sleeve firmly in the proper notch for the sleeve size you're using—the tool will have several notches, only one of which is right. Squeeze the handles until they are completely closed; incomplete crimping will result in a weak, unacceptable splice. After the first crimp, the second should be made beside the first on the side closest to the thimble or bushing. Finally, the third crimp should be made on the other side of the first. Remove the cable clamp before making the final crimp, because the sleeve lengthens somewhat when crimped.

Hint Clamp one handle of the NicoPress tool in a bench vise to make this an easier one-person operation.

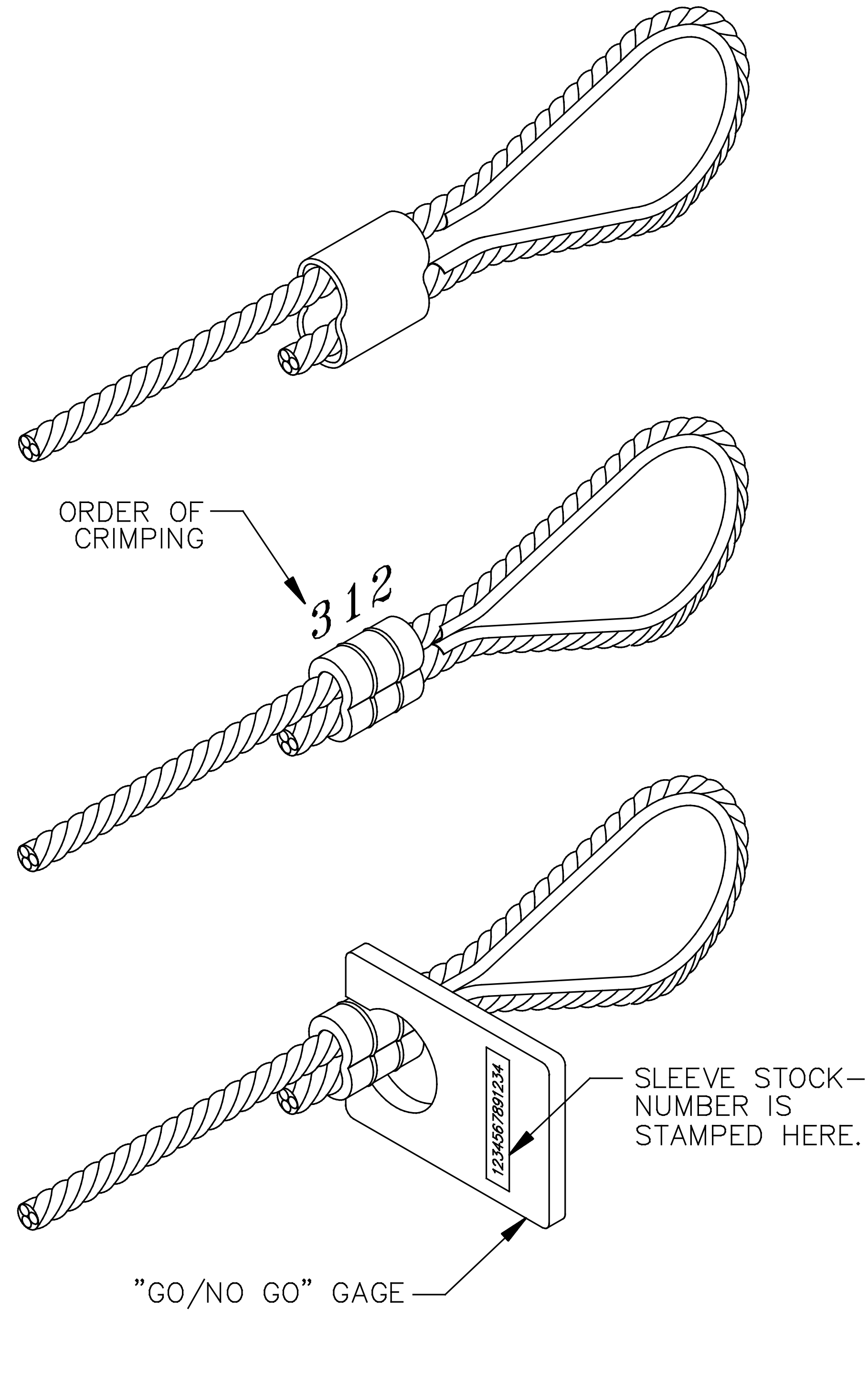

Figure 7: NicoPress Splicing

Hint Some builders like to clip the sharp points off thimbles before making a NicoPress splice. This allows the sleeve to be positioned more tightly against the thimble.

When all three crimps have been made, use the "go, no-go" gauge that comes with the NicoPress pliers to check the width of the crimps. The widest part of the crimped section should slide easily into the appropriate slot in the gauge. If it doesn't, that means the sleeve was insufficiently compressed, and the splice will not be full strength as a result. Try crimping it again to make it fit the gauge, but be careful—the finished crimps should be round and smooth, and if the second crimping leaves the sleeve buckled or cracked, you'll have to abandon the splice and start again.

At least 1/8" of cable should protrude beyond the end of the sleeve when the splice is completed. After you are satisfied with the splice, cut off any excess beyond that length using a cable cutter or a bolt cutter.

Caution When cutting excess off the end of a cable, be **extremely** careful not to nick the working cable with your cutters or chisel. Severing a single strand of the working cable is sufficient reason to discard it and start again.

For a cleaner-looking and safer splice, slip a short length of clear heat-shrink tubing over the cable before you slip the sleeve on. When the splice is completed, slide this tubing over the loose end of the cable until it's tight up against the NicoPress sleeve and shrink it down. This tubing will keep those razor-sharp strand ends away from you when you're connecting or adjusting the cables and at the same time—because of its transparency—will allow easier inspection of the terminal splices during pre-flight and annual inspections.

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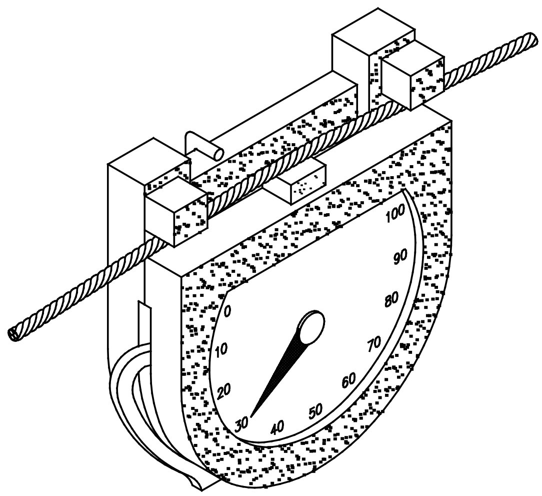
Tensioning

It's essential that proper tension be maintained in all control cables. Tension is adjusted by means of turnbuckles. To measure cable tension, you'll have to lay your hands on a tensiometer (shown in Figure 8), but unless you plan to build lots of airplanes, there's little reason to buy one. Any local A&P mechanic will have one you can probably borrow in exchange for the promise of a ride in your completed GlaStar!

The tensiometer works by measuring the force required to deflect the cable to a pre-determined extent. It does this by pushing a riser against the cable after it has been secured under two anvils. Different risers are used for different cable diameters, so be certain that you're using the right one. Pull the trigger to raise the riser, and then read the indicator. The dial reading is meaningless by itself but must be converted to pounds of tension by using the calibration table supplied with the tensiometer. A sample conversion problem is shown in the calibration table in Figure 8: the tensiometer, with a number 2 riser to measure the tension in a 5/32" diameter cable, indicates "30" on the dial, which converts to 70 lbs. of tension.

To determine the required tension for a control cable of a particular diameter corrected for ambient temperature, use the cable rigging chart shown in Figure 8. For example, assume that a 1/8" diameter, 7 X 19 cable is to be adjusted at an ambient temperature of 85° F. Follow the 85° F. line upward until it intersects the curved line for 1/8", 7 X 19 cable. From the point of intersection, extend a horizontal line to the right edge of the chart. The value at this point is the **maximum** tension (rigging load in pounds) to establish on the cable, which for this example is 70 lbs. To provide free control movement, the tension will generally be set at less than the maximum.

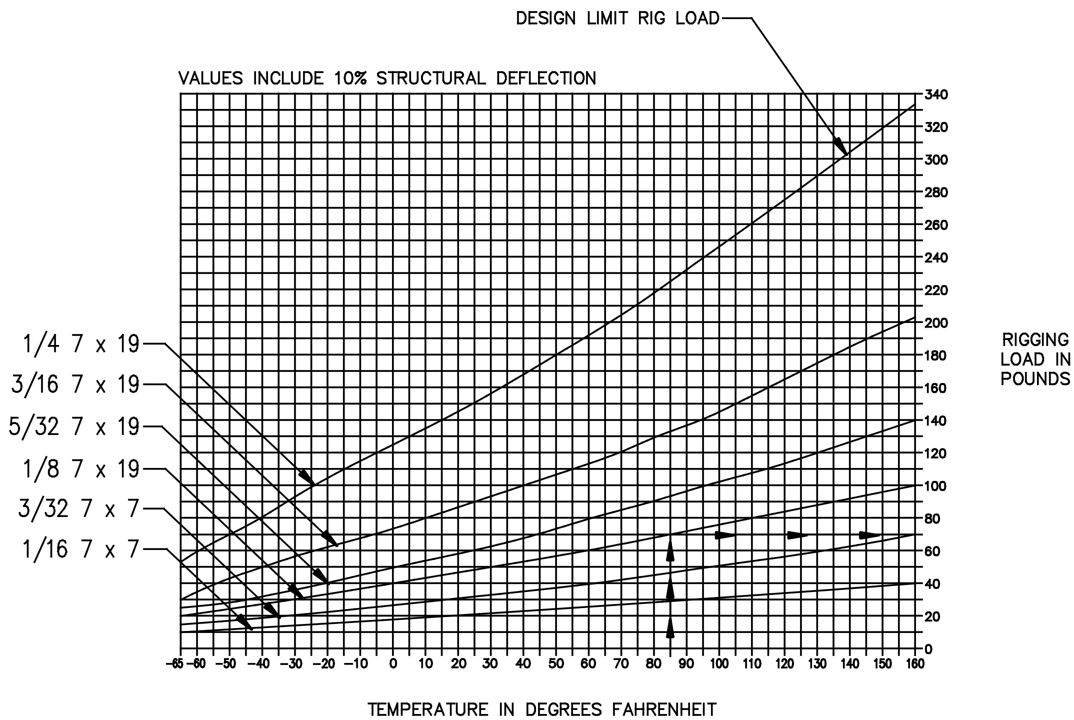
Cable tension is adjusted with turnbuckles installed along each cable run. The only trick in adjusting them is ensuring that the end shanks remain stationary when the center barrel is turned. A good way to do this is to bend a length of stiff music wire into a "U" shape, with the arms of the "U" about as far apart as the shanks of the turnbuckle. Insert one end of the "U" into the hole in each shank, and hold the "U" steady while tightening or loosening the barrel with a straight piece of music wire through its hole.



EXAMPLE

No. 1			RISER	No. 2		No. 3	
1/16	3/32	1/8	TENSION	5/32	3/16	7/32	1/4
12	16	21	30	12	20		
19	23	29	40	17	26		
25	30	36	50	22	32		
31	36	43	60	26	37		
36	42	50	70	30	42		
41	48	57	80	34	47		
46	54	63	90	38	52		
51	60	69	100	42	56		
			110	46	60		
			120	50	64		

CALIBRATION TABLE
SAMPLE ONLY



CABLE RIGGING CHART

Figure 8: Cable Tensiometer, Calibration Chart and Cable Rigging Chart

Safetying Turnbuckles

Once the proper cable tension has been achieved, the turnbuckles must be safetied to prevent loosening. Traditionally, this has been done with elaborate wrapping techniques using aircraft safety wire. However, the turnbuckles supplied with your GlaStar kit are a more modern variety designed to accommodate special locking clips. If you feel drawn to tradition, there's no reason you can't wire your turnbuckles; refer to any standard aircraft maintenance manual for directions. But for simplicity's sake, we recommend the clips.

The turnbuckle barrel and terminals are slotted lengthwise to accommodate the locking clips. After the proper cable tension has been achieved, the barrel slots are aligned with the terminal slots and the locking clips are inserted. The curved ends of the locking clips expand and latch in the vertical slot in the center of the barrel. Refer to Figure 9. Once locked in place, the clips are removed by prying them out of the center hole with a large, flat-blade screwdriver. This procedure destroys the locking clip, making it a throw-away item that can only be used once. Make sure the turnbuckle has had its final adjustment, therefore, before snapping the clip into place. Also, be sure to keep plenty of extra clips on hand.

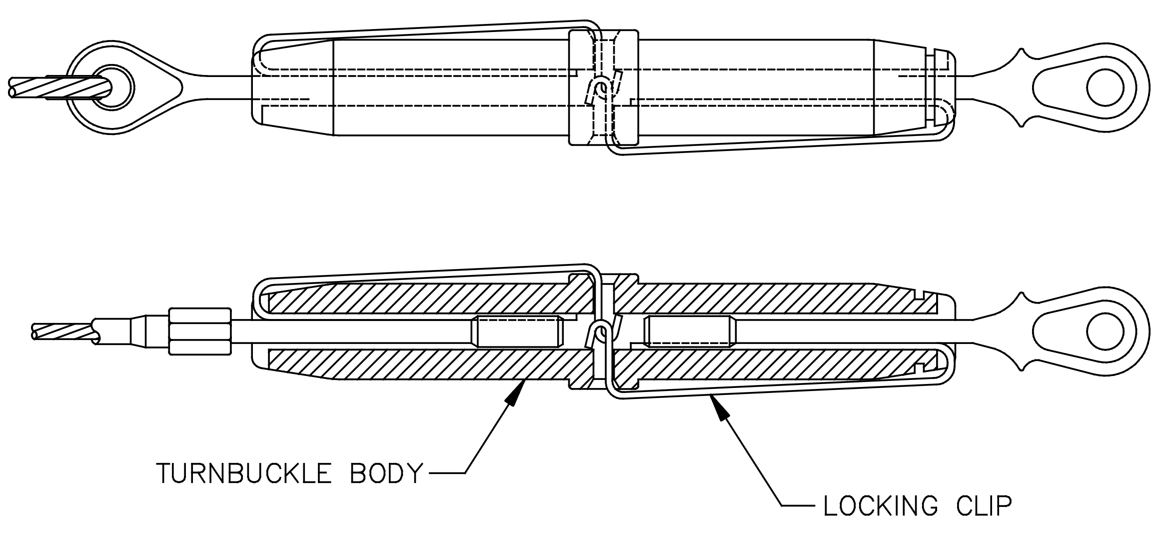


Figure 9: Safetying Turnbuckles

TUBE FORMING PROCESSES

Tube Cutting

When cutting tubing, it is important to produce a square end free of burrs. Use a tubing cutter with any soft metal tubing, such as copper, aluminum or aluminum alloy.

To use a tubing cutter, place the tubing in the cutting tool, with the cutting wheel at the point where the cut is to be made. Rotate the cutter around the tubing (with the open side of the cutter leading), applying a light pressure to the cutting wheel by intermittently twisting the thumbscrew. Too much pressure on the cutting wheel at one time could deform the tubing or cause excessive burring. After cutting, carefully remove any burrs from inside and outside the tube. Use a knife or the burring edge (reamer) attached to the tube cutter.

When performing the deburring operation, use care not to reduce the wall thickness of the tubing or to fracture the end. A fine tooth file can be used to file the end square smooth.

Tube Bending

The objective in tube bending is to obtain a smooth bend without flattening the tube. Tubing under 1/4" in diameter usually can be bent without the use of a bending tool, although a tool results in neater bends. For larger sizes, a hand tube-bender is usually used. A hand tube-bending tool is available from the Glasair Options Catalog.

Bend the tubing carefully to avoid excessive flattening, kinking or wrinkling. A small amount of flattening in bends is acceptable, but the smallest diameter of the flattened portion must not be less than 75 percent of the original outside diameter. Do not install tubing with wrinkled, irregular or excessively flattened bends. Wrinkled bends usually result from trying to bend thin-wall tubing without using a tube bender.

Swagelok Fittings

All of the metal tubing assemblies on the GlaStar aft of the firewall terminate in Swagelok fittings. These fittings provide the same functionality as the flared tubing connections used with standard AN fittings, but they are much easier to install since they eliminate the need to flare the tubing. Each Swagelok fitting consists of four components, as shown in Figure 10: the nut, the back ferrule, the front ferrule and the body. Swagelok fittings are supplied completely assembled and ready for use. Disassembly before use is unnecessary and can result in dirt or foreign material getting into the fitting and causing leaks.

Swagelok tube fittings are installed in three easy steps:

1. Simply insert the tubing into the Swagelok tube fitting. Make sure that the tubing rests firmly on the shoulder of the fitting. Tighten the nut finger tight.
2. Before wrench-tightening, mark the nut at the 6 o'clock position.
3. While holding the fitting body steady with a back-up wrench, tighten the nut 1-1/4 turns. Watch the mark on the nut, make one complete revolution and then continue to the 9 o'clock position. By marking the nut at the 6 o'clock position as it appears to you, there will be no doubt as to the starting position. When tightened 1-1/4 turns to the 9 o'clock position, you can easily see that the fitting has been properly installed. You can verify proper installation by trying to fit the Swagelok Gap Inspection Gage into the gap between the nut and the fitting body. If the gage **will not fit**, the fitting nut is tightened sufficiently. (The Swagelok Gap Inspection Gage is 0.143" thick for the 1/4" and 3/8" fittings used on the GlaStar.)

Note For 3/16" and smaller tube fittings, only 3/4 turn from finger-tight is necessary to install the fitting.

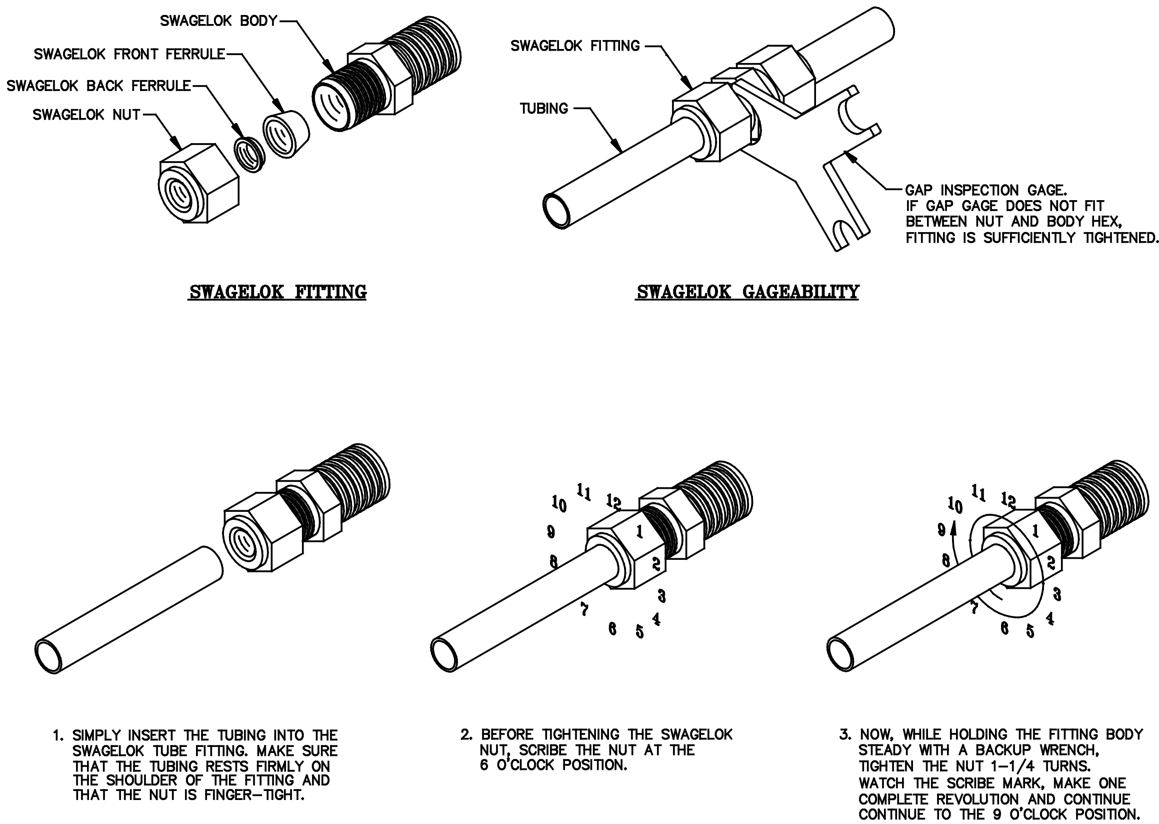


Figure 10: Swagelok Fitting Installation

Connections can be disconnected and re-tightened many times. The same reliable, leak-proof seal can be obtained every time the connection is remade. To do this, insert the tubing with pre-swaged ferrules into the fitting until the front ferrule seats in the fitting. Start the nut and tighten it by hand. Use a wrench to rotate the nut to its original position (an increase in resistance will be encountered at the original position). Then tighten slightly with the wrench. (Smaller tube sizes will take less tightening to reach the original position, while larger tube sizes will require more tightening. The wall thickness of the tubing will also have an effect on tightening.)

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ELECTRICAL WIRING AND CONNECTIONS

To a large extent, a trouble-free electrical system depends on the quality of the connections between the electrical cables and the various components of the system. Cables are connected to the components with crimp-on connectors, such as butt splices or ring-end terminals, or by solder joints.

Use crimp-on connectors rather than solder joints wherever possible. Solder joints are generally not used in aircraft unless the wire is well supported near the connection, such as in radio stacks, with connectors and cable supports attached to the radio stack framework, or in quick-disconnect plugs that utilize a strain-relief for the wire bundle. The reason is that solder makes a rigid connection that defeats the purpose of using multi-strand, flexible, aircraft quality wire. A rigid solder joint can weaken and break when subjected to continuous vibration. Where solder joints are necessary, be sure to support the wire near the joint to prevent the joint from flexing.

Crimp-On Connections

Crimp-on connections are easy to make: strip 1/4" of the insulation from the end of the wire, insert the wire into the connector so the insulation butts against the shoulder of the metal connector socket, and crimp the connector with the proper jaws of the crimping tool.

Note Use a firm tug on the connector to test its security.

Solder Connections

Solder joints, while also fairly simple, are somewhat more prone to error. Accordingly, here are a few suggestions for achieving good solder joints:

1. Use **only** 60/40 rosin-core solder. **Do not** use acid-core solder.

2. After removing 1/4" of the insulation from stranded wire, it helps to "tin" the separate strands together by twisting them tightly and applying a small amount of solder.

3. Before soldering, form a hook in the bare wire end and crimp it tightly around the terminal lug with a pair of needle-nose pliers. This mechanical connection adds to the strength of the solder joint and helps prevent movement of the joint while it cools.

4. When soldering, position the soldering pencil tip, as shown in Figure 11a, so that it contacts and heats both the wire and the terminal lug simultaneously. Apply the solder to the opposite side of the connection as shown in Figure 11b, allowing the heated connection rather than the soldering pencil to melt the solder. Hold the joint still while the solder cools. The finished solder joint should appear smooth and shiny, and the solder should appear to flow onto and blend into both the wire and the lug, as shown in Figure 11c.

5. If the finished joint is not smooth and shiny but rather is dull and grainy or chunky in appearance, it indicates that the joint was disturbed during cooling. Reheat the connection and, if necessary, add more solder.

6. Improper positioning of the soldering pencil tip so that it doesn't heat both the wire and the lug can also result in a faulty connection called a "cold solder" joint. The solder on such a joint will not appear to flow onto both the wire and the lug, but will tend to collect in rounded drops or blobs. Again, reheat the connection until the solder flows properly.

Use heatshrink tubing on all solder joints to protect against moisture and accidental short circuits. Clear tubing is preferable, since it aids inspection of joints.

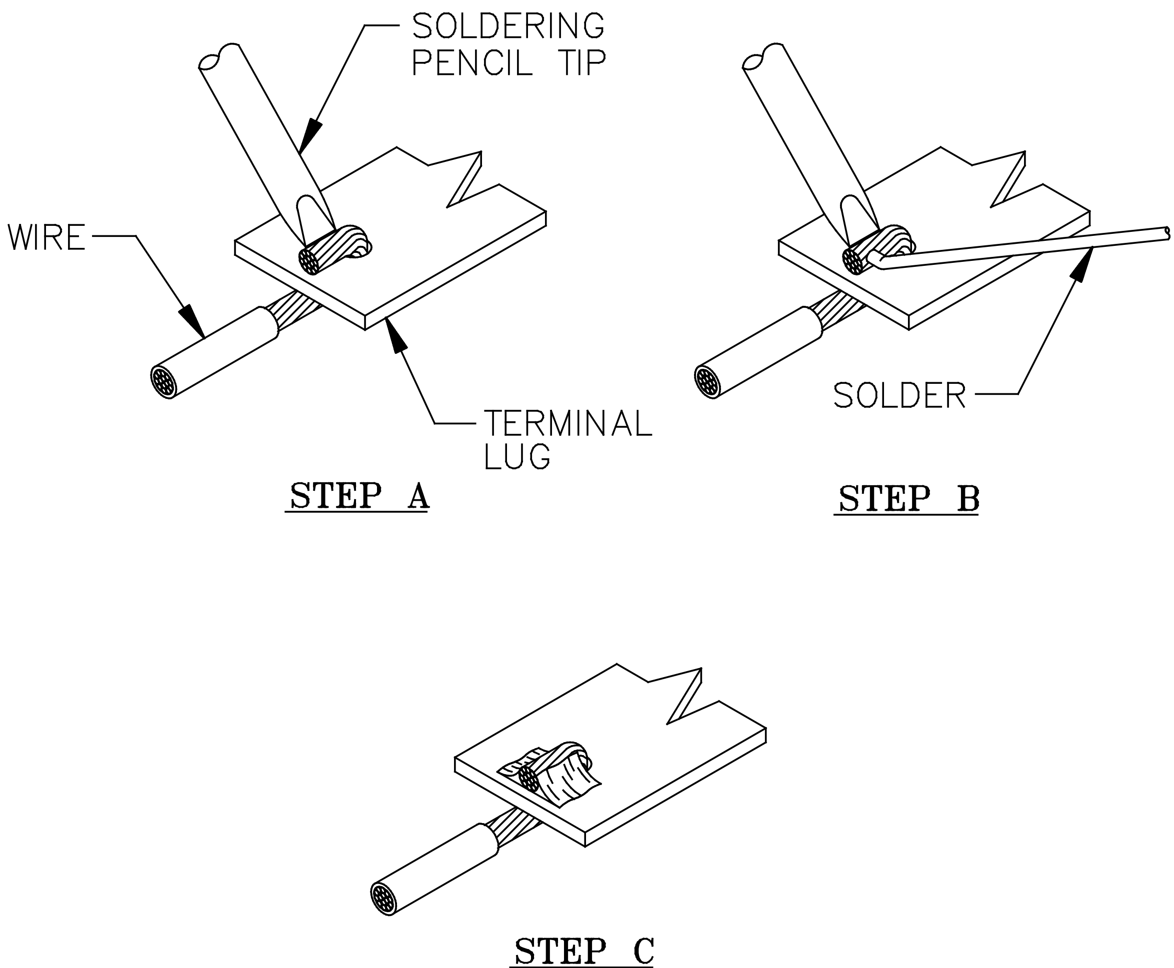

Figure 11: Soldering Procedures

Wire Routing

In routing the wiring for the electrical system, make extensive use of cable clamps, spiral wrap and wire ties to keep the wires clear of moving parts of the various systems, to prevent vibration from chafing the wires and to bundle the wire runs together for a tidy installation.

Warning Always route electrical wires above any fluid lines to help prevent short circuits or fires caused by fluid from a possible leak running down the wires.

Refer to the book, *Acceptable Methods, Techniques, and Practices—Aircraft Inspection and Repair/Aircraft Alterations*, FAA publication number EA-AC43.13-1A & 2A, for descriptions of standard wiring procedures.

Note Wire ties, cable clamps, adhesive mounting pads for securing wire bundles to the airframe, heat shrink tubing, an assortment of crimp-on connectors, quick-disconnect terminals, terminal strips, spiral wrap (both regular and high-temperature) and other electrical components are all available from Stoddard-Hamilton. Consult our *Options Catalog* for details.

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FLEXIBLE HOSE ASSEMBLIES

Flexible aircraft hoses are used in the fuel and oil systems of the GlaStar. Hoses forward of the firewall use braided Aeroquip hose and AN fittings. The hoses are easily fabricated by cutting raw hose stock to the correct length and installing the appropriate hose end fittings. We strongly recommend protecting fuel and oil lines in the engine compartment with fiberglass fire sleeves. When fabricating and installing flexible aircraft hose assemblies, observe the general rules depicted in Figure 12 and in the following list:

1. Install hose assemblies without twisting.
2. Never stretch a hose tightly between two fittings as this will result in over-stressing and eventual failure. When fabricating a hose assembly, provide about 5-8% slack.
3. Avoid tight bends in flex lines as they may result in failure. Never exceed the minimum bend radius specified for the hose.
4. Support all hose installations at least every 24". More frequent supports are preferable.
5. Carefully route and securely clamp hose assemblies to avoid abrasion, kinking or excessive flexing. Excessive flexing may cause weakening of the hose or loosening at the fittings. If some rubbing cannot be eliminated, protect the hose by wrapping with nylon spiral wrap (available from Stoddard-Hamilton).

Note For more information, such as minimum bend radii for different hoses, refer to EA-AC 43.13, Chapter 10.

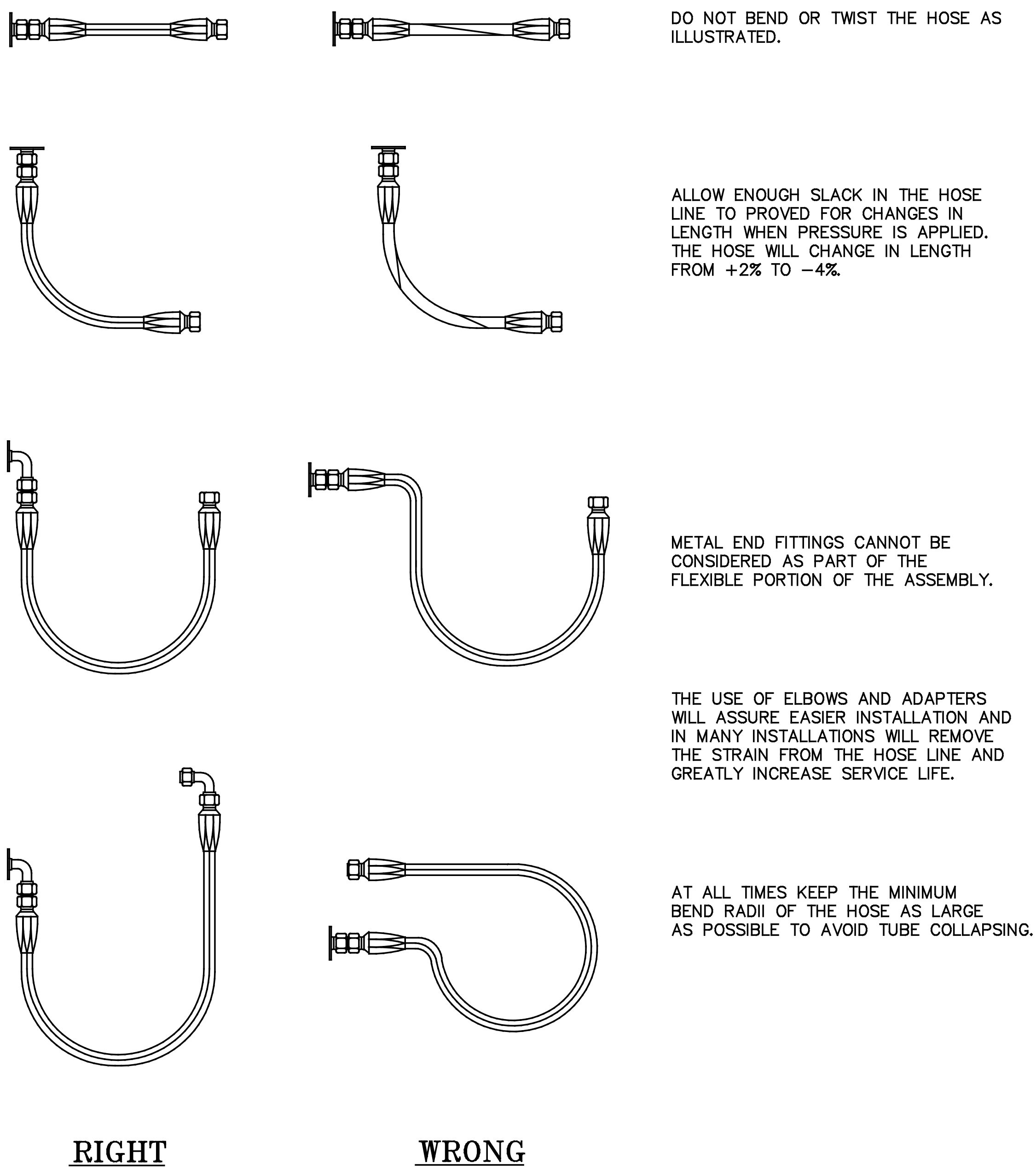


Figure 12: Proper Hose Installations

To size hose, temporarily fasten the hose ends onto the fittings between which the hose will fit. With a tape measure or piece of wire, measure the length needed. When measuring, make sure to allow sufficient length to conform to the slack and minimum bend radius requirements described previously.

Aeroquip Hose Assemblies

To cut Aeroquip hose and install the end fittings, refer to Figure 13 and follow these steps:

1. Cut the hose squarely to length. Use an abrasive cut-off wheel or a fine tooth hacksaw. To minimize wire braid fraying, tightly wrap the hose with masking tape in the area of the cut and saw through the tape. Remove the tape after cutting. Remove any excess wire braid with wire cutters.

2. Place the hose in a vise. Screw the socket onto the hose in a counterclockwise direction.

3. Using tape or a marking pen, mark the hose at the rear of the socket as a reference to detect any slippage of the hose within the socket.

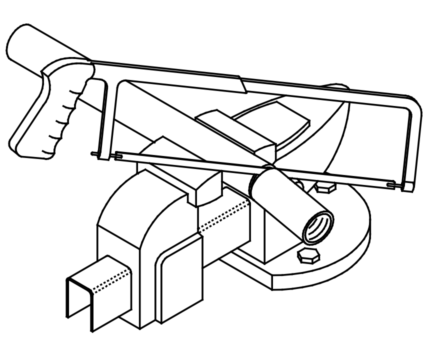
4. Lubricate the inside of the hose and nipple threads liberally with oil or light grease.

5. Place the socket in a padded vise. Carefully insert the nipple and engage the nipple and the socket threads while holding the hose in position with the other hand. Make sure that the hose does not push out of the socket by observing the reference mark made in Step 3.

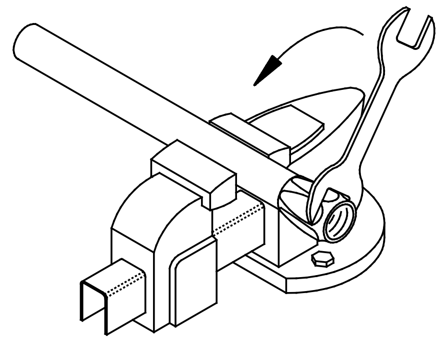
6. Complete the assembly using a wrench while continuing to hold the hose in position. Do not tighten the nipple against the socket, but leave a slight gap (.005" to .031"). The maximum allowable gap between the socket and the nut is .041".

7. Check for hose push-out by observing the hose position mark. No push-out should be evident.

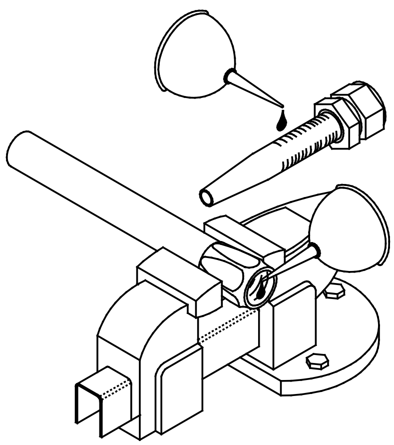
8. Always blow out or flush the hose assembly with solvent after completion. Visually inspect the inside of the hose for obstructions and contamination. A common problem resulting from improper fitting installation is a partially cut inner wall that makes a rubber flap inside the hose.



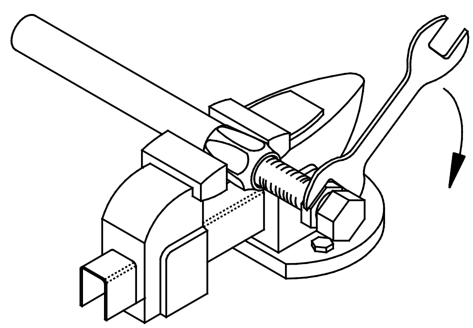
1. PLACE HOSE IN VISE AND CUT TO DESIRED LENGTH USING FINE TOOTH HACKSAW OR CUT OFF WHEEL.



2. PLACE HOSE IN VISE AND SCREW SOCKET ON HOSE COUNTERCLOCKWISE.



3. LUBRICATE INSIDE OF HOSE AND NIPPLE THREADS LIBERALLY.



4. SCREW NIPPLE INTO SOCKET USING WRENCH ON HEX OF NIPPLE AND LEAVE .005 INCHES TO .031 INCHES CLEARANCE BETWEEN NIPPLE HEX AND SOCKET.

Figure 13: Aeroquip Hose Assemblies

Hint A useful tool for assembling aircraft hoses is a **hose assembly mandrel**. This tool threads into the hex nut of the nipple and has a smooth, cylindrical shaft that extends completely through the nipple, beyond its tapered end. The shaft guides the nipple into the hose as the nipple is threaded into the socket, preventing the nipple from tearing the inside of the hose.

If you don't want to fabricate your own hose assemblies, you can order them custom-fabricated to your specifications from several suppliers, some of which are listed here:

Herber Aircraft, (800) 544-0050

Sacramento Sky Ranch, Inc., (916) 421-7672; Fax (916) 421-5719

Aircraft Spruce and Specialty Co., (800) 824-1930; Fax (714) 871-7289

INTERIOR CORROSION PROTECTION

Corrosion of metal components is a potentially serious problem, and steps should be taken to prevent it. However, the degree of protection required depends to an extent on the environment in which the aircraft will be operated. Protection that is adequate for a plane based and primarily flown inland would not be sufficient for a floatplane or a plane based and flown near salt water. On the other hand, the level of protection required for the latter environments might be unnecessarily expensive and time consuming for the former. So, as the builder you will have to judge the sort of environmental demands you'll be placing on your airplane. The following information should help you to make and carry out an appropriate choice.

What Needs Protection?

Some of the steel parts in the GlaStar kit are cadmium plated at the factory and thus require no further anti-corrosion treatment. Many others, however, are untreated and must receive supplemental corrosion protection. The same is true of the aluminum components. The wing, stabilizer and control surface skins are Alclad; this means that the aluminum alloy, which has relatively low corrosion resistance, is clad in a thin layer of pure aluminum, which has excellent corrosion resistance. Therefore, Alclad parts are probably sufficiently corrosion resistant without further treatment for most land-based use. However, other important structural components such as ribs, spars, stiffeners and doublers are not all Alclad and require some extra surface protection, depending on where and how you'll be flying your airplane.

> **Caution** The Alclad coating is extremely thin. Any scratches that penetrate the coating allow corrosion to take root in the underlying alloy. For this reason, don't sand or buff any Alclad surfaces (except to prepare for painting) and be careful to avoid inadvertent scratches. If an Alclad surface becomes scratched, it must be treated as unclad metal and protected as described below.

At a minimum, you need to provide some extra corrosion protection, such as an alodine treatment, to the interior structure of the wings and empennage. If you anticipate floatplane operation, especially on salt water, then a comprehensive interior treatment, including application of a suitable primer, is strongly recommended for all ribs, spars, skins and fittings.

Methods for Corrosion-Protecting Aluminum

The recommended corrosion protection program for aluminum parts consists of three steps: cleaning, alodine treatment and priming. Ideally, these steps should follow one another directly. Letting a cleaned part sit overnight, for example, could, under certain conditions of temperature and humidity, allow oxidation that would necessitate re-cleaning.

Cleaning

The purpose of the cleaning step is to remove dirt, grease and oxidation that will inhibit the bonding of the primer to the metal. Such contamination doesn't need to be visible to mess up an otherwise good priming job. Therefore, you should make it a practice to clean **all** parts before proceeding to the alodine treatment and priming stages regardless of whether a part looks "dirty" or "greasy." Aluminum cleaner is manufactured by a number of different companies and should be readily available in most areas through auto body supply houses.

The first step is to mix the aluminum cleaner, using the manufacturer's instructions. For most applications, you can use a mixture toward the more dilute end of the manufacturer's recommended range; however, if the parts you are treating have been stored for a long time outside their protective plastic coverings or have gotten unusually dirty for any reason, use a stronger dilution.

Note Don't worry about diluting more aluminum cleaner than you need for a particular job; there's no problem storing the dilute cleaner for future use. Just follow the normal storage precautions discussed above.

Apply the aluminum cleaner by wiping it on liberally with a paper towel. For parts that have just recently been uncovered, this is all that is necessary. For oxidized or otherwise contaminated parts, follow the toweling with a thorough scrubbing with a piece of Scotch Brite non-metallic scrub pad (very fine grade, #7448, preferred). When in doubt, remember that scrubbing will never do any harm.

Caution Be especially careful to remove any pencil or pen marks you may have made during assembly. These can require extra Scotch Brite scrubbing to remove, but it is essential to do so, because if allowed to remain they will bleed through the primer.

Caution Never use steel wool to clean aluminum parts. The tiny particles of steel left behind can be extremely difficult to remove completely, and any that remain could bring about dissimilar metals corrosion.

If you Scotch Brite a part, follow up with another paper towel application of aluminum cleaner. Allow the cleaner to lie on the surface of the metal for 1-3 minutes and then rinse the part thoroughly with clean water. However, do not allow the cleaner to sit long enough to dry on the part before rinsing.

Note It is not necessary to use distilled water for either mixing or rinsing the aluminum cleaner.

ALODINE TREATMENT

Like aluminum cleaner, alodine should be available through auto body supply houses. The purpose of alodine treatment is to provide microscopic roughening of a clean metal surface to aid the adhesion of the primer coat. It is essential, therefore that the part be, in fact, clean before alodizing. If a part has been cleaned but has been allowed to sit for a period of hours, it is safest to assume that it has picked up airborne dirt and grease and/or oxidized: clean it from scratch using the procedures outlined above and alodize it immediately afterwards.

Note It is not necessary to let a part dry after rinsing off the aluminum cleaner; you can proceed directly to alodizing.

Mix the alodine solution according to the manufacturer's instructions. Apply the mixture liberally to the parts to be treated. For large surfaces like stabilizer or wing skins, the solution can most easily be applied with a sponge; use a brush for smaller or irregular surfaces like rib webs and flanges.

Note Like the aluminum cleaner, the alodine can be stored diluted if so desired.

As with the aluminum cleaner, the alodine solution should be allowed to sit on the part for a few minutes without being allowed to dry. Rinse the part thoroughly with clean, cold water after 1-5 minutes have elapsed.

If you are going to apply primer for additional protection, let the part dry **thoroughly** before moving on. Air drying is fine if you are in no hurry, since oxidation is no longer a problem now that the part has been alodized. However, if you want to speed the process up, use a heat gun or blow dryer. **Do not** use compressed air, as the air stream from a compressor will likely contain small droplets of oil and water.

PRIMING

To date, the most popular primer choices have been either the traditional zinc chromate or epoxy. Both provide good corrosion protection, although epoxy is somewhat superior and is clearly preferable for airplanes that will be exposed to salt water or spray. The downside of epoxy for other applications is the inconvenience of having to measure and mix the resin and the hardener. For its part, zinc chromate is even more highly toxic than epoxy is, and its use is declining for that reason. The new water-based primers appearing on the market are safer environmentally, but be sure to check with the manufacturer about the corrosion-protection service history of a new product.

Caution Both the solvents used for pre-primer cleaner and the most popular primers themselves are powerful and potentially harmful chemicals. Follow all manufacturers' safety guidelines carefully. Good ventilation is absolutely essential, and the use of rubber gloves, goggles and a respirator is highly recommended.

> **Note** Stoddard-Hamilton offers a Corrosion Protection Option Kit (P/N 962-01000-01) based on Deft-brand, water-based primer. We have found this primer (which is available in retail quantities only through Stoddard-Hamilton) to be easy to apply and to have excellent adhesion qualities.

For the utmost corrosion-protection, dab a little primer in each rivet hole before riveting, especially if bare metal was exposed by drilling or deburring.

Methods for Corrosion-Protecting Steel

The recommended minimum corrosion-protection for steel parts consists of cleaning and priming. An optional step, phosphoric acid-etching, can be completed immediately after cleaning to provide better adhesion for the primer.

CLEANING

The surfaces of steel parts must be completely free of both corrosion and contaminants to provide good adhesion of the primer and to prevent the formation of corrosion beneath the surface finish. Sandpaper, Scotch Brite pads, wire brushes and steel wool are all acceptable tools for attacking surface rust on steel parts, but we recommend sand or bead blasting as this removes corrosion more surely than hand methods and minimizes the amount of residue remaining on the part.

To clean contaminants from rust-free steel parts, use a cleaner formulated for all metals, such as Prep-Sol, Aquaprep or Poly-Fiber Metl-Sol C-2200. Check the label on the cleaner you acquired for aluminum surfaces; it may be okay for use on steel as well. If you are not going to acid-etch your parts, wipe them dry with clean rags or towels, after cleaning and rinsing, and use a heat gun or blow drier in less accessible nooks and crannies. After the parts are dry, protect them from contaminants until they've been primed—even the body oils deposited by handling the parts with your bare hands could inhibit good adhesion of the primer. If you are going to acid-etch your parts, there is no need to dry them after cleaning as long as you proceed directly to the acid-etching step.

Phosphoric Acid-Etch (Optional)

Phosphoric acid serves the same purpose on steel parts as alodine on aluminum parts—it provides microscopic roughening of the surface to promote adhesion of the primer. (If you sandblasted your parts, acid-etching is not necessary as the sandblasting itself produces adequate surface roughness.) Dilute the phosphoric acid with equal parts water and apply to the surface with a sponge or a brush. Allow the solution to remain on the surface for 5—10 minutes and then rinse thoroughly with clean water and dry as described above.

Warning Common sense dictates that you protect yourself from exposure to phosphoric acid. At least, wear rubber gloves and a face shield.

Priming

Our recommendations for priming steel parts are the same as for aluminum parts: use either the traditional zinc chromate or, even better, a two-part epoxy primer such as Dupont DP-50. Whatever primer you choose, apply it as soon as possible after cleaning and etching, preferably within 1—2 hours.

Note The Deft-brand primer supplied in the Corrosion Protection Option Kit (P/N 962-01000-01) is an excellent choice for steel as well as aluminum parts. However, if you sandblasted the parts, you must apply the primer thickly enough to fill the microscopic valleys and cover the peaks left by the sandblasting process; you need 1 mil of primer above the peaks when dry.

Apply the finish paint after the primer has cured. You can use any finish paint that's compatible with your primer, but we recommend painting the parts white or another light color to make it easier to inspect for cracks. The only exception to this is the V-brace in the windshield area of the cage; this should be painted a darker color with a matte finish to minimize glare.

Hint FAA Advisory Circular 43-4A, *Corrosion Control for Aircraft*, is a good source for further information on this subject. See also the article "Rust Protection" by Tony Bingelis in the October 1995 issue of *Sport Aviation*, pp. 86-91.

AIRCRAFT FINISHING AND PAINTING

To exhaustively cover the entire subject of finishing and painting an airplane would almost double the size of the GlaStar Assembly Manual, so we'll provide only some general guidance here. For additional information, refer to the publications listed in "RECOMMENDED READING" in "SECTION I: INTRODUCTION." Probably the best sources of information for painting and finishing procedures are the paint manufacturers' own published guidelines for the use of their products.

The first issue to consider is whether you need to paint the airframe at all. Especially if you want to minimize the weight of the finished airplane, as well as the time and expense required to build it, you can complete the GlaStar without doing **any** painting. All of the airplane's metal skins are Alclad aluminum, so they are fairly corrosion resistant without finish paint. The biggest disadvantage to leaving the aluminum skins unpainted is the occasional polishing required to keep them looking bright. The fiberglass parts are finished with a white gel coat that can simply be buffed to a high gloss to provide a good finish. If you achieve a good fit along the seams between the parts before bonding the fuselage together, you can leave the seams unfinished; the hairline crack that remains is not at all obtrusive (especially for the belly seam, which is rarely seen). You can even hide the seam along the top of the fuselage with a trim stripe. Instead of painting decorative trim stripes, you can make them from self-adhesive vinyl. Sign shops exist almost everywhere that can computer-generate vinyl trim stripes, graphics and "N" numbers in virtually any size, shape and color. Or you can use ready-made vinyl stripes, which are available in a variety of widths. So, only those builders operating their GlaStars as floatplanes—especially in a saltwater environment—need to apply any paint to their airplanes at all, and then only the aluminum parts really need painting.

Assuming that you have decided to paint your GlaStar, the next issue to consider is whether you want to paint it yourself. We recommend completing most of the surface preparation yourself and letting a professional apply the conversion coating (if used) for metal parts, the primer and the finish paint. A good professional painter has a climate-controlled work area to achieve the best finish and also has experience with different types of paint to avoid problems (such as "orange peel," "blushing," "fish eyes" or paint runs) that a novice might encounter.

Letting a professional apply the paint also saves the price of a spray gun, reduces your exposure to hazardous chemicals and eliminates the problem of dealing with overspray in your home workshop environment. If you choose this route, consult with the painter before beginning surface preparation to both clarify what is expected in terms of surface preparation and to ensure that the solvents and primer you use will be compatible with the finish paint.

If you decide to paint your GlaStar's fuselage, be aware that fiberglass products are adversely affected by extreme high temperatures. We strongly recommend painting the fuselage white, or at least a very light color, with a minimum of dark color trim. Light colors, especially white, absorb less solar energy and keep the painted surfaces as cool as possible. As an example, a dark finish can absorb enough solar energy on a hot, sunny day to attain a surface skin temperature of almost 200° F. A white surface, on the other hand, will be at or only slightly above the ambient air temperature.

If you choose to do the final painting yourself, we will leave it to you to learn the procedures and acquire the necessary skills on your own. The work to prepare the GlaStar for painting naturally divides into two separate topics: preparing the sheet metal parts and preparing the fiberglass parts.

Preparing Sheet Aluminum Parts for Painting

The steps to prepare sheet aluminum parts (the wings, empennage and control surfaces) for painting are essentially the same as the steps for "CORROSION PROTECTION" discussed previously: cleaning, sanding and/or etching and priming. Cleaning involves using a suitable solvent or a detergent solution to remove oils and other contaminants from the surfaces of the parts. The parts are then wet-sanded with 400 grit paper and/or etched with some kind of conversion coating or acid etching process. Finally, a suitable primer is applied. Refer to the "INTERIOR CORROSION PROTECTION" section for a further discussion of these steps.

Before you can begin this process, however, you will have to choose the type and brand of paint you are going to apply. The most common paints for aluminum airplanes are acrylic enamels and lacquers, and polyurethane enamel. Consult with your paint professional to choose a paint system, then follow the paint manufacturer's recommendations for preparation. Remember that it is always best to stick to the same brand for primers, thinners, top coat and other chemicals. While two different manufacturers might specify the same type of thinner, for example, compatibility is not guaranteed unless you use each manufacturer's own products exclusively.

Finishing Fiberglass Parts

We do not recommend painting the fiberglass fuselage on the GlaStar. The gel coat finish is durable, attractive and easily repaired. Applying a paint finish over the gel coat just adds unnecessary weight, as well as increasing the time and the expense needed to finish your airplane. Your choices for finishing the GlaStar's fiberglass fuselage are, first, leaving the fuselage seams unfinished and just buffing the gel coat to a glossy finish; second, filling and gel coating the fuselage seams; and, third, painting the fuselage. As mentioned previously, our recommendation is to leave the seams unfinished (except possibly the small seams at the leading edges of the wing fairings and between the base of the windshield and the cowling). Ignore the belly seam and, if you want, apply a vinyl trim stripe over the dorsal seam or, at least, along the leading edge of the vertical fin.

GEL COATING THE FUSELAGE SEAMS

The composite fuselage panels are made by first spraying gel coat into the mold and then applying the structural laminates on top of it. The gel coat and the resin are both styrene based compounds, so they bond together to become integral parts of the whole structure. When gel coating the fuselage seams, the same bonding occurs. The gel coat serves as an ultraviolet ray barrier and its white color prevents heat absorption from solar energy.

If you decide not to paint but to leave the fuselage in its original gel coat, you might at least want to finish the seam areas. The only drawback to this is that, although it can be close, it is almost impossible to achieve a perfect color match between the gel coat used on the seam and the gel coat used on the rest of the fuselage. The color mismatch is most noticeable only under artificial light, however, and such a small area is involved that we don't consider this a serious objection. Gel coating a seam involves filling the seam with Ultralite body filler (Bondo), sanding it smooth, applying the gel coat, wet-sanding with progressively finer grits (down to 600) and, finally, buffing the gel coat to achieve a high polish. Since gel coat sands easily, you could even use a brush to apply a thick coat of gel coat to the seam areas and then sand it smooth.

To spray gel coat with a conventional paint spray gun may require some thinning. To thin the gel coat, add just enough acetone so the spray gun will push it. Thinning is necessary only to allow the spray gun to function. Before thinning the gel coat, catalyze it at a 2% ratio (2cc of catalyst to 100 grams of gel coat) in the same manner as done for the vinyl ester resin. Be ready to immediately test the spray gun to see if it will push the gel coat. If not, add some acetone thinner. Some practice spraying may be necessary. Gel coat will never flow out perfectly smoothly on the surface as do normal paints; it will always have to be sanded and buffed to achieve a glossy surface.

Note The cure rate of gel coat is similar to that of resin. If temperatures are 75° F or higher, be very careful that the gel coat does not jell in the spray gun or the gun will be ruined. If you are working at high temperatures, use small batches of gel coat. Pay close attention to how long the gel coat has been in the gun. Immediately after spraying, disassemble the gun and clean it thoroughly with acetone.

When the gel coat has cured enough to run a brush over it without smearing (about an hour), take a foam brush and coat the fresh gel coat with a thin layer of PVA. This will seal the gel coat from oxygen so that it will cure to a hard surface. Let the gel coat cure for 24 hours before washing off the PVA coating.

Wet sand the cured gel coat with 180 grit sandpaper. Continue wet sanding with 220, 320, 400 and 600 grit successively, and then buff with rubbing or buffing compound. Ditzler DRX-16 or the equivalent works well.

To blend the new gel coat most effectively into the existing gel coat on the fuselage panels, follow these procedures:

1. Fill the seam with body putty and sand smooth and flush. Using 320 grit paper, wet sand an area 3-4" wide centered on the seam, as shown in Figure 14. Sand the surface until all shiny areas have been removed. Do not sand any deeper than it takes to dull the surface. Wash the area with water and allow it to dry.

2. Using a foam brush, apply a thin coat of PVA 6" wide on both sides of the sanded area, as shown in Figure 14, overlapping 1" onto the sanded area. The PVA will protect the surface from overspray and will later come off with water. Use paper and masking tape to cover areas outside of the PVA release area.

3. Spray gel coat onto the seam. Concentrate the gel coat onto the seam area and allow the overspray to overlap onto the PVA zone. Be sure to spray the gel coat thick enough to allow future sanding and buffing.

4. When the gel coat has cured enough to run a brush over it without smearing, use a foam brush to apply a light coat of PVA over the gel coat and the overspray area. Let the gel coat cure for 24 hours and then wash off the PVA with water.

5. The surface should now be hard enough to sand without gumming the sandpaper. There should be a 1" wide (approximately) green layer of PVA under the gel coat where the PVA and the gel coat overlap. This green overlap area is an indicator to show how far and how much to sand to get a perfect feather edge and match-up. Wet sand with 220 and then 320 grit sandpaper until the green band of PVA disappears. At this point, sand with 400 and then 600 grit sandpaper and then buff out with buffing compound.

To give the airplane a high gloss look after completing the seams as described above, wet sand lightly with 600 to 900 grit sandpaper and buff using a power buffer and buffing compound.

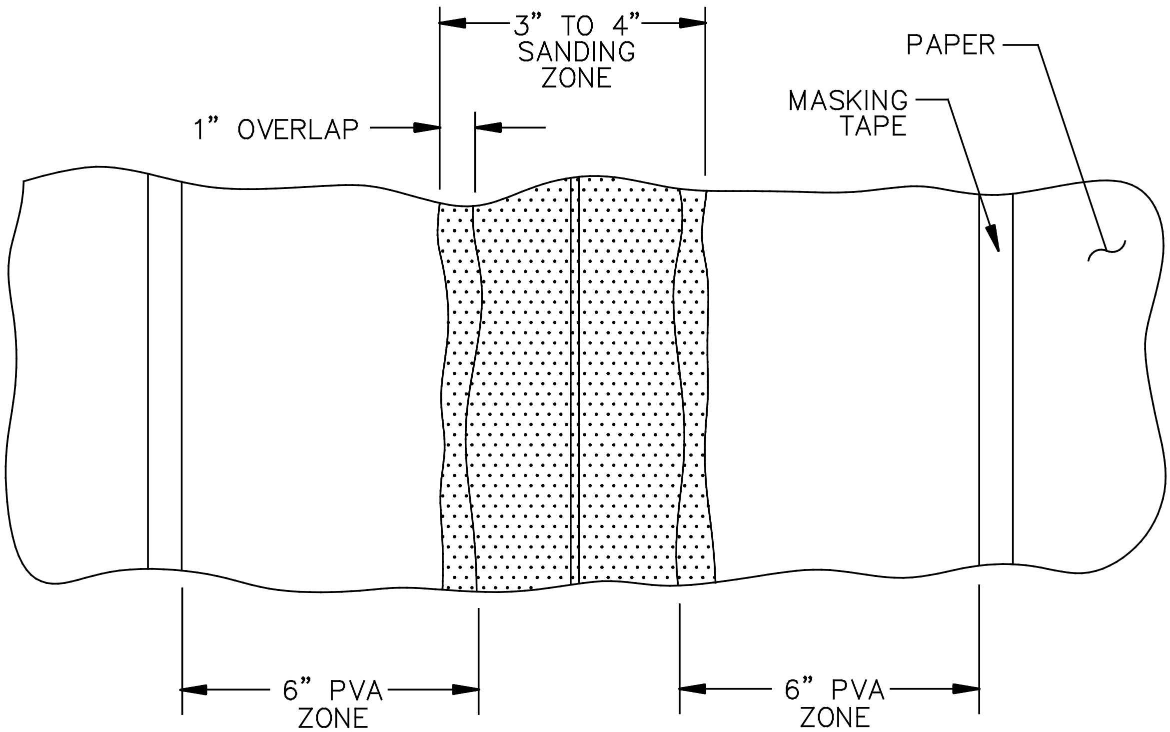


Figure 14: Gel Coating the Fuselage Seams

PREPARING FIBERGLASS PARTS FOR PAINTING

If you insist on painting the fuselage, we recommend doing as much of the preparation work as possible yourself and then having a professional apply the primer and the finish paint. Consult with your paint shop in advance to choose a paint (we recommend an acrylic urethane or polyurethane top coat) and follow the manufacturer's (and the paint shop's) recommendations for preparation. The general preparation sequence is filling the seams and other surface imperfections, then sanding the entire fuselage and, finally, cleaning in preparation for the finish primer and paint. All of the fillers, cleaners, solvents and putties used in preparation must be compatible with the top coat you plan to use.

Surface Filling

Because of its factory-molded fuselage panels, preparing the GlaStar fuselage for painting involves much less filling and smoothing than is typical with an aircraft fabricated from hot-wired foam cores and built-up fiberglass laminates. The only filling required on the GlaStar is in the seam areas where the fuselage panels fit together.

Use Ultralite body filler (Bondo) to fill seam areas on the fuselage and then sand smooth and flush starting with 180 grit and progressing to 320 grit sandpaper. If a depression exists in the gel coated fuselage panels which you want to fill, you must first roughen the gel coat thoroughly with sand paper to provide a good grip for the filler material. Several applications of filler, with sanding in between, may be required to achieve the desired results.

For filling irregularities of significant depth (not likely to be encountered) we recommend using a very thick Q-cell/resin mixture. This will result in the minimum extra airframe weight and will be fairly easy to sand when cured. Fill smaller imperfections with Ultralite body filler. Although the body filler is much heavier than a thick Q-cell mixture, the weight penalty is acceptable (for the small areas involved) in return for the body filler's other advantages: quick curing and easy sandability.

After initial sanding of the filled areas, go over the areas with an air nozzle. This will reveal any dust-filled cavities and pin holes. Fill these holes with Ultralite body filler or glazing putty (we recommend Evercoat Polyester Glazing Putty) before final sanding.

Sanding the Fuselage

The factory-applied gel coat finish is glossy from being next to the mold when the fuselage panels are fabricated. The glossy surface must be sanded to provide a "tooth" to grip the primer and finish paint. When sanding, use a good light and view the surface from different angles to make sure that no shiny or glossy areas remain.

Achieving the best possible finish on your GlaStar fuselage requires a complete sanding with several progressively finer grades of sandpaper until a smooth, even surface condition exists. Since the entire GlaStar fuselage consists of compound curves, use a flexible sanding block for all sanding.

First, use a 220 grit dry sandpaper to remove all glossy or shiny areas. After this initial sanding, use a finer grit (320) wet or dry sandpaper to work on small imperfections and scratches. Just before painting, lightly sand the entire fuselage with 400 grit wet or dry sandpaper, using strokes parallel to the direction of airflow in flight. Wet sanding is preferable because it keeps dust to a minimum and the water keeps the sandpaper from loading up with gel coat.

Final Surface Preparation

After you are satisfied with the sanding phase of surface preparation, you are ready for the final finish coats of primer and paint. Use an air nozzle to blow out any dust that may have accumulated in cracks and crevices throughout the fuselage. If you don't do this now, the air from the paint spray gun will raise the dust during final paint spraying, to the detriment of the airplane's final finish. Also, thoroughly vacuum the entire fuselage and, if you are doing your own painting, use a solvent compatible with the finish to wipe down the surfaces to be painted. Besides helping to remove dust, the solvent removes fingerprint oils and other surface contaminants that might interfere with good paint adhesion. As a final step immediately before painting, use a tack cloth to remove dust from the airframe surfaces. (If you are taking the fuselage to a professional painter, the paint shop will take care of the final cleaning and tack rag steps.)

For optimal results if you are painting the fuselage yourself, seal the entire surface with one or two coats of epoxy primer that has been reduced as a sealer. An epoxy primer provides the best adhesion and durability for urethane top coats. Again, follow the manufacturer's recommendations for preparation, mixing, application and safety.

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SECTION III: RUDDER ASSEMBLY

PARTS LIST

Key No.:	Part Name:	Qty:	Part No.:
1	Skin	1	301-00001-01
2	Skin, forward	1	301-00002-01
3	Spar, forward	1	301-00003-01
4	Spar, aft	1	301-00004-01
5	Rib, counterweight	1	301-00005-01
6	Rib, root	1	301-00006-01
7	Rib, tip	1	301-00007-01
8	Bracket, forward spar/counterweight rib	1	301-00008-01
9	Bracket, forward spar/hinge	1	301-00009-01
10	Plate, hinge mounting	1	301-00010-01
11	Bracket, aft spar/counterweight rib	1	301-00011-01
12	Bracket, aft spar/root rib	1	301-00012-01
13	Hinge	1	301-00013-01
14	Shim, hinge	1	301-00014-01
15	(Part deleted by Revision C)		
16	Yoke weldment	1	301-01000-01
17	Sheet, lead, 12" wide	16"	750-0372-002
18	Bolt	2	AN3-10A
19	Nut	3	AN315-3R
20	Nut, nylon self-locking	3	AN364-1032A
21	Bolt	2	AN4-6A
22	Screw	2	AN507-10R16
23	(Part deleted by Revision C)		
24	Washer	3	AN960D416
25	Large washer	3	AN970-3
26	Nutplate	6	K1000-08
27	Nutplate	2	K1000-4
28	Sheet metal practice kit	1	075-00001-01

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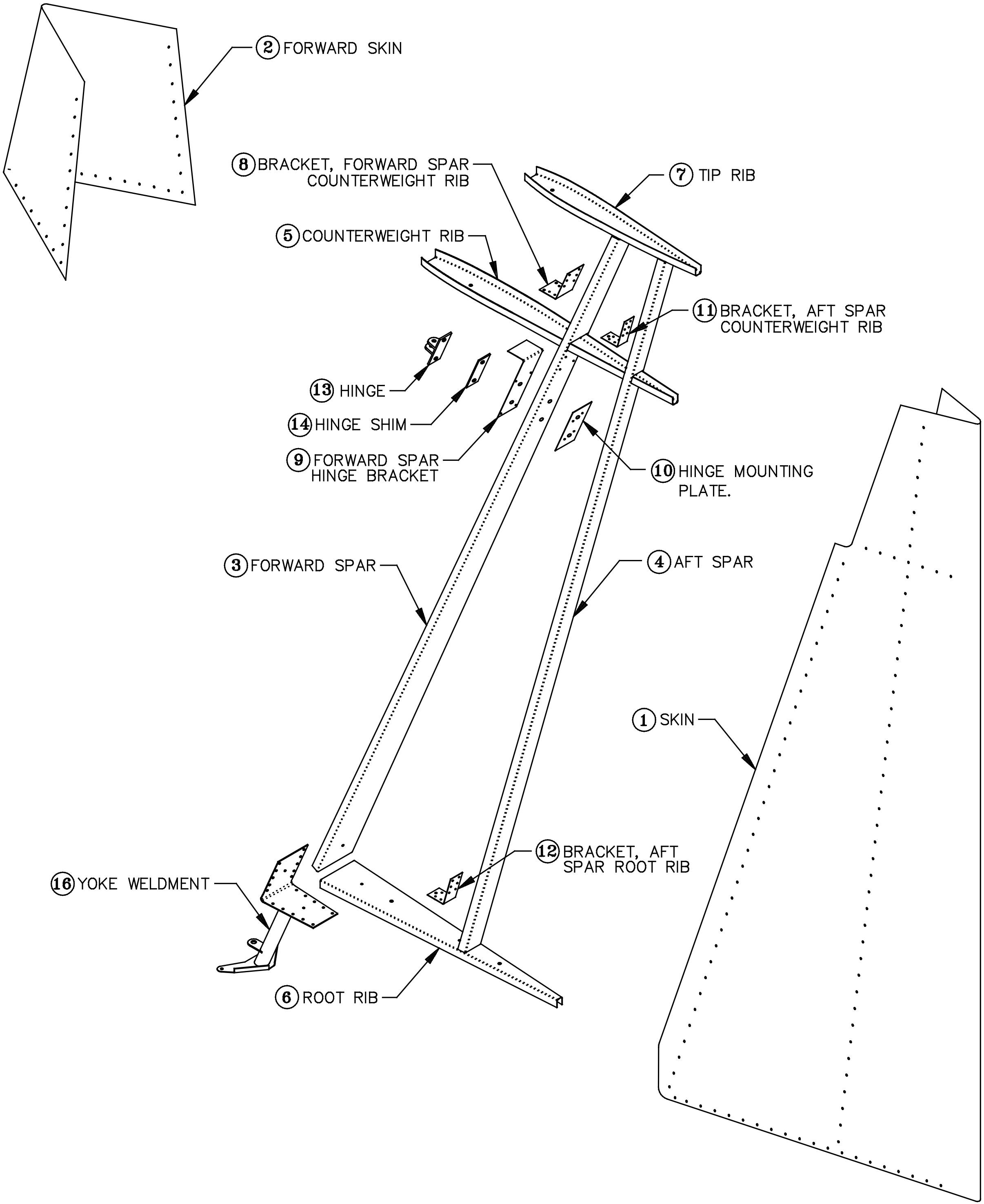

Figure 1: Rudder Assembly

Tool List

1. Flat and round files or edge deburring tool
2. Fine point marking pen, pencil
3. 6' straightedge (or chalk line)
4. Carpenter's square (framing square)
5. Clecos, 3/32" and 1/8" (approximately 80 and 25 each, respectively), with pliers
6. Cleco side-grip clamps or small C-clamps
7. Electric drill or air drill with #40, #30, #19 and #10 bits
8. Right-angle drill with #40 and #30 bits
9. Hole deburring tool
10. Dimple dies, 3/32"
11. Machine stop countersink tool with #40 and #10 piloted cutters
12. Riveting frame (optional)
13. Rivet gun, air compressor and bucking bars
14. Flush-head rivet set
15. Universal-head rivet sets, 1/8" and 3/32"
16. Rivet squeezer with 3/32" and 1/8" sets (optional)
17. Blind rivet puller

Additional Materials

1. Sheetrock screws and driver bit for drill
2. 2' X 3' piece of 1/2" plywood
3. Wood scrap blocks
4. Corrosion-proofing materials

Workspace

To assemble the rudder, you will need a six foot long (minimum) work table and adequate space to walk all around the table. The width of the table is not important, although a narrower table (three feet wide, or less) will provide easier access to both sides of the rudder when it is in the jig. The best procedure would be to build your wing jig table, as described in "Section VI: Wing Assembly," and use one end of the table to assemble the rudder. The wing jig table can also be used to build the horizontal stabilizer and the elevator.

ASSEMBLY SEQUENCE

The goal of the rudder assembly procedures is to produce a straight finished rudder without bows or twists. A simple jig will be used to help accomplish this goal, but the jig by itself will not guarantee a straight rudder; you must also think about what you're doing and check the rudder for proper alignment in the jig at every step, especially before any major drilling or riveting operation. Also, make sure that rivet lines marked on rib and spar flanges are parallel to the flange; if the rivet line on a spar is allowed to drift toward the edge of the flange, for example, the result will be a twisted rudder if the skin rivet holes are drilled through the line. Finally, follow the standard procedures for drilling lines of rivet holes and driving lines of rivets, as detailed in "SECTION II."

The general assembly sequence is as follows:

1. Inspect, deburr and straighten the parts, as necessary.
2. Fabricate the rudder jig.
3. Cleco together the internal structural framework (the spars and ribs)
4. Clamp the skins to the structural framework and drill the rivet holes to size
5. Disassemble the rudder, deburr all the rivet holes, and remove chips and shavings
6. Fabricate the counterweight
7. Corrosion-proof the parts
8. Install the counterweight
9. Rivet the assembly together

PREPARING THE PARTS

Step 1: Inspect and Deburr the Parts

Use small, fine files or an edge deburring tool to deburr the edges of the rudder spars, ribs and skins as necessary.

Completed: [ ]

Step 2: Mark the Flange Centerlines

Use a marking pen to mark centerlines on all of the spar and rib flanges. Take care, as mentioned above, to mark the lines parallel to the flanges of the parts.

Completed: [ ]

Fabricating the Rudder Jig

Step 3: Mark the Rudder Trailing Edge Line

Draw a straight line on a 6' long (minimum) work table perpendicular to the end of the table, as shown in Figure 2. This line positions the rudder trailing edge when the rudder is in the jig. The trailing edge is slightly above the table during assembly.

Completed: [ ]

Step 4: Install and Mark the Spar Support Board

Use sheetrock screws (or whatever other means is handy) to fasten a 2' X 3' piece of 1/2" plywood, the "spar support", to the end of the table centered on the trailing edge line, as shown in Figure 2. Position the spar support with its long dimension oriented vertically. Draw a vertical line onto the spar support upward from and perpendicular to the rudder trailing edge line on the table. The trailing edge line on the table and the vertical line on the spar support define the center plane of the rudder panel. Draw a horizontal line on the spar support **25-1/2"** above the surface of the table. Drill two **1/4"** holes through the spar support; each hole is centered on the horizontal line **2-31/32"** from the vertical line, as shown.

Note When the rudder yoke is fastened to the spar support at the 25-1/2" dimension, the trailing edge of the skin will not contact the table. This is desirable, as it will allow you to slide the skin on and off the framework without unfastening the yoke from the support. Wooden blocks on each side will be used to center the skin over the trailing edge line. Also, the holes for fastening the rudder yoke to the spar support board are 1/4" rather than 3/16" in diameter to ensure that the yoke is free to pivot up and down when fastened to the support. (See the Note on page 9.) Finally, the spar support board can twist from side to side when viewed from above. This is not a concern; string lines and plumb bobs will be used to verify proper alignment of the structure before drilling any rivet holes.

Completed: [ ]

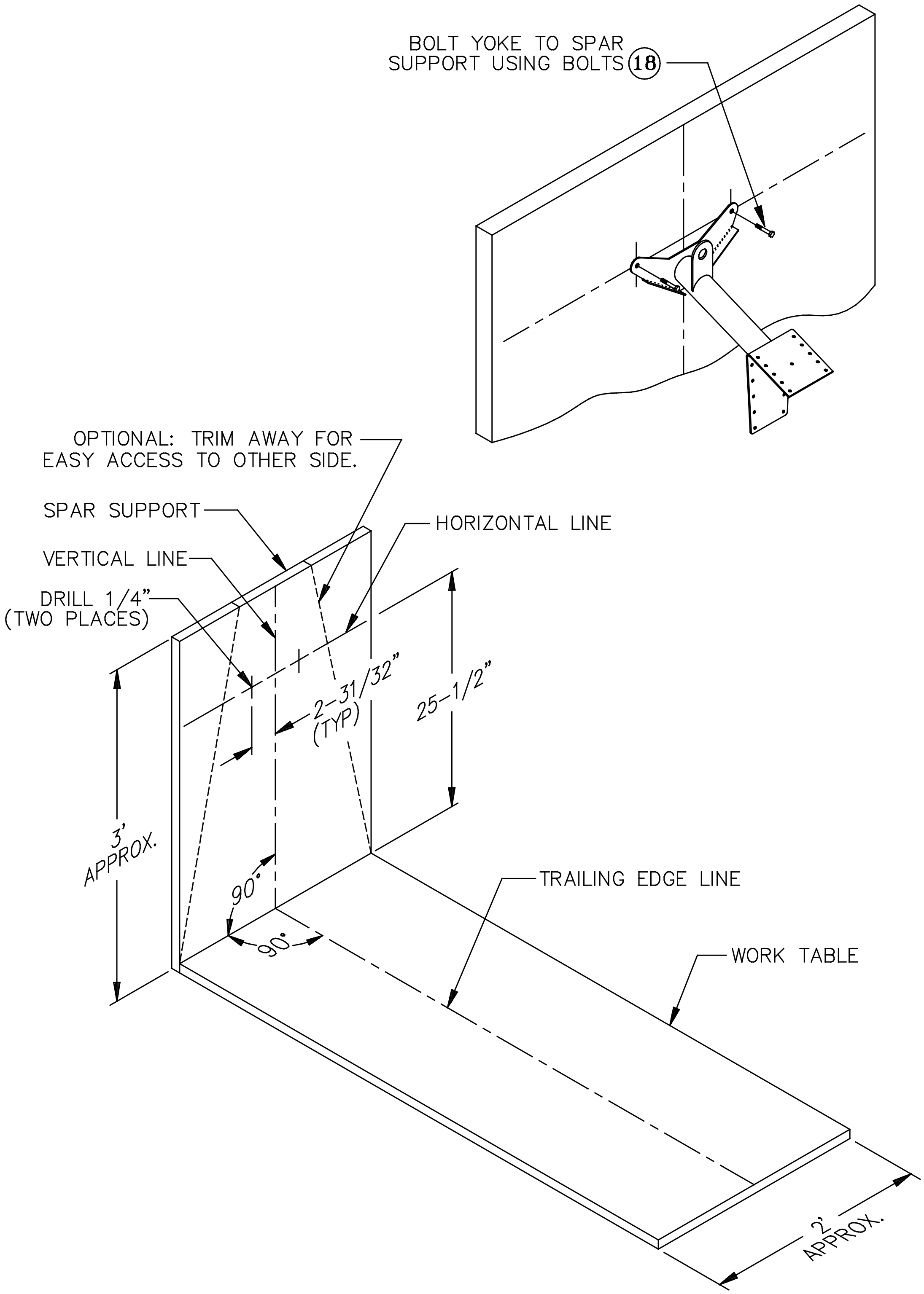

Figure 2: Rudder Jig

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Step 5: Fasten the Yoke Weldment to the Spar Support

As shown in Figure 2, use two 3/16", AN3-10A **bolts** [18] and AN315-3R **nuts** [19] to fasten the **yoke weldment** [16] to the spar support through the two holes drilled in the previous step. Don't tighten the nuts; the yoke weldment should be free to pivot up and down slightly to accommodate changes in the rudder assembly's position.

> **Note** This jig **is** intended to allow the yoke to pivot freely up and down. If it does not, slightly enlarge the bolt holes in the support board.

Completed: [ ]

PRELIMINARY ASSEMBLY OF THE STRUCTURAL FRAMEWORK

In this section, the rudder's internal structure (the forward and aft spars and the root and counterweight ribs) will be assembled and mounted to the jig. In order to avoid building a twist into the rudder, it is important that all components be properly aligned with the jig during assembly, so check the structure for straightness at every step. The other important consideration here is to assemble the internal structure in such a way that the pre-punched rivet holes in the skin fall on the centerlines of the spar and rib flanges. Specific procedures for ensuring straightness and rivet hole alignment are incorporated in the following instructions.

Step 6: Join the Forward Spar/Hinge Bracket and the Hinge Mounting Plate to the Forward Spar

Use small C-clamps (or the equivalent) to clamp the **forward spar/hinge bracket** [9] to the forward surface and the **hinge mounting plate** [10] to the aft surface of the **forward spar** [3], aligning the three parts with 1/4", AN4-6A **bolts** [21] inserted through the pre-punched holes, as shown in Figure 3.

> **Note** Check the fit of the forward spar/hinge bracket inside the flanges of the forward spar. This bracket must **not** ride on the bend radii of the spar at any point, but rather must lie flat against the spar web. If necessary, use fine-toothed files or a belt sander on the bracket to relieve any interference. Remove as little material as possible and try to do it equally on both sides.

Use the four small holes in the forward spar/hinge bracket as guides to drill **#40** holes through the assembly from the forward side. Cleco each hole after drilling.

Also, use the pre-punched holes near the rectangular hole in the forward spar as guides to drill **#40** holes through the assembly from the aft side.

Finally, use the four small holes in the hinge mounting plate as guides to drill **#40** holes through the assembly from the aft side. These last holes are for the AN426AD3 flush-head rivets that mount the nutplates; countersink these holes on the forward side of the forward spar/hinge bracket.

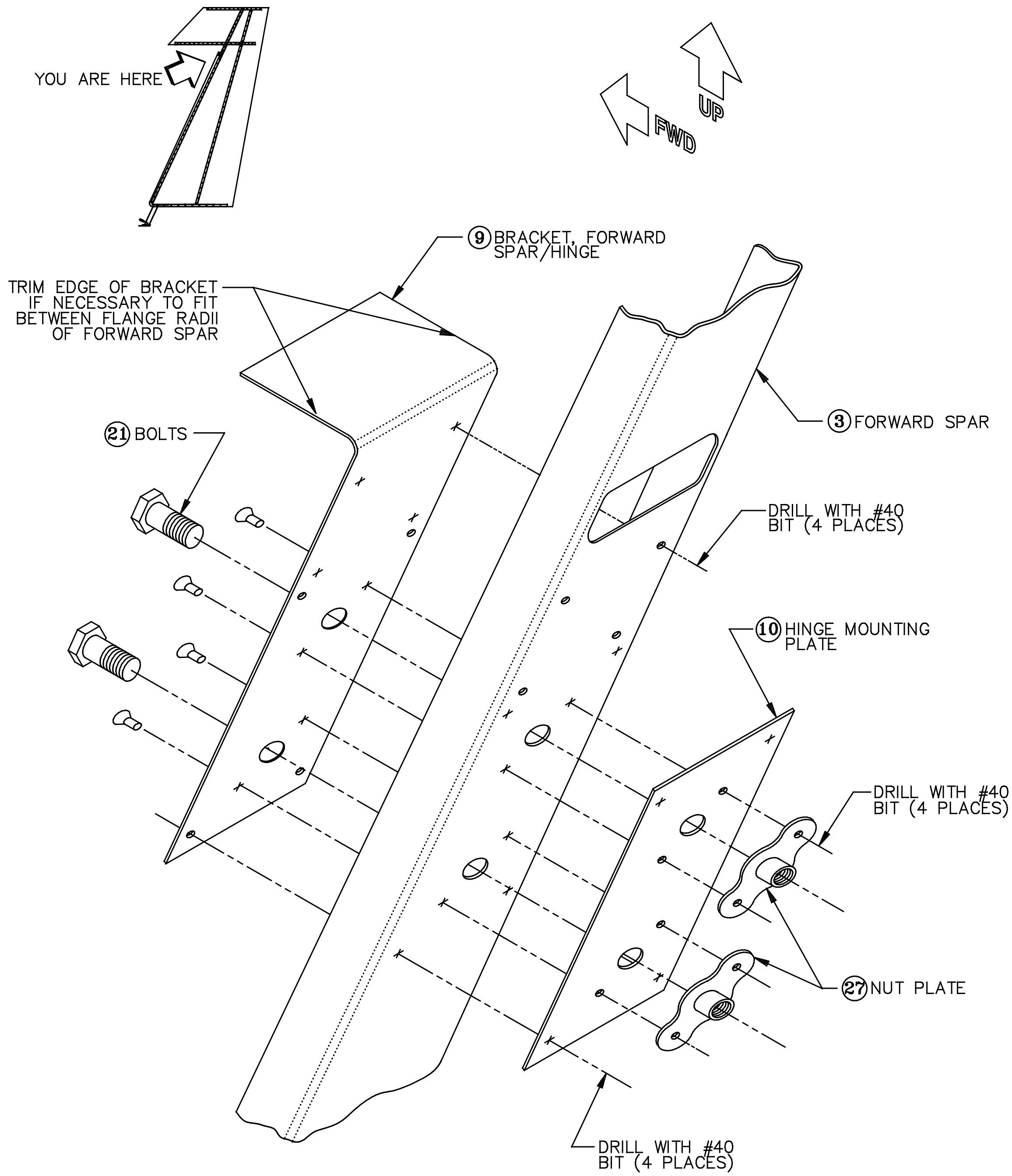

Figure 3: Hinge Mounting Plate and Forward Spar/Hinge Bracket Assembly

Separate the hinge bracket and the hinge mounting plate from the forward spar; these will be reinstalled later, in Step 10.

Completed: [ ]

Step 7: Drill and Cleco the Forward Spar to the Yoke Weldment

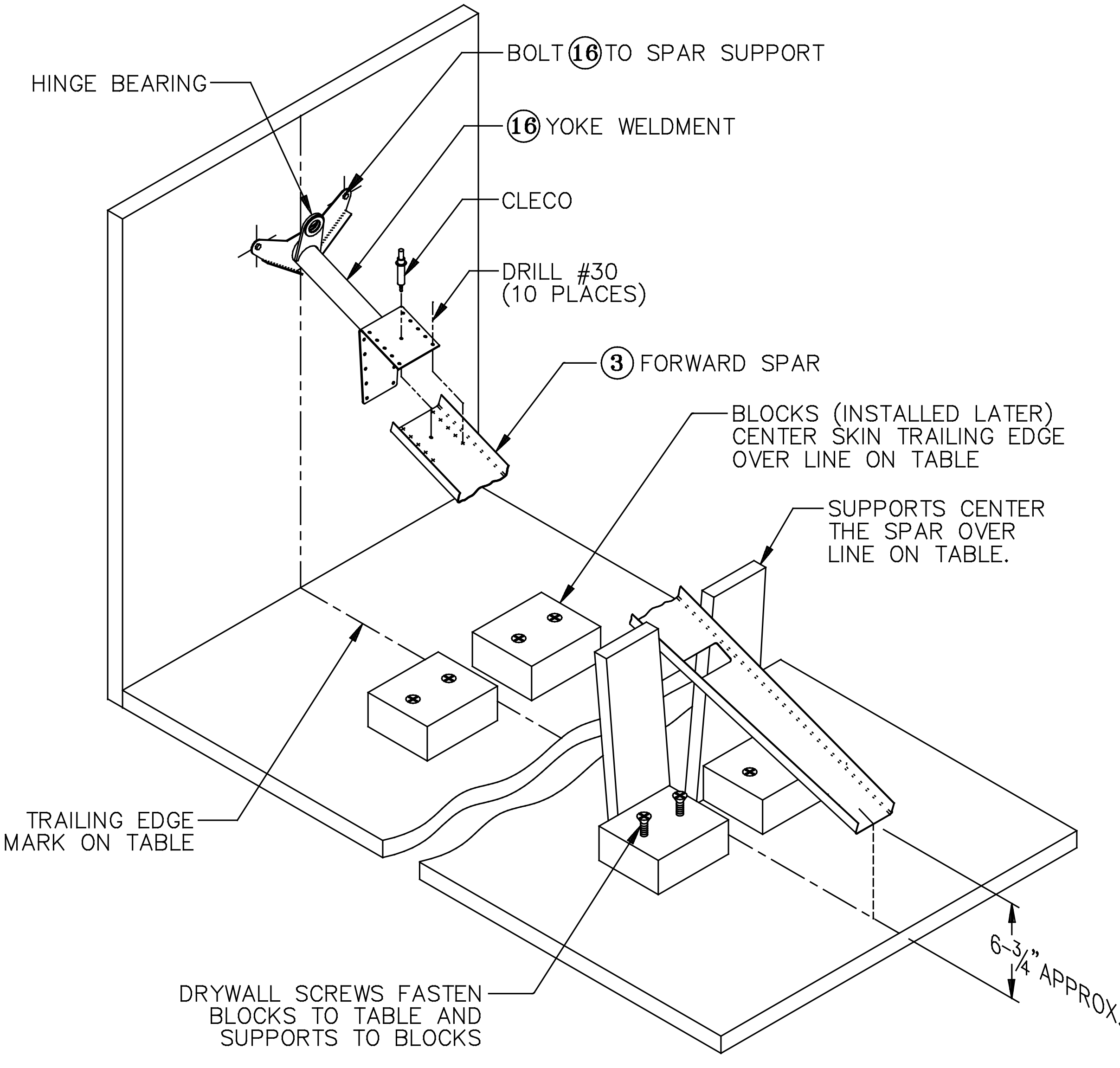

Figure 4: Forward Spar/Yoke Weldment Assembly

Cleco the forward spar to the yoke weldment, using the one pre-drilled hole in each part. (The spar fits on the **aft** side of the yoke weldment plate, as shown in Figures 1 and 4.) Fabricate supports from scrap wood, as shown in Figure 4, to center the forward spar over the trailing edge mark on the table. Position the supports an inch or so **below** the hole in the spar for the counterweight rib.

Note As with all other location and direction references used throughout the *Assembly Manual*, the words "aft" and "below" refer to a direction **as installed in the aircraft**, not relative to the jig.

Note Since the supports that center the spar over the trailing edge line are angled and the yoke is free to pivot up and down, you should be able to lift the spar/rib assembly up slightly to slide the skin into position without removing the rudder structure from the jig. Position (or bevel) the cleats that fasten the angled supports to the table to allow the skin to fit all the way down into the "vee" between the supports.

Do not drill any holes through the spar, yet.

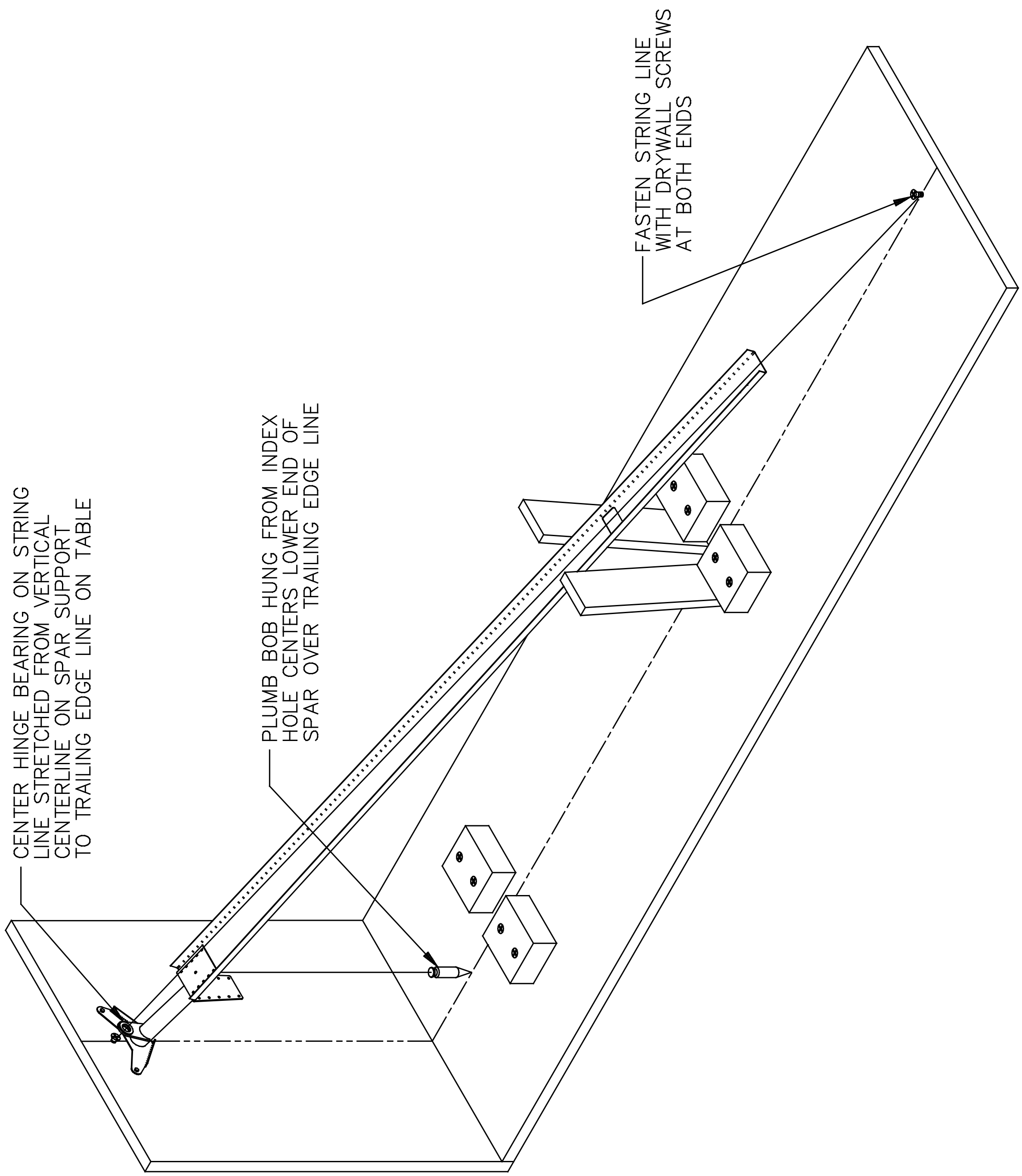

Figure 5: Centering the Forward Spar over the Trailing Edge Line

It is very important that the hinge bearing on the yoke weldment and the centerline of the forward spar both remain centered over the trailing edge line on the bench top. One way to ensure this is shown in Figure 5: run a string line from the vertical centerline on the spar support through the center of the bearing hole in the yoke weldment to the centerline at the tip of the forward spar and then to the trailing edge line on the table. In addition, hang a plumb bob from the Cleco hole that fastens the forward spar to the yoke weldment to center the lower end of the spar over the trailing edge line. Adjust the positions of the spar and the yoke until the hinge bearing is centered on the string line when the spar is centered over the trailing edge line at both ends.

> **Note** Naturally, your table must be **level** in order for the plumb bob to be useful in centering the rudder spar over the trailing edge line.

> **Note** Because of slight (and unimportant) manufacturing variances in the angles of the yoke arms, you may need to insert washers as shims between the yoke and the jig in order to bring the yoke and the spar into proper alignment. If this is necessary, don't worry about it; keeping the hinge bearing and the spar plumb takes precedence over keeping the yoke square against the jig.

When you're satisfied that the forward spar and the hinge bearing in the yoke are properly aligned and centered, use C-clamps to clamp the forward spar to the yoke weldment. Use the ten holes in the yoke as a guide to drill matching **#30** holes in the spar, as shown in Figure 4. Insert Clecos into several of the holes to maintain alignment.

Completed: [ ]

Step 8: Drill and Cleco the Root Rib to the Yoke Weldment

Cleco the **root rib** [6] to the yoke weldment using the one pre-drilled hole in each part, as shown in Figure 6.

> **Note** All of the ribs typically have two relatively large tooling holes (3/16" diameter or larger) that are used to reference the rib blank to the form block during manufacture. These holes will not be used for anything during assembly.

Center the aft end of the root rib over the trailing edge line on the table and clamp the rib to the yoke to maintain its position while drilling. Use the holes in the yoke as a guide to drill matching **#30** holes in the rib. Cleco several of the holes, after drilling, to maintain alignment.

> **Note** Use a right-angle drill for this procedure, or carefully remove the entire assembly from the jig, without disturbing the position of the root rib relative to the yoke weldment, to provide access for a regular drill.

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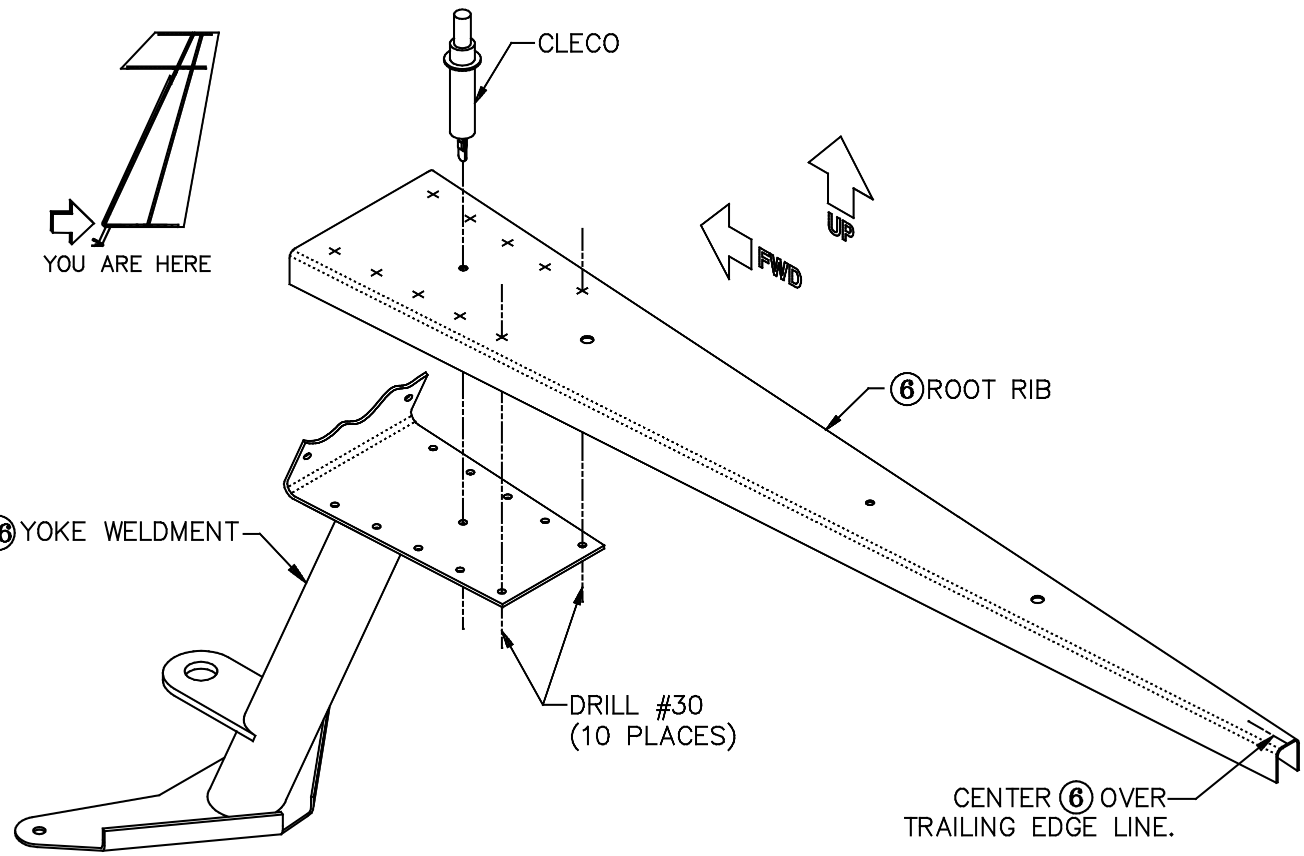

Figure 6: Root Rib/Yoke Weldment Assembly

Step 9: Join the Aft Spar to the Root Rib

As shown in Figure 7, Cleco the **aft spar/root rib bracket** [12] to the root rib [6] using the single pre-punched hole in each part. Use C-clamps to clamp the **aft spar** [4] to the aft spar/root rib bracket while centering the aft spar over the trailing edge line on the work table. Make sure the aft spar is centered laterally on the root rib. (The "vee" support described in Step 7 centers the **upper** end of the aft spar over the trailing edge line. If the root rib is centered over the trailing edge line and the aft spar is centered relative to the root rib, then the lower end of the aft spar will also be centered.)

> **Note** Position the aft spar so that there is just the very slightest gap (1/32" or less) between the lower end of the spar and the surface of the root rib (if the spar actually contacts the root rib, vibration could wear a hole in the rib).

Use the pre-punched holes in the aft spar/root rib bracket as guides to drill **#40** holes through the bracket, the root rib and the aft spar. Insert enough Clecos to maintain alignment while drilling.

Completed: [ ]

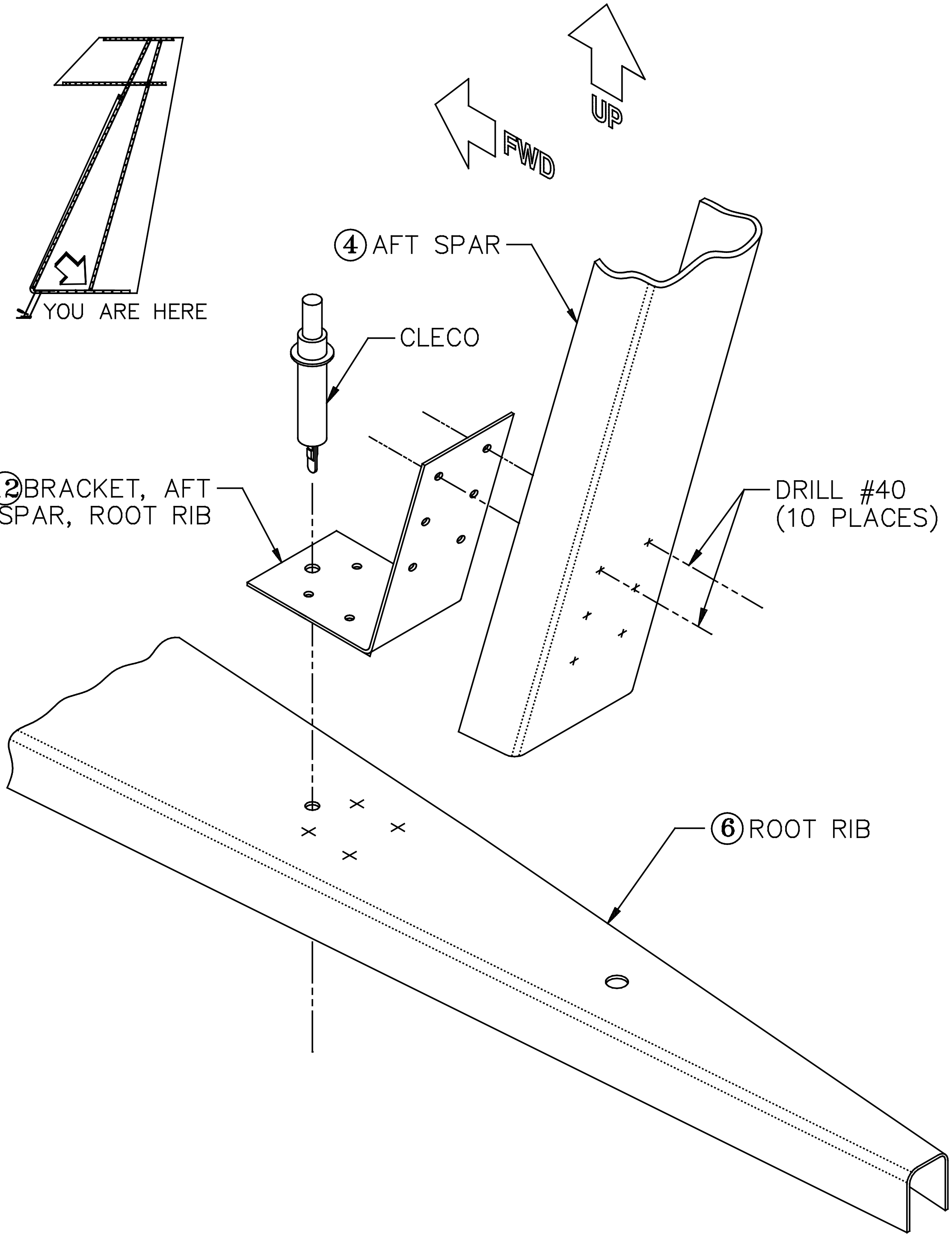

Figure 7: Aft Spar/Root Rib Assembly

Step 10: Join the Counterweight Rib to the Spars

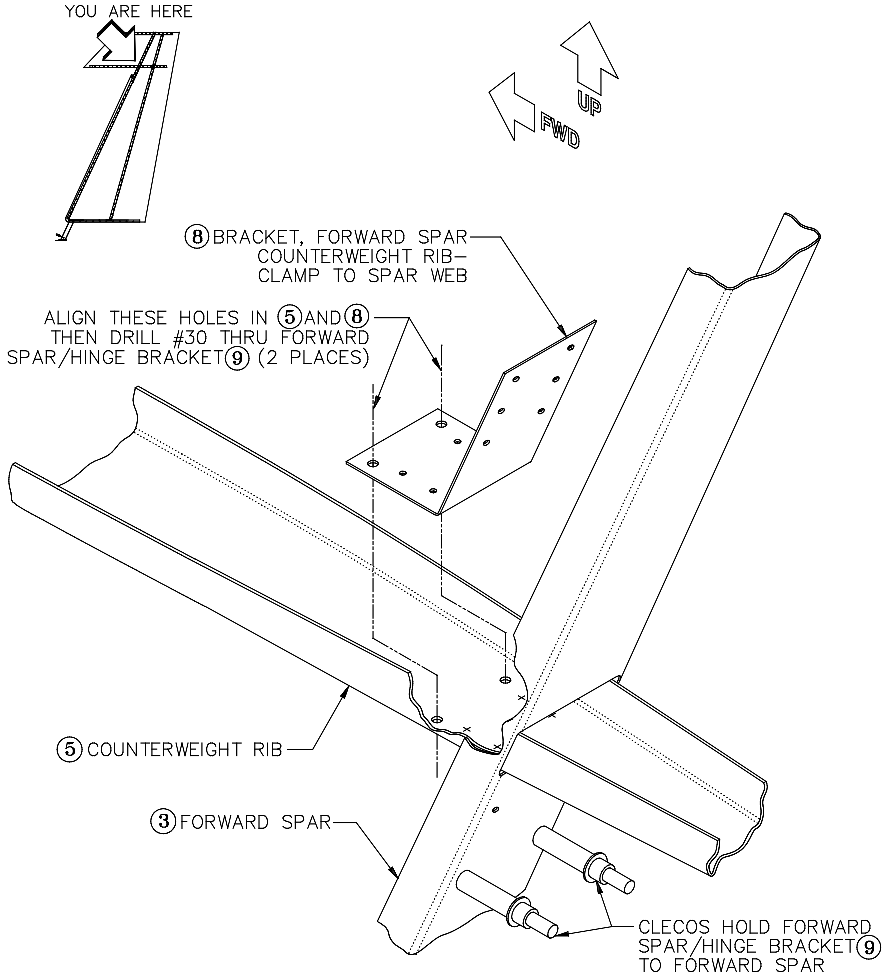

Figure 8: Counterweight Rib/Forward Spar Assembly

Using two or three Clecos, re-attach the forward spar/hinge bracket to the forward spar (see Figure 3). Slide the **counterweight rib** [5] through the holes in the forward and aft spars. (The forward spar/hinge bracket sets the vertical position of the counterweight rib relative to the forward spar.)

Note Enlarge the opening in the forward spar in both the horizontal and the vertical directions, if necessary, to allow the counterweight rib to be slipped into place.

With the web of the counterweight rib resting on the top flange of the forward spar/hinge bracket, use a small C-clamp to clamp the **forward spar/counterweight rib bracket** [8] to the spar web. Position the bracket so that: (a) it is **centered** between the flanges of the spar, and (b) its lower flange effectively clamps the rib web tightly against the forward spar/hinge bracket.

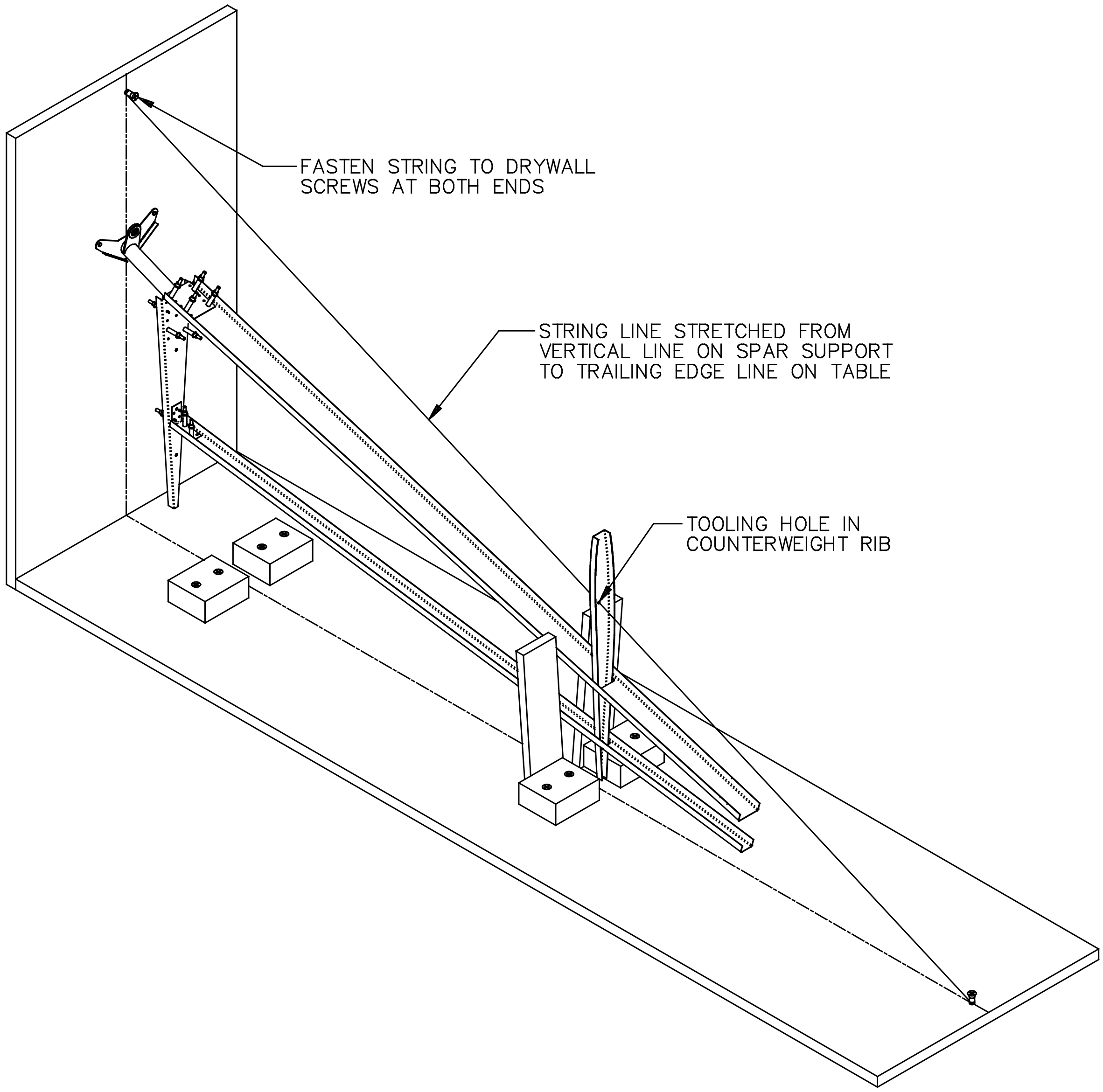

Figure 9: Centering the Counterweight Rib

Now, before drilling any holes through the bracket/spar/counterweight rib assembly, check to make sure that the counterweight rib is properly aligned with the rest of the rudder framework. You can use a plumb bob or a try square to verify that the trailing edge of the counterweight rib is centered over the trailing edge line on the table. To check alignment of the rib's forward end, stretch a string from the vertical centerline on the spar support through the forward tooling hole in the counterweight rib to the trailing edge line on the table, as shown in Figure 9.

Both the **counterweight rib** and the **forward spar/counterweight rib bracket** have two pre-punched #30 holes, which are used to align the two parts. Since the **forward spar/hinge bracket** lacks the two #30 index holes, it cannot be Clecoed to the other two parts for drilling. To transfer the locations of the two index holes to the forward spar/hinge bracket, proceed as follows: Slide the counterweight rib forward and aft as necessary to bring the two pre-punched #30 index holes in the rib web into alignment under the corresponding holes in the forward spar/counterweight rib bracket. Be careful to **keep the counterweight rib centered** relative to the jig while doing this. If necessary, adjust the side-to-side position of the bracket on the spar in order to align these two holes as precisely as possible. With the holes aligned, use a **#30** bit to drill both these holes through the underlying forward spar/hinge bracket, as shown in Figure 8. Insert a Cleco in each hole after drilling.

With Clecos holding the counterweight rib to both brackets, and after verifying that the counterweight rib is still centered relative to the jig, you can drill the six **#40** holes through the forward spar/counterweight rib bracket and the forward spar, as shown in Figure 10. Cleco a couple of these holes, and remove the C-clamp holding the forward spar/counterweight rib bracket. Finally, use the pre-punched holes in the other flange of the forward spar/counterweight rib bracket as guides to drill four #40 holes through both brackets and the rib web, as shown in Figure 10. Cleco to maintain alignment while drilling.

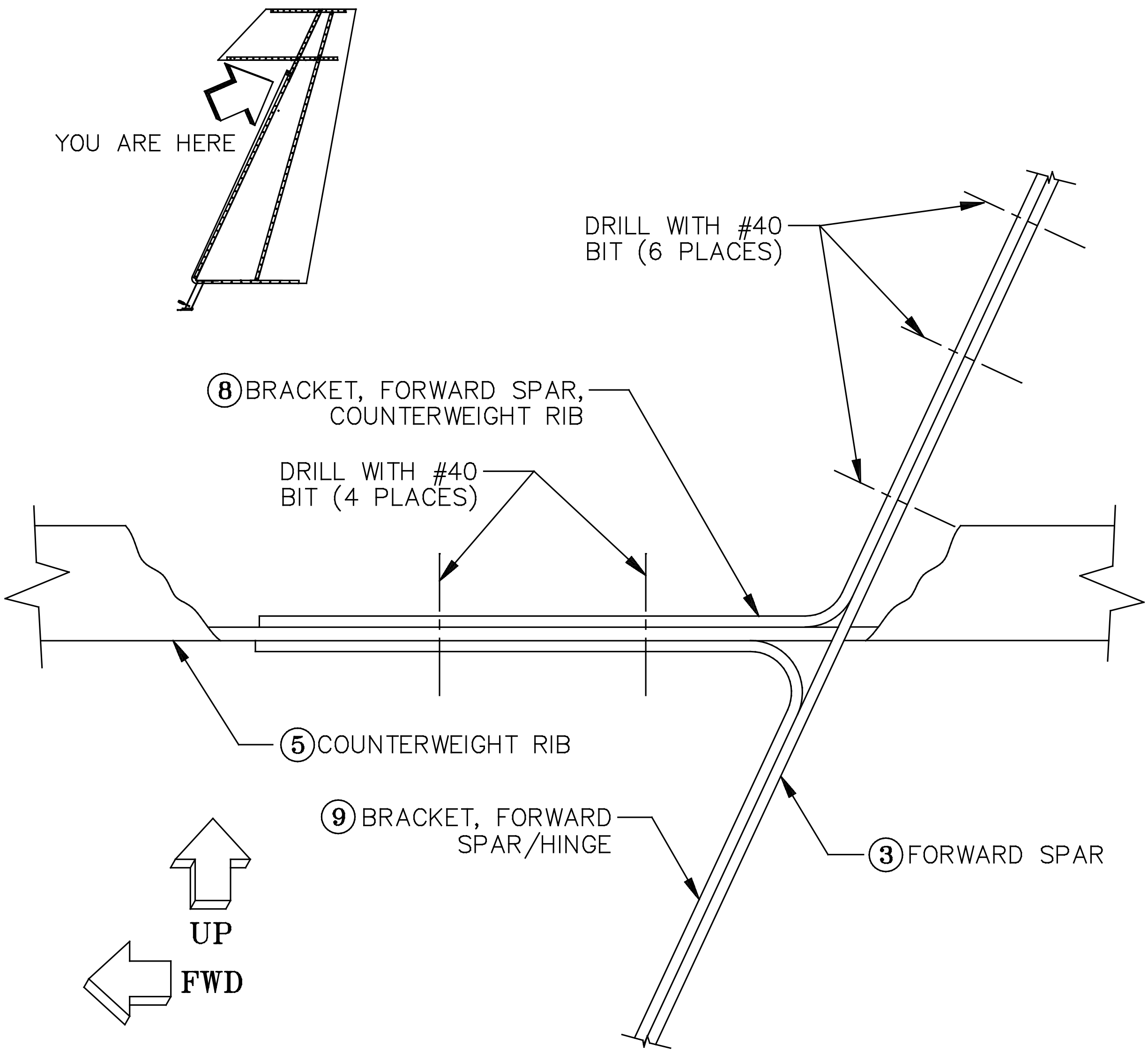

Figure 10: Forward Spar/Hinge Bracket Assembly

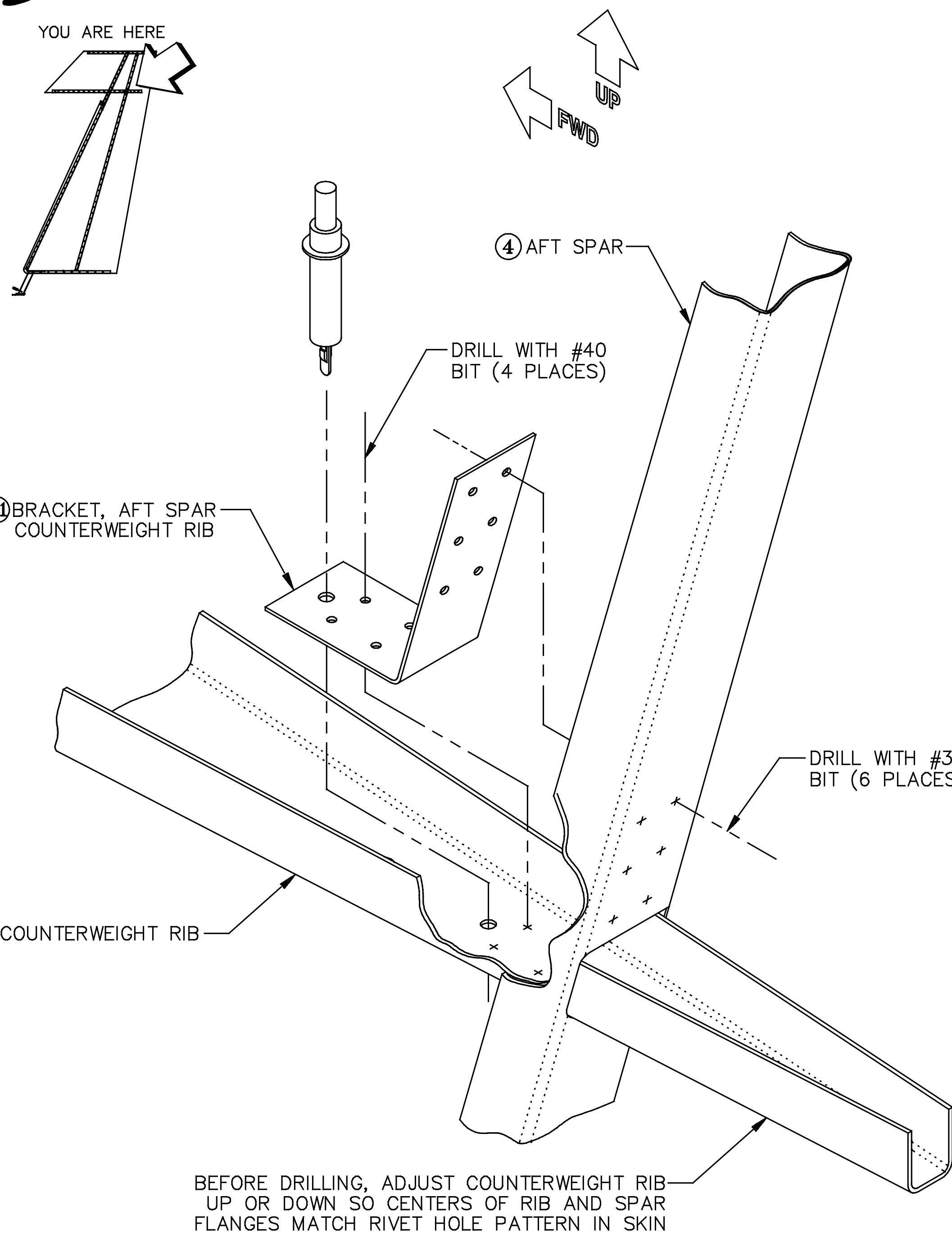

Figure 11: Aft Spar/Counterweight Rib Assembly

Cleco the **aft spar/counterweight rib bracket** [11] to the counterweight rib [5], as shown in Figure 11, using the single pre-drilled hole in each part. **Do not drill any holes yet.**

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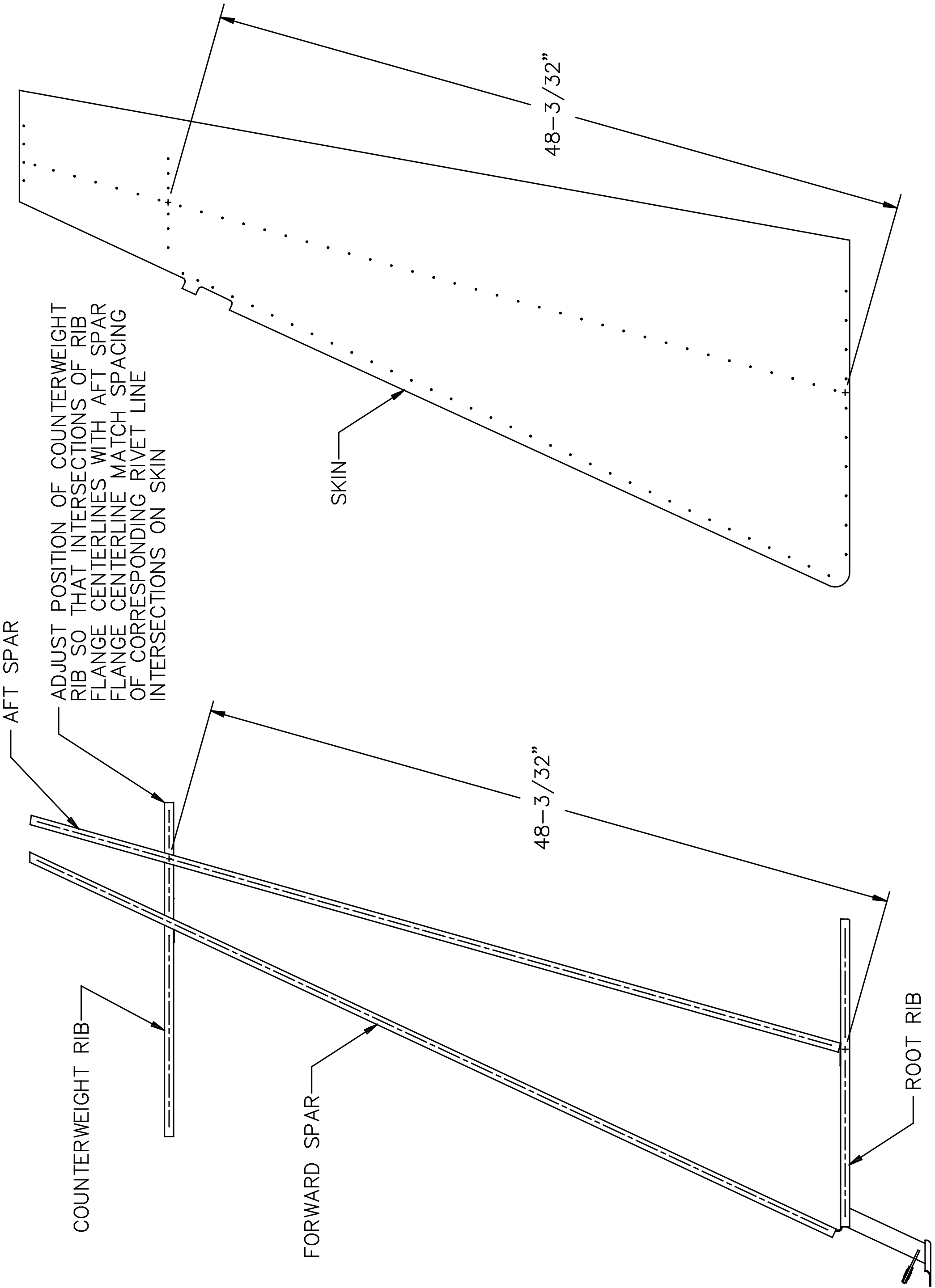


Figure 12: Setting the Vertical Position of the Counterweight Rib

Note Before drilling any holes in the aft spar/counterweight rib bracket, the counterweight rib must be positioned vertically relative to the aft spar such that the pre-punched skin holes will fall on the centers of the rib and spar flanges when the skin is installed. On the **skin**, the point where the **counterweight rib** rivet line intersects the aft spar rivet line is **48-3/32"** from the point where the **root rib** rivet line intersects the aft spar rivet line, measured along the aft spar rivet line. So, as shown in Figure 12, move the counterweight rib up or down, as necessary, until the centerline of its flange is **48-3/32"** from the centerline of the root rib flange, measured along the centerline of the aft spar flange. With the counterweight rib in this position, use small C-clamps to clamp the aft spar/counterweight rib bracket to the aft spar.

Now that the counterweight rib is correctly positioned relative to the aft spar, use the four pre-punched holes in the leg of the aft spar/counterweight rib bracket that fits against the counterweight rib as guides to drill **#40** holes through the **bracket** and the **rib**, as shown in Figure 11. Use the holes in the leg of the bracket that fits against the spar as guides to drill six **#30** holes through the **bracket** and the **spar**. Cleco to maintain alignment while drilling.

Note The hole that you Clecoed initially through the bracket and the rib is simply an index hole to make alignment of the bracket easier. It does not itself need to be drilled to any final size, nor does it need to be riveted later, although you may do so if you wish.

Completed: [ ]

PRELIMINARY ASSEMBLY OF THE SKINS TO THE STRUCTURAL FRAMEWORK

Step 11: Slide the Skin into Place

With the spar/rib assembly still in the jig, slide the rudder **skin** [1] into place over it.

Hint To keep the skin from becoming scratched, leave the protective covering on until you are ready to begin riveting.

Verify that the trailing edge of the skin is centered over the trailing edge line on the table. Fasten scrap wood blocks to the table near the lower end of the skin, as shown in Figure 4, to keep the skin centered over the trailing edge line. If necessary, adjust the supports described in Step 7 to center the spars and the upper end of the skin trailing edge over the trailing edge line.

Adjust the position of the spar/rib framework inside the skin so that the centerlines marked on the spar and rib flanges in Step 2 show through the pre-punched pilot holes in the skin. Also, align the lower edges of the skin with the edges of the root rib flanges, and align the leading edges of the skin above the counterweight rib with the forward spar flanges. Use side grip clamps or small C-clamps to secure the skin in several places to the spar/rib framework.

Note If the aft spar is bowed slightly, you may not be able to align its marked rivet lines with the rivet holes in the skin for its entire length. Just do the best you can for now; the alignment will be adjusted before drilling.

Completed: [ ]

Step 12: Drill and Cleco the Skin

Use the pre-punched holes in the skin as guides to drill the **#40** rivet holes through the assembly. First, drill the two holes on each side where the counterweight rib rivet line intersects the forward and aft spar rivet lines. Cleco the intersection holes.

Hint You may find it helpful to take the assembly out of the jig and lay it on a flat table to drill the first half dozen holes on one side. The advantage of doing this is that it's easier to align the skin rivet holes with the rivet centerlines on the framework when the assembly is flat. The table also provides firm support to keep the pressure of your drill from forcing the rudder out of alignment while drilling. If you decide to use this method, just drill and Cleco the holes where the counterweight rib intersects the forward and aft spars and then drill and Cleco a couple of holes through both the root rib and the forward spar. Return the rudder to the jig and clamp the skin on the other side to finish drilling.

Now, drill the forward spar on both sides **below the counterweight rib only**, inserting a Cleco into every third to fifth hole after drilling. Follow standard procedures for drilling a line of holes, as described in "SECTION II: TOOLS AND TECHNIQUES:" first, drill holes at the end of the line and at several places along the line; Cleco these first holes to maintain alignment, and then drill the intervening holes.

Note As always, the word "below" refers to a direction **as installed in the aircraft**, not relative to the jig.

Next, drill and Cleco the root rib and the counterweight rib. Finally, verify that the rivet lines on the aft spar flanges are properly aligned with the rivet holes in the skin, and drill and Cleco the aft spar. If the aft spar is bowed, lift the skin on one side so you can reach in to align the spar with its rivet holes; drill enough holes to hold the spar in alignment and then re-Cleco the skin on both sides and finish drilling.

> **Note** The holes for the front spar **above the counterweight rib** are not pre-drilled through the skin. Do not drill these holes at this time. The pre-drilled holes in the **forward skin** [2] will be used as guides to drill these holes in the next step. Also, **1/8"** pull rivets will secure the skin to the counterweight rib **aft of the forward spar only.** Use a **#30** bit to drill these holes.

Completed: [ ]

Step 13: Drill and Cleco the Forward Skin

Mark forward spar rivet lines **above the counterweight rib** on both sides of the rudder skin. To do this, use a straightedge to extend the existing lines of forward spar rivet holes to the top of the skin, and mark the lines with a felt pen. Make sure the rivet line corresponds with the center of the forward spar flange at the top.

> **Note** Some adjustment of the counterweight rib flange angles will be necessary before the **forward skin** [2] can be installed. The rib flanges are hydroformed at 90°, which isn't an exact match, especially near the leading edge of the forward skin. Use smooth or padded duck bill pliers to adjust the flanges.

Position the **forward skin** [2] on the rudder assembly. Align the pre-punched rivet holes along its aft edges with the rivet centerlines just marked; align the row of pre-punched holes along its lower edges as nearly as possible with the rivet lines marked on the counterweight rib flanges.

Use nylon strapping tape, some extra hands, and/or large C-clamps (padded) to secure the forward skin to the counterweight rib.

> **Note** When the pre-punched rivet holes along the lower edge of the forward skin are aligned with the rivet lines on the counterweight rib, the skin will probably hang down a bit below the bottom of the rib, but that's OK. Likewise, the top of the forward skin may not be perfectly aligned with the top of the main skin; that's OK too.

Install the **tip rib** [7] and position it with its leading edge **10-1/8"** forward of the forward spar web. (Adjust the rib flanges with duck-bill pliers to fit the contours of the forward skin.) Use side-grip clamps or small C-clamps to clamp the tip rib to both the rudder skin and the forward skin.

> **Note** If necessary, trim the upper ends of the forward and aft spars so that the tip rib can be installed with the upper edges of its flanges even with the upper edges of the skins. Trim enough to provide a small gap (approximately 1/32") between the tip rib and the ends of the spars.

Use the pre-punched holes in the forward skin as guides to drill **#40** holes through the skins, the counterweight rib and the forward spar. Insert a Cleco into every other hole after drilling.

Drill **four #40** rivet holes per side through the skins and the tip rib in the locations shown in Figure 13. Center the holes vertically on the tip rib flanges. The forward hole is centered between the first and second flutes in the rib; the second hole is centered between the second and third flutes; the third hole is **5-3/4"** from the aft end of the rib; the last hole is centered on the overlap between the two skins.

Completed: [ ]

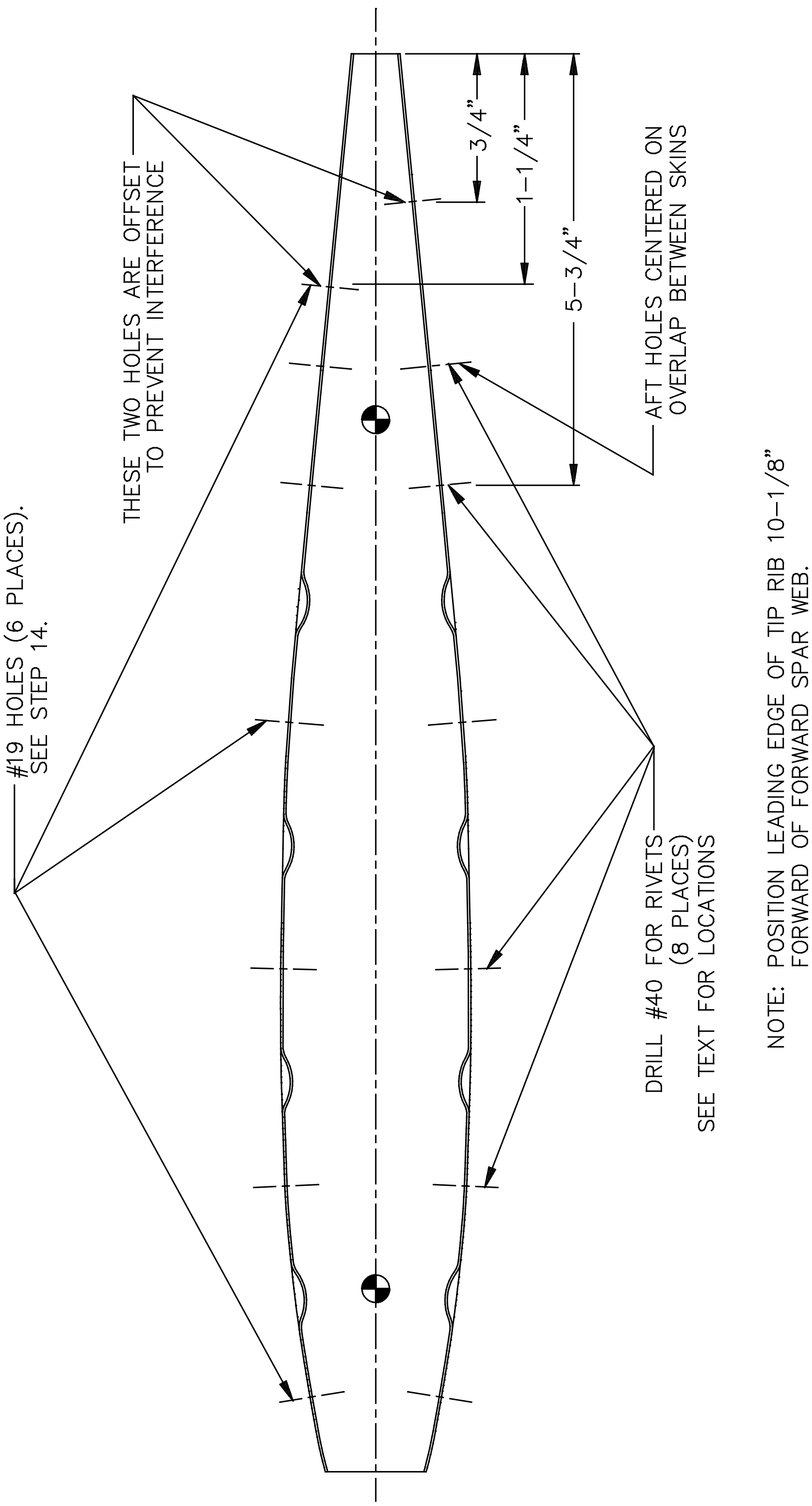
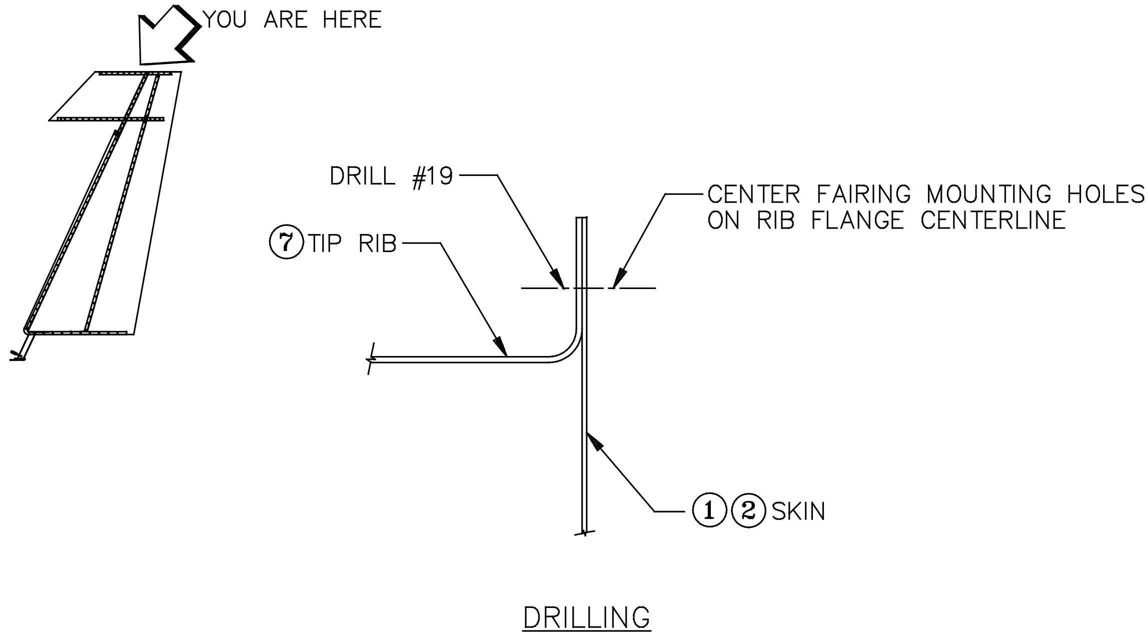


Figure 13: Tip Rib Hole Locations



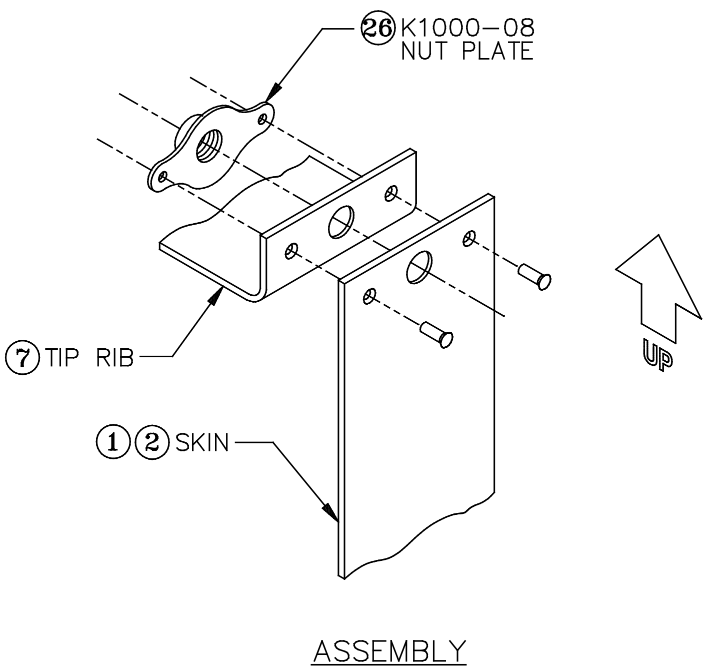


Figure 14: Tip Fairing Nutplate Installation

Step 14: Drill Holes for Mounting the Tip Fairing

Note The rudder tip fairing is shipped as **left** and **right tip fairing halves** that you will seam together using fiberglass cloth and vinyl ester resin. Since the resin has a limited shelf life, however, it won't be shipped until you request it for work on the fuselage. Instructions for installing nutplates to mount the rudder tip fairing are included in this section. Instructions for seaming the fairing halves together and for final mounting are included in "SECTION X: FINAL ASSEMBLY."

Mark the locations of the tip fairing mounting holes on the outside of the rudder skins on both sides, as shown in Figure 13. The holes are centered vertically on the tip rib flanges. The forward hole is midway between the tip rib leading edge and the first flute; the second hole is midway between the third and fourth flutes; the third hole is **3/4"** from the aft end of the tip rib on one side and **1-1/4"** from the aft end of the tip rib on the other side. Drill **#19** holes through the tip rib and the main and forward skin at the six marked locations.

Note The two mounting holes near the trailing edge are intentionally staggered relative to each other to facilitate installing the nutplates and to prevent interference between the two mounting screws.

Use a **#40** drill bit to drill mounting holes for K1000-08 **nutplates** [26] through the skins and the tip rib flange at every #19 hole, as shown in Figure 14. Use the nutplates themselves as guides for drilling the rivet holes.

Completed: [ ]

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FINAL RUDDER ASSEMBLY

Step 15: Disassemble, Clean and Deburr

Remove all of the Clecos to completely disassemble the rudder assembly.

Use a hole deburring tool or a drill bit to deburr the rivet holes in all of the parts. Use an air nozzle to remove all drilling chips, both from the parts and from the work table.

Completed: [ ]

Step 16: Dimple the Skin, the Forward Spar and the Tip Rib

Use 3/32" dimple dies and either a rivet squeezer or a riveting frame to dimple the rivet holes in the forward spar flanges below the counterweight rib and the corresponding holes in the skin.

Note Dimple **only** the rivet holes below the counterweight rib. “Below” means closer to the bottom of the aircraft **as installed**, not as it is positioned in the jig.

Also, dimple the eight tip rib rivet holes in both the skin and the rib. Finally, dimple the rivet holes for mounting the nutplates to the skins and the tip rib. (Do not dimple the holes for the screws that will secure the tip fairing.)

Completed: [ ]

Step 17: Fabricate the Lead Counterweight

Cut **4"** long pieces of the **lead sheet** [17] shaped to fit between the flanges at the leading edge of the counterweight rib; cut enough pieces to make a **1-1/2 lb.** (680 ±20 grams) counterweight. Stack the lead pieces and clamp them in place in the counterweight rib, as shown in Figure 15. (The stack might have to angle back slightly as it goes up to clear the inside of the forward skin.) Drill two **#10** holes through the counterweight rib/counterweight assembly in the locations shown.

Note Don't worry about the loss of mass due to the bolt holes; the specified 1-1/2 pounds provides adequate material to produce the proper final mass.

Hint Drilling through lead can be rather difficult. The drill bit tends to pull itself into the soft material, which causes binding. Use drill wax, soap, or some other lubricant on the drill bit and work slowly, backing off frequently to clear the chips. Since the bit tends to bind, make sure the work is clamped securely to prevent damage or injury. You can also grind flats onto the cutting edges of the drill bit so that they meet the material at a steeper angle; this reduces the tendency of the bit to pull into the material.

Mark the locations of the rivet holes in the counterweight rib flanges onto the lead counterweight. Disassemble the lead counterweight from the rib and use a **#10** bit to drill a **1/2"** deep hole into the counterweight at each rivet location. (Again, don't worry about the loss of mass.) These holes provide clearance for the 1/8" blind rivets that will be used to secure the forward end of the forward skin to the counterweight rib. Use a **#30** bit to enlarge the four rivet holes at the forward end of the counterweight rib flange on each side to accommodate the 1/8" blind rivets. Also use a **#30** bit to enlarge the corresponding holes in the forward skin.

Hint We made a template from thin aluminum sheet to fit between the rib flanges and then drilled the two #10 mounting holes through the template and the rib. We then used the template to cut the counterweight pieces from the lead sheet, drilling the mounting holes as we went. The counterweight was bolted into place and the rivet holes in the rib flanges used as guides to drill into the counterweight, marking the locations of the rivet holes.

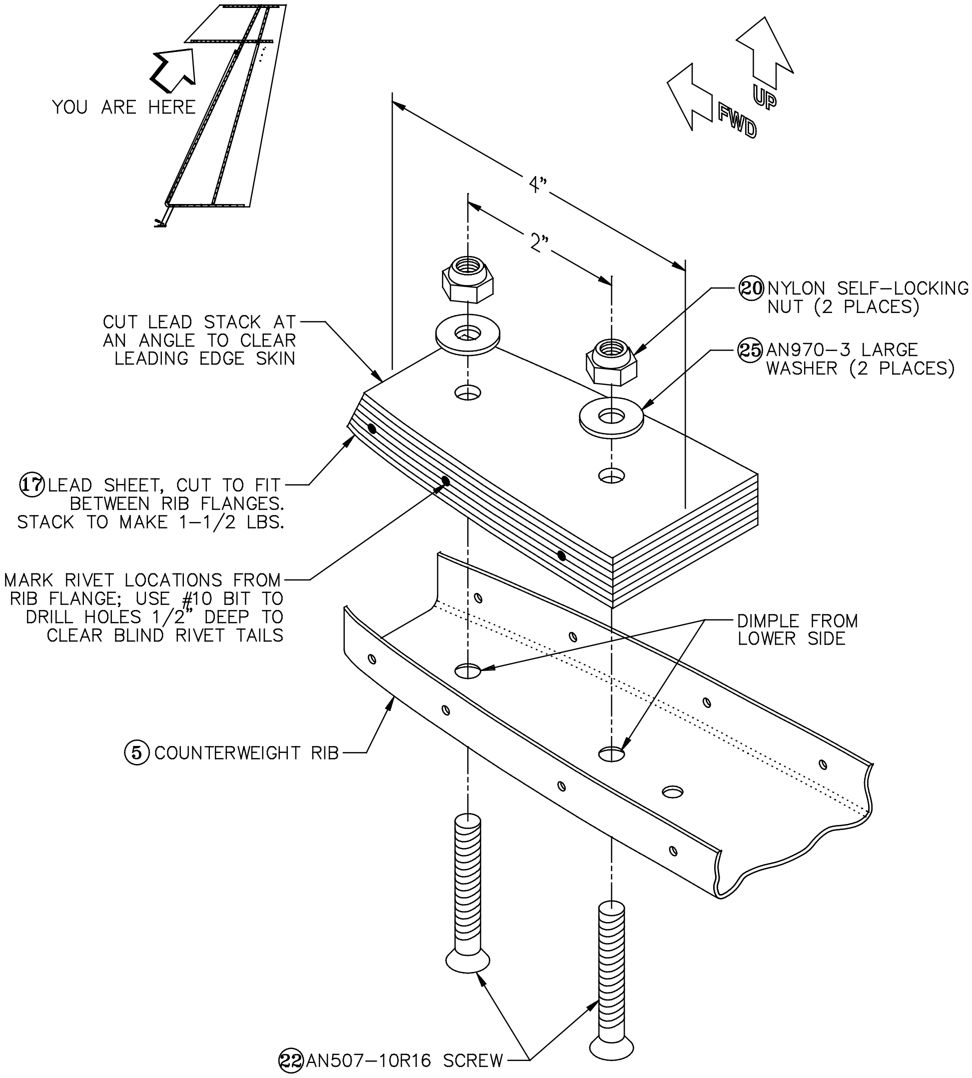


Figure 15: Lead Counterweight Assembly

Dimple the counterweight mounting holes in the counterweight rib to match the heads of the mounting screws. You can make your own female dimpling die for this application by drilling and countersinking a **3/16"** hole in a hardwood or aluminum block. Use the mounting screw itself as the male die, and drive it with a hammer or a flush rivet set to deform the rib into the female die.

Countersink the mounting holes in the lead counterweight so they fit over the dimples in the ribs. Set the counterweight aside for later installation.

Completed: [ ]

Step 18: Apply Corrosion Protection

At this time, apply the corrosion protection of your choice to the rudder components. At the very least, first apply an aluminum cleaner or an acid etch and then alodine all interior parts. Refer to "INTERIOR CORROSION PROTECTION" in "SECTION II: TOOLS AND TECHNIQUES" for a further discussion of this subject.

Completed: [ ]

Step 19: Install the Counterweight

Fasten the lead counterweight to the counterweight rib with the AN507-10R16 **screws** [22], AN364-1032A **nuts** [20], and AN970-3 **washers** [25]. Apply packing tape between the lead counterweight and both the aluminum rib and the steel fasteners to help prevent corrosion caused by contact of the dissimilar metals (or just apply a thick coat of paint to the counterweight before installation).

Completed: [ ]

Step 20: Rivet the Rudder Assembly Together

Hint Before riveting the rudder assembly, you must remove the protective plastic covering from the skins, at least along the rivet lines. An easy way to do this is to run a hot soldering iron down both sides of the rivet line to melt through the plastic. Then you can peel off the plastic between the melted lines.

Note As you're riveting the rudder assembly together, it is very important to continually check that the assembly is straight and untwisted as you proceed. Before starting, verify that the support blocks center the rudder over the trailing edge line on the table. To help make sure the rudder is straight, you can also run a string line from the vertical centerline on the spar support board, through the forward tooling holes in both the counterweight and the tip ribs, and down to the trailing edge line on the table. Follow standard procedures for installing a line of rivets: start by driving rivets at the center and each end of the line; then drive a rivet halfway between the center and the end on each side; continue in this manner, driving rivets at the centers of unriveted areas, until the line is finished. Check frequently for twist by sighting down the rudder assembly from the top. If the rudder begins to twist, apply force in the opposite direction from the twist and ream the rivet holes to bring the structure back into line.

Rivet the rudder assembly together in the sequence listed below. Place the parts in the rudder jig while riveting, and use as many Clecos as you can, to ensure that the assembly remains straight and true. The rivet type and diameter for each location is specified; choose a rivet of the proper length as described in "SECTION II: TOOLS AND TECHNIQUES".

Work in this order:

a) Rivet the aft spar/root rib bracket [12] to the aft spar [4] with 3/32"-diameter, AN470AD3 universal-head rivets. See Figure 7.

b) Using 3/32"-diameter, AN470AD3 universal-head rivets, rivet the skin [1] to both sides of the **aft** spar [4] **below the counterweight rib only**. Rivet the skin to **one side only** of the aft spar **above** the counterweight rib. **Do not install rivets where the counterweight rib fits through the aft spar.** Inspect your work and replace any defective rivets before proceeding.

c) Rivet the hinge mounting plate [10] and the forward spar/hinge bracket [9] to the forward spar [3], using 3/32" AN470AD3 universal-head rivets. Use 3/32" AN426AD3 flush-head rivets to rivet the K1000-4 **nutplates** [27] to the forward spar assembly. Refer to Figure 3.

d) Rivet the root rib [6] and the forward spar [3] to the yoke weldment [16], using 1/8" AN470AD4 universal-head rivets. Wherever possible, install the rivets with the tails (shop heads) on the yoke side and the manufactured heads on the aluminum side. See Figures 4 and 6.

e) Insert the counterweight rib [5] through the hole in the forward spar [3]. Use 3/32" AN470AD3 universal-head rivets to rivet the forward spar/counterweight rib bracket [8] to the counterweight rib, the forward spar/hinge bracket and the forward spar. See Figures 8 and 10.

Note The two #30 holes through these two brackets and the rib were intended to serve only as alignment holes. However, if you prefer, you can certainly put 1/8" rivets in them.

f) Rivet the aft spar/counterweight rib bracket [11] to the **counterweight rib** [5], using 3/32" AN470AD3 universal-head rivets. Refer to Figure 11.

g) Slide the yoke/forward spar/counterweight rib/root rib assembly into the aft spar/skin assembly, inserting the aft end of the counterweight rib through the hole in the aft spar.

h) Use 1/8" AAPQ-42 Cherry Q pull rivets to rivet the aft spar/counterweight rib bracket [11] to the aft spar [4]. See Figure 11. This is a tight fit for your rivet puller and will require carefully lifting up the skin for access.

i) Rivet the skin [1] to the aft spar [4] above the counterweight rib, using 3/32" AN470AD3 universal-head rivets. Again, gently lift up the skin for access for a small bucking bar. Start at the counterweight rib and work upwards to the top.

j) Use 3/32" AN470AD3 universal-head rivets to rivet the aft spar/root rib bracket [12] to the root rib [6]. See Figure 7. Carefully lift up the skin to gain access inside.

k) Cleco the skin to the root rib, counterweight rib and forward spar.

l) Rivet the skin to the root rib, using 3/32" AN470AD3 universal-head rivets. You can use a rivet squeezer here.

m) Blind rivet the skin to the counterweight rib **aft of the forward spar**. Use 1/8" AAPQ-42 Cherry Q rivets.

n) Rivet the skin to the forward spar **below the counterweight rib**, using 3/32" AN426AD3 flush-head rivets.

o) Rivet the forward skin to the counterweight rib and to the forward spar. Use 1/8" AAPQ-42 Cherry Q rivets for the four rivets on each side in the area of the lead counterweight; for three of these rivets on each side, the tails fit into the #10 holes drilled in the counterweight in Step 17 (the fourth will be just aft of the counterweight). Use 3/32" AN470AD3 universal-head rivets for the rest of the rivets in the counterweight rib and for the spar. Gain access for bucking from the open top of the rudder.

p) Rivet the tip rib into place, using four flush rivets per side in the locations described in Step 13.

q) Using 3/32" AN426AD3 flush-head rivets installed through both the tip rib and the skins, rivet the K1000-08 nutplates to the insides of the tip rib flanges. Refer to Figure 14. (Mounting the fairing itself will be described in "SECTION X: FINAL ASSEMBLY.")

Completed: [ ]

Step 21: Install the Hinge and the Hinge Shim

Bolt the **hinge shim** [14] and the **hinge** [13] to the forward spar using the AN4-6A bolts and AN960D416 **washers** [24].

Hint After the hinge installation is complete, we recommend marking the bolt heads with a product called "Torque Seal," which is a colorful paste used as an inspection aid. Torque Seal is applied across the interface between two objects (the end of a bolt and its nut, for example, or a fitting and the bolt head that secures it) that you want to ensure are not moving relative to each other. Movement between the two objects breaks the seal, indicating the need for remedial action. Stoddard-Hamilton offers Torque Seal in a set of five different colors. Order P/N 620-0642-501.

Completed: [ ]

Step 22: Check the Rudder Trailing Edge for Convexity and Adjust, If Necessary

Because of the size of the bend radius along the trailing edge of the rudder skin, the finished rudder can have a slight convexity in the trailing edge cross-sectional profile (see Figure 16a). This condition can have a negative effect on the directional stability of the finished aircraft and is thus unacceptable. A tighter bend radius along the trailing edge will produce either a perfectly flat (Figure 16b) or slightly concave (Figure 16c) cross-sectional profile, and either of these conditions results in desirable flight characteristics.

Inspect the trailing edge profile of your finished rudder either by sighting along the trailing edge or by laying a straightedge across the trailing edge parallel to the rudder chord. If the profile appears flat (as in Figure 16b) or slightly concave (as in Figure 16c), no further action is required. **If the profile appears slightly convex** (as in Figure 16a) **at any point along the trailing edge, then the corrective procedure described below is mandatory before flight.**

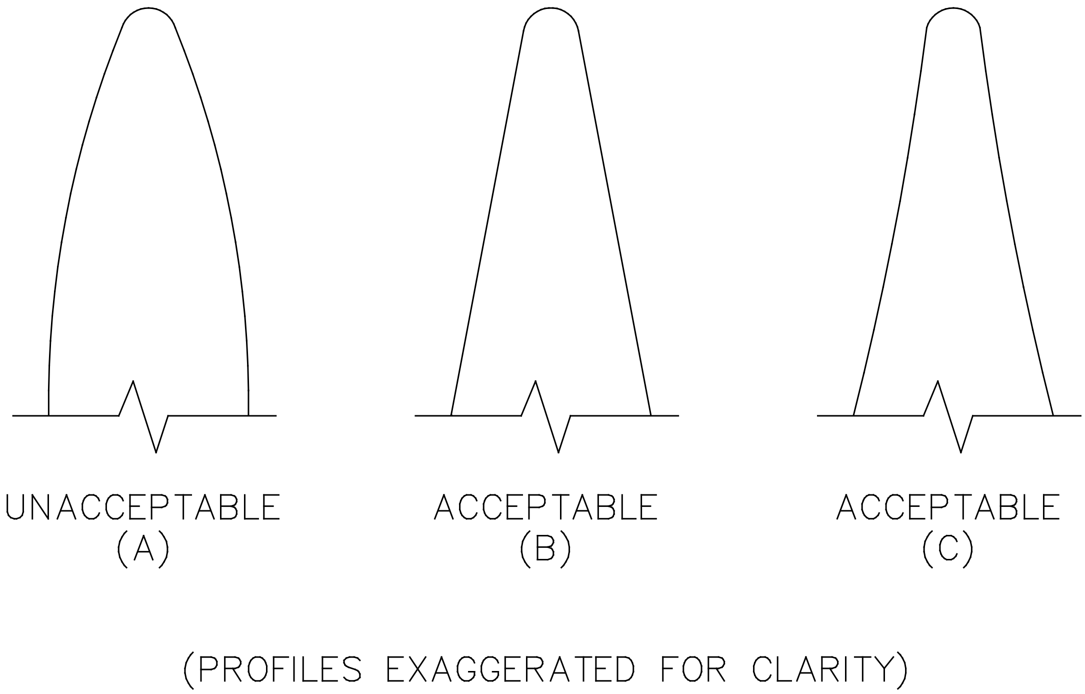


Figure 16: Possible Rudder Trailing Edge Cross-Sectional Profiles

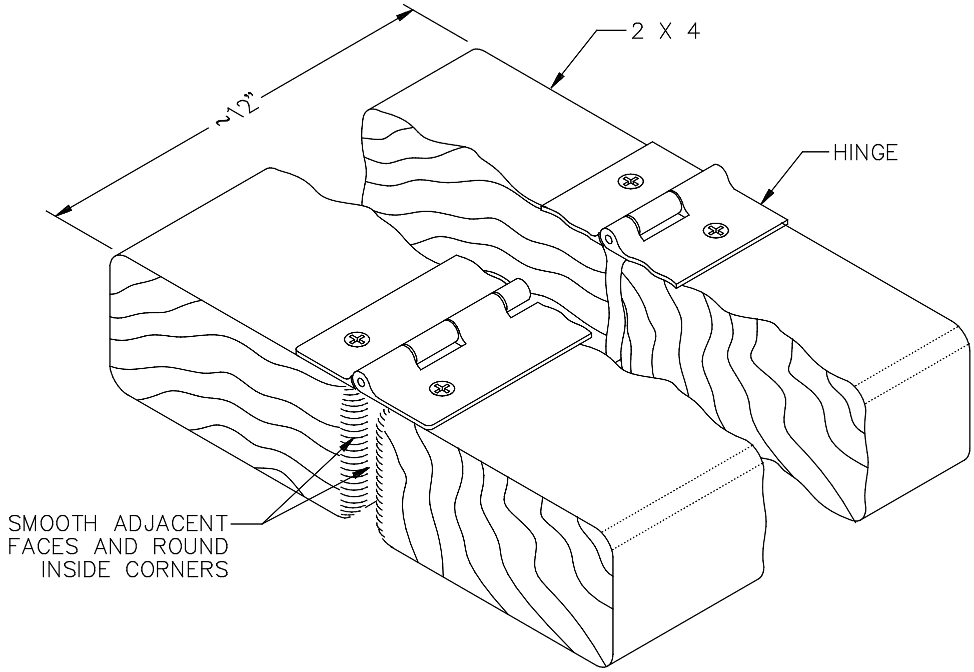


Figure 17: Tool for Tightening the Trailing Edge Bend Radius

The convexity of the trailing edge can be corrected quickly and easily using a squeezing tool constructed from two pieces of 2 X 4 lumber hinged together, as shown in Figure 17. Cut two pieces of 2 X 4 approximately **12"** long. Remove any surface irregularities from one narrow edge of each piece on a belt sander or jointer, and then put a generous radius on the corners at the ends of these faces. Join the two pieces with these faces adjacent to one another using a hinge or hinges. Any variety of piano hinge (either hardware-store or aircraft grade) works especially well, but 2–4 strap hinges (depending on size) will work fine, too. Set the gap between the 2 X 4s at about **1/8"** and secure the hinges with sheetrock screws.

Figure 18 shows how the tool is applied to the trailing edge of the rudder to tighten the radius of the trailing edge bend and thus to remove the convexity from the trailing edge profile. Work the tool gradually along the entire trailing edge, moving it 6–8" each time. Each squeeze of the tool should overlap the one before it. Only very moderate pressure is required; it's much better to make two or three passes along the trailing edge pressing gently than to try to do the entire job in one pass.

Check the trailing edge profile after each complete pass. When the convexity disappears, stop.

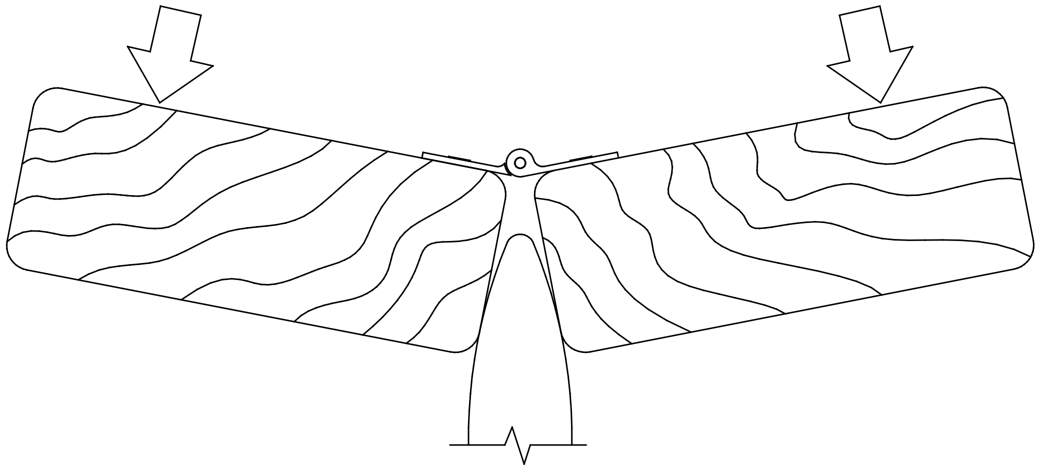


Figure 18: Tightening the Trailing Edge Bend Radius

Caution Squeezing the tool too hard can result in kinks or waves in the trailing edge. These problems will also result if you fail to round the inside corners of the blocks, as shown in Figure 2. Be aware that the skin will yield more easily near the ends than it will in the middle; relatively greater pressure may be required in the middle of the trailing edge.

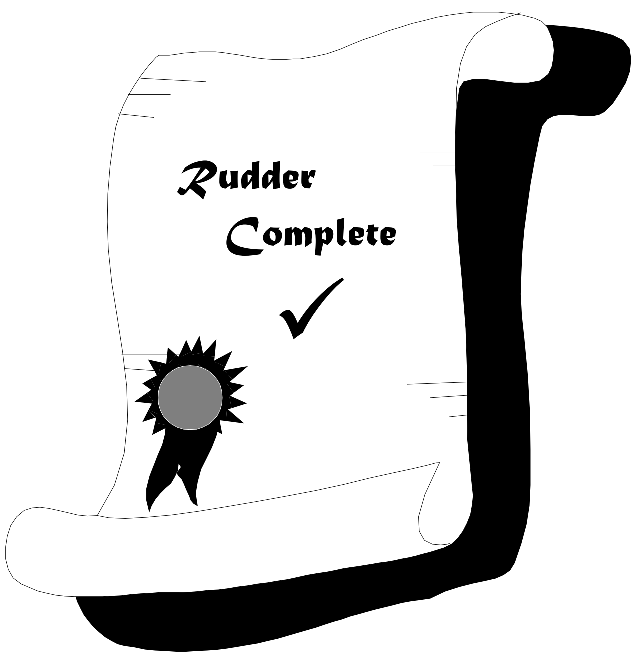
If you wish to eliminate the risk of kinking the trailing edge, you can build a tool similar in design to the one described above, but using boards long enough to crimp the entire length of the skin at once. However, such a tool will require exceptionally straight lumber. Also, it will need to be clamped to a bench top or in a vise, and you'll have to fashion extension handles on the unclamped board to provide enough leverage to crimp the skin successfully.

Completed: [ ]

Note Now that the rudder has been completed, store it carefully in a safe place to prevent damage until it is needed for mounting to the fuselage. Mounting the rudder will be described in "SECTION VIII: FUSELAGE ASSEMBLY."

CONGRATULATIONS!

You've completed the rudder assembly! You're off to a good start and are ready to move on to the next major component, the horizontal stabilizer.



SECTION IV: HORIZONTAL STABILIZER ASSEMBLY

PARTS LIST

Key No.:	Part Name:	Qty:	Part No.:
1	Skin, left	1	302-00001-01
2	Skin, right	1	302-00002-01
3	Spar, forward	1	302-00003-01
4	Spar, aft	1	302-00004-01
5	Doubler, forward spar web, front	1	302-00005-01
6	Doubler, forward spar web, rear	1	302-00006-01
7	Bracket, aft attach	1	302-00007-01
8	Cap, forward spar	2	302-00008-01
9	Rib, nose	12	302-00009-01
10	Rib, main, left-flange	6	302-00010-01
11	Rib, main, right-flange	6	302-00010-02
12	Pin, alignment	2	302-00011-01
13	Flange, main rib	1	302-00012-01
14	Tape, aluminum, 2" width	265"	062-00001-01
15	Bracket assembly, forward attach	1	300-01000-01
16	Nut	3	AN315-6R
17	Nut, nylon self-locking	3	AN365-624A
18	Washer	3	AN960D616

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TOOL LIST

1. Screwdriver (cordless electric recommended)
2. Try square or combination square
3. Duck bill pliers (with jaws taped to protect Alclad aluminum parts)
4. Assorted flat and round files
5. Edge deburring tool (optional)
6. Rule, 12", graduated in 1/32nds of an inch
7. Fine-point marking pen
8. Clecos, 3/32" and 1/8" (approximately 150 and 100 each, respectively), with pliers
9. Cleco side-grip clamps or small C-clamps (approximately 10)
10. Digital level, accurate to 1/2° (recommended) or carpenter's level (acceptable)
11. Electric or pneumatic drill motor with #40, #30 and 1/16" bits
12. Rib alignment probe, or scriber or awl
13. Straightedge, 72" or longer
14. Hole deburring tool
15. Tape measure
16. Adjustable wrench or 9/16" open-end wrench
17. Aviation snips, straight and offset
18. Belt sander, bench-mounted (optional)
19. Bandsaw or scroll saw (optional)
20. Center punch
21. 90° drill motor or adapter, with bits
22. Universal-head rivet sets, 3/32" and 1/8"
23. Rivet gun, air compressor and bucking bars
24. Socket wrench with 9/16" socket
25. Blind rivet puller
26. Rivet squeezer with 3/32" and 1/8" universal-head sets (optional)
27. Curved-tooth body file ("panzer file")

Additional Materials

1. Scrap wood blocks
2. Anti-corrosion primer
3. Four small sand or shot bags

Workspace

The horizontal stabilizer is built in one assembly. It has a total span of 119" and a chord of about 17-1/2". The main workspace requirement is thus a **flat** table of sufficient area. Keep in mind, however, that in the next section ("SECTION V: ELEVATOR ASSEMBLY"), the elevator will be mounted to the horizontal stabilizer, resulting in an overall assembly that is 129" X 35". Plan your workspace accordingly. As with the rudder assembly, it may be best to build the stabilizer on one end of the wing jig table described in "SECTION VI: WING ASSEMBLY."

Other than the flat table mentioned above, no jig is required to build either the stabilizer or the elevator. To help avoid the introduction of twist into the stabilizer, clamps and/or sand or shot bags will be used to hold the stabilizer flat to the table while drilling and riveting.

Caution Be very careful and take your time when removing the protective covering from aluminum sheets. If you pull too hard in the wrong direction, you could permanently crease or kink the sheet. To remove the covering, start from one end and then hold that end down while pulling the covering low and parallel to the surface. Do not pull the covering up perpendicular to the surface. Additionally, take care when picking up large pieces of sheet metal (like the stabilizer skins, for example) that have a joggle or a bend in one edge. If you allow the sheet to flex perpendicular to the bent edge, you will crease it, and such creases are difficult or impossible to remove.

Note Figure 1 has been deleted by Revision C.

Assembly Sequence

The configuration of the horizontal stabilizer is shown in Figure 2. The basic assembly sequence consists of a positioning and drilling phase and a riveting phase. In the former, the ribs and spar web doublers are first drilled and Clecoed to the spars. Next, the skins are positioned on the spar/rib assembly, and the pre-punched skin holes are used to guide the drilling of rivet holes in the underlying structure. Then the skins are removed and additional components—spar caps and the aft attach bracket—are positioned and drilled. Finally, the assembly is riveted together.

The primary goal of the horizontal stabilizer assembly procedures is essentially the same as for the rudder assembly—to produce a straight part without bends, bows or twists. It is especially important to maintain a straight trailing edge on the upper surface of the stabilizer, as this is where the elevator hinge fastens; the elevator hinge line must be straight to allow free movement of the elevator. To accomplish these goals, it is very important to pay careful attention to the proper alignment of all the parts as assembly proceeds. In particular, make sure that the spars are held straight from end-to-end when the skins are positioned and drilled; since the stabilizer skin is supplied in two pieces, it's possible to end up with a "kink" in the stabilizer at the skin junction if you're not careful. Also, as in all other sheet metal work, it's important to satisfy the minimum edge distance requirements for rivet holes, as described in "Section II: Tools and Techniques." Besides weakening the assembly, inadequate edge margins can also affect the straightness of a part—if a row of rivet holes on a spar is allowed to drift too close to the edge for part of its length, for example, the result will almost certainly be a twisted stabilizer after riveting. So, check the stabilizer for straightness and freedom from twist at every step and be sure that it is held straight for all drilling and riveting. Follow standard procedures for drilling lines of rivet holes and for driving lines of rivets, as described in Section II.

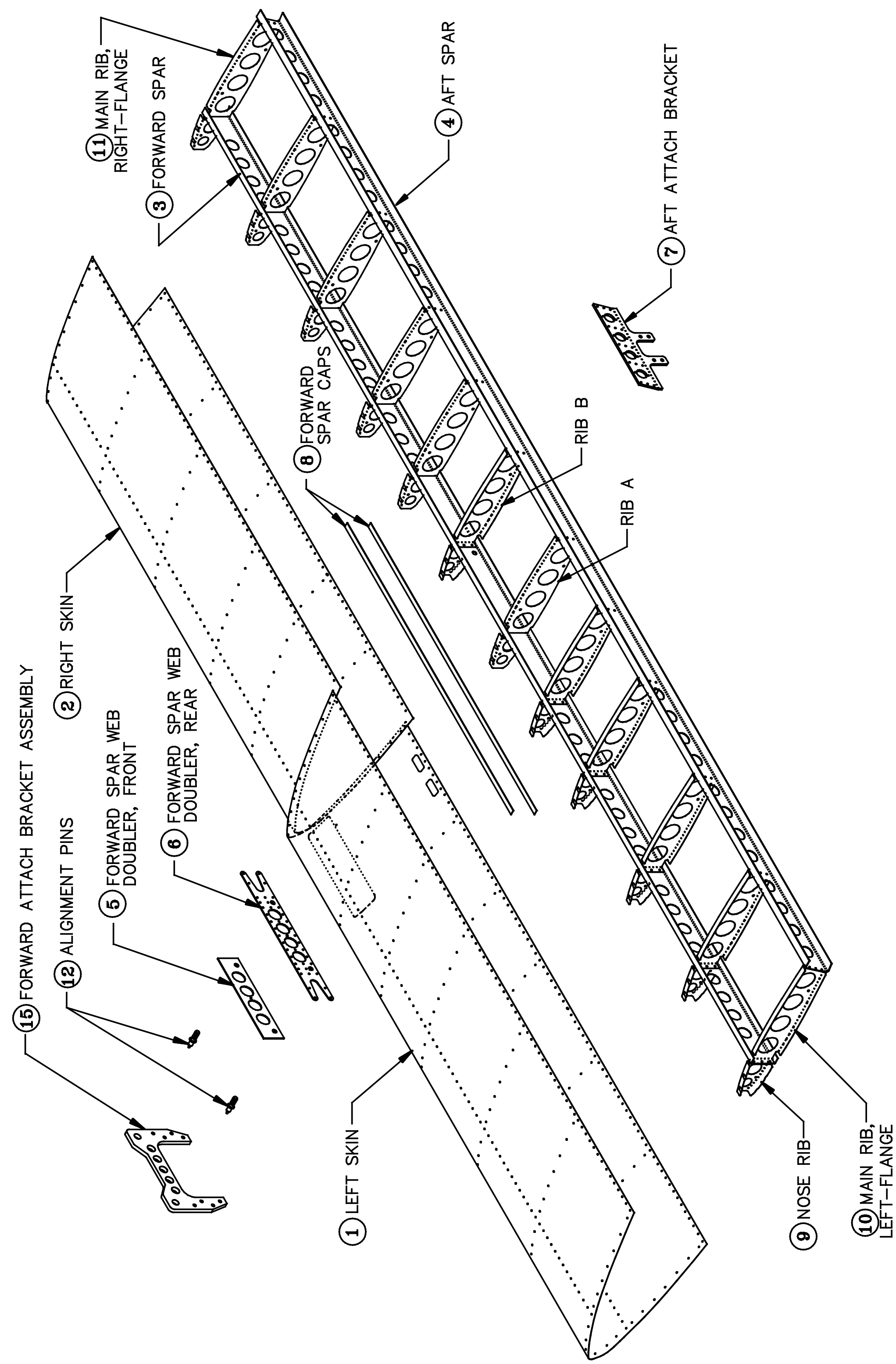


Figure 2: Horizontal Stabilizer Assembly

Positioning and Drilling

Step 1: Straighten and Deburr the Parts

Using a square, check the flanges on all the **nose ribs** [9] and **left-flange** [10] and **right-flange main ribs** [11] for squareness, straightening as necessary with a pair of duck bill pliers.

> **Note** **Left-flange** ribs are those ribs with flanges that project to the **left** relative to the aircraft when properly positioned in the assembly; **right-flange** ribs have flanges that project to the **right**. This nomenclature (which is also used in the wing, aileron and flap assemblies) is necessary because ribs of **both** flange orientations are used on **both** the left and the right sides of the assembly.

> **Note** Be sure to pad the jaws of your pliers to avoid scratching the Alclad aluminum. Simply wrapping the jaws in masking tape is sufficient.

Deburr the edges and lightening holes of all parts as necessary.

Completed: [ ]

Step 2: Mark Rivet Lines on the Flanges of the Nose Ribs and Spars

Using a **very fine** marking pen, mark centerlines on the upper and lower flanges of all the nose ribs. Rivet lines must also be marked on both the upper and lower flanges of both the **forward spar** [3] and the **aft spar** [4], but these are not strictly centerlines: as shown in Figure 3, mark these rivet lines parallel to and **3/8"** forward of the trailing edges of the spar flanges.

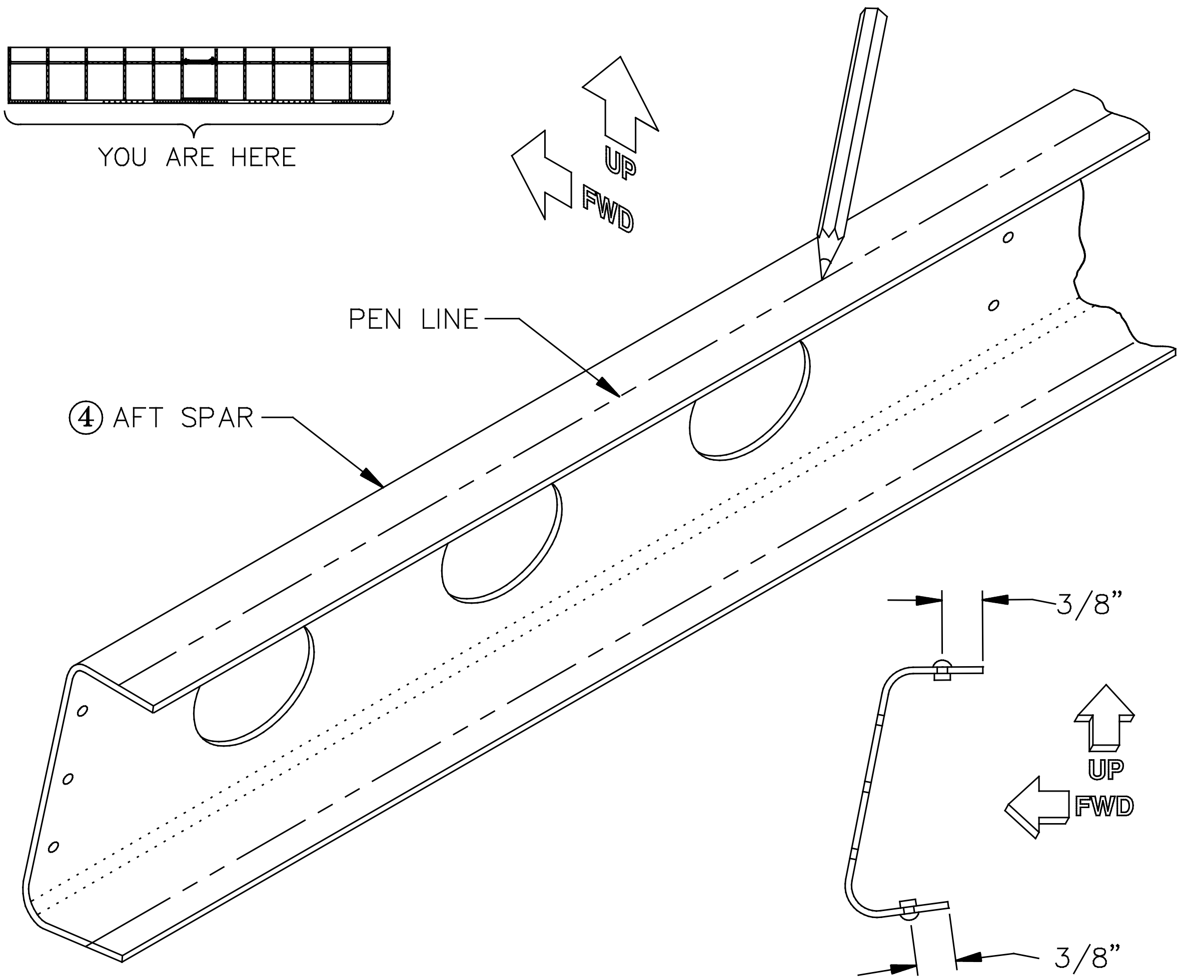


Figure 3: Aft Spar Rivet Lines

> **Note** As a result of the bending process, the spar is likely to have a slight bow in it when viewed from above. You will remove this bow in the process of aligning the skins over the spar, but in order for this to be successful, the rivet line you mark must remain **parallel** to the spar flange trailing edge. Do **not** mark a **straight** line if the spar is bowed.

Completed: [ ]

Step 3: Cleco the Main and Nose Ribs to the Forward Spar and Drill the Rivet Holes to Final Size

As shown in Figure 4, use two Clecos per rib through the pre-punched holes to clamp the main and nose ribs to the **forward spar** [3]. Each pair of Clecos holds both the main and nose rib at each position. Note that the forward end of the main ribs is the end with the flange perpendicular to the chord line. Also note that the forward spar **is not** perfectly symmetrical top and bottom; to orient it properly, make sure the two 3/8" holes near the center of the spar are **below the longitudinal centerline** of the spar. Finally, it is vital that the rib and spar flanges be oriented properly, as shown in Figure 2; the flanges of both spars should point **aft**, and all main and nose ribs should point **outboard**, **except** for Ribs A and B and their corresponding nose ribs, which should point **inboard**.

After all the ribs are Clecoed in place and you have confirmed that the flanges are properly oriented, mark each rib, specifying its location on the spar. Use any numbering or lettering system that makes sense to you; the important thing is simply that you be able to return each rib to its original position on the spar after repeated disassembly and reassembly.

Finally, juggling the Clecos as necessary, drill through the flanges of each main and nose rib and the corresponding spar web holes with a **#40** bit. Leave two Clecos holding each pair of ribs to the spar when finished.

Completed: [ ]

Step 4: Cleco the Aft Spar to the Main Ribs and Drill the Rivet Holes to Final Size

Again using two Clecos per rib through the pre-punched holes, clamp the aft spar to the ribs. Note that the aft spar also has a definite top and bottom. When properly mounted on the main ribs, the spar flanges should smoothly continue the curvature of the main ribs' upper and lower flanges (see Figure 4). If the spar flanges head off in different directions from the rib flanges, you have mounted the spar upside down!

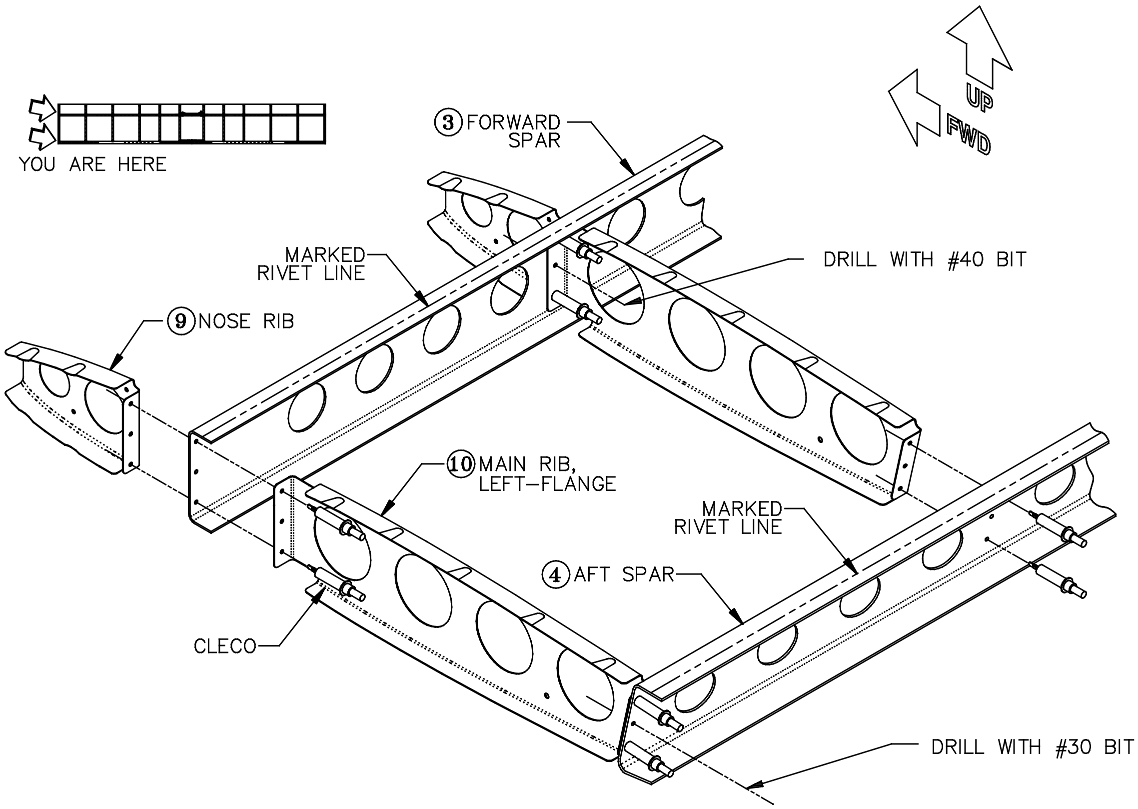


Figure 4: Clecoing the Spar/Rib Assembly

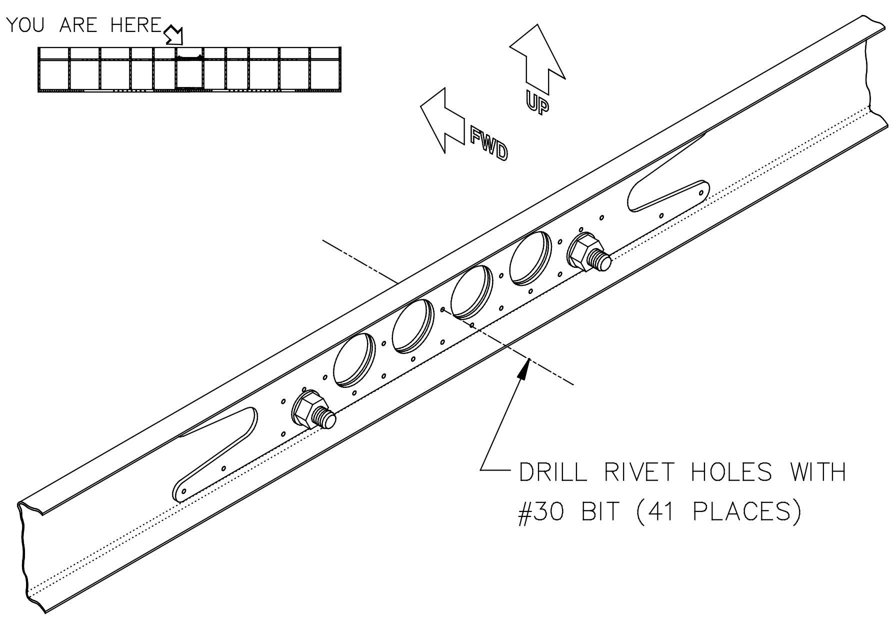
With the spar Clecoed in place, redrill through the spar and aft rib flange at each of the three holes at each rib location with a **#30** bit. Juggle the Clecos from hole to hole so that two Clecos are always holding each rib in place.

Completed: [ ]

Step 5: Position and Drill the Forward Spar Web Doublers

Remove at least Ribs A and B and their associated nose ribs from the spar/rib framework, although you may find it easier to complete this step if you disassemble the forward spar completely from the spar/rib framework. Temporarily mount the **front** [5] and **rear** [6] **forward spar web doublers** on the forward spar using the **alignment pins** [12], AN315-6R **jam nuts** [16] and AN960D616 **aluminum washers**, as shown in Figure 6. The pins should be inserted from the forward side of the spar, with the pointed ends forward. Tighten the nuts firmly with an adjustable wrench or a 9/16" open-end wrench on the flats on the forward end of each pin.

> **Warning** The plain nuts are used in this step only. They allow the use of the alignment pins in positioning the spar doublers, but are easily removable. Self-locking nuts will be used later for the actual installation of the pins.



When both doublers are firmly pinned in place, use the pre-punched pilot holes in the rear doubler to drill through the spar and both doublers with a **#30** bit, as shown in Figure 5.

Completed: [ ]

Figure 5: Drilling the Forward Spar Doublers

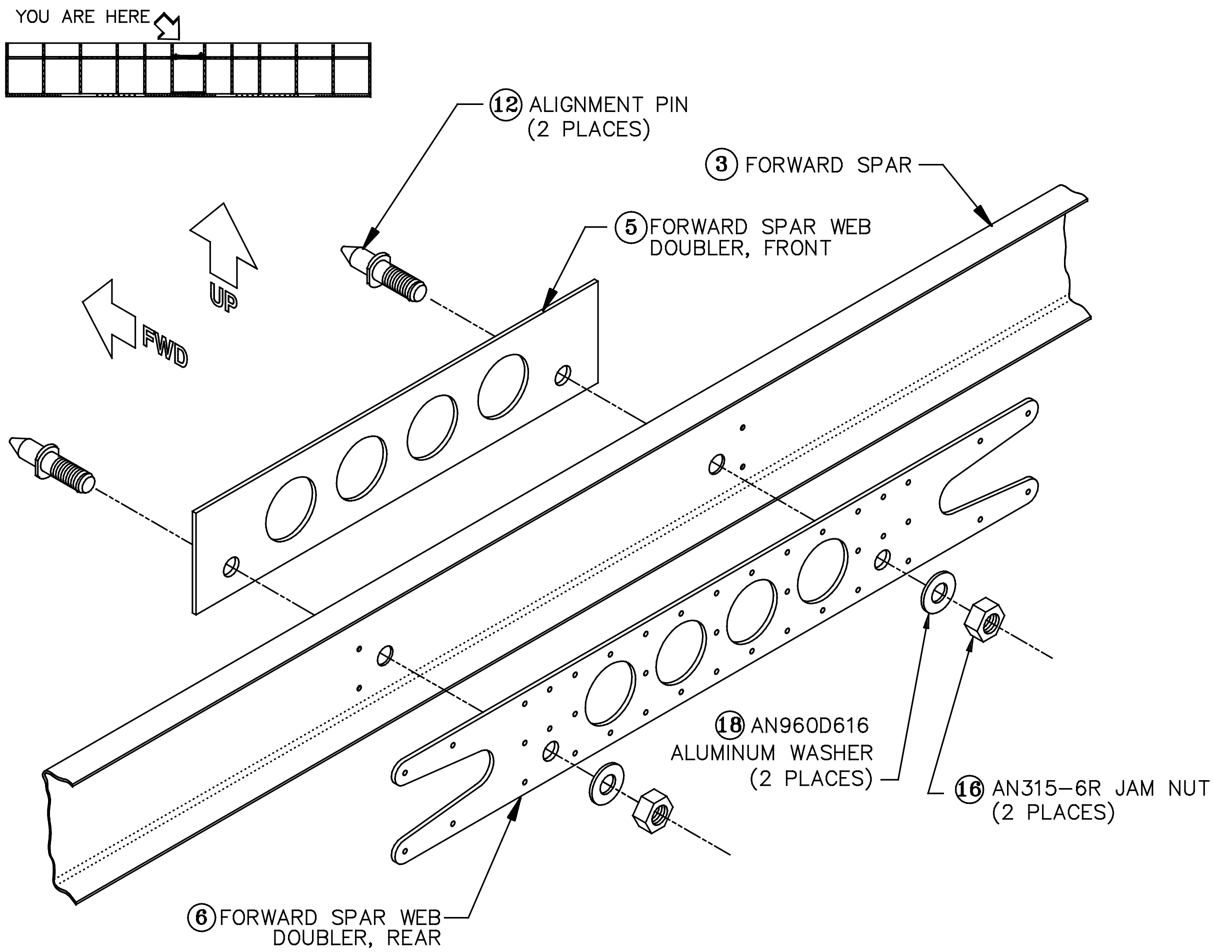


Figure 6: Forward Spar Web Doublers

Step 6: Modify the Center Main Ribs

Because the rear doubler on the forward spar extends in a spanwise direction beyond the points at which Ribs A and B attach to the spar, these two ribs must be shortened. This will be accomplished by cutting off the original forward flanges and riveting new flanges in place.

A) Remove the Original Flanges

Using a pair of aviation snips, cut the forward flanges off both center ribs right at the beginning of the bend radius, as shown in Figure 7a. Use a fine-toothed file to smooth the cut edges and round the corners.

Hint If you have one, a belt sander also works well for smoothing snipped edges and for rounding corners of sheet aluminum.

B) Cut the Replacement Flanges

Your GlaStar kit contains a piece of bent aluminum angle stock (called **main rib flange** [13] in the parts list) from which you must cut the two replacement flanges needed. The length of each new flange should be approximately the same as the height of the original flange—about **2-1/4"**—but this dimension is not critical.

Hint Use one of the flanges you just cut off as a length guide for cutting the new ones.

Use snips or a fine-toothed saw to make the cuts. Afterwards, smooth the cut edges and round the corners.

C) Drill Rivet Holes in the Rib Tabs

As shown in Figure 7c, mark a line parallel to and **1/4"** aft of the forward edge (i.e., the edge you cut) on the web of each center rib. On this line, mark and lightly center punch four rivet hole locations. The outermost holes should be a minimum of **1/4"** from the top and bottom edges of the tab, and the remaining

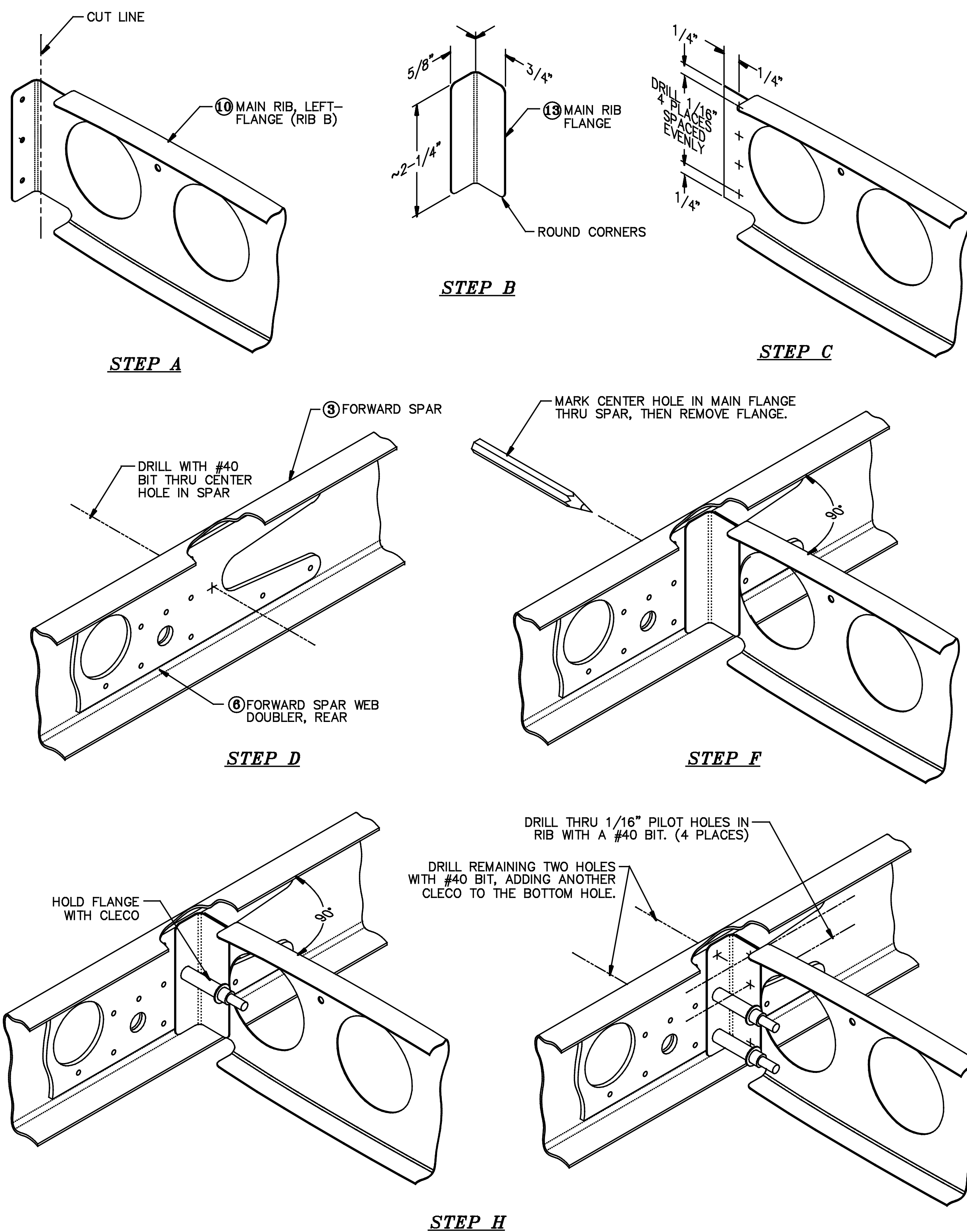


Figure 7: Center Main Rib Modification

two holes should be spaced equidistantly between the outer pair. These dimensions are not critical.

Drill all four holes with a **1/16"** bit.

D) Drill the Center Rivet Hole Through the Spar Web and the Rear Doubler

> **Note** The front and rear spar web doublers should still be pinned to the forward spar at this point; if you took them apart, pin them back together now.

The three holes for riveting the forward end of each center rib to the spar/doubler assembly have been pre-punched in the spar, but not in the doubler. At this time, drill with a **#40** bit **only the middle** one of these three holes on each side, as shown in Figure 7d. A Cleco through this hole will hold the flanges in place while the remaining holes are drilled.

E) Reassemble the Spar/Main Rib Assembly

If you disassembled the spar/rib framework to mount the forward spar web doublers, use two Clecos per rib end to refasten the main ribs between the forward and aft spars. Cleco Ribs A and B to the aft spar.

F) Mark Center Rivet Hole Locations on the Replacement Flanges

Position the replacement flange with the wider flange against the web of the rib and the narrower flange tight against the rear doubler, as shown in Figure 7f. The vertical alignment of the replacement flange is not critical; simply center it on the rib tab from which you cut the original flange. With the replacement flange held in approximate position against the rib web, mark any interference between the flange and the flared edge of the rib lightening hole. Relieve this interference by cutting away a crescent-shaped piece of the flange. Remove as little material as possible, but make sure that the flange completely clears the bend radius of the flare. Use a fine-toothed file or coarse sandpaper to smooth the cut edge of the flange.

Reposition the replacement flange, and use a square to check that the rib is perpendicular to the forward spar. While holding the replacement flange in position, use a marking pen through the hole you drilled in the spar web and doubler to mark the location of the center rivet hole on the forward face of the replacement flange.

It would also be a good idea at this time to mark the replacement flanges to distinguish the left from the right.

G) DRILL THE CENTER RIVET HOLES IN THE REPLACEMENT FLANGES

Center punch lightly on the mark you made in the last step and drill with a **#40** bit.

H) CLECO THE FLANGES IN PLACE AND DRILL THE REMAINING RIB/ FLANGE RIVET HOLES

From the aft side of the spar, insert a Cleco in the center hole of the replacement flange, as shown in Figure 7h. From the forward side of the spar, drill the remaining two holes through the spar web, doubler and flange with a **#40** bit. After the first of these holes has been drilled, add a second Cleco before drilling the final hole.

Next, from the outboard side of the center rib, drill through the four 1/16" holes in the rib web with a **#40** bit. You will probably need a 90° drill to get inside the cove of the spar to drill these holes. Take care to keep the holes as perpendicular to the rib web as possible. Also, you will need to juggle the Clecos holding the flange to the spar to keep them out of the way of the bit.

After all the holes have been drilled, disassemble, clean and deburr all the parts, including the forward spar doublers.

Completed: [ ]

Step 7: Position the Right Skin

In this step, the right stabilizer skin will be positioned over the spar/rib framework in preparation for drilling rivet holes for securing the skin to the framework. The important result of the step is to position the skin so that the spar line rivet holes in the skin are roughly centered over the flanges of both spars. By "roughly centered" we mean positioned so that the spars can be drilled without violating the minimum edge margin requirement of two rivet diameters between the **centers** of the holes and either the trailing edges or the bend radii of the spars. **It is also vital in this step that the spars be kept straight** and that the skin be pulled down tightly over the spar/rib assembly everywhere. Use a string line on the aft spar and/or clamp the aft spar to a long, metal-angle straightedge to maintain spar straightness.

Caution Maintaining spar straightness in the fore-and-aft direction is of paramount importance because this affects the straightness of the elevator hinge. If you're not careful, you can end up with a bowed stabilizer, even while maintaining proper rivet hole edge margins. Remove any bow in a spar by clamping the tips of the spar and pulling on the center; then hold the spar straight while fitting the skins.

The marked rivet lines on the spar flanges are intended only to provide a method of gauging where the pre-punched holes are falling on the spar flanges. For a variety of reasons—different clamping procedures, slight variations in manufacturing tolerances, slightly bent ribs, etc.—it's quite possible that none of the rows of pre-punched holes will be centered **precisely** on their respective rivet lines. Simply use the lines as guides to try to reduce such mismatches as much as possible. Again, the most important requirements are simply to keep the spar straight and avoid violating the minimum edge distance requirement.

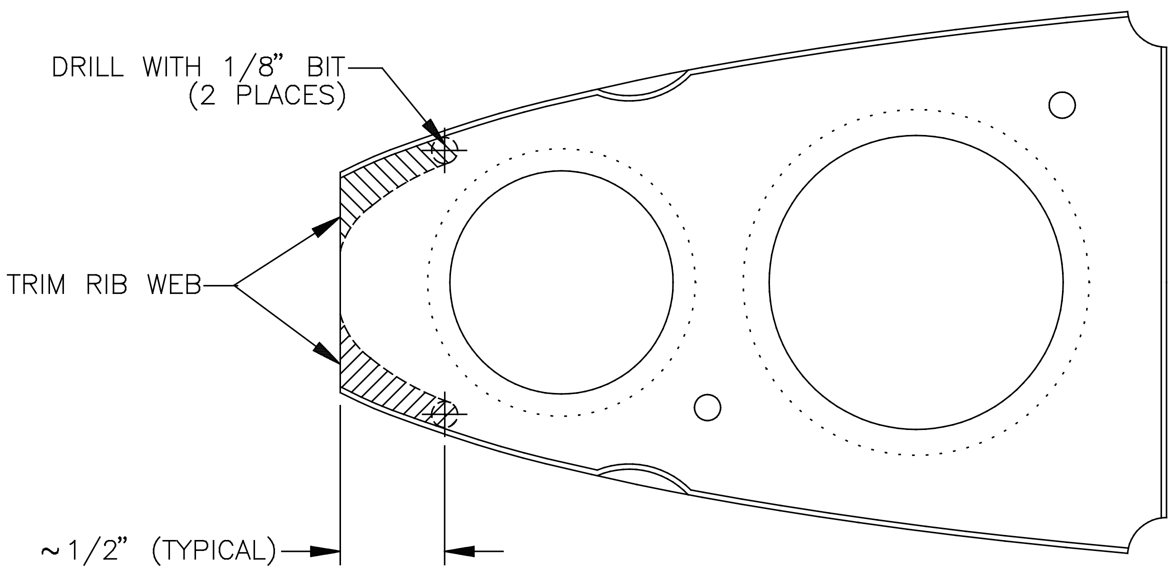


Figure 7.1: Trimming the Horizontal Stabilizer Nose Ribs *(-01 Ribs Only)*

Note In January 1997, the stabilizer nose ribs were shortened by roughly 1/4" to an overall length of about 3-3/4" to facilitate positioning the stabilizer skins over the spar/rib assembly. If you have the original ribs [P/N 302-00009-**01**] it will be easier to pull the skin far enough aft over the spar/rib framework to satisfy the edge-margin requirements if you modify the ribs as shown in Figure 7.1. Begin by drilling a **1/8"** hole through the rib web about **1/2"** aft of the leading edge immediately above or below the rib flange. Then use a pair of snips to cut away the rib web as shown by the dashed line, leaving only the flange itself. Sand or file the cut edges smooth. If you received the shorter, **second-run** nose ribs [P/N 302-00009-**03**], there is no need to modify them.

The **right skin** [2] is the one without the rectangular cutouts; it is also shorter than the **left skin** [1]. Although the stabilizer airfoil is symmetrical, the skins **do** have a definite top and bottom. The surfaces can be distinguished by measuring from each trailing edge to the first row of pre-punched rivet holes; on the upper surface, this distance is less than 1/2", while on the lower it is more than 1/2".

Lay the spar/rib assembly right-side up on the bench and slip the skin over the assembly. Align the skin left-and-right by placing the outboard edge of the skin flush with the outboard ends of the spars. Align the skin fore-and-aft by centering the upper-flange rivet line of the aft spar under the pre-punched holes in the trailing edge of the upper surface of the skin. When the skin is aligned left-and-right and fore-and-aft, clamp it in place using four or five Cleco side-grip clamps or rubber-padded spring clamps along the upper flange of the aft spar, as shown in Figure 8.

Note When the upper surface of the skin is properly positioned, the trailing edge will hang over the trailing edge of the upper aft spar flange by about 1/16". **Do not** attempt to make the skin and spar flange trailing edges flush with one another.

Note The spars may have slight bows in them. Devise some means to hold the aft spar straight when clamping the skin to it, and make sure that you keep the spar rivet line roughly centered under the skin holes **along the entire length** of the skin. If the aft spar is kept straight, the forward spar will also be straight.

Turn the assembly over and repeat the alignment process on the lower surface, again centering the aft spar rivet line under the pre-punched skin holes. Place some 2 X 4s or sand bags under the assembly so that the clamps along the upper spar flange clear the bench top. Clamp the skin into position along the lower spar flange as you did on the upper flange. Try to get all four spar rivet lines aligned with the rivet hole rows in the skin. If perfect alignment isn't possible, the next best situation is to have the upper skin rivet holes slightly **aft** of the spar rivet lines and the lower rivet holes slightly **forward** of the spar rivet lines.

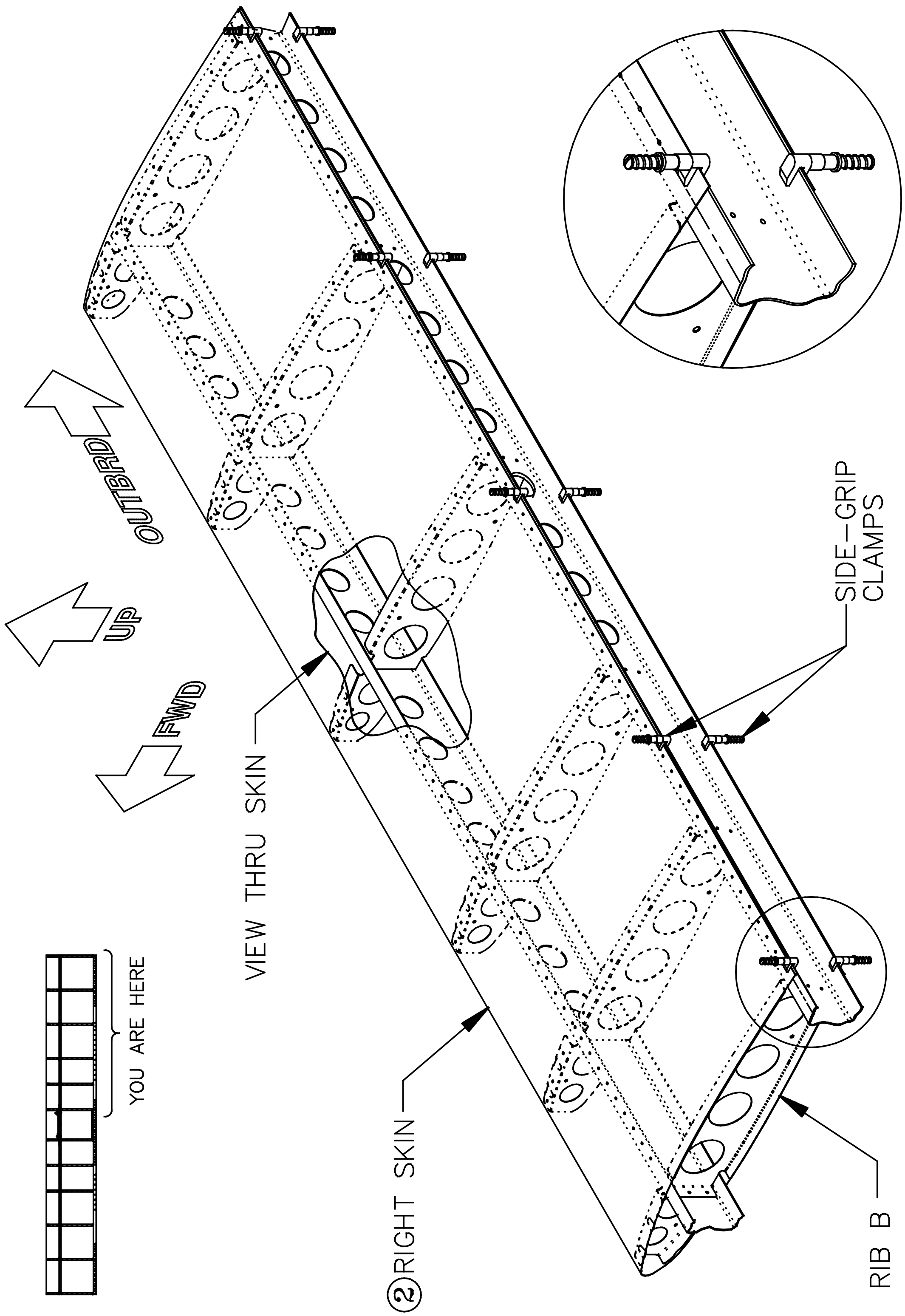


Figure 8: Positioning the Right Skin

When the lower trailing edge of the skin has been securely clamped to the aft spar, turn the whole assembly over again. Before proceeding to the next step, you need to double check to make sure that the skin is positioned squarely; otherwise, a twist will be introduced into the assembly. Figure 9 shows how this can be checked accurately. Temporarily affix a couple of small wooden blocks to the underside of a digital level (recommended) or carpenter's level (acceptable) so that the level can be set chordwise on the curved surface of the stabilizer. Place the level near the outboard end of the skin with one of the blocks on the forward spar rivet line. Use scrap shims or sand bags to adjust the assembly until the level reads level. Then move the level to the inboard end of the skin, taking care to put the same block again on the forward spar rivet line. If the level again reads level, then you have a twist-free stabilizer half; if not, shim the inboard end until it comes into level.

Note This procedure does not depend on the stabilizer **as a whole** being level relative to any given reference line; rather, it reveals whether the two ends are level relative to each other without any twist, and this is what's important.

Hint You may find the leveling process easier if you make a pair of supports for either end of the assembly. Take a 2' length of scrap 2 X 8 and trace the outline of the nose and main rib on it. Stack this piece with another one of equal size and cut out the stabilizer cross-section in both pieces. (Cut a bit outside the traced outline to accommodate the skins and spars.) Slide one of these sleeves over each end of the stabilizer assembly, and shim as necessary to bring the assembly into level. Note that the chord line of the stabilizer need not be precisely centered on the supports; they just provide a convenient shimming surface.

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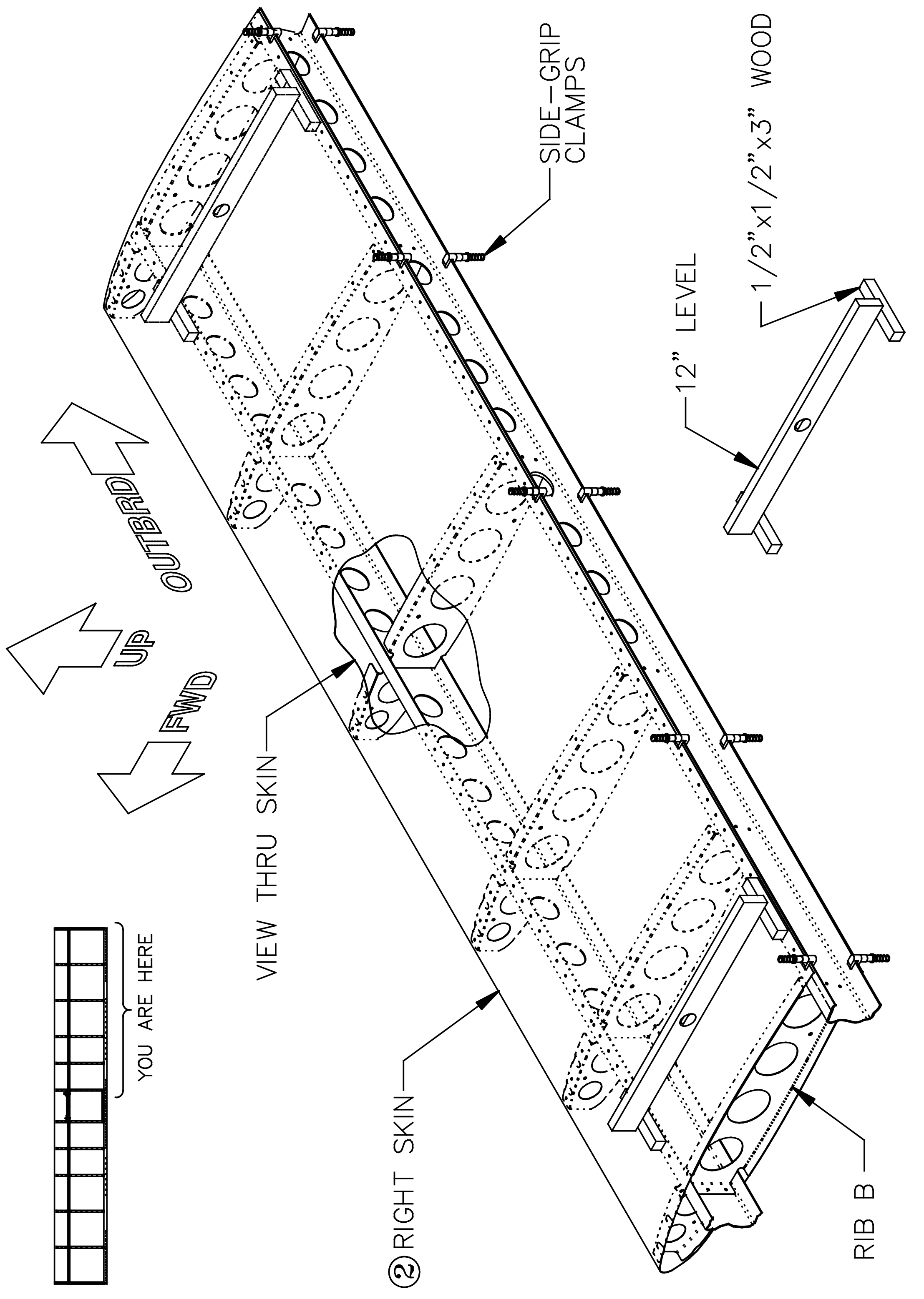

Figure 9: Stabilizer Alignment Procedure

Step 8: Drill the Upper Surface Main Rib and Forward Spar Rivet Holes

> **Note** In this and subsequent steps pay particular attention to the drill sizes specified for the rivet holes. Most of the holes are drilled with a #40 bit, but those along the lower flange of the aft spar are drilled with a #30 bit. There is no penalty for drilling an undersize hole, as these can always be enlarged, but drilling an oversize hole will force you to use a larger rivet than necessary.

After verifying that the spars are straight in the fore-and-aft direction, use the pre-punched pilot holes as guides to drill through the skins, main ribs and forward spar with a **#40** bit. Begin at the inboard end of the spar and drill outboard once at every rib location, Clecoing these holes as you go. Then drill the remaining forward spar holes, putting a Cleco in every third or fourth hole. Repeat this process on the main ribs, drilling and Clecoing in a fore-to-aft direction along each rib.

> **Note** Some of the forward spar rivet holes lie almost directly over the web of a main rib, making it very difficult to properly buck a hard rivet in these holes. Check your spar holes as you drill; if they appear to be too close to the underlying rib web to enable bucking—say, within 1/8"—drill them up to **#30** size for later installation of blind rivets. Use a drill stop set at **3/16"** when drilling these holes to avoid the possibility of damaging the underlying rib web.

> **Note** Don't drill any holes along the centermost rib (Rib B in Figure 10); these will be drilled after the left skin is lapped over the right. Also, don't drill the nose rib holes; these will be done in a subsequent step.

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Step 9: Drill the Upper Surface Aft Spar Rivet Holes

After completing all the main rib and forward spar drilling, double check to make sure that the aft spar rivet lines remain centered under the trailing edge skin holes top and bottom. If necessary, loosen the clamps holding the trailing edges in place and persuade the spar back into alignment.

When you're satisfied, drill along the aft spar once at each rib location with a **#40** bit. Again, Cleco as you go. **Do not** drill the remaining aft spar holes at this time; they will be drilled when the elevator hinge is mounted in the next section.

When the drilling is complete, remove the side-grips or C-clamps along the aft spar upper flange.

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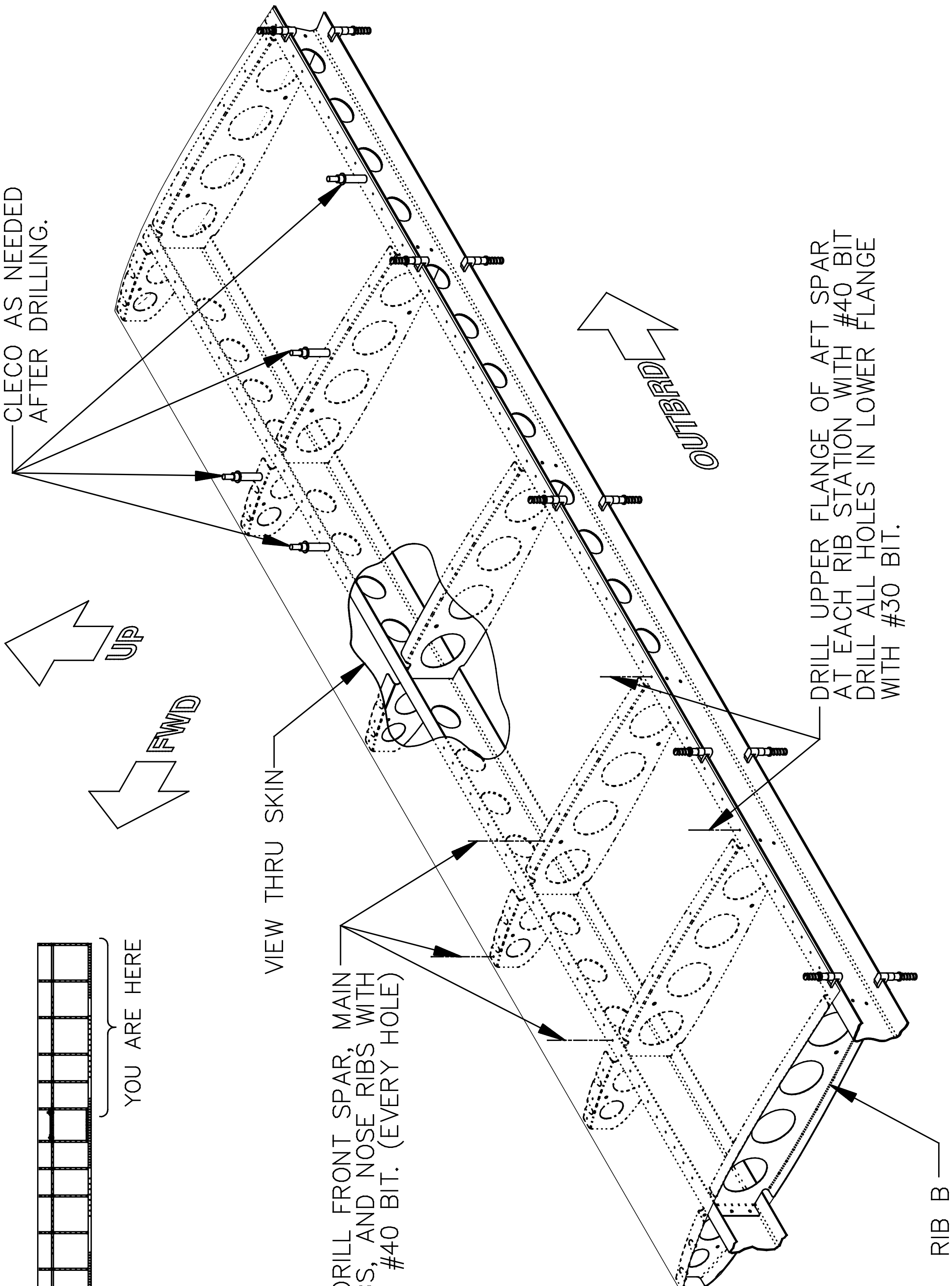

Figure 10: Drilling the Right Skin

Step 10: Realign and Drill the Lower Surface of the Right Skin

Turn the assembly over and repeat the leveling procedure to check that everything is still aligned. If necessary, adjust the remaining side-grips or C-clamps along the lower flange of the aft spar to bring the assembly back to true.

Then drill the spars and main ribs with a **#40** bit using the same procedures and sequences outlined above, with the following exceptions:

> **Note** Drill **all** the holes along the **lower flange** of the aft spar—not just once at each rib station—and use a **#30** rather than a #40 bit.

Completed: [ ]

Step 11: Align and Drill the Right-Side Nose Ribs

With the right-hand skin drilled and Clecoed firmly in place, it's necessary to ensure that the nose ribs are square with respect to the forward spar. Check this by looking for the rivet line you marked on each rib; it should be visible through the pre-punched rivet holes in the leading edge of the skin. If the line is not centered under the holes, shift the rib left or right as necessary using the rib alignment probe described in "ALUMINUM SHEET METAL WORK, *Clamping Parts Together*" in "SECTION II: TOOLS AND TECHNIQUES." The probe is simply a 4- to 5-foot length of 1/4" aluminum tubing with a small hook bent in one end, which can be inserted into the structure through the rib lightening holes to push or pull a rib into alignment. If the misalignment is slight, you can probably also correct it simply by inserting a scriber or an awl through one of the rivet holes and prying the rib slightly in the necessary direction.

When the nose ribs are all square, drill through each of the pre-punched skin holes with a **#40** bit. Begin at the spar and work forward on both the upper and lower surfaces.

> **Note** **Do not** drill any holes in the **outermost** nose rib at this time; these will be drilled in "SECTION X: FINAL ASSEMBLY" when the tip fairings are installed.

Completed: [ ]

Step 12: Position the Left Skin

The left skin is handled virtually the same way as the right. Distinguishing the upper and lower surfaces of the left skin is easier, however—the bottom is the side with the large, rectangular cutout in it.

Note The goals to be achieved in this step are identical to those described in Step 7 for the right skin. Review Step 7 for a detailed discussion of the goals.

Slide the skin over the spar/rib assembly with the rectangular hole inboard, as shown in Figure 11. Again, align the upper surface of the skin left-and-right on the outboard ends of the spars and fore-and-aft on the aft spar rivet line. Pull the skin aft into its final position, aligning the lower surface trailing edge holes on the aft spar rivet line as before, and clamp into place.

Caution The left skin **overlaps** the right skin at the centermost right-side rib (Rib B in Figure 11). **Do not** attempt to align the left skin in a flush butt joint with the right.

Again, use the leveling procedure shown in Figure 9 to check for twist in the left half of the stabilizer. In addition, before any left-side holes are drilled, it's important to check that the stabilizer **as a whole** is flat and that the leading and trailing edges are perfectly straight across both the left and right halves. Any bow in the spars will be reflected in crooked leading and/or trailing edges and will make it more difficult to achieve a straight elevator hinge line; this must be corrected now, because if you finish drilling the left side of the assembly without doing so, you'll be carving the problem in stone. Check for straightness with a long straightedge or a string line and adjust the assembly as necessary.

Note Because the left skin wraps around the right, there will be a **slight** mismatch (on the order of 1/32") where the trailing edges of the two skins meet top and bottom. Try to roughly split this difference between the upper and lower surfaces.

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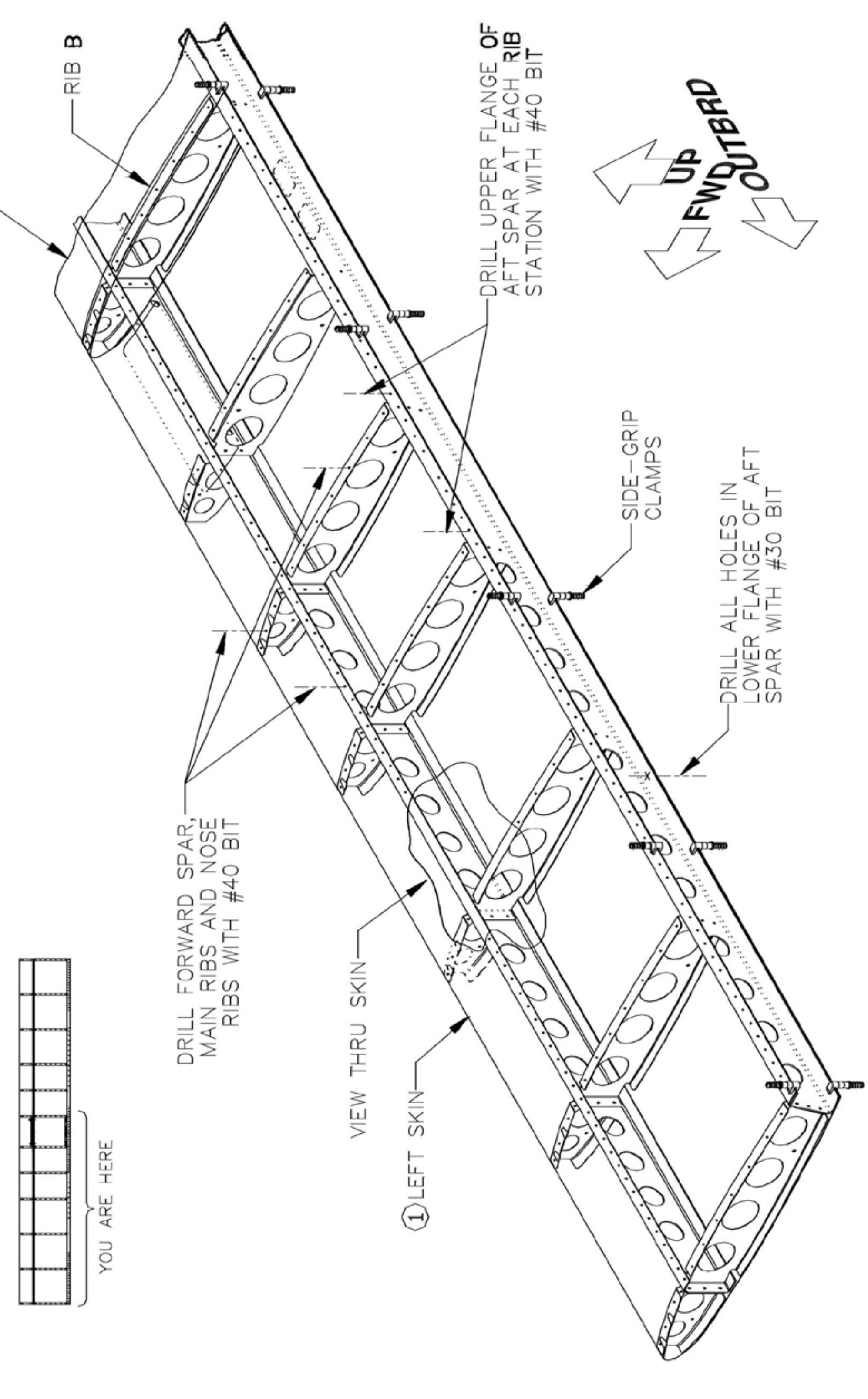

Figure 11: Positioning and Drilling the Left Skin

Step 13: Drill the Rib and Spar Rivet Holes

Note Some of the forward spar rivet holes lie almost directly over the web of a main rib, making it very difficult to properly buck a hard rivet in these holes. Check your spar holes as you drill; if they appear to be too close to the underlying rib web to enable bucking-say, within 1/8" – drill them up to **#30** size for later installation of blind rivets. Use a drill stop set at **3/16"** when drilling these holes to avoid the possibility of damaging the underlying rib web.

Drill and Cleco the left-side rib and spar holes with a #40 bit as you did on the right side, with the following exception: don't drill the holes along Ribs A and B (or their corresponding spar holes) **until last**. Before drilling these last holes, check the aft spar one last time for straightness. On the upper flanges of the saft spar, remember to drill only one hole at each rib location; the remainder will be drilled when the elevator is installed.

Note At the overlap between the left and right skins, you will be drilling through the right skin as well as the rib flanges. As on the right side, **do not** drill any holes in the nose ribs at this time.

Completed: [ ]

Step 14: Align and Drill the left-Side Nose Ribs

Repeat the nose-rib alignment and drilling procedures (**#40** bit) described above. Again, **do not** drill any holes in the outermost nose rib at this time.

Completed: [ ]

Step 15: Disassemble the spar/Rib Assembly and Deburr the Parts

Un-Cleco the skins from the spar/rib assembly and the ribs from the spars. Deburr all the holes. Be sure also to brush off any shavings that might be clinging to the p-arts away from the holes. Set the skins and ribs aside.

Completed: [ ]

Step 16: Chamfer an Edge of the Forward Spar Caps

Figure 12 illustrates the position of the two **spar caps** [8] inside the upper and lower flanges of the forward spar. In order for the caps to nestle snugly inside the flanges of the spar, it's necessary to slightly chamfer the edges of the caps that will be against the bend radius between the spar flange and web.

To do this, simply clamp each spar cap along the edge of your bench and file the corner off one edge; any edge will do. Use long, spanwise strokes and try to leave a smooth, rounded finish. Check the cap periodically inside the spar to make sure you remove just enough material for the cap to lie flat.

Completed: [ ]

Step 17: Position the Forward Spar Caps and Drill the Rivet Holes

Note Builders who received **36"** spar caps, instead of the current **35"** caps, should initially position their caps **41-1/2"** from either end of the spar. In this position, one or both ends of the cap are likely to fall directly under rivet holes in the spar flange. Shift each cap left or right as necessary until the ends fall between holes with a minimum edge margin of two rivet diameters from the **centers** of the holes. Alternatively, simply shorten the cap strips to **35"**.

On the inside of the upper flange, measure **42"** inboard from either end of the spar, as shown I figure 12, and make a mark. Position one of the spar caps inside the flange even with one end on this mark. In terms of fore-and-aft alignment, slide the cap forward as far as possible while still keeping it flat against the spar flange. When positioned, clamp the cap in place with Cleco side-grips or small C- clamps.

Once the cap is positioned and clamped, use the rivet holes in the spar flange as guides and drill through the spar cap with a **#40** bit. Since the holes in the spar flange were already drilled to final size when the skins were drilled, be extra careful to center the drill bit in the existing hole and to keep the drill perpendicular to the surface in order to avoid enlarging the spar flange holes.

It is vitally important that the spar caps be help tightly against the spar flanges while being drilled. For this reason, you should begin drilling at one end and proceed a hole at a time toward the other end, clecoing every hole as you go, rather that drilling and clecoing at a few locations and then drilling the intervening holes as we have usually suggested. As you drill, be particularly attentive to make sure that no aluminum chips get caught between the cap and the flange. For the most certain results, you might want to place side-grips or C-clamps on either side of the each hole before drilling.

When the upper spar cap has been drilled, remove it from the spar and mark it as the upper cap.

Repeat the process on the lower spar cap, which is installed inside the lower flange of the forward spar. After both caps have been drilled, thoroughly clean and deburr them and the forward spar.

Hint It's important to keep the spar straight while drilling the caps. A good way to ensure this is to clamp the spar to the edge of your bench with rubber padded spring clamps while fitting the caps.

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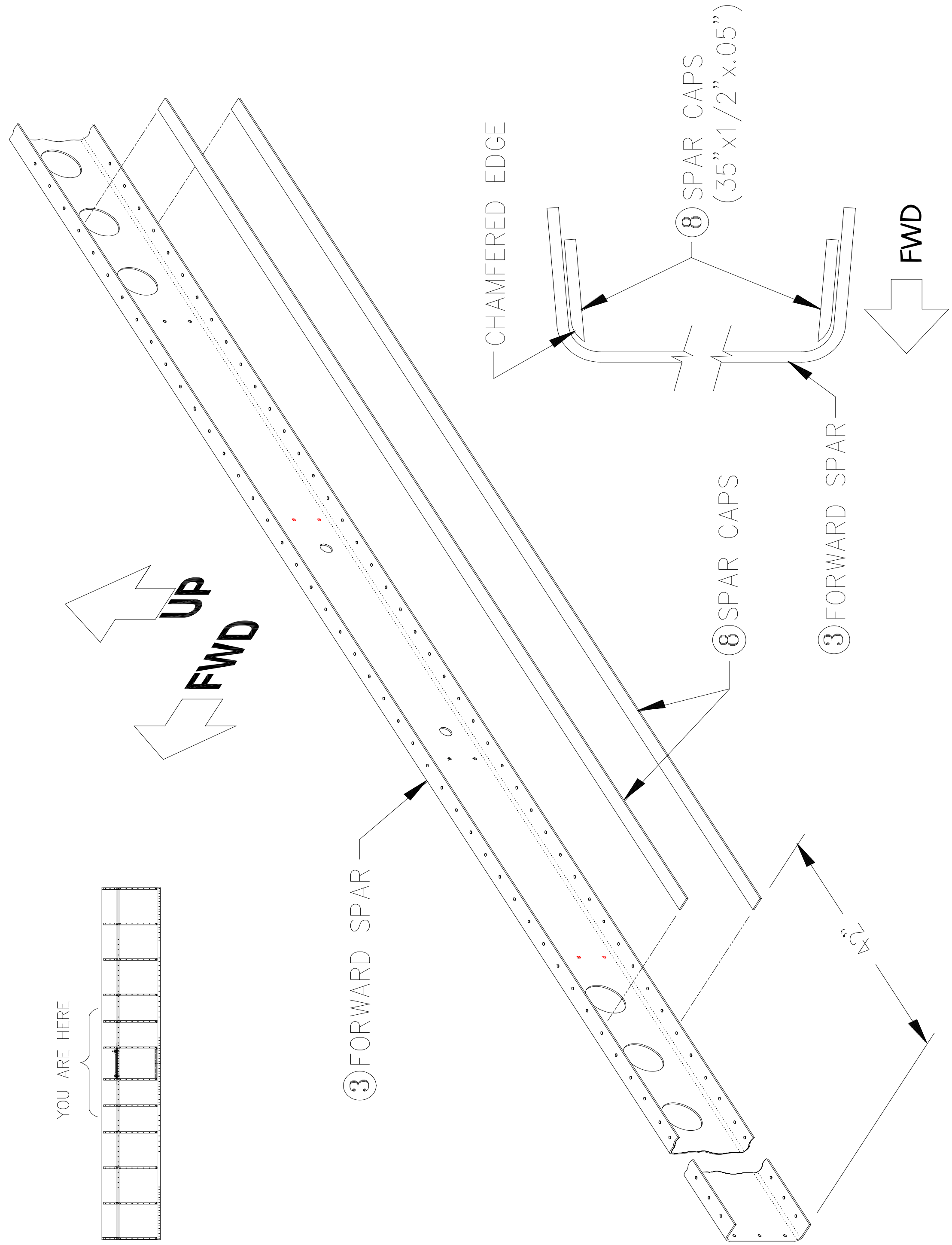

Figure 12: Forward Spar Caps

Step 18: Position and Drill the Aft Attach Bracket

Position the **aft attach bracket** [7] against the forward face of the aft spar web midway between the ends of the spar, as shown in Figure 13; clamp it in place with a pair of Clecos through the pre-punched holes in the spar web and in the middle hole in each row of three at the outermost edges of the bracket.

> **Note** When the bracket is properly **oriented, the two tongues of the bracket that project below the spar are angled** aft (see Figure 13).

When the bracket is clamped in position, use its pre-punched pilot holes to drill through the bracket and the spar with a **#30** bit. Insert a couple of larger Clecos into two of the newly drilled holes, remove the original pair of Clecos, and drill those two holes up to #30 size.

When the drilling is complete, disassemble, clean and deburr all parts.

Completed: [ ]

Step 19: Corrosion-Proof the Stabilizer Interior

Corrosion-proof all interior parts as you deem necessary (see "INTERIOR CORROSION PROTECTION" in "SECTION II: TOOLS AND TECHNIQUES"). Minimally, we recommend first applying an aluminum cleaner and then alodizing all interior parts.

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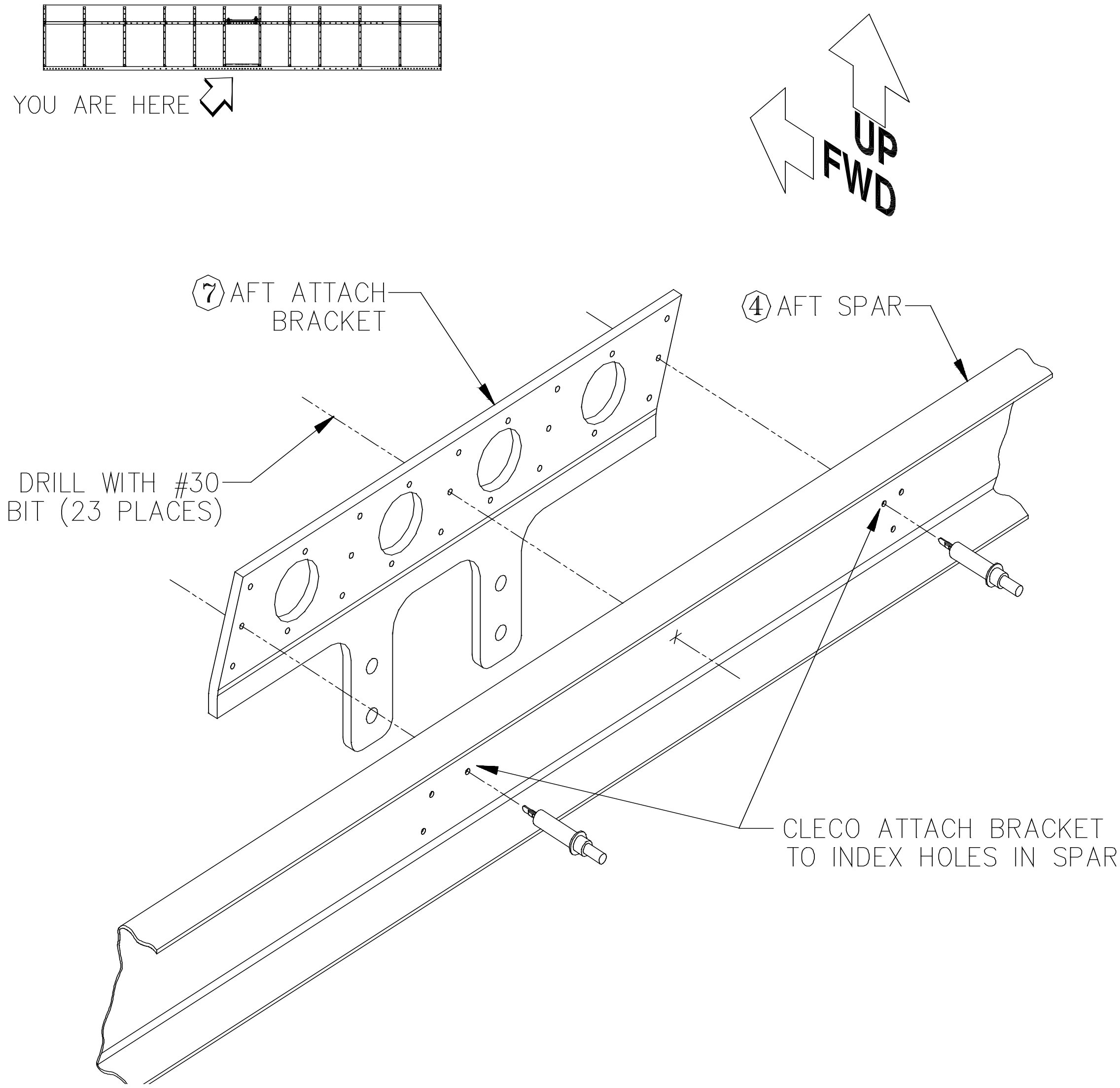

Figure 13: Aft Attach Bracket

RIVETING

Step 20: Rivet the Attach Bracket to the Aft Spar

Using 1/8" AN470AD4 universal head rivets of appropriate length, rivet the attach bracket to the aft spar. The manufactured heads should be on spar side, as shown in Figure 14. As before, be sure the two tongues of the bracket that project below the spar are **angled aft**.

Completed: [ ]

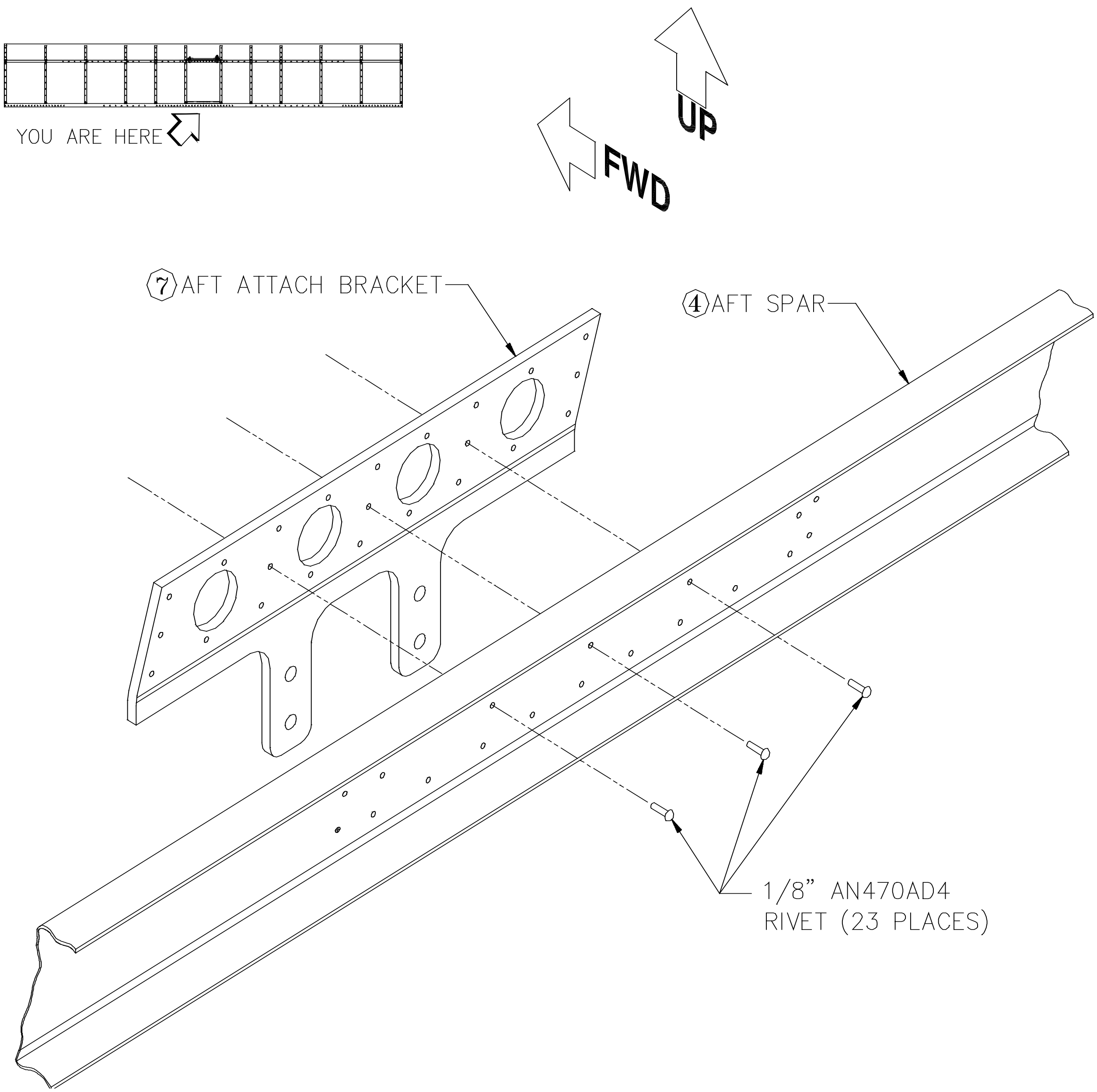

Figure 14: Riveting the Aft Attach bracket

Step 21: Install the Alignment Pins

Insert the alignment pins through both doublers and the spar web, with the pointed ends forward, as shown in Figure 15. Secure with AN960D616 aluminum washers and AN365-624A **nylon self-locking nuts** [17].

Check the positioning of the alignment pins by sliding them into the corresponding holes in the **forward attach bracket assembly** [15]. The pins should slide in easily and precisely. When you are satisfied with the positioning of the pins, hold them with a wrench on the flats and tighten the nuts with a socket wrench.

Note Tighten the nuts **firmly**; once the stabilizer skins are riveted in place, there is no access to these nuts.

Completed: [ ]

Step 22: Rivet the Spar Web Doublers to the Forward Spar

With the alignment pins secured in place, use 1/8" AN470AD4 universal-head rivets to rivet both doublers to the forward spar. The rivet heads should be on the **forward** side of the spar/doubler assembly, as shown in Figure 15.

Note Be aware that the thickness of the stack-up you are riveting changes depending on whether you are riveting doubler and spar or doubler, spar and doubler. This situation will recur frequently throughout the riveting process; always alter your choice of rivet length accordingly.

Completed: [ ]

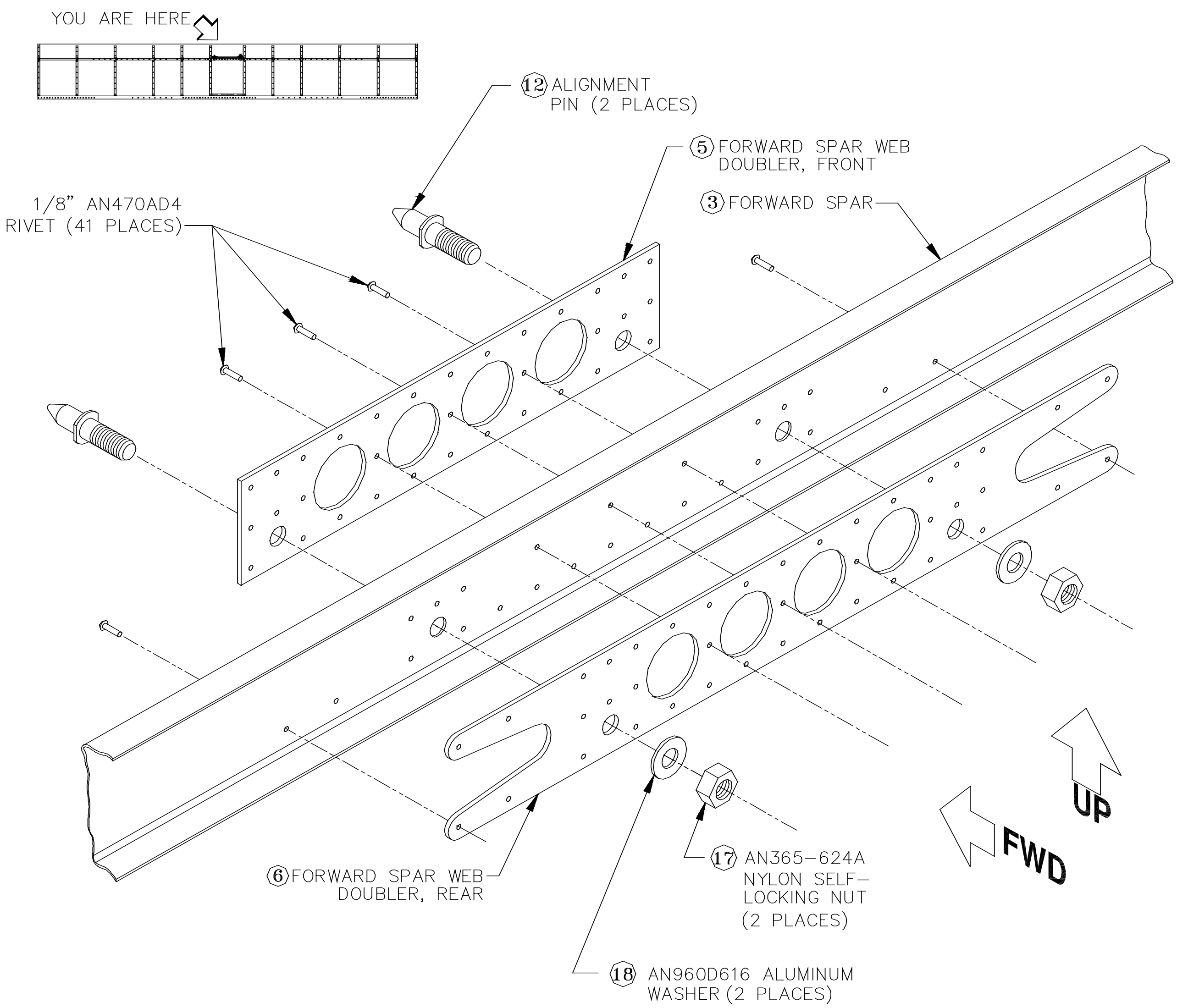

Figure 15: Riveting the Forward Spar Web Doublers

Step 23: Rivet the Replacement Flanges to Ribs A and B

Using 3/32" AN470AD3 universal-head rivets, rivet the replacement flanges to Ribs A and B. Be certain you match up each rib with the proper flange. The manufactured heads can be on either the rib or the flange—whichever is easiest for you.

Completed: [ ]

Step 24: Rivet the Ribs to the Forward Spar

Using 3/32" AN470AD3 universal-head rivets, rivet the nose and main ribs to the forward spar. Again, pay careful attention to the orientation of the rib flanges, as shown in Figure 2, and keep the ribs in the order they were in when you drilled them. The rivet heads can be either on the forward or aft side of the spar, but you will probably find it easier to place the bucking bar on the forward side, as shown in Figure 16.

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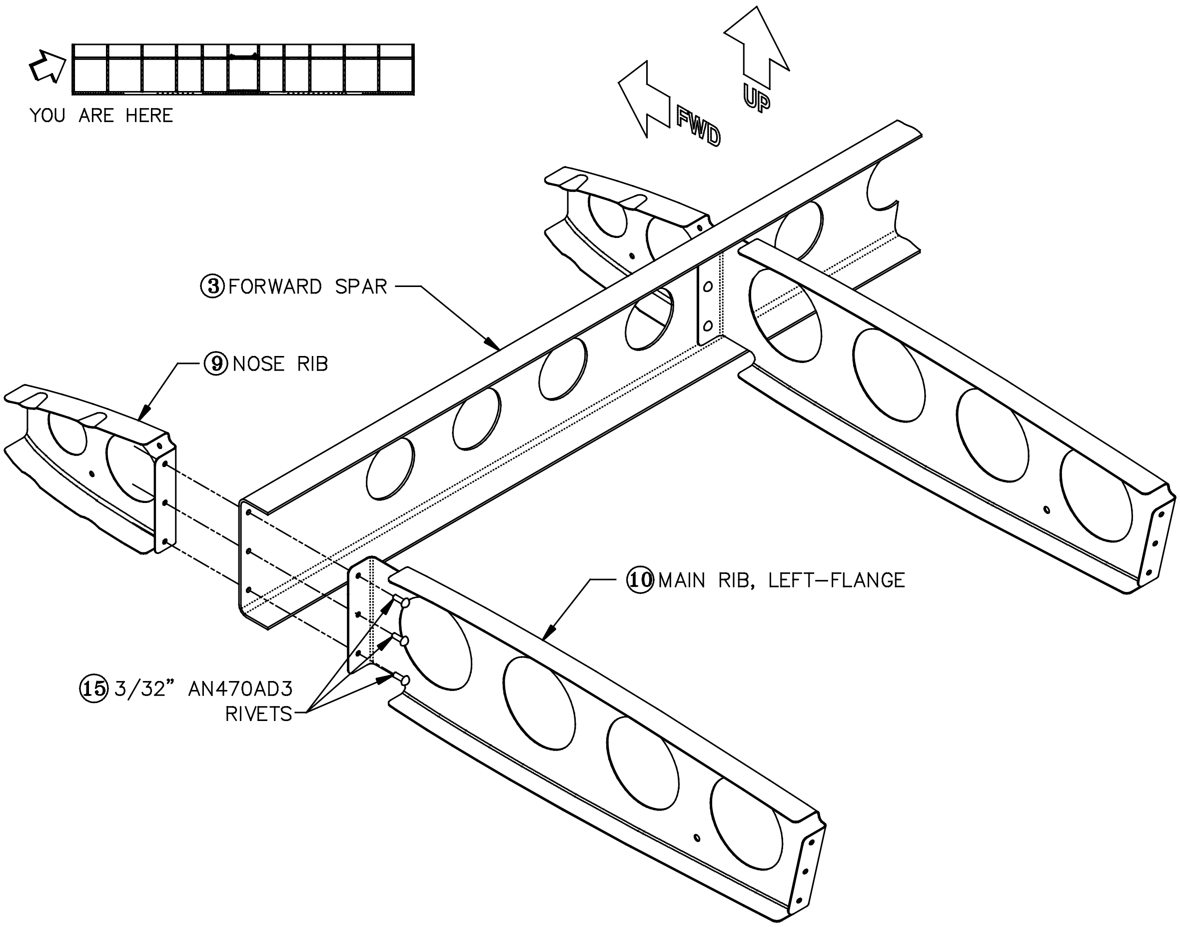

Figure 16: Riveting the Ribs to the Forward Spar

Step 25: Check the Forward and Aft Attach Brackets for Clearance with the Skin Cutouts

Cleco the aft spar to the main ribs. Cleco the right skin in place on the spar/rib assembly. Then, sliding the cutouts in the left skin over the two protruding tongues of the aft attach bracket, position the left skin over the right skin and the spar/rib assembly. Clamp the left skin in place with a few Clecos.

First check the clearance of the aft cutouts in the left skin around the tongues of the aft attach bracket. The cutouts should fit closely around the tongues, but should **not** quite touch. Check especially to make sure that no corner of the tongues binds in one of the corner radii of the cutouts. Mark any interference on the skin.

Next, slide the forward attach bracket assembly through the large forward skin cutout and over the alignment pins. Holding the bracket tightly against the forward spar doubler, check for interference with both the left and the right skin. Again, the cutout in the left skin and the edge of the right skin should fit closely with but not touch the bracket. Mark any interference.

Remove all the Clecos. If there was no interference, move on to the next step; if there was interference on either skin, use the marks on the skin as a guide and file or snip the skin as necessary until a clean, interference-free fit is achieved. Smooth and deburr all cut edges. It's especially important that the cutouts have smooth, clean radii rather than 90° corners.

Note Structurally, the forward attach bracket assembly is actually part of the fuselage; it is never permanently attached to the horizontal stabilizer structure. At this point, it will not be needed again until the fuselage is assembled. You might put it aside with the remaining fuselage parts at this time.

Completed: [ ]

Step 26: Rivet the Lower Surface of the Right Skin to the Spar/Rib Assembly

Note When riveting the skins to the forward spar, as described in this and the next three steps, use **AAPQ-42 blind rivets** in the holes that were drilled up to #30 diameter because they were too close to the webs of the main ribs.

Slide the lower forward spar cap into position inside the lower spar flange and Cleco the right skin to the forward spar and cap at each end and a few points in the middle. Using 3/32" AN470AD3 universal-head rivets, rivet the skin to the spar/cap/main rib structure. As described in "SECTION II: TOOLS AND TECHNIQUES" under "ALUMINUM SHEET METAL WORK, *Installing a Line of Rivets,*" begin by installing a rivet in one corner of the area defined by the spar/rib framework; then install a rivet in the opposite corner; then somewhere in the middle. Establish a pattern in which you are always riveting approximately in the middle of the remaining unriveted area.

Note **Do not** rivet the **centermost** row of holes along Rib B, as these are shared with the overlapping left skin.

Completed: [ ]

Step 27: Rivet the Upper Surface of the Right Skin to the Spar/Rib Assembly

Repeat the process you used to rivet the lower skin surface and lower forward spar cap to the spar/rib assembly: Cleco the upper surface of the skin and the upper cap to the forward spar; Cleco the skin to the main ribs; and finally, rivet the skin to the spar/rib framework in the standard sequence—first the corners of the area, then the middle, and finish by riveting in the approximate middle of the remaining unriveted area. This will require reaching inside from the trailing edge and maneuvering the bucking bars in fairly tight quarters, but it can be done! Once again, avoid riveting the centermost row of holes (Rib B) where the skins will overlap.

Completed: [ ]

Step 28: Rivet the Right Skin to the Nose Ribs

Using 3/32" AAP-32 blind rivets, rivet the right skin to all the right-side nose ribs, beginning at the spar and working forward, top and bottom.

Completed: [ ]

Step 29: Rivet the Left Skin to the Spar/Rib Assembly

Duplicating the procedures above and in a similar order, position and rivet the left skin to the spar/rib assembly. As in Steps 26 and 27, follow the standard sequence for riveting an area: install rivets in the corners of the area first, then the middle, and finish by always riveting in the approximate middle of the remaining unriveted area.

> **Note** Now is the time to finally rivet the row of holes through the overlapped skins along Rib B. Use 3/32" AN470AD3 universal-head rivets.

Completed: [ ]

Step 30: Rivet the Aft Spar to the Main Ribs

Bring the aft spar up close to the trailing edge of the stabilizer assembly and, taking care not to crimp the trailing edges of the skins, slip the spar between the skins until it is tight against the aft flanges of the main ribs. Cleco it in place at several locations.

Use 1/8" AAPQ-42 blind rivets to rivet the spar to the main ribs, as shown in Figure 17, except for the two outboard ribs which are accessible for riveting with 1/8" AN470AD4 universal-head rivets.

Completed: [ ]

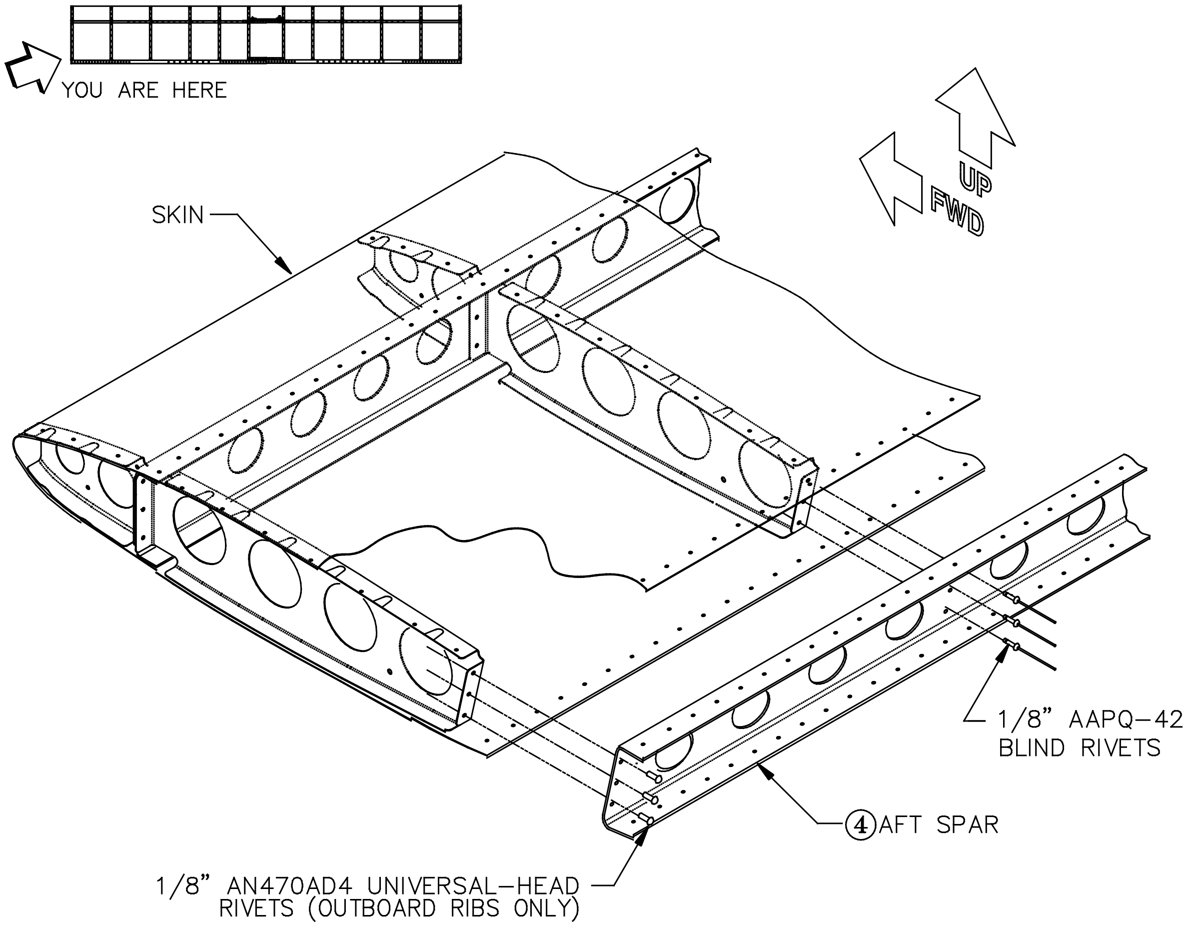

Figure 17: Riveting the Aft Spar to the Ribs

Step 31: Rivet the Lower Skin Trailing Edge to the Aft Spar

Use 1/8" AN470AD4 universal-head rivets to rivet the lower trailing edge of the left and right skins to the lower flange of the aft spar, again observing proper sequencing. If you have access to a rivet squeezer, this is an ideal place to use it.

> **Note** The trailing edge of the upper skin surface should remain unriveted to the upper flange of the aft spar for the time being. This will be remedied in "SECTION V: ELEVATOR ASSEMBLY" when you mount the elevator hinges.

Completed: [ ]

Step 32: Tape the Lightening Holes in the Outermost Ribs and the Aft Spar

Apply strips of **2"-wide aluminum tape** [14] to the webs of the outermost main ribs and the aft spar to seal the lightening holes.

Completed: [ ]

Step 33: Trim the Trailing Edges of the Upper Skins

You will notice that the upper surface of each skin extends aft beyond the trailing edge of the upper flange of the aft spar. You may also notice—unless you did an unusually painstaking job!—that when you sight down the trailing edge of the skins, they waver or bow slightly. Both the overhang and the waviness (that all but the very best stabilizers are likely to have) will make it more difficult to position the elevator hinge properly in the next section. Therefore, at this time you should shave the skin trailing edges so that they are straight and flush with the spar flange trailing edge.

Use offset aviation snips to trim off the bulk of the overhanging skin, leaving about **1/32"** aft of the spar flange trailing edge. Remove this remaining material with a curved-tooth body file. Use long, smooth strokes to file the skins flush with the spar flange. When this has been achieved, sight along the trailing edge to check for any bow or waviness in the spar flange itself. If necessary, it's acceptable to file slightly into the spar flange itself to remove such curves and produce a clean, straight trailing edge. However, you should **not** remove more than about **1/32"** from any part of the spar flange.

When you're satisfied with the straightness of the trailing edge, use a fine-toothed file or an edge deburring tool to remove any burrs or file marks. Also, if you applied anti-corrosion primer to the spar, use a small brush to touch up the trailing edge wherever you might have filed into the primer.

Completed: [ ]

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CONGRATULATIONS!

You've completed the horizontal stabilizer assembly! Next up—the elevator assembly, where you will not only assemble the elevator and trim tab but also mount them on the horizontal stabilizer. Onward and aft!

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SECTION V: ELEVATOR ASSEMBLY

PARTS LIST

Key No.:	Part Name:	Qty:	Part No.:
1	Skin, upper left	1	303-00001-01
2	Skin, upper right	1	303-00002-01
3	Skin, lower left	1	303-00003-01
4	Skin, lower right	1	303-00004-01
5	Spar, forward	1	303-00005-01
6	Spar, aft partial	1	303-00006-01
7	Doubler, forward spar/hinge, center	1	303-00007-01
8	Doubler, forward spar/hinge, outboard	2	303-00007-03
9	Rib, inboard	4	303-00008-01
10	Rib, outboard	8	303-00009-01
11	Rib, tip	2	303-00010-01
12	Horn, control	2	303-00011-01
13	Angle, control horn attach	2	303-00012-01
14	Stiffener, rib/control horn	1	303-00013-01
15	(Part deleted by Revision C)		
16	(Part deleted by Revision C)		
17	Angle, trim cable bracket	1	303-00020-01
18	Sheet, trim cable bracket	1	303-00021-01
19	Skin, trim tab	1	303-01001-01
20	Angle, trim tab rib	1	303-01002-01
21	Aluminum tee, .050" X 1-1/4" X 1-1/2"	3.6"	100-0640-007
22	Rib, trim tab	2	303-01004-01
23	Arm, trim tab counterweight	1	303-01005-03
24	Tape, aluminum, 2" width [from Sec. IV]	265"	062-00001-01
25	Extruded hinge with pin	72"	MS20001P4
26	Rolled hinge with pin	44"	MS20257P2

Tool List

1. Try square
2. Duck bill pliers (with jaws taped to protect Alclad aluminum parts)
3. Assorted flat and round files
4. Edge deburring tool (optional)
5. Tape measure
6. Fine-point marking pen
7. Assorted Cleco side-grip clamps (with pliers) and small C-clamps, approximately 15 each
8. Electric or pneumatic drill motor, with #40, #30, #19, #10, 1/16" and 1/4" bits
9. Center punch
10. Clecos, 3/32" and 1/8" (approximately 150 each), with pliers
11. Protractor
12. Aviation snips, straight and offset
13. Rule, 12", graduated in 1/32nds of an inch
14. Hole deburring tool
15. Bench grinder (optional)
16. Extension bit, 12" length, #40 (recommended)
17. Blair hole cutter or Unibit, 9/16" (recommended)
18. Large spring clamps with padded jaws (recommended) or large C-clamps (acceptable)
19. Straightedge, 6'
20. Framing square
21. Scriber or awl
22. Locking C-clamp, 3" jaw (Vise-Grip-type)
23. Phillips screwdriver
24. Small hammer or mallet
25. Dimple dies, 3/32", and rivet squeezer (recommended) or riveting frame (acceptable)
26. Rivet gun, air compressor and bucking bars
27. Universal head rivet sets, 3/32" and 1/8"
28. Flush head rivet set
29. Offset universal head rivet set, 3/32"
30. Blind rivet puller

31. Two adjustable wrenches and/or 3/16" wrenches
32. Hand seamer (optional)
33. Heavy-duty wire cutter
34. Bench vise
35. Chip chaser
36. Countersink bits, for #8 and #10 screws
37. Fluting pliers (optional)

ADDITIONAL MATERIALS

1. Four sandbags or scrap lengths (approximately 12-14" long) of 2 X 4
2. One 1/4" dowel or 1/4" bolt, any length
3. Corrosion protection materials
4. One 2 X 4, approximately 48" long
5. One 3/16" hex-head bolt and nut (hardware-store quality)
6. Two 2 X 6s, approximately 24" long
7. Scraps of wood or metal, 3/16" thick (optional)
8. Wide masking tape or duct tape

WORKSPACE

As with the horizontal stabilizer, the elevator is built in one assembly without complicated jigging. The elevator, with its tip ribs, is slightly larger than the horizontal stabilizer: 129" X 30" . In the final stages of this section when the elevator is mounted on the horizontal stabilizer, the size of the entire assembly will be approximately 129" X 35". For assembly steps in which aluminum skins are lying flat on the bench, it's a good idea to pad your bench surface with cardboard to avoid unnecessary scratching of the finish. Also, you might consider leaving the plastic protective film on the outside of the skin through the positioning and drilling stages; remove it for hole deburring and riveting.

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Assembly Sequence

Having already completed the rudder and the horizontal stabilizer, you'd be right to guess that the primary objective of the elevator assembly procedures is to produce a straight, untwisted finished elevator. By now you will also have experienced some of the difficulties in achieving this goal and devised some strategies for overcoming the difficulties. As with the other tail feathers, it is important to monitor the proper alignment of all parts at every step of the assembly, to maintain the proper edge margins for rivet holes in all parts and to follow proper sequences for drilling lines of rivet holes and driving lines of rivets. It is particularly important to make sure the elevator spar is held straight for all drilling and riveting operations.

The assembly of the elevator and trim tab is broken down into ten major operations:

1) **Preliminary Assembly**: fabricating, positioning and drilling components such as the spar/hinge doublers, the rib/control horn stiffeners, the control horn assemblies and the trim cable bracket assembly.
2) **Main Structure**: positioning and drilling the spar/rib assembly and the elevator skins.
3) **Main Structure Riveting**: final assembly of all the elevator components.
4) **Trim Tab**: positioning and drilling the trim tab ribs and skins.
5) **Trim Tab Riveting**: final assembly of the trim tab.
6) **Elevator Hinges**: positioning and drilling the elevator hinges.
7) **Trim Tab Hinges**: positioning and drilling the trim tab hinges.
8) **Hinge Riveting**: final mounting of the elevator and trim tab hinges.
9) **Final Assembly**: mounting the trim tab and the elevator on the stabilizer.

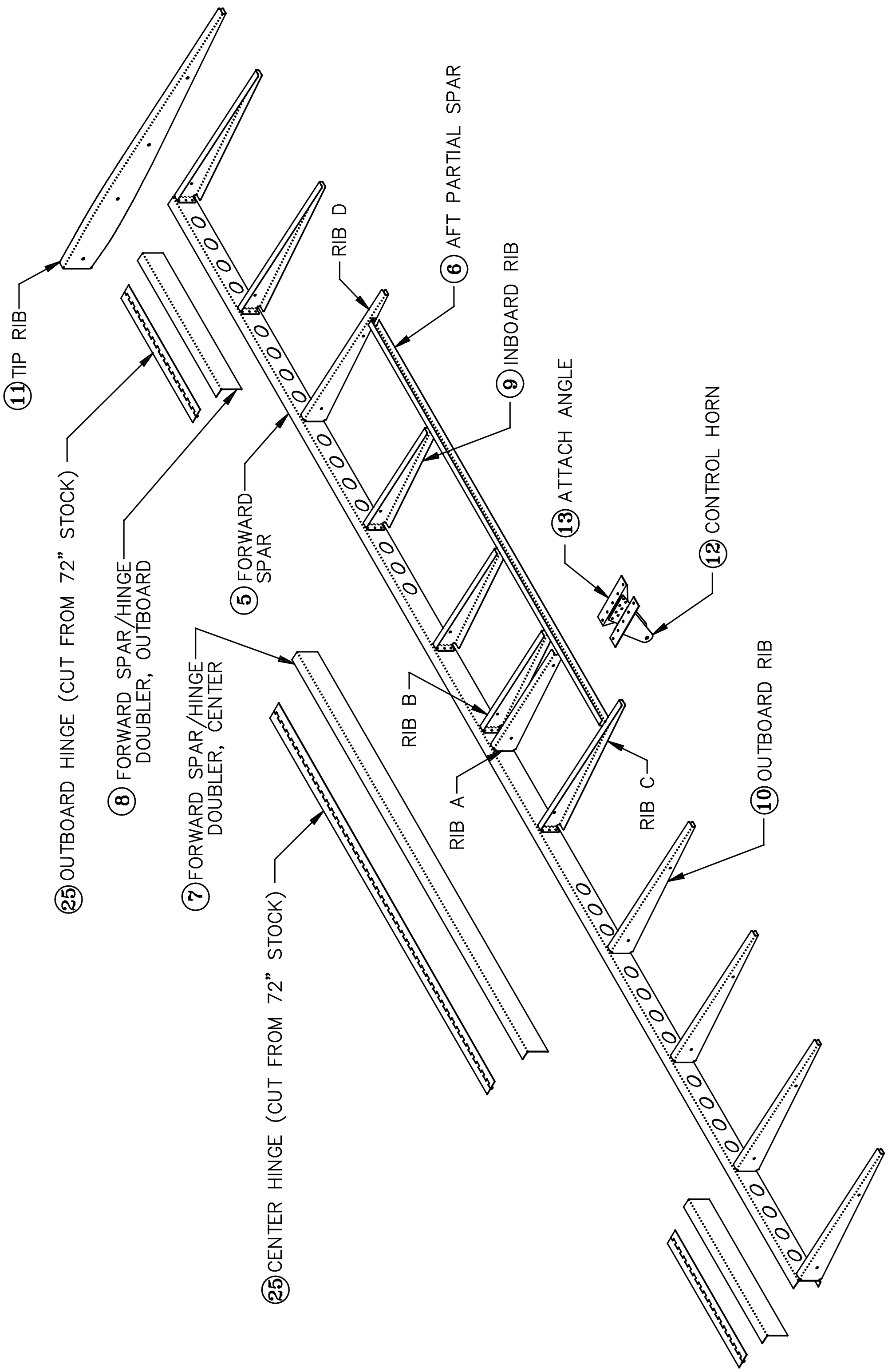

Figure 1: Elevator Assembly

PRELIMINARY ASSEMBLY

Step 1: Straighten and Deburr the Parts

Using a square, check the flanges on all the **inboard** [9], **outboard** [10] and **tip** [11] **ribs** for squareness, straightening as necessary with a pair of duck bill pliers. Also, especially for the tip ribs, use a straightedge placed against the rib web parallel to the length of the rib to check for bows. If necessary, use fluting pliers to straighten the ribs by adjusting the existing flutes in the rib flanges. Work gently, a little bit at a time, moving from flute to flute in the rib and checking the straightness frequently. It's better to make several light passes around the rib with the fluting pliers than to try to accomplish too much all at once.

Note The **inboard** ribs are the short ribs that terminate in the **aft partial spar** [6]. The **outboard** ribs are the long ones outboard of the aft partial spar. See Figure 1.

Completed: [ ]

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Step 2: Mark Hole Positions on the Forward Spar/Hinge Doublers

As shown in Figure 2, the **forward spar/hinge doublers** (**center** [7] and **outboard** [8]) are riveted inside the **upper** flange of the **forward spar** [5]. In this step, you will drill the sets of three holes at each rib station and use these to help mark the locations of the additional rivets that will fasten the doublers to the spar web.

> **Note** The **upper** flange of the forward spar is the **longer** one, as shown in Figure 14.

Use side-grips as shown in the figure to clamp the doublers in place. Align the outboard doublers on the outboard ends of the spar; center the center doubler with each end **36-15/16"** from the spar end. See Figure 3. When the doublers are clamped, drill through each set of three pilot holes in the spar web with a **#40** bit.

> **Note** Builders of early kits who received a **44"** center doubler should position it **37-11/16"** from either end of the spar.

Next, remove the doublers and mark and lightly center punch locations for the remaining rivets according to the dimensions shown in Figure 2. Mark the locations on the **forward** side of the doubler web.

> **Note** Builders with a **44"** center doubler should eliminate the **center** hole in the **outermost** column at each end of the doubler. There is not enough material between the end of the doubler and the spar lightening hole to allow adequate edge margin, and the loss of these two rivets will not adversely affect the strength of the doubler.

> **Note** Make the two outboard doublers mirror images of each other to clear the lightening holes in the spar.

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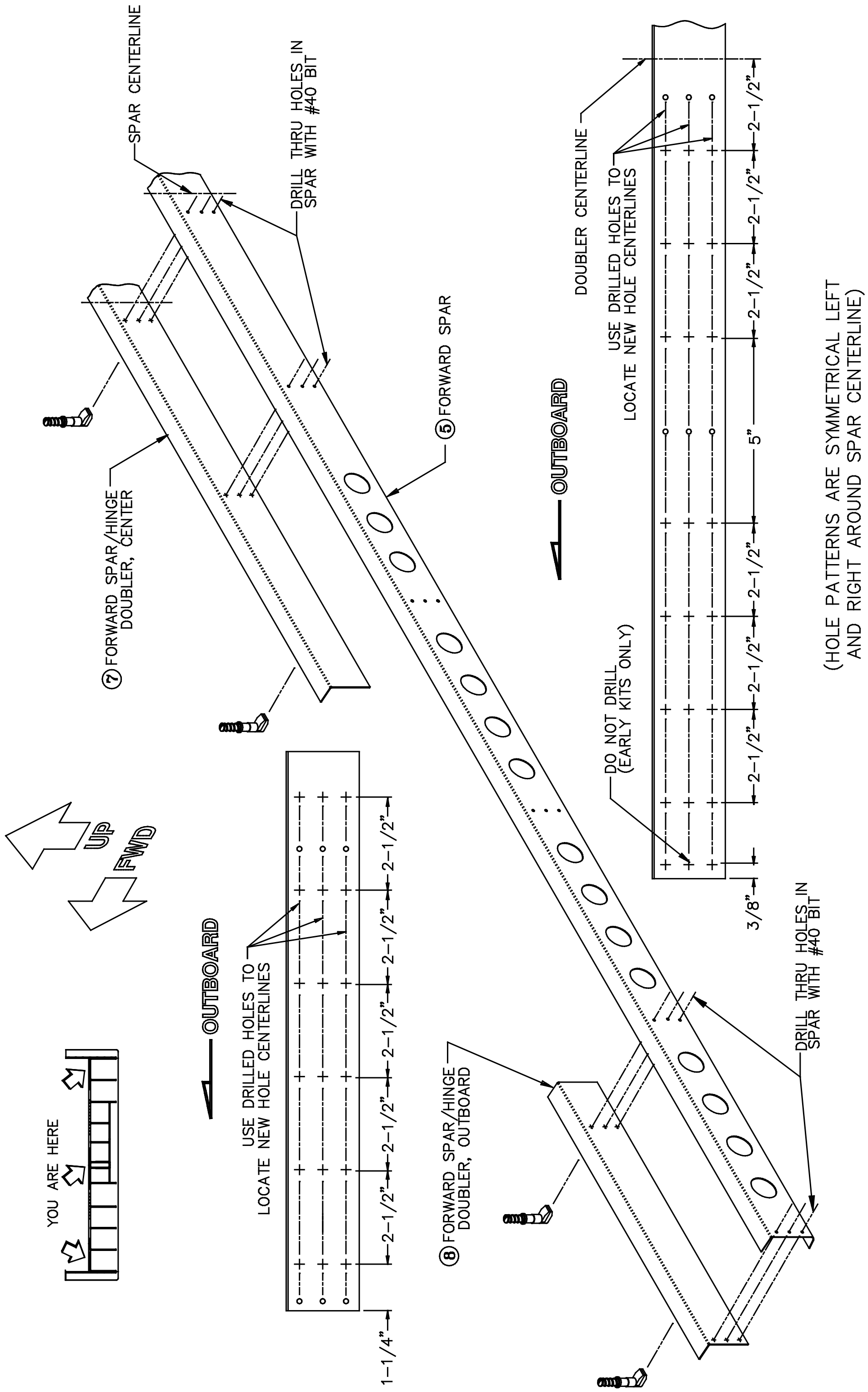

Figure 2: Forward Spar/Hinge Doubler Hole Locations

Step 3: Position and Drill the Doublers

When you have marked and center punched all three doublers, re-position them on the forward spar and clamp them in place with several Clecos through the holes at the rib stations, as shown in Figure 3.

Double check that you have marked the left and right doublers properly by making sure that the marked rivet holes clear the lightening holes on the respective spar ends.

With the doublers clamped in place, drill through the doubler and the spar web at each marked hole location with a **#40** bit, Clecoing as you go.

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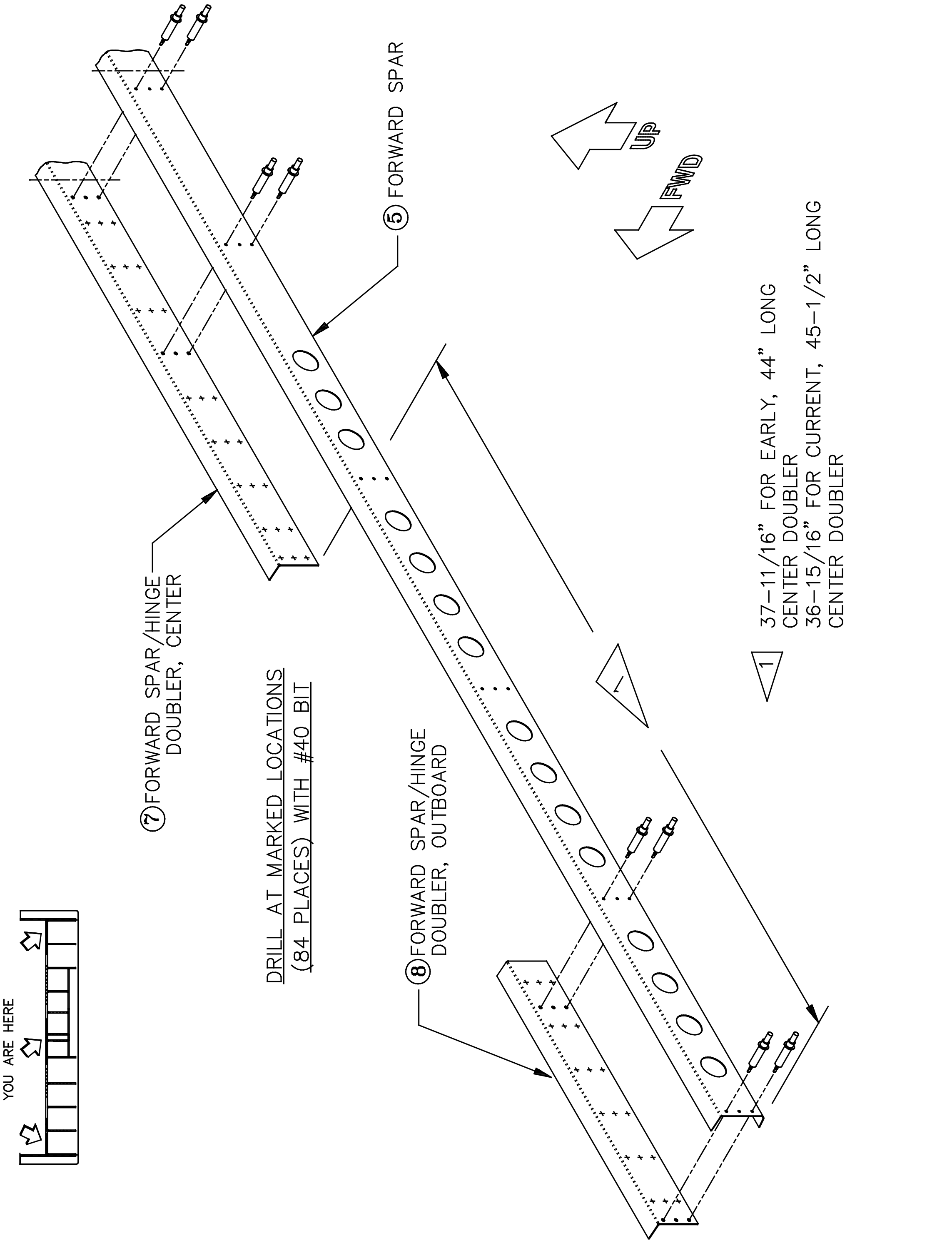

Figure 3: Positioning and Drilling the Spar/Hinge Doublers

Electric Trim Option (P/N 921-01000-01) The following step and many subsequent steps are not necessary if you are installing the GlaStar electric trim option but are required for the manual trim system. The electric trim system is designed so that it **can** be retrofitted to your GlaStar even if you complete and fly it with the mechanical system first. The converse is **not** true, however: if you build your GlaStar solely for the electric trim option now, you will be unable to revert to manual trim at a later date without fundamentally rebuilding your elevator. For this reason, we recommend completing all the required steps for the mechanical system unless you are **certain** that you will be installing the electric trim option.

There are three main advantages to the electric trim system.

- First, it makes removal of the horizontal stabilizer for trailering or storage much easier. Simply unplug an electrical connector and you're done. With the manual trim, by contrast, you have to unbolt the trim tab pushrod from the control horn and snake the trim cable through the interior of the elevator.
- Second, because the electric trim system can be controlled with a hat switch on the control grip rather than with a manual wheel, it offers less distraction to the pilot during maneuvering.
- Third, the electric trim system is easier to install, requiring less construction time.

Contact Stoddard-Hamilton's Options Sales Desk for current pricing information.

If you are **certain** that you'll be installing electric trim, **skip to Step 5**.

Step 4: Cut an Angle Template *(Manual Trim Only)*

At several points in the subsequent steps, you will need to lay out a 105° angle on various parts, and this is most easily accomplished if you make a simple angle template, as illustrated in Figure 4.

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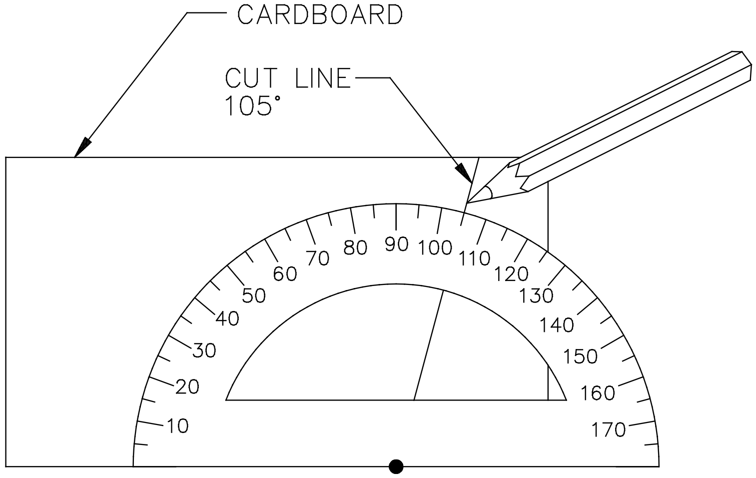

Figure 4: Cutting an Angle Template

Step 5: Cut the Rib/Control Horn Stiffeners

The **rib/control horn stiffeners** [14] strengthen the points where the control horns are fastened to the elevator. They must be cut from the angle stock provided to fit inside the flanges Ribs A and B (see Figure 1). Use a pair of aviation snips to cut out each stiffener according to the dimensions shown in Figure 5.

Note The ribs are symmetrical top-and-bottom, but the stiffeners **are not**. Before you cut, make sure that the stiffeners will nest inside the **lower** flange of each rib while the rib flanges are oriented **inboard**. Refer to Figure 5.

Completed: [ ]

Step 6: Mark Hole Locations on the Stiffeners *(Manual Trim Only)*

Electric Trim Option If you are installing electric trim, **skip this step and turn to the** ***Electric Trim Option Instructions***. Return to **Step 10** of this *Assembly Manual* when the specified option steps have been completed.

☞

Figure 5 shows the pattern of the rivets used to fasten the stiffeners to the ribs. Mark and lightly center-punch these hole locations on the **inside** face of each stiffener. The precise placement of the holes is not critical, but maintain minimum distances of 1/4" from the centers of all holes to the edges of the stiffeners and 3/8" between the centers of all holes.

Completed: [ ]

Step 7: Lay Out the Trim Cable Bracket Reference Lines *(Manual Trim Only)*

As shown in Figure 5, mark a reference line on the **inside** face of each stiffener. Use your cardboard angle template to lay out lines 105° off the flange line, intersecting the flange **6-3/16"** from the aft end of the stiffener.

Completed: [ ]

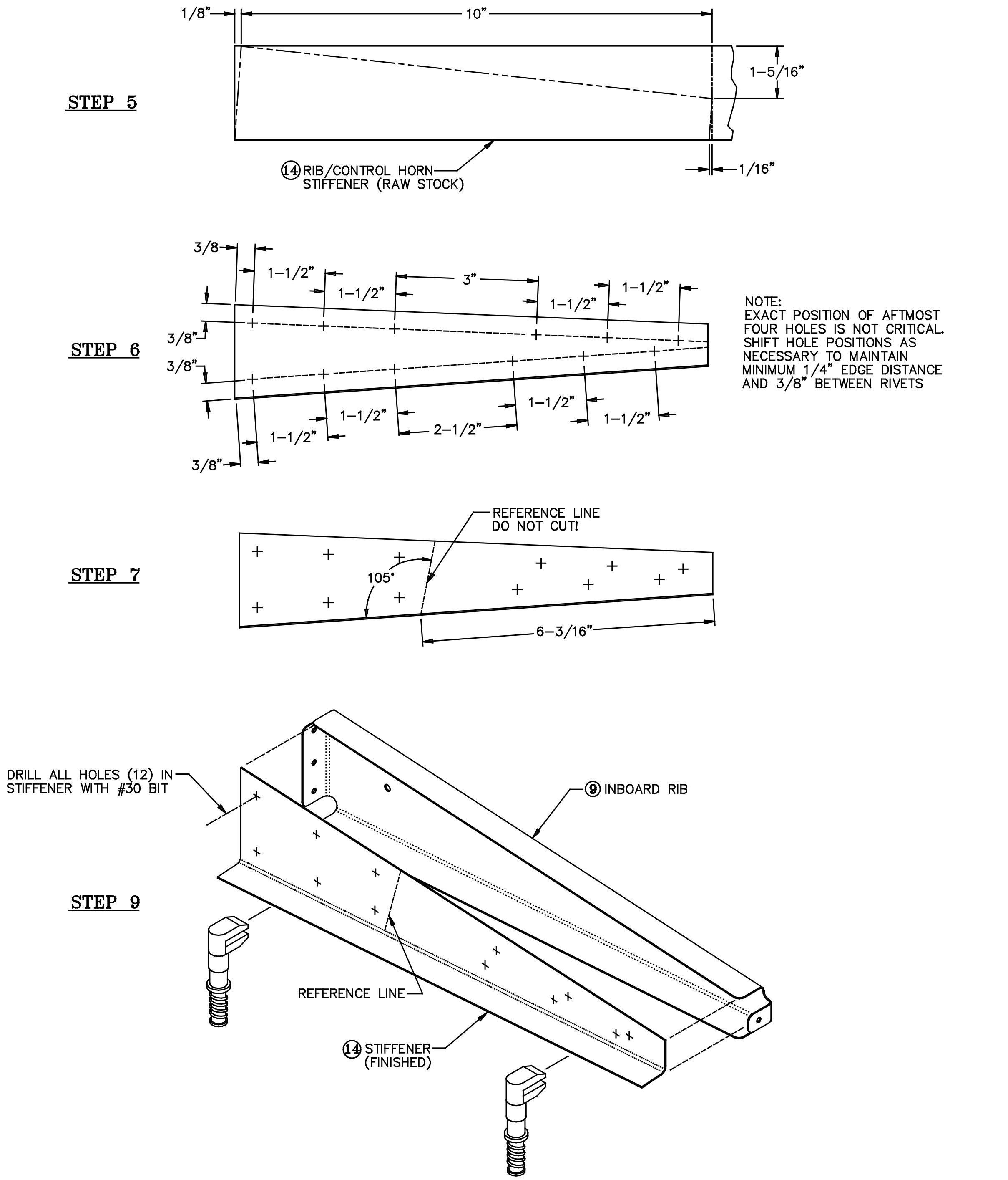

Figure 5: Cutting and Drilling the Rib/Control Horn Stiffeners

Step 8: Mark the Trim Cable Bracket Hole Locations on Ribs A and B *(Manual Trim Only)*

Before positioning the stiffeners inside Ribs A and B and drilling the holes you marked on them, you need to mark some hole locations on the ribs as well. These holes will be used to rivet the trim cable bracket to the ribs.

As shown in Figure 6, these holes are marked on the outboard side of the rib webs. Use your cardboard angle template to lay out the two reference lines, and then mark and lightly center punch the four hole locations according to the dimensions shown.

Completed: [ ]

Step 9: Position and Drill the Stiffeners *(Manual Trim Only)*

Position the stiffeners inside their respective ribs. They should nest snugly inside the lower flange of each rib, as shown in Figure 5. Align them fore-and aft on the ends of the lower flange of the rib and clamp them in place with Cleco side-grips or C-clamps along the flange

With the stiffeners clamped in place, drill through each stiffener and rib web at each of the twelve marked locations with a **#30** bit. When the drilling is completed, remove the side-grips or C-clamps and reattach the stiffeners to their respective ribs with two or three Clecos inserted from the rib (outboard) side.

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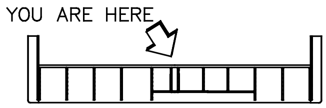

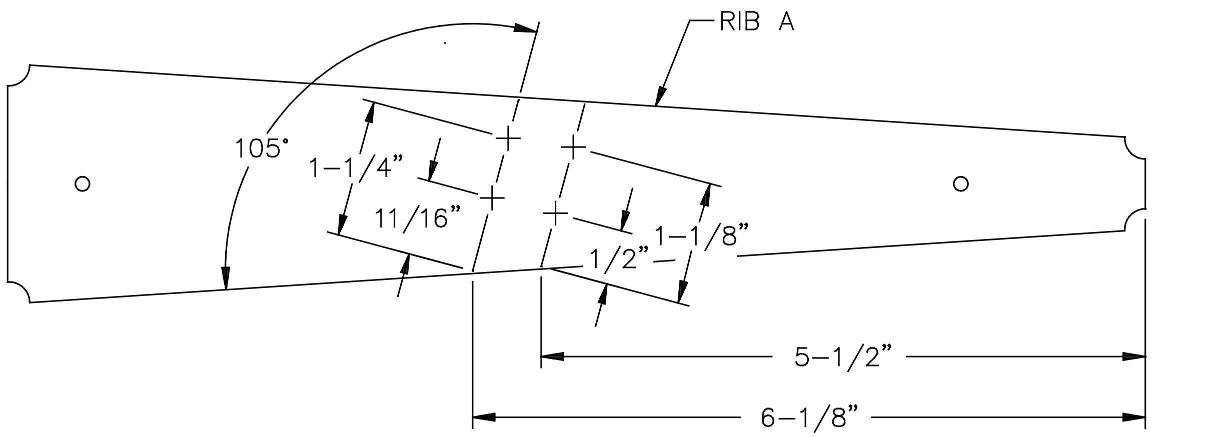

(MARK MIRROR-IMAGE PATTERN ON OUTBOARD WEB OF RIB B)

Figure 6: Trim Cable Bracket Rivet Hole Locations on Ribs A and B

Step 10: Mark Holes on the Control Horn Attach Angles

Each elevator **control horn** [12] is riveted to its respective **attach angle** [13] in seven places, and then the attach angle in turn is riveted to the underside of the elevator in five places. In this step, you will mark these hole locations.

The dimensions of the hole pattern are shown in Figure 7. Mark and lightly center punch the five attach angle/elevator hole locations as precisely as possible **inside** one flange of **each** attach angle. Then mark and punch the seven attach angle/control horn holes on the other flange of **one** angle only. Do not drill any of the holes at this time.

Note Be careful to maintain a minimum distance of **1/4"** (twice the rivet diameter) from the centers of all holes to the edges of all parts. Shift the locations of holes, if necessary, to satisfy this condition.

Completed: [ ]

Step 11: Drill Index Holes in the Attach Angles

In this step, three index holes are drilled in each attach angle—two to locate it on the underside of the elevator and one to locate the control horn on the angle. These holes are labeled A, B and C, respectively, in Figure 7. Clamp the two angles together back to back with side-grips and drill Holes A and B through both with a **#40** bit. Reclamp them with their other flanges together and drill Hole C through both with a **#30** bit. Remove the clamps

Completed: [ ]

Step 12: Mark and Drill Index Holes in the Control Horns

One hole is drilled in each control horn to locate it on its attach angle. Mark and center punch this hole on one horn according to the dimensions shown in Figure 7. Clamp the two horns together back to back with side-grips and drill through both at the marked location with a **#30** bit. Remove the side-grips.

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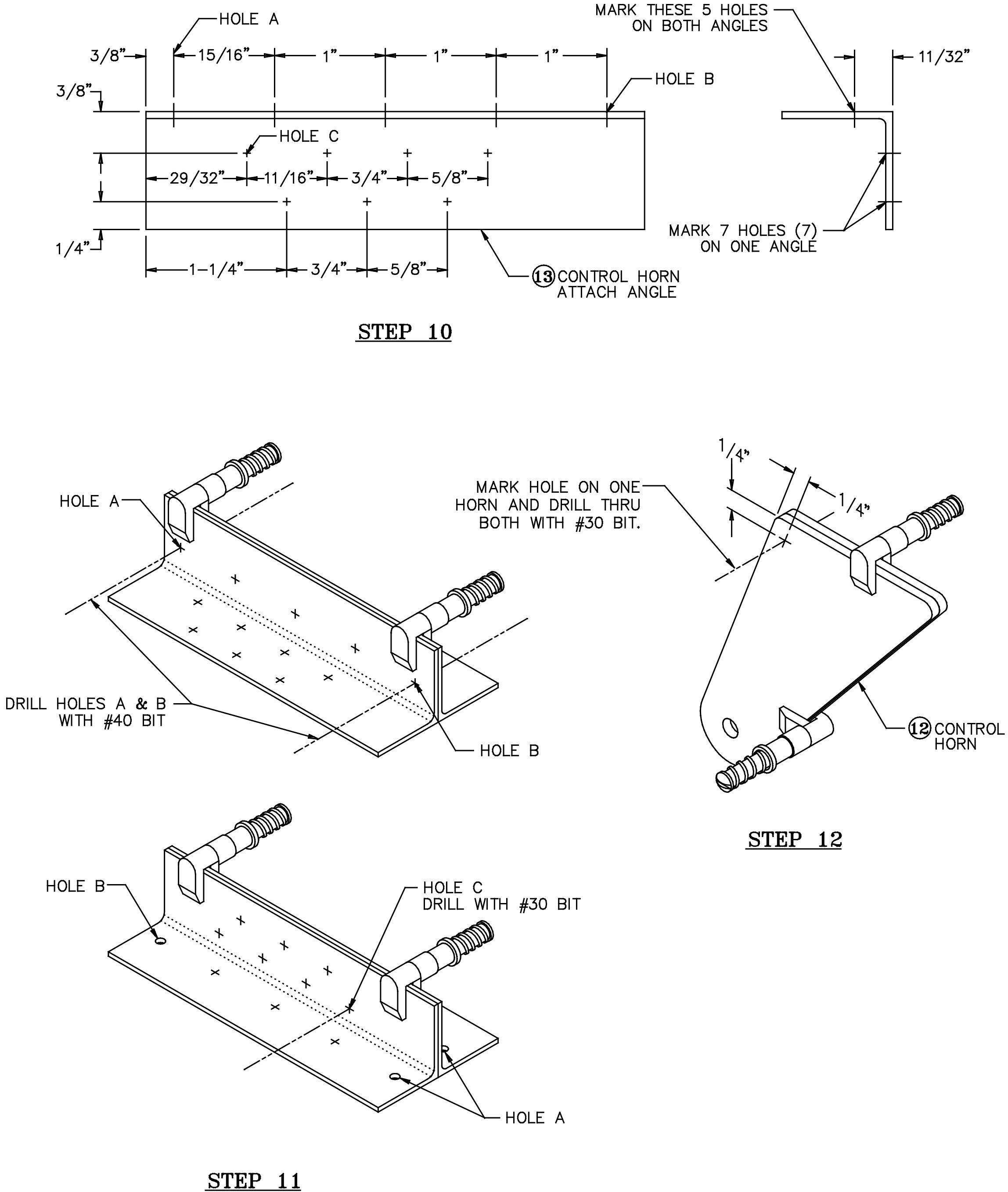

Figure 7: Marking and Index Drilling the Control Horns and Attach Angles

Step 13: Finish Drilling the Attach Angles and the Control Horns

Stack up both control horns and their respective attach angles and insert a Cleco through the common hole in all four pieces—the only hole in each horn and Hole C in the angles. Refer to Figure 8 to ensure that you have each part properly oriented.

Align the horns so they are flush with each other and clamp them together with a side-grip near the tips. Rotate the horns and the angles around the Cleco as necessary until the upper edges of the horns and the upper flanges of the angles are all parallel and then clamp the entire assembly together with a C-clamp opposite the Cleco.

With the horns and angle securely clamped together, drill the six undrilled holes through the angle and the horn with a **#30** bit. After drilling one hole, remove the side-grips and insert a Cleco for the remainder of the drilling. When the drilling is completed, mark each horn and angle to distinguish left from right. Leave the horns and angles Clecoed together.

Completed: [ ]

Step 14: Trim the Corners Off the Attach Angles

The solid lines in Figure 8 show the original shape of the attach angles. Trim off the corners as indicated by the dashed lines in the figure. While each set of horns and angles is still attached, make a mark on one of the angles where the forward and aft edges of the horn intersect it. (These points are labeled D and E in Figure 8.) Then remove the Clecos. Clean and deburr the control horns and set them aside.

Draw lines on the angle from the points you marked to the upper corners of the angle as illustrated by the dashed trim lines in Figure 8. Re-Cleco the two angles together back to back, and use a hacksaw to trim off the corners. Un-Cleco the angles, smooth the cut edges, round the corners and deburr the holes.

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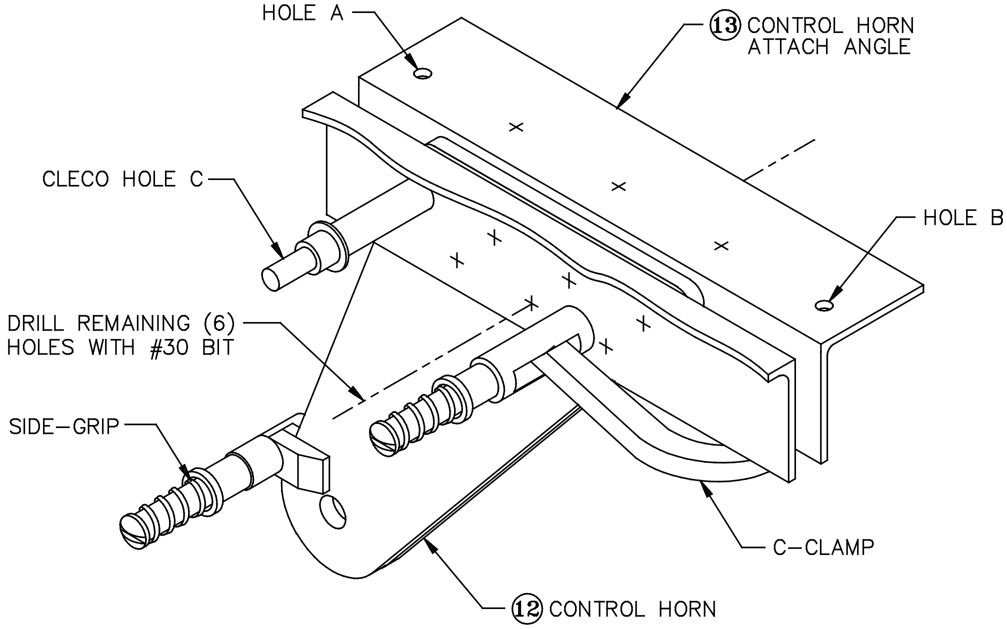
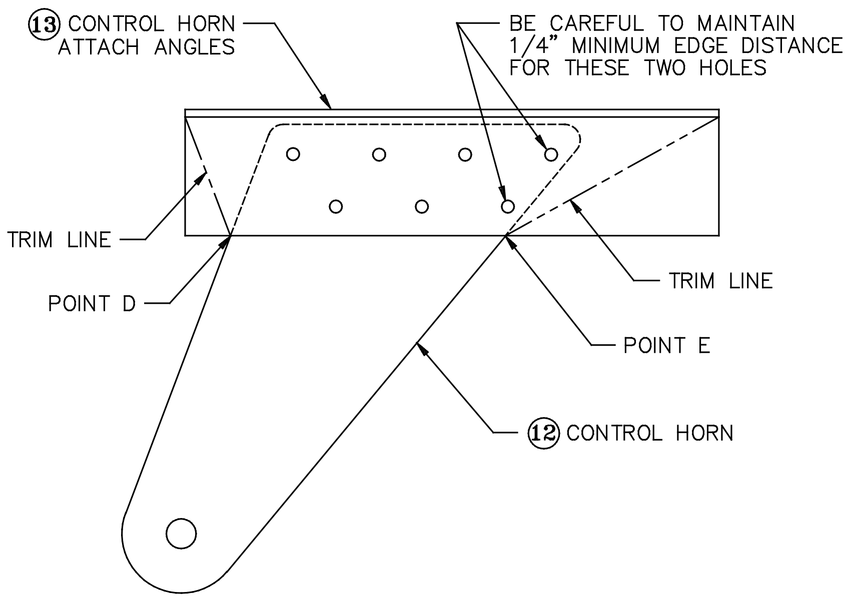


STEP 13



STEP 14

Figure 8: Final Drilling and Finishing the Control Horns and Attach Angles

Step 15: Cut Out the Trim Cable Bracket Parts (Manual Trim Only)

Electric Trim Option If you are installing electric trim, **skip this step and turn to the *Electric Trim Option Instructions***. Return to **Step 20** of this *Assembly Manual* when the specified option steps have been completed.

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The elevator trim tab is actuated by a sheathed cable that exits the fuselage through the fairing beneath the rudder, enters the elevator through a slot in the upper skin and exits the elevator to connect to the trim tab control horn through a slot in the lower skin. A bracket assembly installed in the interior of the elevator secures the end of the cable sheath. This assembly is made of six small parts that you must fabricate from the **trim cable bracket angle** [17] and **sheet** [18] supplied with the kit.

Figure 9 shows the final arrangement of the six finished parts in the bracket assembly as well as the dimensions for cutting each part from the raw stock. Use aviation snips or a bandsaw to make these cuts; the material is too thin to cut cleanly with a hacksaw. After you've cut all the parts to the designated length and width, cut the slanted edges of the two bracket angles. Refer to Figure 9 to ensure that you make the bracket angles mirror images of one another.

Finally, smooth and deburr the edges and round the corners of the bracket halves, gates and spacers and set them aside. Don't clean up the retainer clip piece yet, because it still requires some work in a subsequent step.

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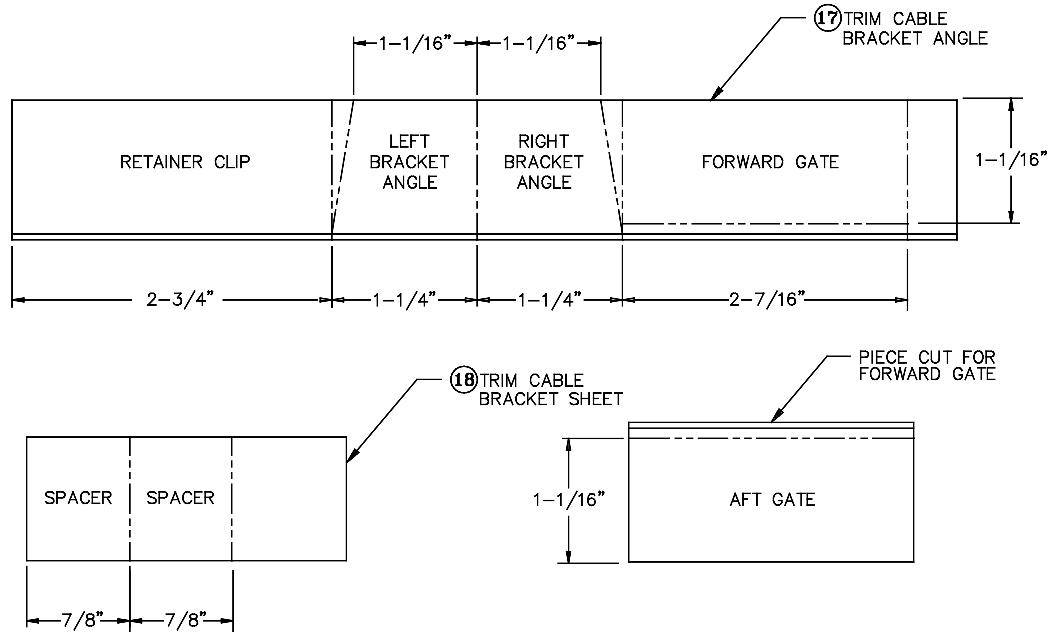
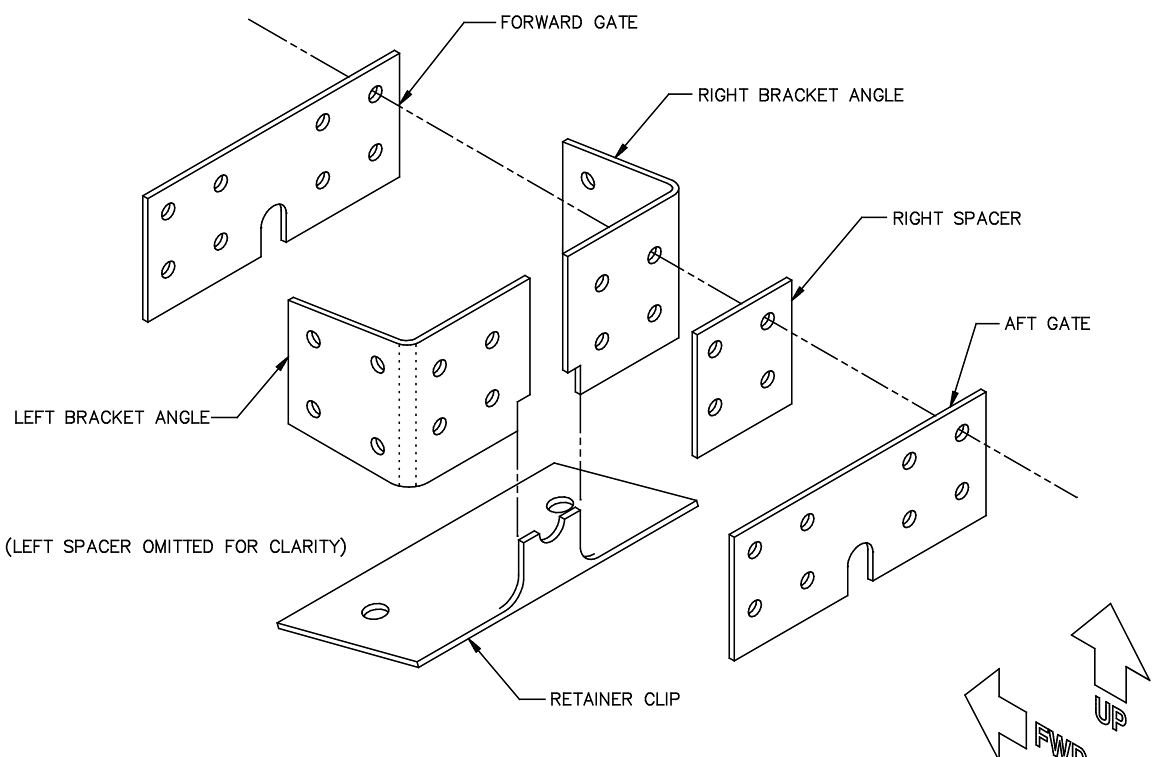


CUTTING THE PARTS FROM RAW STOCK – STEP 15



FINAL ARRANGEMENT OF THE FINISHED PARTS

Figure 9: Cutting the Trim Cable Bracket Parts

Step 16: Fabricate the Trim Cable Gates *(Manual Trim Only)*

A) Mark and Center Punch Hole Locations on the Forward Gate

Figure 10a shows the locations of the holes for the eight rivets that hold the trim cable bracket assembly together. Mark and lightly center punch these locations on the forward gate **only**. The figure also shows the centerpoint location of the 1/4" cable hole. Mark and punch this location as well—once again on the forward gate **only**. **Do not** drill any holes at this time.

B) Drill the Cable Hole

Clamp the forward and aft gates together back to back with a pair of side-grips, as shown in Figure 10b. Be sure the hole locations you marked on the forward gate are visible. Drill through both gates at the cable hole location with a 1/4" bit.

C) Cut the Cable Slot

With the gates still clamped together (as shown in Figure 10c), draw lines on the forward gate perpendicular to the lower edge and tangent to the edges of the cable hole. Use a fine-toothed saw to cut out the material between the lines.

D) Finish the Gates

Remove the clamps. With fine toothed round and flat files, deburr the arc and smooth the cut edges of the cable slot in each gate. Avoid enlarging the slot either vertically or horizontally.

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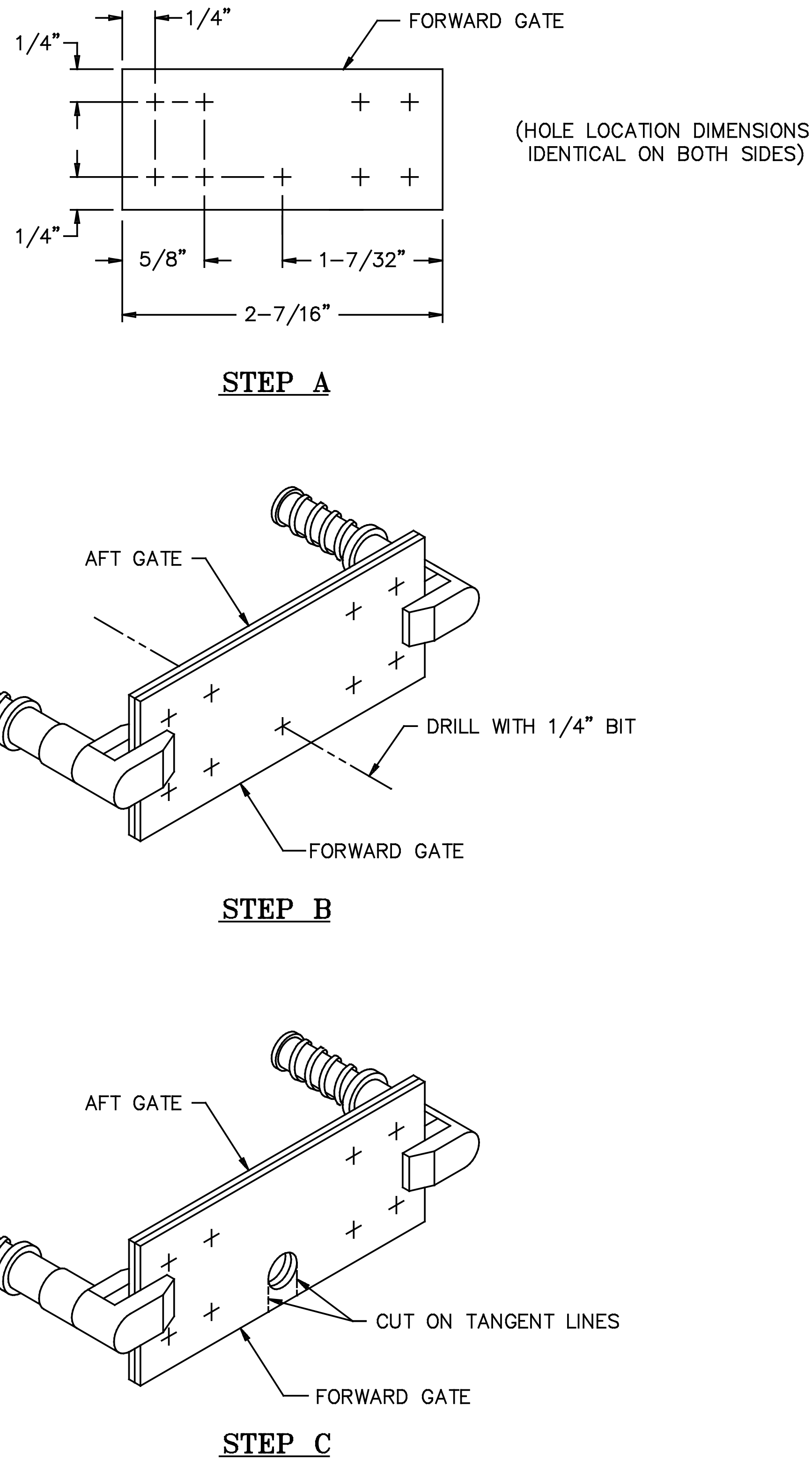

Figure 10: Fabricating the Trim Cable Gates

Step 17: Notch the Trim Cable Bracket Angles (Manual Trim Only)

As shown in Figure 9, the lower, inboard corners of the two bracket angles must be slightly notched to accommodate the tongue of the retainer clip.

A) Mark the Notch Corner Location

The notches in the two bracket angles are mirror images of each other. Figure 10a shows the location of the corner of the notch in the **right-hand** bracket angle. Mark and lightly center punch this location according to the dimensions in the figure on the right angle **only**. Refer to the orientation of the slanted edge in the figure to make sure that you are marking the right-hand angle.

B) Drill the Corner Hole

To avoid a square corner (which could serve as a stress riser, leading to cracking), you will drill a small hole where the corner of the notch will fall. Clamp the bracket angles together back to back, as shown in Figure 10b, and drill through both with a 1/16" bit.

C) Cut the Notches

With the angle still clamped together, use a fine-toothed saw to cut out the notch on lines perpendicular to the edges of the angles and tangential to the edges of the corner hole

D) Finish the Angles

Unclamp the angles and smooth the cut edges with a file.

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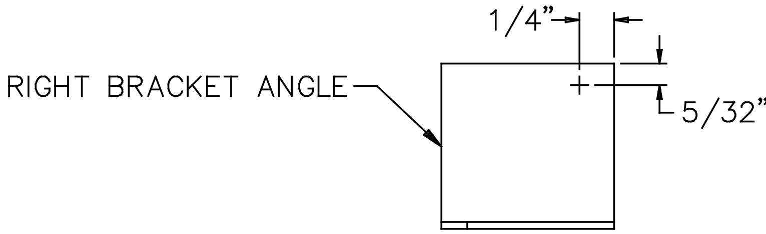
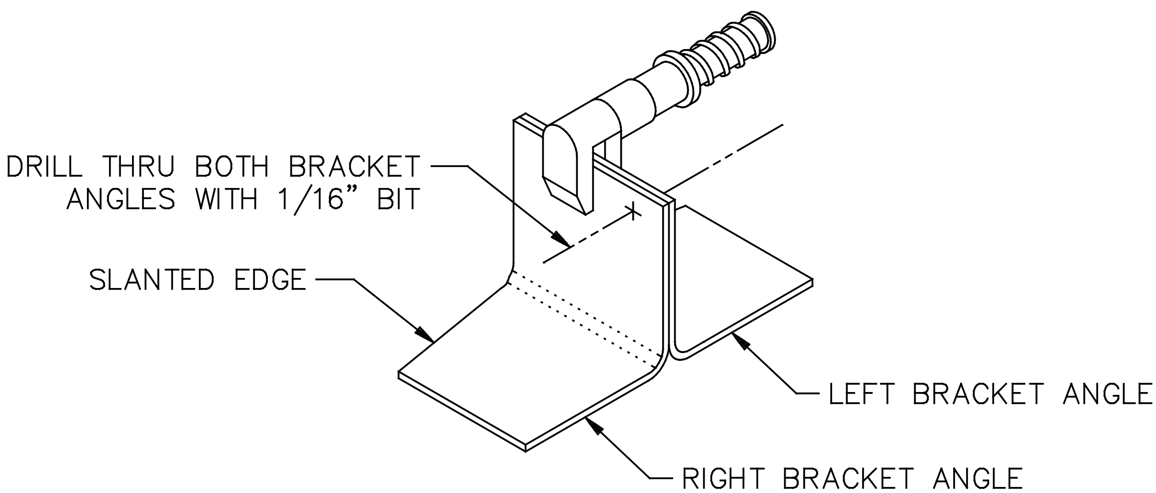
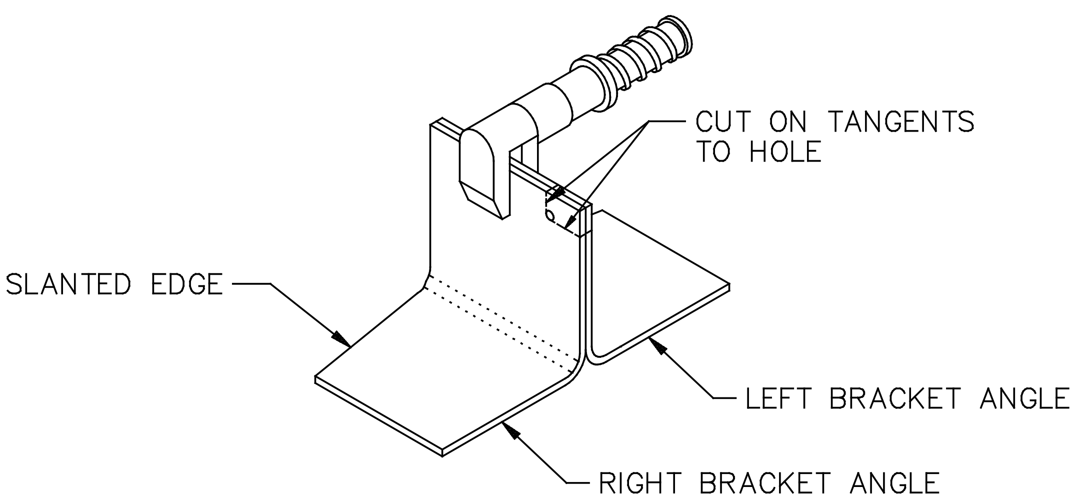


STEP A



STEP B



STEP C

Figure 11: Notching the Trim Cable Bracket Angles

Step 18: Drill the Left-Side Rivet Holes in the Bracket Parts (Manual Trim Only)

In this step you will clamp together all the left-side bracket parts and drill the holes that will be used to rivet them together.

Begin by marking a reference line on the forward face of the left bracket angle. This line will be used to align the outboard edges of the forward and aft gates and the left spacer. As shown in Figure 12, this line should be marked **1-1/32"** outboard of the inboard edge of the angle.

When the line has been marked, align the gates and spacer horizontally on the line and vertically on the lower edge of the angle, as shown in Figure 12. Clamp all the parts in place with a pair of side-grips.

When all the parts are secured, drill through each of the four left-side holes with a #30 bit. After drilling the first hole, insert a Cleco from the aft side; after drilling the second, Cleco it (also from the aft side) and remove the side-grips before finishing up the third and fourth holes. Leave the Clecos in place for the moment.

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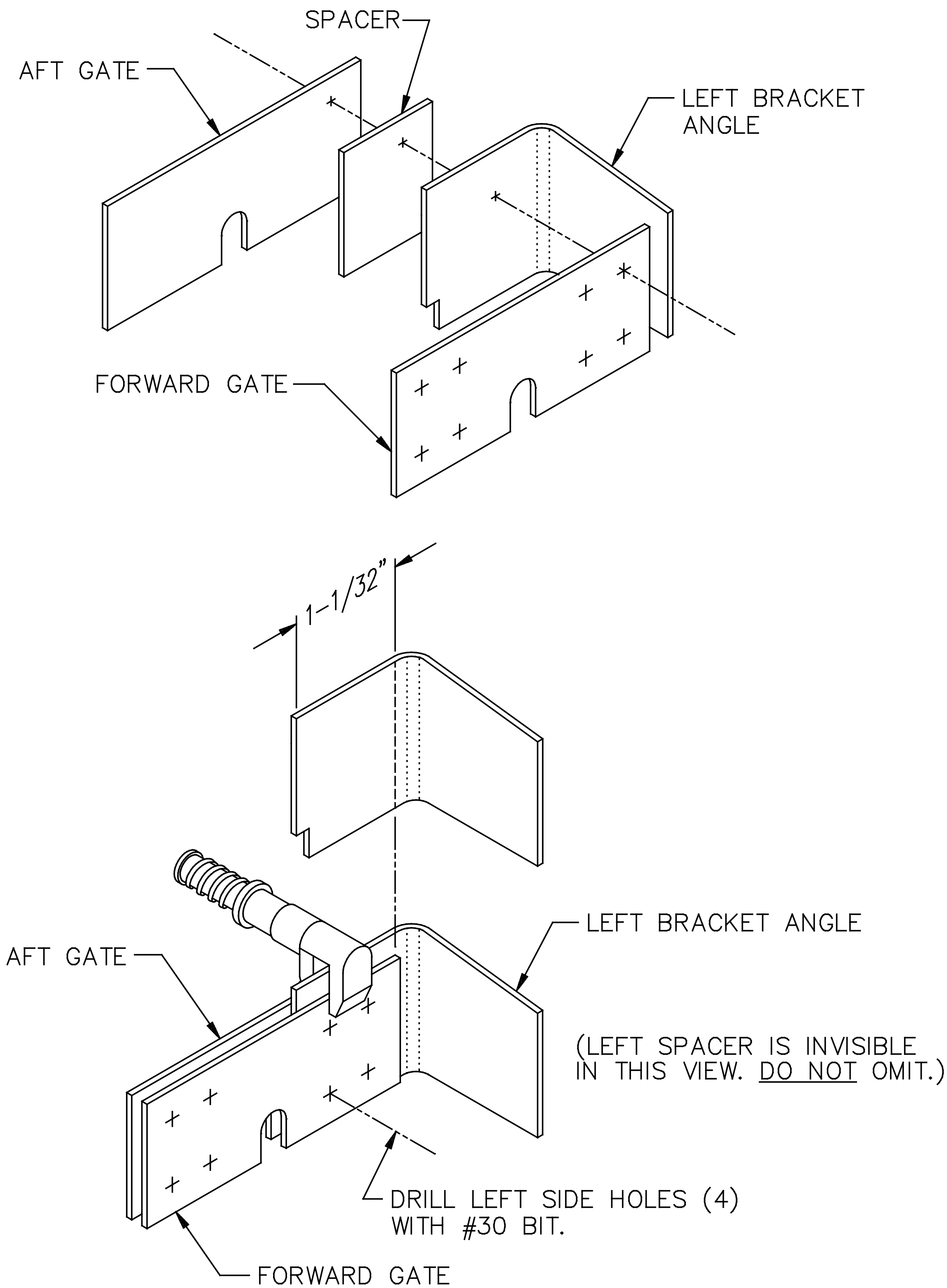

Figure 12: Drilling the Left-Side Trim Cable Bracket Rivet Holes

Step 19: Fabricate the Trim Cable Retainer Clip (Manual Trim Only)

Final drilling of the trim cable bracket angles, gates and spacers must be done in later steps, but you can finish up the retainer clip now. Figure 13 illustrates the additional drilling and cutting that's required.

A) MARK AND DRILL THE CABLE HOLE

Mark and lightly punch a centerpoint at the location on the vertical flange shown in Figure 13a and drill the hole with a 1/4" bit.

B) MARK AND PILOT DRILL THE SCREW HOLE LOCATIONS

Mark and lightly punch centerpoints at the locations on the horizontal flange shown in Figure 13b. Drill these holes with a #40 bit.

C) CUT OFF THE TOP OF THE VERTICAL FLANGE

As shown in Figure 13c, cut off the top of the vertical flange **1/2"** from the bottom (through the centerpoint of the cable hole).

D) CUT THE RETAINER TONGUE TO FINAL WIDTH

Cut away the remaining vertical flange material **1-3/32"** from each end of the clip, as shown in Figure 13d.

E) BEND THE RETAINER TONGUE

Using a pair of duck bill pliers, bend the retainer tongue to 105°. Check the angle with the cardboard angle template, as shown in Figure 13e.

F) SMOOTH, DEBURR AND ROUND THE CORNERS

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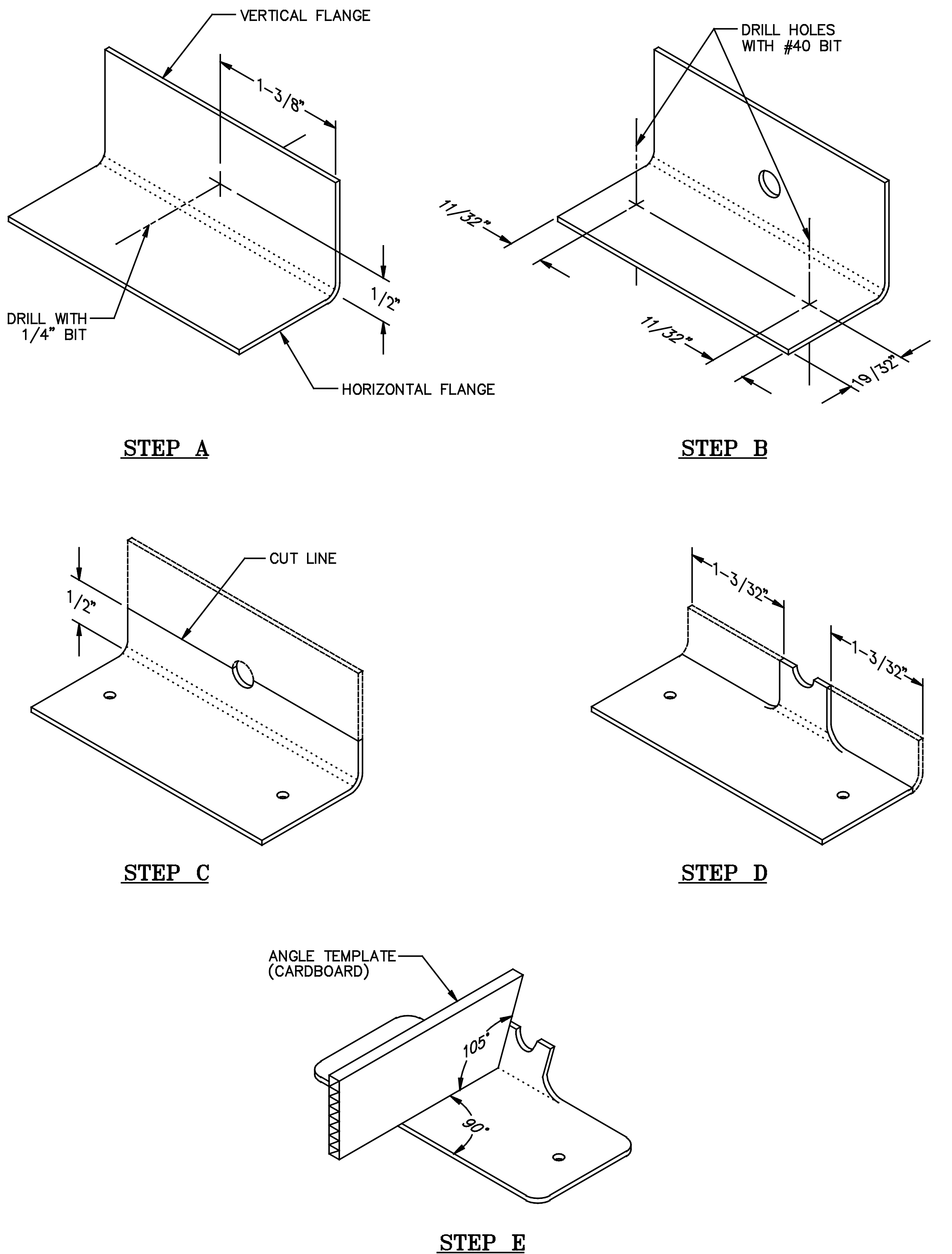

Figure 13: Fabricating the Trim Cable Retainer Clip

Step 20: Mark Rivet Lines on the Forward Spar and the Ribs

Using a marking pen, mark a centerline on the upper and lower flanges of all the ribs. Rivet lines must also be marked on both the upper and lower flanges of the forward spar, but these are not strictly centerlines: as shown in Figure 14, the **upper flange line** should be marked **7/16"** in from the edge of the flange; the **lower flange line** should be marked **1/4"** in from the edge of the flange.

Note The lower flange of the forward spar is the narrower of the two flanges.

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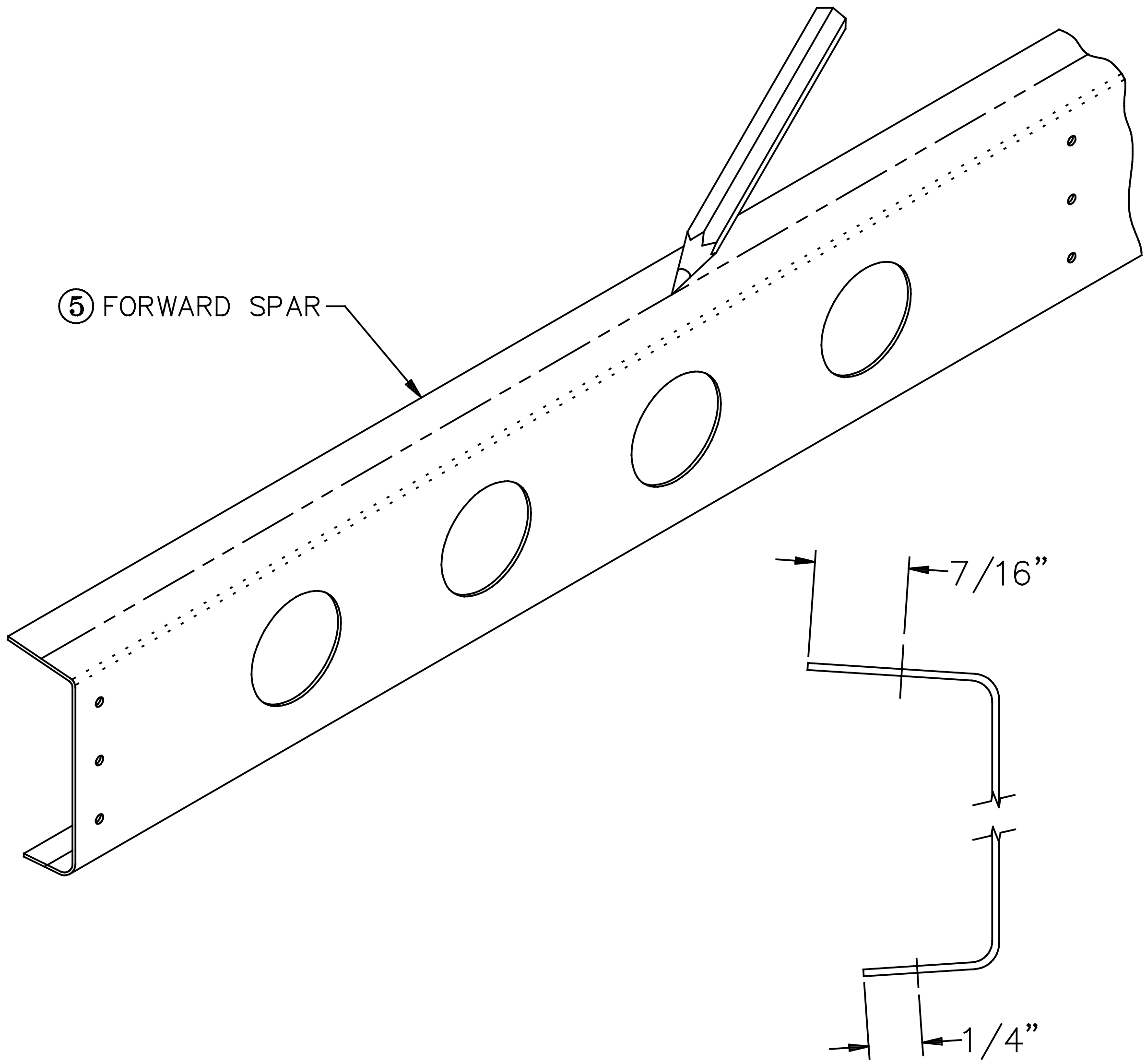

Figure 14: Marking the Forward Spar Rivet Lines

Step 21: Cleco the Ribs to the Forward Spar

Using two Clecos per rib through the pre-punched holes, clamp the inboard and outboard ribs to the forward spar, as shown in Figure 15. Make sure that the spar is properly oriented with the **larger flange on top**. Also note that the shorter, inboard ribs occupy the first position to the left of center and the first three positions to the right of center. Finally, it is vital that the rib and spar flanges be oriented properly, as shown in Figure 1; the spar flanges should point **forward**, and all inboard and outboard ribs should point **inboard**, **except** for Ribs C and D, which should point **outboard**.

After all the ribs are Clecoed in place and you have confirmed that the flanges are properly oriented, mark each rib, specifying its location on the spar. Use any numbering or lettering system that makes sense to you; the important thing is simply that you be able to return each rib to its original position on the spar after repeated disassembly and reassembly.

Finally, use a **#30** bit to drill all the spar/rib rivet holes up to final size. Juggle the Clecos as necessary, replacing the 3/32" ones with 1/8" ones after drilling.

Completed: [ ]

Step 22: Cleco the Aft Partial Spar to the Inboard Ribs and Drill the Rivet Holes to Final Size

Cleco the **aft partial spar** [6] to the aft end of the four inboard ribs. Note that the aft spar has a definite left and right determined by the locations of the rivet holes; if the holes in the spar don't line up with the four inboard ribs, then it's backwards! Be sure that the flanges of the aft spar point aft. Refer to Figure 15.

Finally, remove individual Clecos as necessary, drill through the aft flanges of each rib and the corresponding partial spar web holes with a **#40** bit. Replace each Cleco after drilling.

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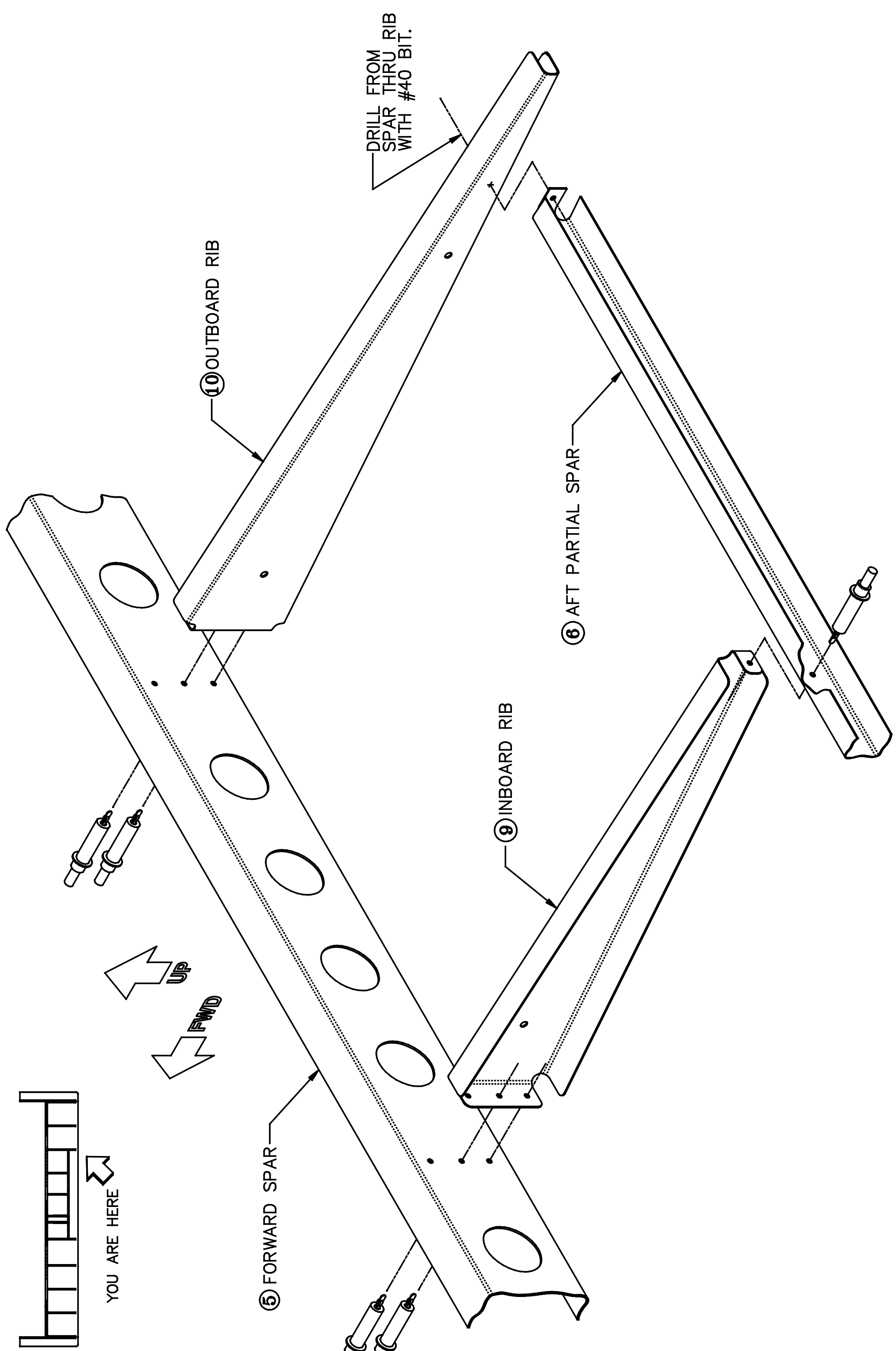

Figure 15: Clecoing the Spar/Rib Assembly

Step 23: Drill the End Flanges of the Aft Partial Spar

The aft partial spar will be riveted to the adjoining outboard rib at each end. The flanges on the spar ends are pre-punched for this purpose, but you must drill through the ribs with a #40 bit (see Figure 15). Because of the close quarters inside the spar, this is a tricky hole to drill. If you have a 12" extension bit, you can use your fingers as a guide and flex the bit enough to get inside the spar cove. If you don't have such a bit, you'll have to mark the hole on the inboard web of each rib and drill the rib by itself after disassembling the spar/rib assembly. Also, don't forget to drill the spar flange itself—the pre-punched hole is slightly undersized.

Regardless of whether you're drilling through the spar and rib together or simply marking the rib through the spar, use a square to make sure that the spar and rib are perpendicular to one another.

Completed: [ ]

Step 24: Mark and Cut the Tip Rib Notches in the Lower Skins

As shown in Figure 16, small notches must be cut in the outboard, leading edge corners of both the **left** [3] and **right** [4] **lower skins** to accommodate the tip ribs, which extend forward of the skins' leading edges.

Begin each notch by marking a corner hole centerpoint **21/32"** in from the outboard edge of the skin and **1/4"** forward of the forward spar rivet line (see Figure 16). Lightly center punch this hole and drill it with a #40 bit.

Cut the notch with aviation snips and smooth the edges with a file.

> **Note** You can cut toward the **center** of each hole along the lines you marked to locate the holes, or you can cut along lines tangent to the aft and inboard edges of the hole. If you choose the latter, just be sure you leave a radius in the corner. A square corner will invite cracking.

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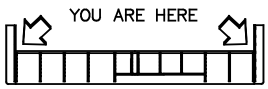

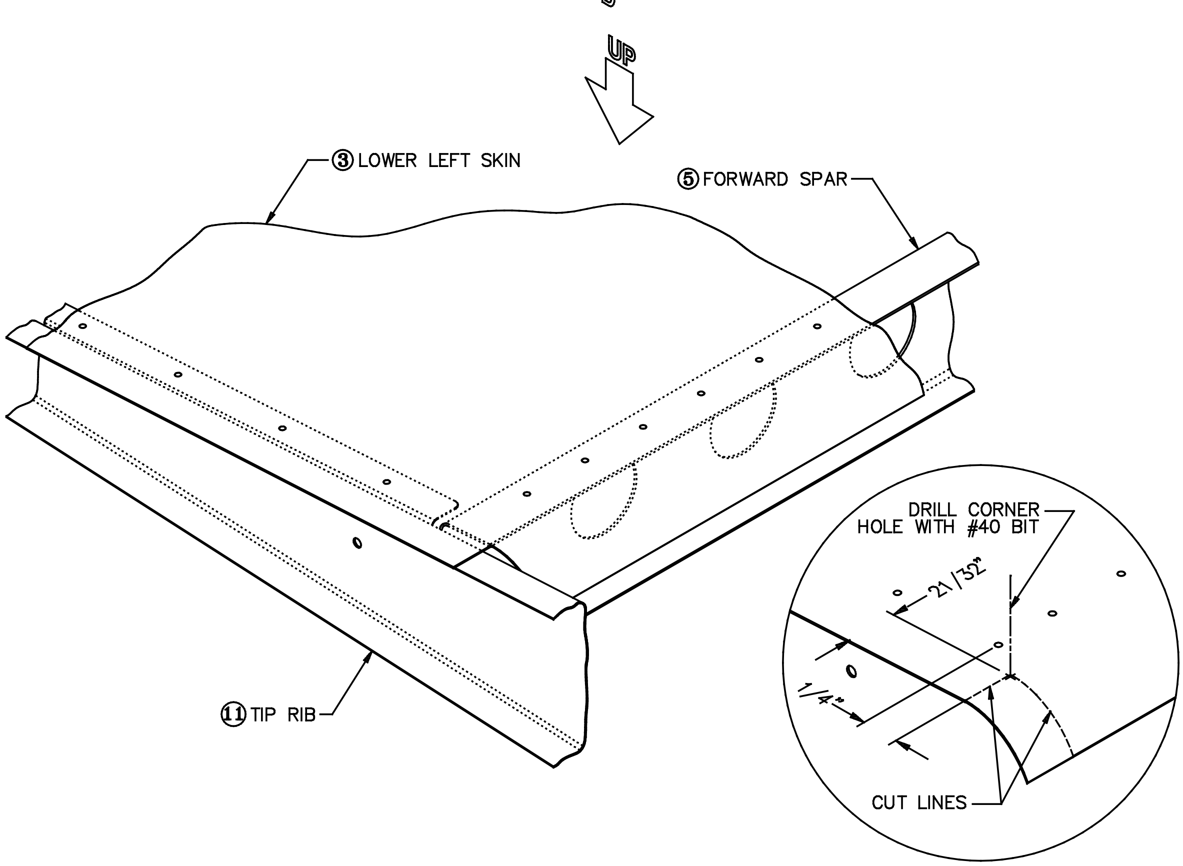

Figure 16: Cutting the Tip Rib Notches in the Lower Skins

Step 25: Position the Lower Right Skin

Lay the spar/rib assembly upside down on the bench with the upper spar flange flush with the edge of the bench. Use spring clamps (preferably with padded jaws) or large C-clamps to clamp the spar flange to the bench top. As you clamp, use a long straightedge along the spar web to make sure the spar is straight.

Caution In handling the elevator skins—especially the lower ones—be careful not to allow any more lengthwise flexing than necessary. Excessive bending in this direction will put kinks in the curved leading edges of the lower skins and the trailing edge joggles of all four skins. These kinks are almost impossible to remove and will spoil the appearance of an otherwise well-built elevator.

> **Note** Because Figure 17 and subsequent diagrams of the spar/rib assembly place the trailing edge nearest to you, all right-side parts will naturally be on the left from your vantage point when the assembly is shown upside-down. Pay careful attention to the directional arrows in each figure!

Lay the lower right skin on top of the assembly, as shown in Figure 17. This is the skin with the curved leading edge and the longer trim tab cutout. Ultimately, of course, you want the skin aligned so that the rivet lines you marked on the spar and rib flanges are centered under the pre-punched skin holes. However, because the outboard ribs are only anchored at one end, things are likely to be somewhat skewed initially.

Begin, therefore, by aligning the skin on the forward spar rivet line. Use a framing square to make sure that the outermost rib is exactly perpendicular to the spar, and then move the skin left and right until the rivet line on that rib is centered under the line of holes along the outboard edge of the skin.

> **Note** When the elevator skins are aligned properly, they extend beyond the outboard ends of the forward spar and the webs of the outermost ribs. Don't be alarmed! This overhang accommodates the tip ribs.

When the skin and the outermost rib are in alignment, clamp the skin in place to the spar. The curved leading edge of the lower skins prevents the use of side-grips along the length of the spar, but, as shown in Figure 17, you can use a C-clamp at the outboard end if you come in from the side, rather than from the forward edge.

With this clamp in place, move to the inboard end and align the rivet line on Rib A under the pre-punched skin holes. When it is aligned, clamp the skin to the aft partial spar near the inboard end with a pair of side-grips, as shown in the figure.

With the skin clamped in two places, drill through the skin and spar at the **innermost** hole along the forward spar line with a #40 bit (see Figure 17). Insert a Cleco. Then move outboard along the spar, repeating the drilling (#40) and Clecoing once at each rib location until you reach the outboard end of the spar. As you go, check to make sure that the spar rivet line remains centered under the pre-punched skin holes.

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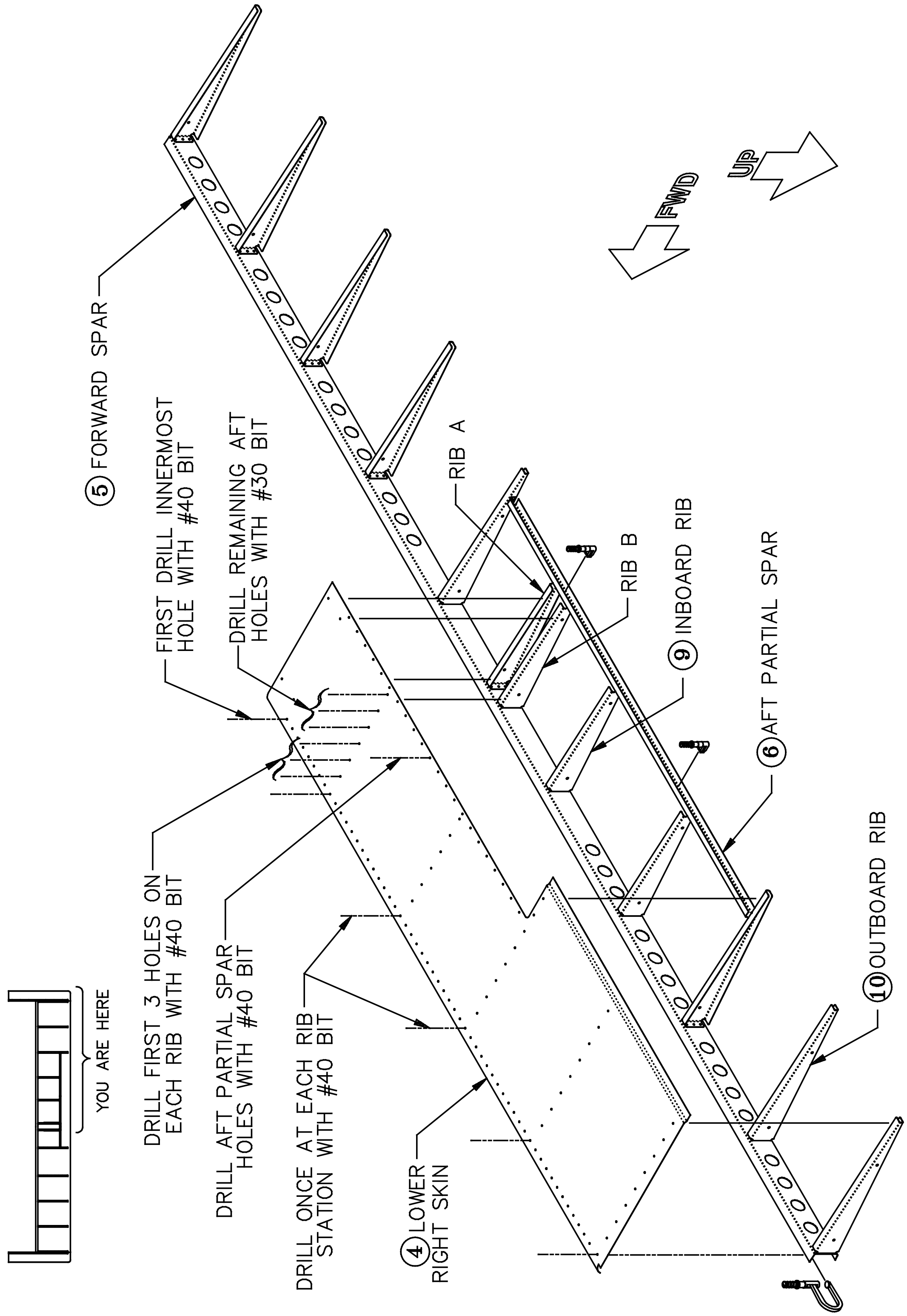

Figure 17: Positioning and Drilling the Lower Right Skin

Step 26: Drill the Remaining Lower Right-Side Holes in the Spars and Ribs

With the leading edge of the lower right skin Clecoed in place along the forward spar, drill all the remaining spar and rib holes. Finish the ones through the forward spar first using a **#40** bit, and then move on to the outboard ribs. As with the nose ribs in the last section, the outboard ribs may have to be moved left or right to bring them into alignment under the pre-punched holes. In this case, however, you won't need to use a tool; simply reach under the trailing edge and move the ribs by hand as necessary.

Due to limited space for maneuvering the bucking bar during final riveting, driven rivets can be used only in the first three holes in each rib (counting fore-to-aft); the remainder will take blind rivets. Use a **#40** bit to drill the first three holes for the driven rivets. The solid-shank, structural blind rivets are only available in 1/8" diameter, so drill **#30** holes from the fourth hole aft. Start drilling at the forward end of each rib and move aft, Clecoing as you go.

The inboard ribs may also need to be aligned left-and-right, but since they are anchored to both the forward and aft spars, they should move as a unit and all come into alignment at the same time. Drill them in a forward-to-aft sequence with a **#40** bit for the first three holes and a **#30** subsequently. Cleco as you go.

Note The right skin has only four pre-punched holes over Ribs A and B. Drill **only** those four at this time; the remainder will be drilled after the left skin has been lapped over the right.

Finally, drill the aft spar with a number **#40** bit and Cleco.

Note There are no pre-punched aft spar rivet holes in the area where the left skin overlaps. These holes will be drilled after the left skin is positioned in a subsequent step.

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Step 27: Mark and Cut the Trim Tab Pushrod Slot in the Lower Left Skin *(Manual Trim Only)*

Electric Trim Option If you are installing electric trim, **skip this step and turn to the *Electric Trim Option Instructions***. Return to **Step 28** of this *Assembly Manual* when the specified option steps have been completed.

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The pushrod that actuates the elevator trim tab exits the elevator through a tapered slot in the lower skins, as shown in Figure 18. The wide end of this slot also accommodates the trim cable retainer clip. In this step, you will mark and cut this slot in the lower left skin; you will duplicate the slot in the lower right skin, in a subsequent step.

You will make the slot by drilling three holes and then cutting out the material between them. The first step is to locate the centerline of these holes. On the lower left skin, mark a parallel line **1-13/32"** in from the inboard edge of the skin. Then measure forward from the trailing edge of the skin and make marks at **3-5/8"**, **5-7/8"** and **6-5/8"** to locate the centerpoints of the three holes. Because of the curved leading edge of the lower skin, you will find it much easier to lay out these slot dimensions on the **inside** surface of the skin.

Lightly center punch these holes. Drill the aft hole with a **1/4"** bit and the two forward holes with a **9/16"** hole cutter. Draw tangent lines connecting the holes and cut out the material between them with a rotary cutting tool. Finish the slot with appropriate round and flat files, making sure that all the interior edges are smooth and deburred.

✔

Note Do not try to drill the forward hole with a standard 9/16" bit. If you attempt to drill such a large hole in such thin sheet, the bit will almost certainly grab the material, and you will not get a clean hole. If you don't have a hole cutter, step drill the hole—that is, begin with a small hole (1/4" or smaller) and work up to final size in 1/16" increments.

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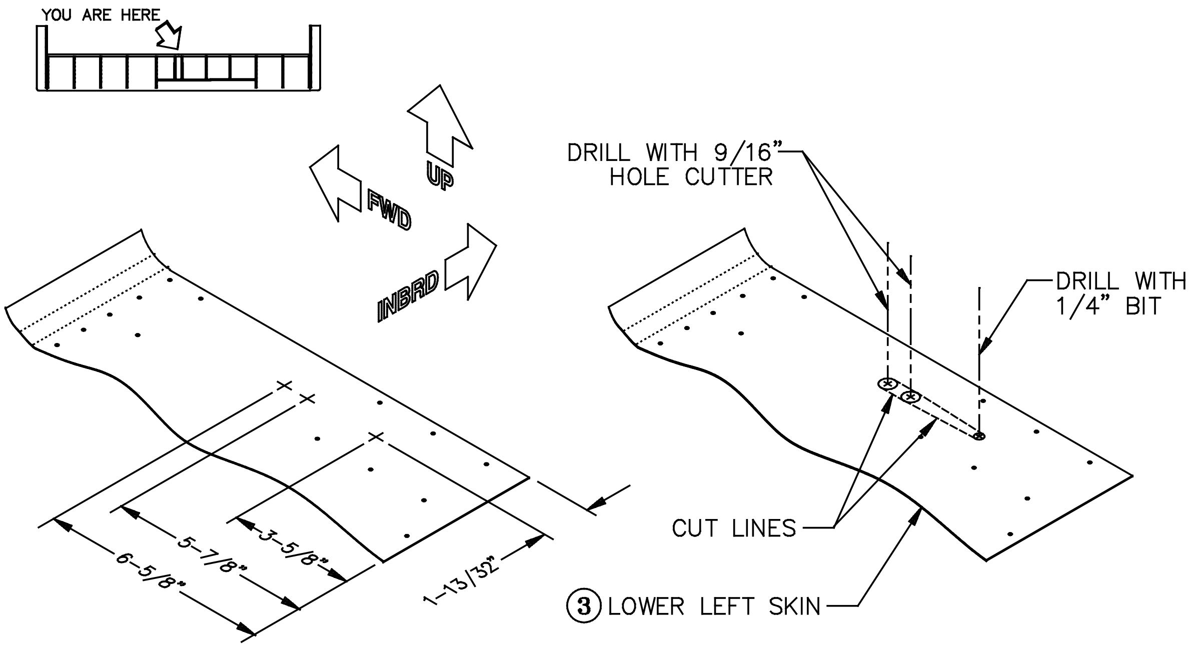

Figure 18: Cutting the Trim Tab Pushrod Slot

Step 28: Position and Drill the Lower Left Skin

The procedures for positioning and drilling the lower left skin essentially repeat those used to position and drill the lower right skin, as shown in Figure 19. In particular, before drilling any holes, make sure that the forward spar is straight from end to end, that the end ribs are square to the spar and that, as always, all the rivet holes in the skin are aligned with lines marked on the spar/rib framework.

Begin by drilling the forwardmost and aftmost Rib B holes along the inboard edge of the skin up to **#40** size so they will accept Clecos. Then lay the left skin in place overlapping the right skin and clamping it to the spar/rib assembly at the inboard end with a pair of Clecos through the common, Rib B holes. Drill (**#40**) and Cleco outboard from the center along the spar, checking as you go to see that the rivet line you marked on the forward spar flange is centered under the leading edge skin holes.

When the spar has been drilled and Clecoed, move on to the ribs, drilling in a forward-to-aft sequence with a **#40** bit. Don't forget to drill both skins along Ribs A and B. Finally drill the aft spar with a **#40** bit and Cleco.

> **Note** Early GlaStar elevator skins lacked the pre-punched aft spar rivet holes in the area of the skin overlap. For these skins, lay out the locations of the missing rivet holes on the **left** skin and drill them through both skins and the aft spar with a **#40** bit. Use the same hole spacing as the rest of the rivet line, adjusting as necessary to maintain the standard minimum edge distance (**3/16"** for 3/32" rivets) in both the left and right skins.

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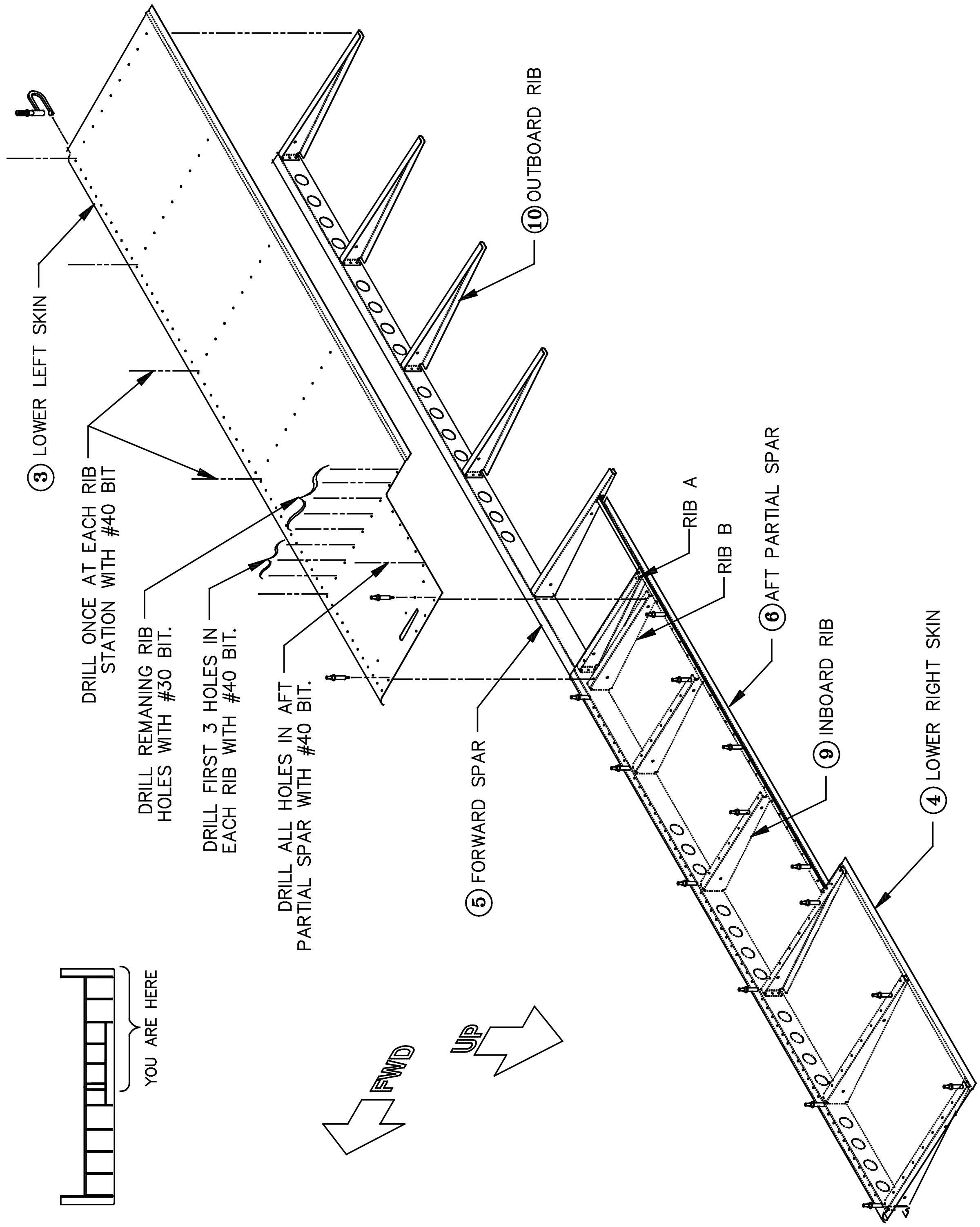

Figure 19: Positioning and Drilling the Lower Left Skin

Step 29: Mark and Cut the Trim Tab Pushrod Slot in the Lower Right Skin

With the lower left skin Clecoed in place overlapping the lower right skin, use a scriber to trace the circumference of the trim cable slot on the lower right skin.

Remove both lower skins and cut out the right-skin pushrod slot using the same techniques you used to make the left one. Make the right-skin slot slightly oversized—say, an extra 1/32" all around. Finish the slot with fine-toothed files and re-Cleco the skins to the spar/rib assembly.

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Step 30: Position and Drill the Control Horn Attach Angles

The control horn attach angles are riveted to Ribs A and B and the forward spar flange. The first step in positioning them is to remove the Clecos holding the skins to Rib A. Lay a straightedge on the lower left skin along this rib and mark a chordwise centerline through the rivet holes. Replace the Rib A Clecos and repeat the procedure on Rib B but do not replace those Clecos.

Next, clamp the right-side attach angle to the underside of the elevator assembly by inserting a Cleco through Hole A on the angle and the corresponding skin hole—the forwardmost hole on the Rib B line you just marked. Refer to Figure 20 to ensure that you have used the proper skin hole and have oriented the angle correctly.

With the Cleco in place, rotate the angle until the centerline you just marked on the lower left skin comes into alignment under Hole B (see Figure 20) at the aft of the attach angle. Holding the angle firmly in place with your fingers, use a **#30** bit to drill through Hole B, the overlapped skins, the rib and the stiffener.

> **Note** The rib/control horn stiffeners should still be Clecoed to Ribs A and B from earlier steps. If you disassembled them, Cleco them back together before drilling these holes.

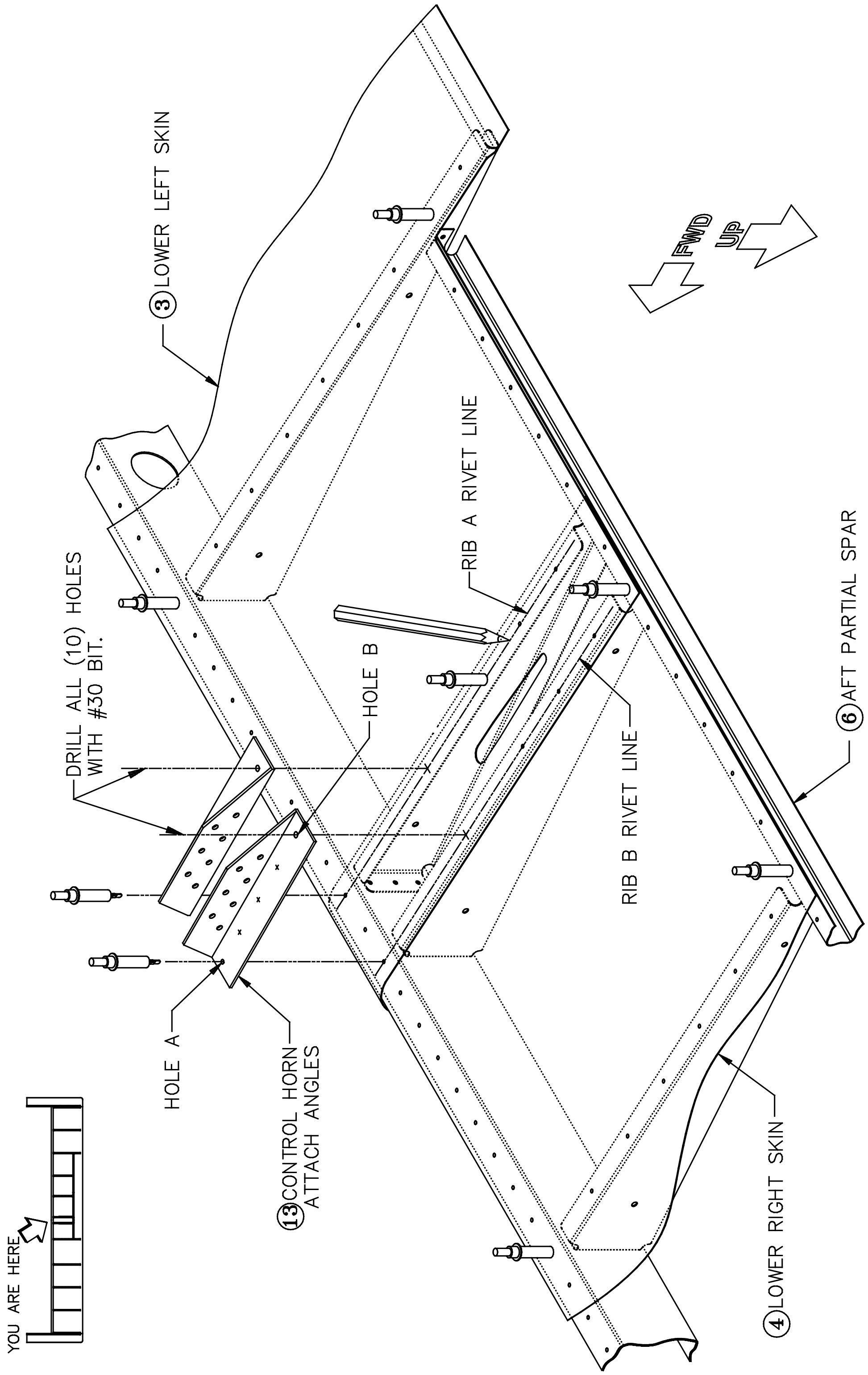

Figure 20: Positioning and Drilling the Control Horn Attach Angles

Insert a Cleco in Hole B and then drill through the angle, skins, rib and stiffener at the three undrilled hole positions with a **#30** bit. Finally, insert a Cleco in one of these holes, remove the Cleco from Hole A, and drill Hole A with a **#30** bit. Repeat the process for the left-side angle. Leave the angles Clecoed in place for the moment.

Note In early GlaStar kits, there may be two additional pre-punched skin holes just aft of the ones that match Hole A in the angles—one hole on Rib A and one on Rib B. These holes are intended to line up with the holes you drilled in the attach angles just aft of Hole A, but there is likely to be a slight mismatch between them. Don't worry about this. The #30 final-size holes you are drilling are larger than the pilot holes by enough to take care of any misalignment. Just try to drill the hole as perpendicular to the attach angle as possible.

Completed: [ ]

Step 31: Position and Drill the Right Trim Cable Bracket Angle (Manual Trim Only)

Electric Trim Option If you are installing electric trim, **skip to Step 35**.

In this step you will position the right trim cable bracket angle against the web of Rib B and drill the four holes through which it will be riveted in place. Figure 21 shows how the angle should be C-clamped in place: with its forward edge on the 105° reference line you marked on the rib/control horn stiffener and its top edge parallel to and **1/16"** down from the upper flange of the rib.

Note Because of the overhanging rib flange and the narrow space between Ribs A and B, a conventional C-clamp cannot be used here. We recommend the Vise-Grip-type locking C-clamp, as depicted in Figure 22.

When the angle is securely clamped in position, drill through the rib web, the stiffener and the angle at the four locations you marked on the outboard side of the rib web with a **#30** bit. Cleco after drilling the first and second holes and then remove the C-clamp to finish up. The Clecos should be inserted from the outboard side of the rib.

Completed: [ ]

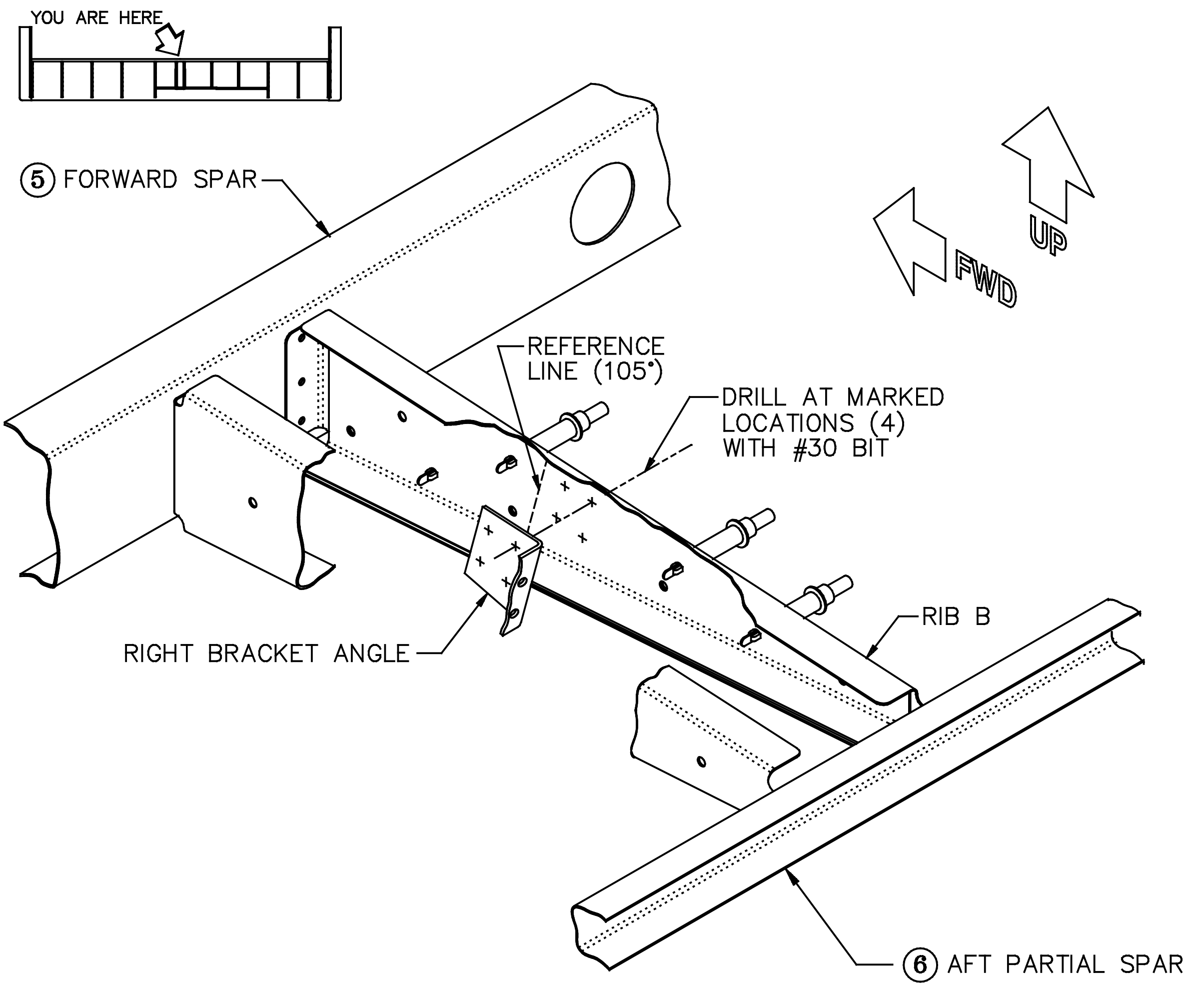

Figure 21: Positioning and Drilling the Right Trim Cable Bracket Angle

Step 32: Position and Drill the Left Trim Cable Bracket Half *(Manual Trim Only)*

The left bracket half (the two gates, left angle and left spacer you already Clecoed together) is positioned exactly as the right angle was in the previous step. Align the left angle's forward edge on the 105° reference line and its top edge parallel to and **1/16"** down from the upper flange of Rib A.

You have additional help in achieving the proper position, because the flange of the right-hand angle that projects inboard from Rib B will be sandwiched between the forward and aft gates when the left half is in place. The forward gate should lie flat against the forward face of the right angle, and there should be space between the aft face of the angle and the aft gate, since the right spacer is absent. Figure 22 shows these relationships.

With the left half clamped in place, drill through the rib web, stiffener and angle at the four marked locations with a **#30** bit. Cleco as you go.

Completed: [ ]

Step 33: Drill the Right-Side Holes in the Trim Cable Bracket Assembly *(Manual Trim Only)*

As shown in Figure 23, once the left bracket half is Clecoed in place on Rib A, drill the rivet holes through the right half of the assembly. First insert and align the right spacer, and then clamp the four parts (forward gate, right bracket angle, right spacer, aft gate) together with side-grips. Then drill at the four locations marked on the forward gate with a **#30** bit. Cleco after the first and second holes are drilled.

Note Because the upper flange of Rib B overhangs the right bracket angle, it may be difficult to drill the outboard pair of holes. If so, simply drill and Cleco the inboard pair and remove the entire bracket assembly. Then you can drill the final two holes.

Completed: [ ]

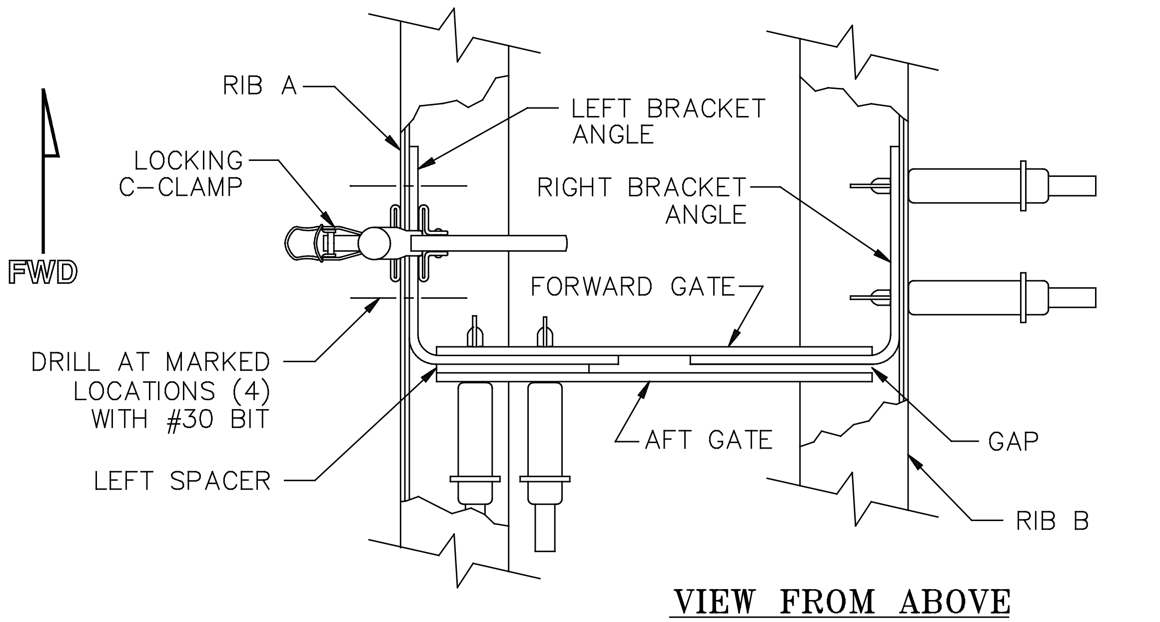

Figure 22: Positioning and Drilling the Left Trim Cable Bracket Half

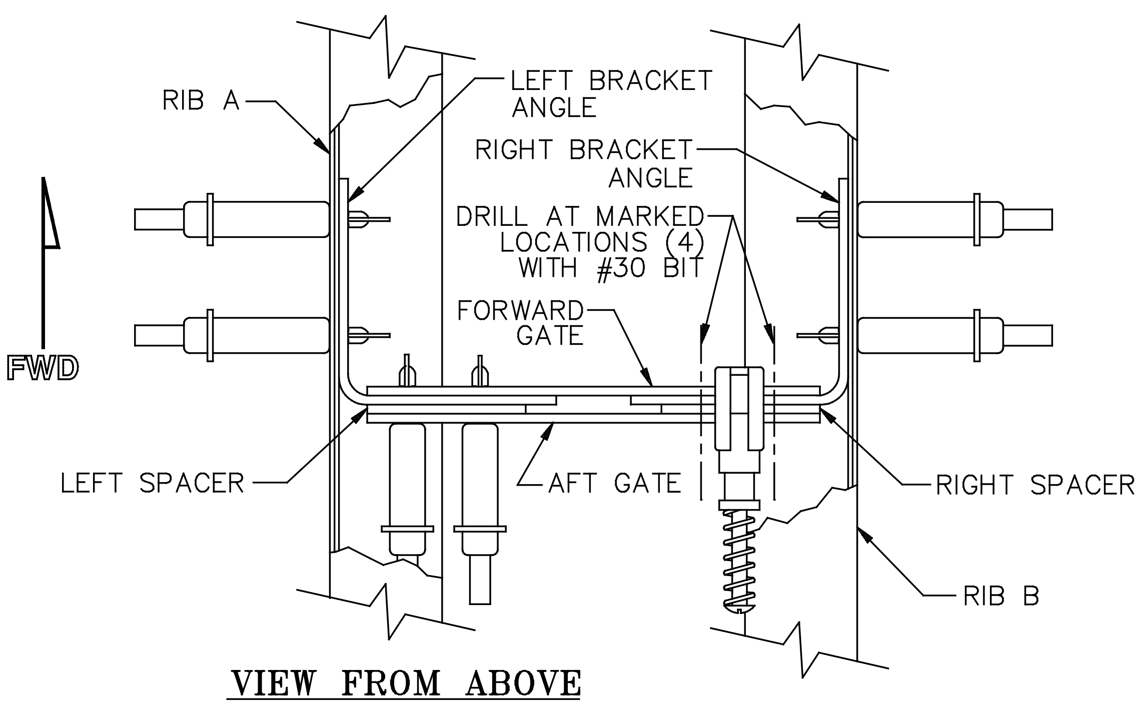

Figure 23: Drilling the Right-Side Trim Cable Bracket Rivet Holes

Step 34: Position and Drill the Trim Cable Retainer Clip
(Manual Trim Only)

As shown in Figure 24, the trim cable retainer clip mounts to the lower skins immediately aft of the control horn attach angles. The retainer tongue enters the interior of the elevator through the trim tab pushrod slot and slides inside the slot in the cable bracket assembly.

Place the clip in position and slide it forward and aft until the tongue is approximately centered in the bracket slot. To help position it left and right, slide a piece of 3/16" dowel or a 3/16" bolt into the cable hole.

Holding the clip firmly in place with your fingers, drill through one of the two pilot holes with a **#19** bit. Use an AN526-8R6 **round-head machine screw** [31] and a K1000-8 **nutplate** [34] in this hole to hold the clip in alignment while you drill the second hole. After drilling the second hole, remove the clip and deburr the holes.

Completed: [ ]

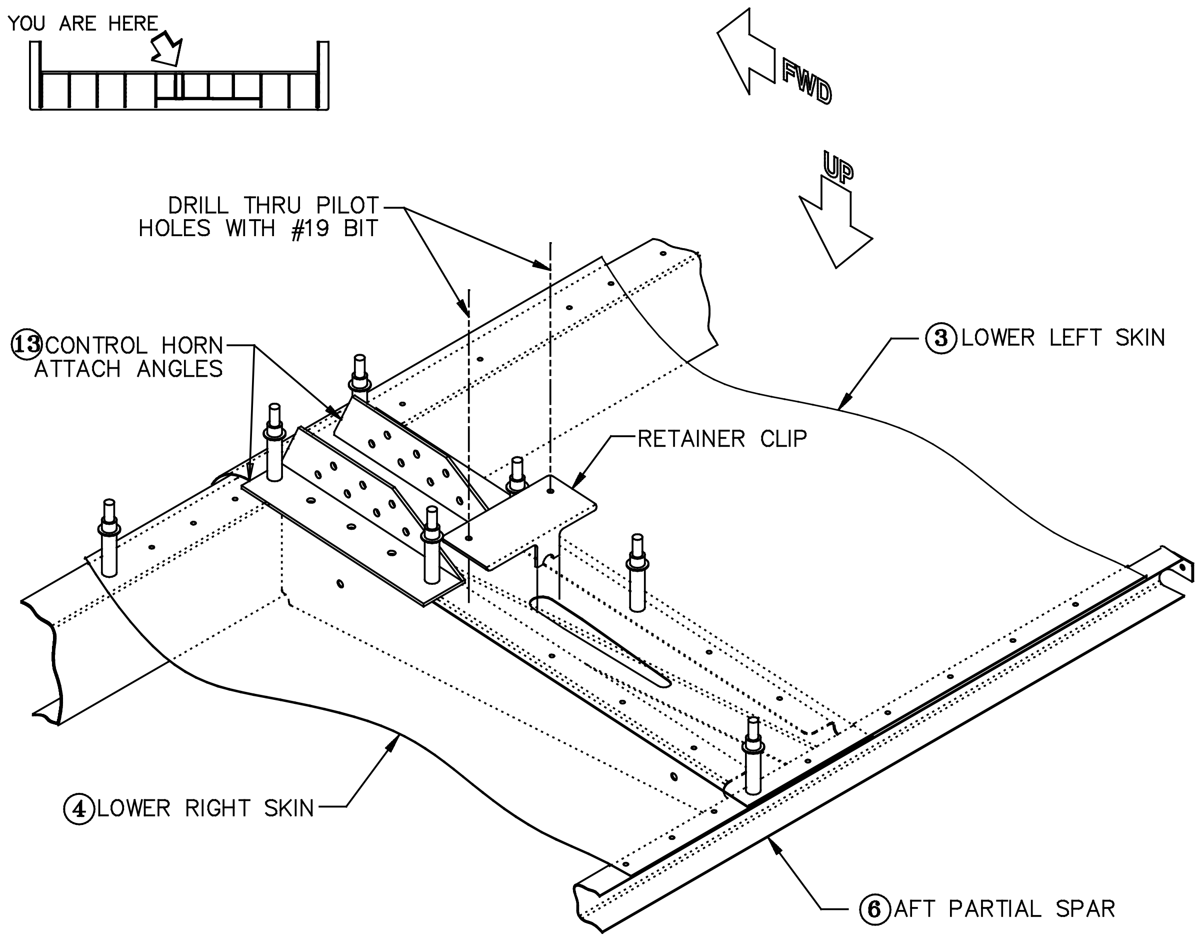

Figure 24: Positioning and Drilling the Trim Cable Retainer Clip

Step 35: Position and Drill the Upper Right Skin

Lay the **upper right skin** [2] over the assembly, aligning its trailing edge with the trailing edge of the lower right skin and the two rivet holes along Rib A with the Rib A flange centerline. Clamp the skin in place with side-grips or C-clamps along the aft partial spar flange, as shown in Figure 25. Drill the two Rib A holes with a **#40** bit and Cleco them. Remove the side-grips or C-clamps.

Next, align and drill the forward spar. Begin at the innermost hole, and work outboard, drilling (**#40**) and Clecoing once at each rib station. For the time being, **do not** drill the intervening holes; these will be drilled when the elevator hinges are installed.

> **Note** Drill only where there are pre-punched pilot holes in the skin. If there isn't a pre-punched hole precisely at a rib station, simply drill the nearest one. Also, don't drill any holes at Ribs A or B until the left skin is lapped over the right in a subsequent step.

Move on to drill the ribs with a **#40** bit, beginning inboard at the forward spar and moving aft and outboard. Next, drill (**#40**) and Cleco the trailing edge joggle.

> **Note** To avoid producing a wavy trailing edge, it's very important that the trailing edge joggle be supported from underneath while it's being drilled. Use a block of wood held at right angles to the joggle to provide this support.

Finally, align and drill the aft partial spar with a **#40** bit once at each rib station. **Do not** drill the remaining aft spar holes at this time; these will be drilled when the trim tab hinge is installed.

> **Note** Do **not** drill holes through the aft spar at the Rib A or B stations. These will be drilled after the left skin is positioned in a subsequent step.

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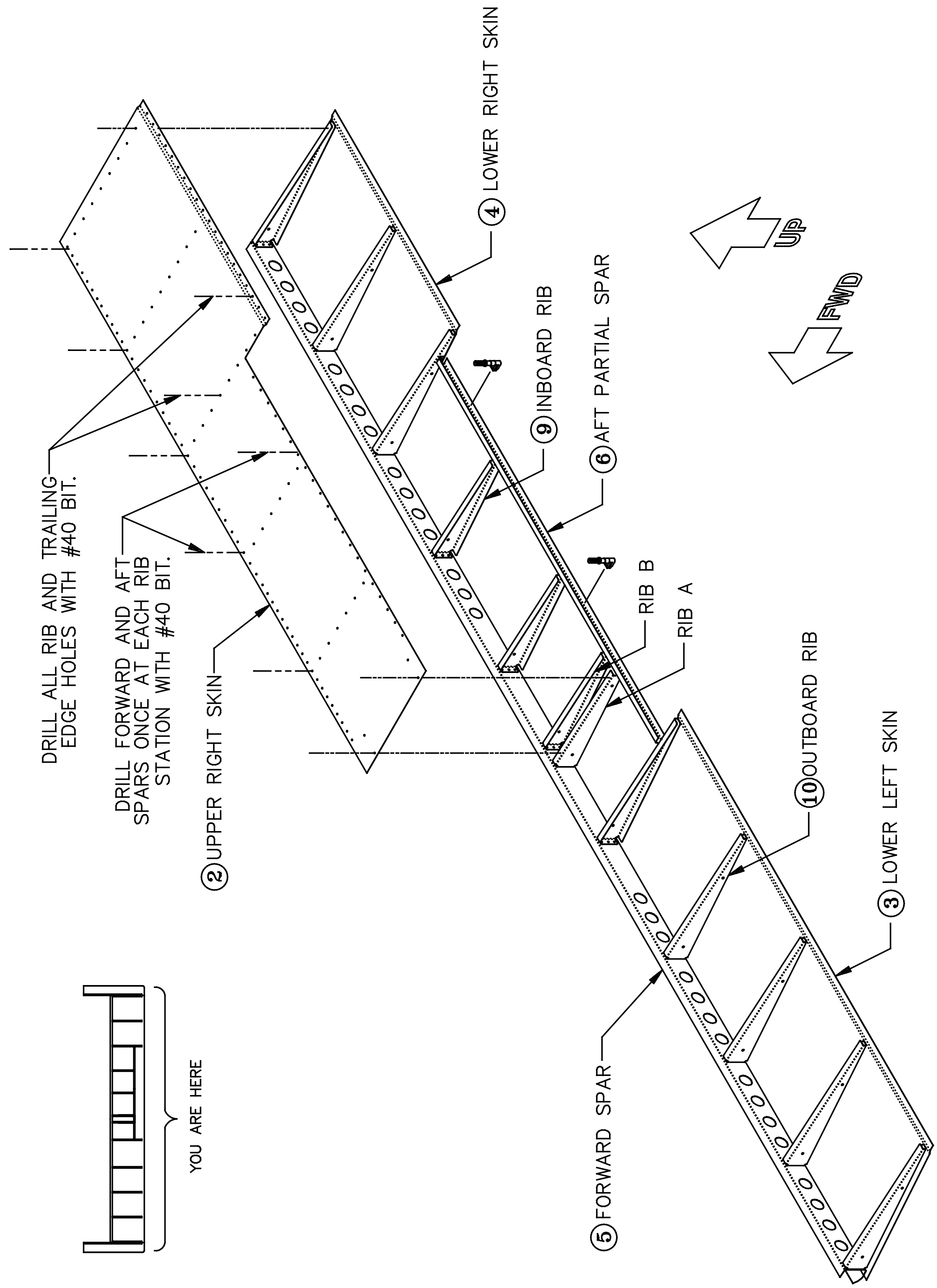

Figure 25: Positioning and Drilling the Upper Right Skin

Step 36: Mark and Cut the Trim Cable Slot in the Upper Left Skin *(Manual Trim Only)*

Electric Trim Option If you are installing electric trim, **skip this step**.

The trim cable exits the fuselage through the fairing under the rudder and enters the elevator through a slot, as shown in Figure 26.

As with the pushrod slot in the lower skin, begin by marking a hole centerline on the top of the **upper left skin** [1] **1-13/32"** in from and parallel to the inboard edge of the skin. Mark the two hole centerpoints on this line by measuring aft from the leading edge of the skin **1-23/32"** and **2-17/32"**.

Drill these holes with a **9/16"** hole cutter, cut out the material between them and smooth and deburr as you did for the lower slot.

Completed: [ ]

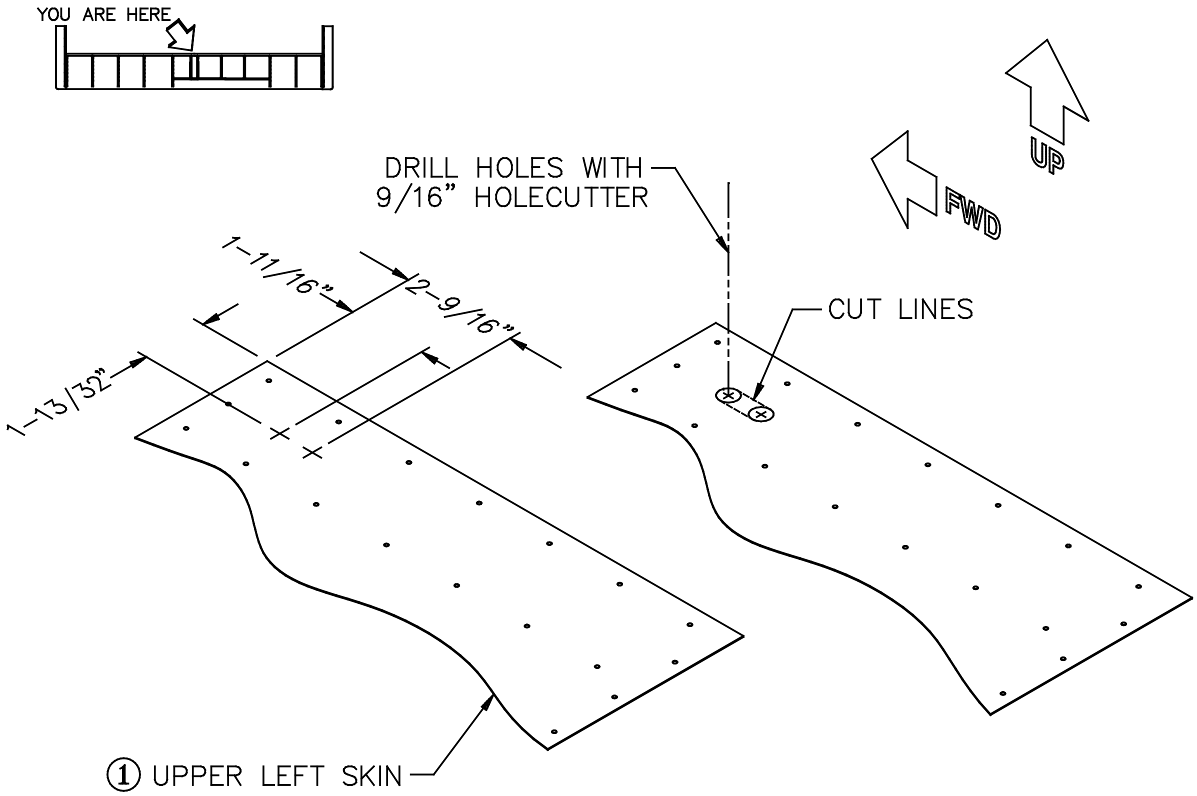

Figure 26: Cutting the Trim Cable Slot

Step 37: Position and Drill the Upper Left Skin

The procedures for positioning and drilling the upper left skin should be familiar by now. Begin by drilling the forwardmost and aftmost Rib B holes along the inboard edge of the skin up to **#40** size to accept Clecos. Then lay the skin in place overlapping the right skin and clamp along the inboard edge with a pair of Clecos through the common, Rib B holes and along the trailing edge joggles with three or four side-grips (see Figure 27). Check to see that the rivet line you marked on the forward spar flange is centered under the leading edge skin holes and drill (**#40**) and Cleco outboard from the center along the spar once at each rib station. **Do not** drill the remaining spar holes at this time; they will be drilled when the elevator hinge is installed.

When the forward spar has been drilled and Clecoed, move on to the ribs, drilling all holes inboard -to-outboard and forward-to-aft with a **#40** bit. Don't forget to drill both skins along Ribs A and B.

> **Note** If you are installing electric trim, **do not** drill the forwardmost two holes in Rib A or B. The skins will be secured in this area with the rivets that also secure the trim servo mounting nutplates.

Finally, as with the right skin, drill all holes along the trailing edge joggle and one hole at each rib station along the aft partial spar with a **#40** bit.

> **Note** Early GlaStar elevator skins lacked the pre-punched aft spar rivet holes in the area of the skin overlap. For these skins, lay out the locations of the missing holes on the left skin, using the same hole spacing as the rest of the rivet line and adjusting the spacing as necessary to maintain the standard minimum edge distance (**3/16"**) in both the left and right skins. Of these holes, drill the **two** that are closest to Ribs A and B with a **#40** bit.

Completed: [ ]

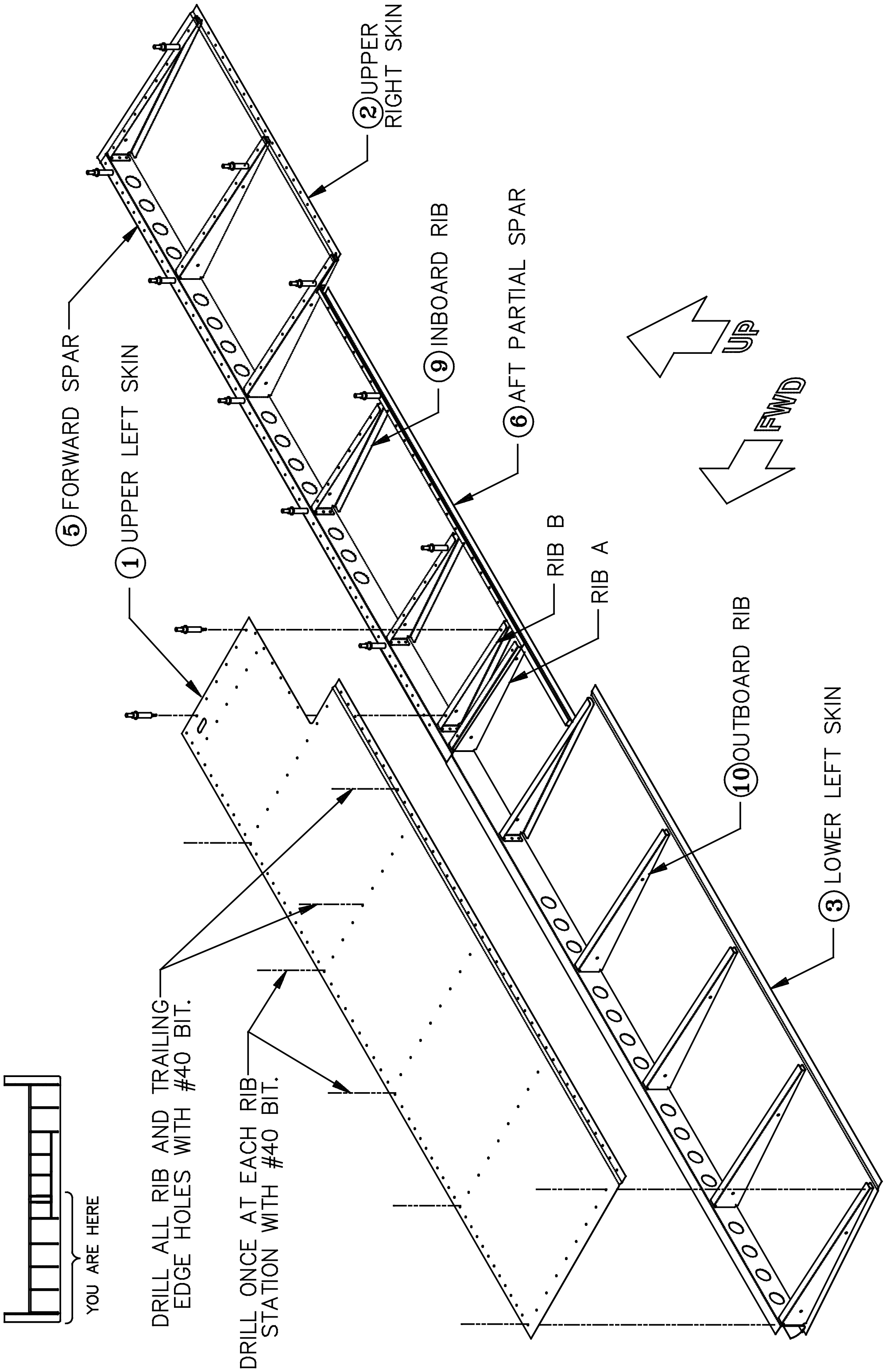

Figure 27: Positioning and Drilling the Upper Left Skin

Step 38: Mark the Trim Cable Slot in the Upper Right Skin *(Manual Trim Only)*

Electric Trim Option If you are installing electric trim, **skip this step**.

With the upper left skin Clecoed in place overlapping the upper right skin, use a scriber to trace the circumference of the trim cable slot on the upper right skin. Don't cut it out at this point; you'll do that a few steps down the road.

Completed: [ ]

Step 39: Mark Hole Positions on the Tip Ribs

In this step you will mark the locations of the rivet holes for fastening the tip ribs to the outermost main ribs and the holes for mounting the elevator counterweights to the tip ribs.

Lay out the holes according the dimensions shown in Figure 28 **inside** the flanges of each tip rib. Lightly center punch each location. These dimensions are not critical (i.e., dimensional tolerance ±1/16").

Note The locations of the holes are referenced to the forward end of the main elevator rib to which the tip rib will be riveted; this is shown by the dashed line in the plan view portion of Figure 28. Also, the isometric view in Figure 28 shows three rivet holes down the center of the tip rib between the two aft tooling holes in the rib. Since no dimensions are given for these three holes in the plan view, simply mark them by eye in the approximate positions shown in the isometric. No great precision is necessary for the three centerline holes, but try to maintain the standard minimum spacing of three rivet diameters (9/32") between the centers of all holes.

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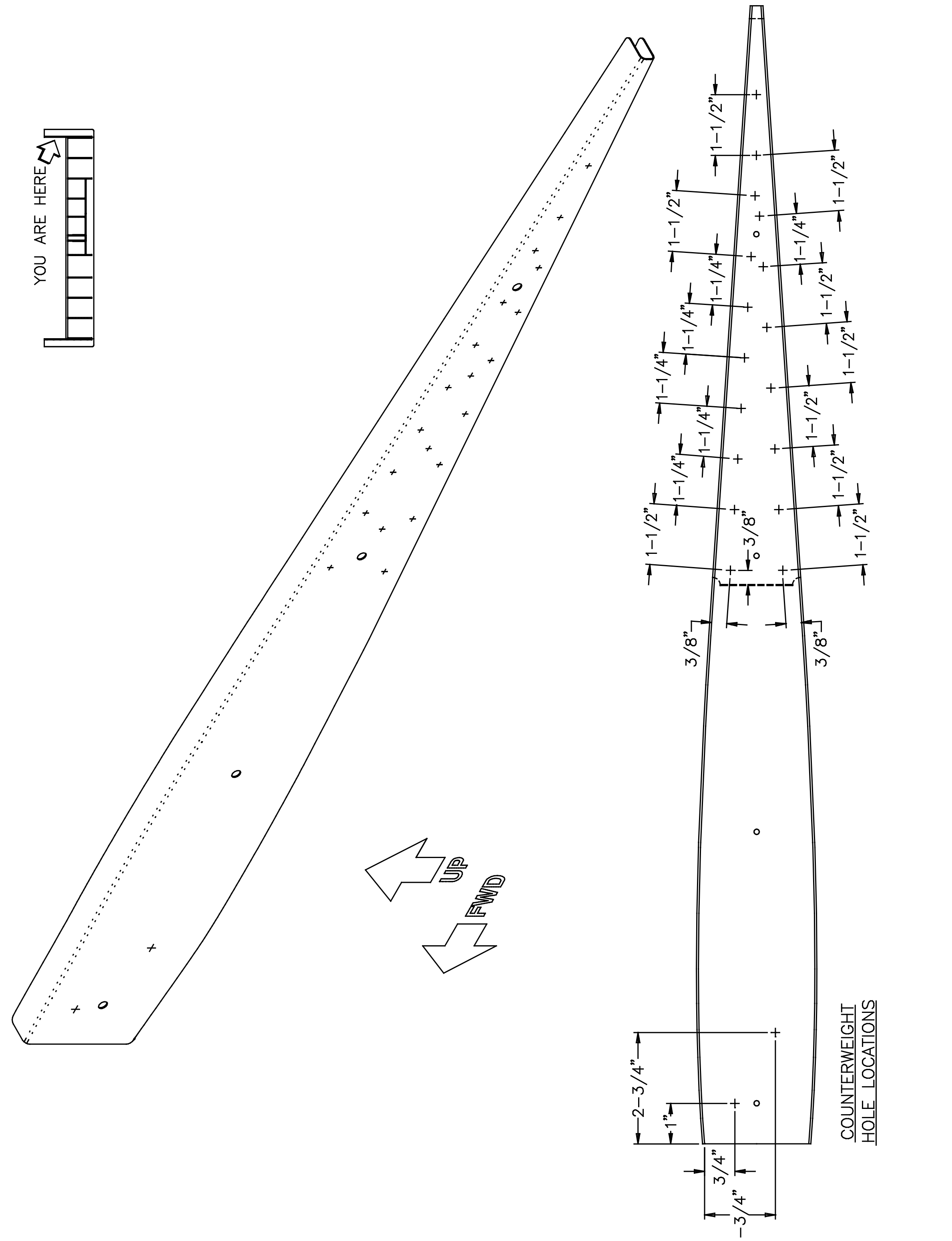

Figure 28: Tip Rib Hole Locations

Step 40: Position and Drill the Tip Ribs

Position the tip ribs inside the overhanging upper and lower skins, as shown in Figure 29. Note that the tip rib flanges are oriented **outboard** and that the tip rib webs are flat against the webs of the outermost main ribs. The skins determine the fore-and-aft position of the tip ribs; slide them aft as far as you can without distending the skins. **Do not** try to line up the aft ends of the tip rib and the adjacent main rib, because when properly positioned, the tip rib will extend slightly aft of the main rib. When you have the tip ribs in position, clamp them to the upper and lower skins as shown in Figure 29 with side-grips along the flanges.

When the tip ribs are clamped in place, drill through each tip rib and its corresponding main rib with a **#40** bit at each common location. Then remove the tip ribs from the elevator assembly and drill the counterweight mounting holes with a **#10** bit.

Clean and deburr both tip ribs.

Completed: [ ]

Step 41: Cut the Trim Cable Slot in the Upper Right Skin (Manual Trim Only)

Electric Trim Option If you are installing electric trim, **skip this step and turn to the *Electric Trim Option Instructions***. Return to **Step 43** of this *Assembly Manual* when the specified option steps have been completed. ☞

Remove all the Clecos and completely disassemble the entire elevator. Using the same techniques you used to cut the trim cable slot in the upper left-hand skin (Step 36), cut the slot in the upper right-hand skin. Make the right-skin slot slightly oversized—say an extra **1/32"** all around.

Completed: [ ]

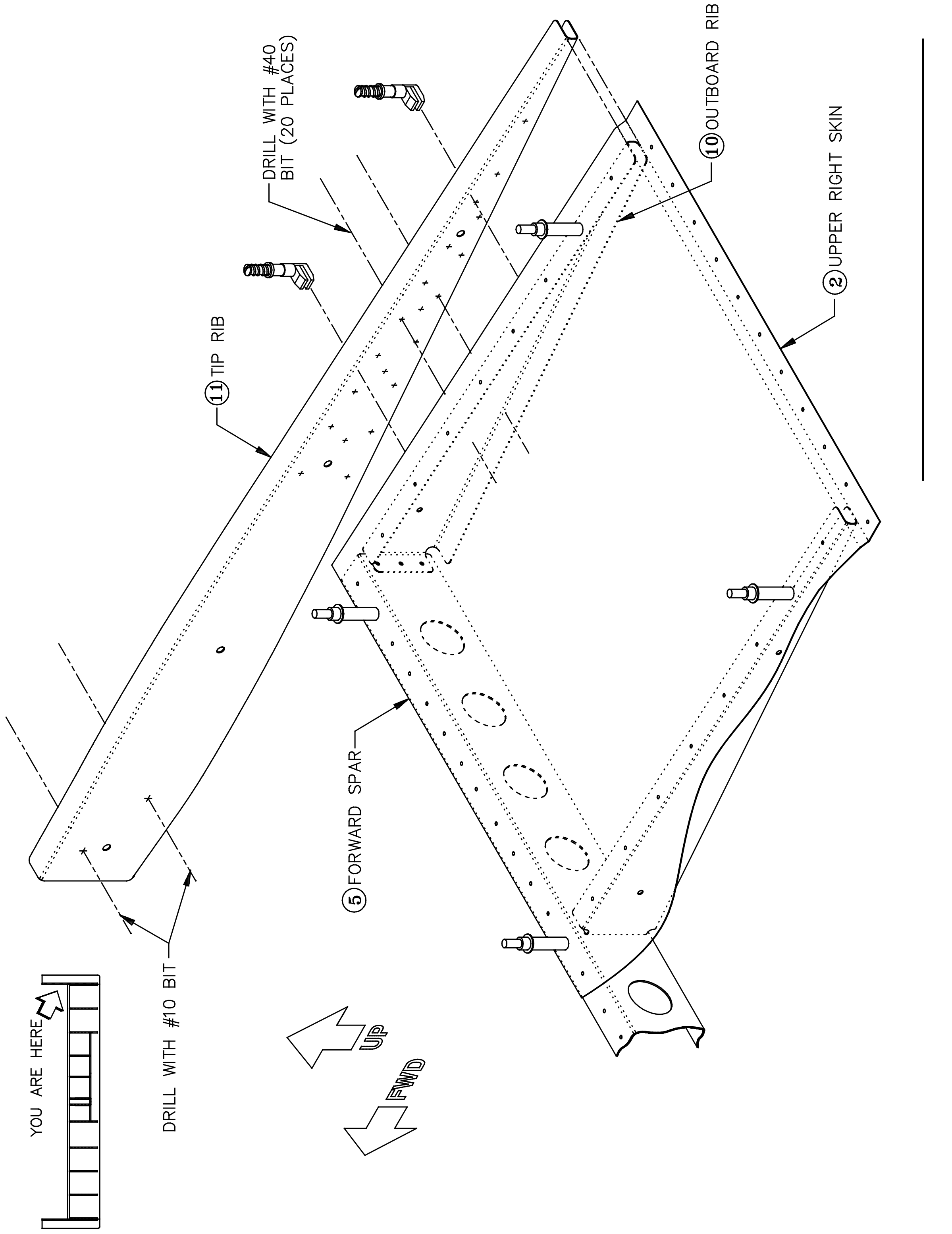

Figure 29: Positioning and Drilling the Tip Ribs

Step 42: Drill and Dimple the Rivet Holes for the Trim Cable Retainer Clip Nutplates (Manual Trim Only)

The nutplates that hold the trim cable retainer clip in place are riveted to the rib/control horn stiffeners only. Referring to the subsection on "INSTALLING NUT PLATES" in "SECTION II: TOOLS AND TECHNIQUES," drill the rivet holes in the flanges of the stiffeners necessary to accommodate the nutplates. Because this material is so thin (.025), you must dimple it and the nutplates themselves to accommodate the flush rivet heads.

> **Hint** In order to dimple nutplates—a procedure you will be called on to do many times—you may have to grind the corner off the die to relieve interference between the die and the body of the nutplate.

Completed: [ ]

Step 42.1: Trim the Elevator Upper Leading Edge

In order to achieve the required minimum edge margins for the elevator hinge rivets, the forward spar upper flange and the leading edges of the upper skins must be trimmed. Trim the spar flange and the skins until the edge margin to the **centers** of the upper forward spar/skin rivet holes is between **5/16"** and **3/8"**. If you're very careful, you can use a belt sander to accomplish most of the trimming on the spar flange; use shears for the skins. Finish with a panzer file and then sandpaper to remove any tool marks.

Completed: [ ]

Step 43: Clean and Deburr All the Parts

Carefully clean and deburr all cut edges and all holes of all the elevator parts.

Completed: [ ]

Step 44: Corrosion-Proof the Elevator Interior

Corrosion-proof all interior parts as you deem necessary (see the subsection on "INTERIOR CORROSION PROTECTION" in "SECTION II: TOOLS AND TECHNIQUES"). Minimally, you should apply an aluminum cleaner and then alodize all interior parts. In addition to interior corrosion protection, we strongly recommend treating such exterior components as the control horns and attach angles, especially if you'll be operating your GlaStar as a floatplane.

Completed: [ ]

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MAIN STRUCTURE RIVETING

Step 45: Rivet the Doublers to the Forward Spar

Using 3/32" AN470AD3 universal-head rivets of the appropriate length, rivet the spar/hinge doublers to the forward spar web. **Do not rivet the holes at the rib stations.** As shown in Figure 30, the manufactured heads should be on the spar side (aft). Sequence the driving of these rivets as described in the section on "ALUMINUM SHEET METAL WORK, *Installing a Line of Rivets*" in "SECTION II: TOOLS AND TECHNIQUES."

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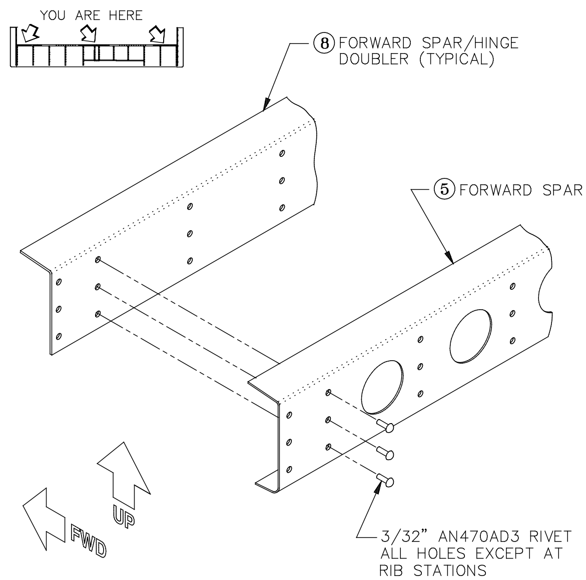

Figure 30: Riveting the Forward Spar Web Doublers

Step 46: Rivet the Trim Cable Retainer Clip Nutplates to the Rib/Control Horn Stiffeners (Manual Trim Only)

Electric Trim Option If you are installing electric trim, **skip this step and turn to the *Electric Trim Option Instructions*.** Return to **Step 50** in this *Assembly Manual* when the specified option steps have been completed.

☞

Using 3/32" AN426AD3 flush-head rivets, rivet the trim cable retainer clip nutplates to the inside of the flanges of the rib/control horn stiffeners. The rivet heads should be on the stiffener side.

Completed: [ ]

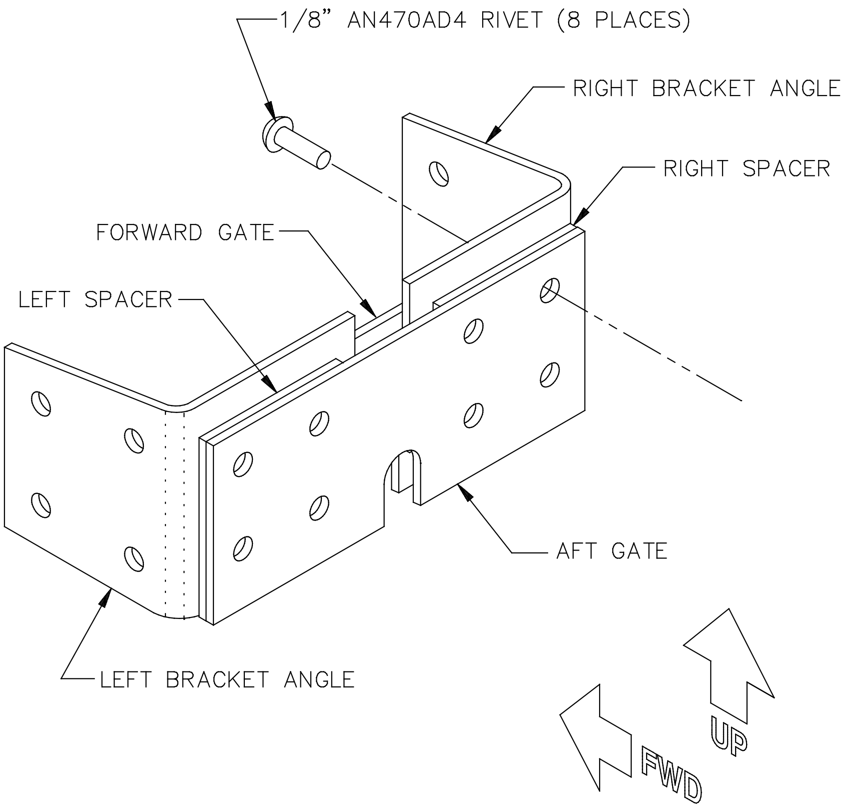

Figure 31: Riveting the Trim Cable Bracket Assembly

Step 47: Rivet the Trim Cable Bracket Assembly

(Manual Trim Only)

Using 1/8" AN470AD4 universal-head rivets, rivet together the six parts of the trim cable bracket assembly, as shown in Figure 31.

Completed: [ ]

Step 48: Rivet the Control Horn Stiffeners and Trim Cable Bracket Assembly to Ribs A and B

(Manual Trim Only)

Rivet the rib/control horn stiffeners and the trim cable bracket assembly to Ribs A and B through the four holes in each bracket angle. Use 1/8" AN470AD4 universal-head rivets. The manufactured heads should be on the outboard (rib web) side, as shown in Figure 32.

Completed: [ ]

Step 49: Finish Riveting the Control Horn Stiffeners to Ribs A and B *(Manual Trim Only)*

With 1/8" AN470AD4 universal-head rivets, finish riveting the control horn stiffeners to Ribs A and B through the holes forward and aft of the trim cable bracket. The rivet heads should be outboard, as shown in Figure 32.

Completed: [ ]

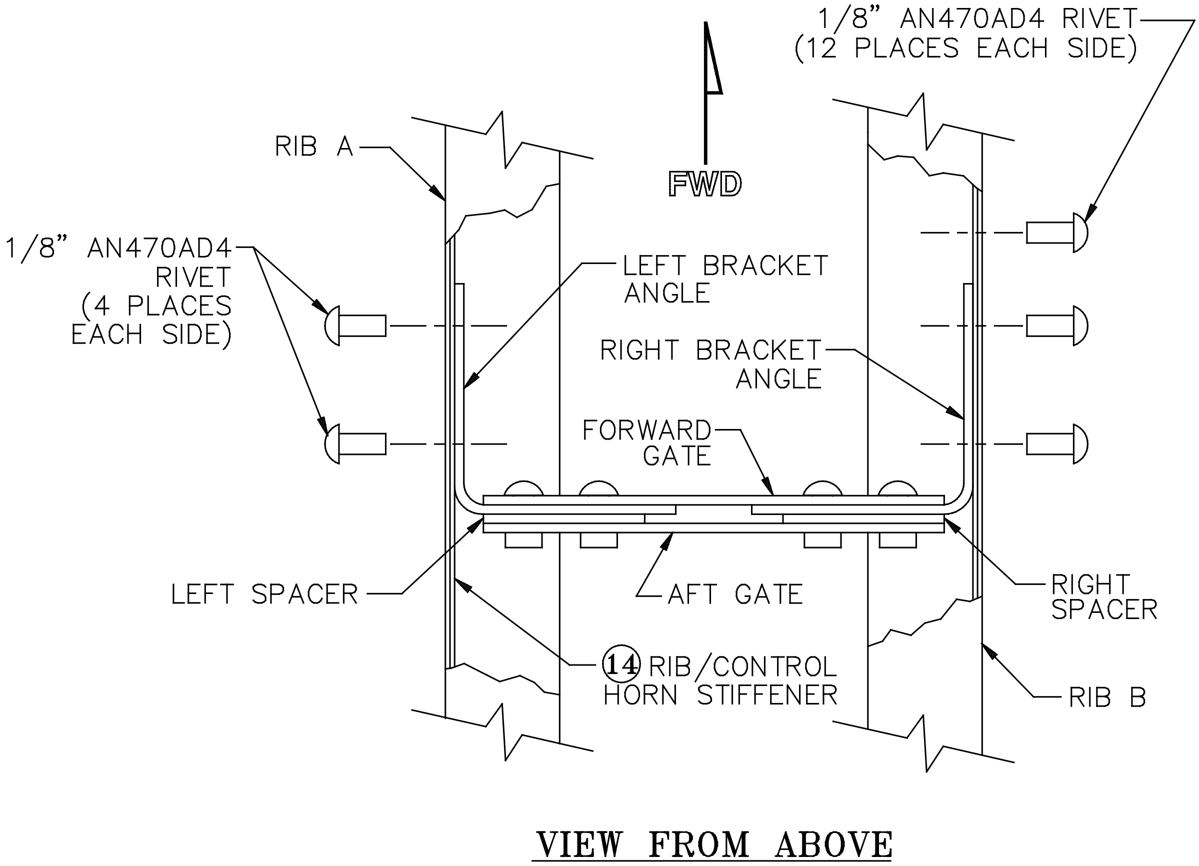

Figure 32: Riveting the Control Horn Stiffeners and Trim Cable Bracket Halves

Step 50: Rivet the Attach Angles to the Control Horns

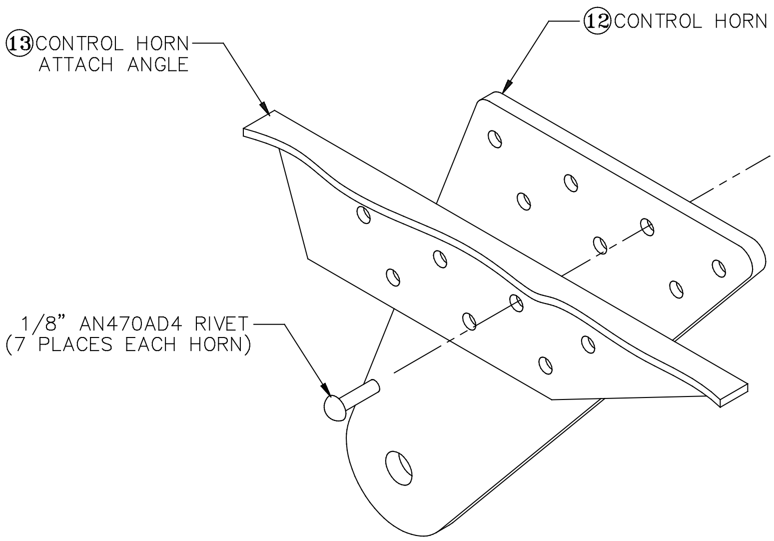

Figure 33: Riveting the Attach Angles to the Control Horns

Use 1/8" AN470AD4 universal-head rivets to rivet the attach angles to the control horns. Make sure you rivet the horns inboard of the angles. As shown in Figure 33, the manufactured heads should be on the angle side (outboard).

Completed: [ ]

Step 51: Rivet the Inboard Ribs to the Aft Partial Spar

Using 3/32" AN470AD3 universal-head rivets, rivet the four inboard ribs to the aft partial spar. Refer to Figure 1 to confirm the proper orientation of the rib flanges. As shown in Figure 34, the manufactured heads should be on the spar side (aft).

Completed: [ ]

Step 52: Rivet Ribs C and D to the Aft Partial Spar

Rivet Ribs C and D to the ends of the aft partial spar with 3/32" AN470AD3 universal-head rivets. Be sure the rib flanges point outboard at each end. As shown in Figure 34, the manufactured heads should be on the spar side (inboard).

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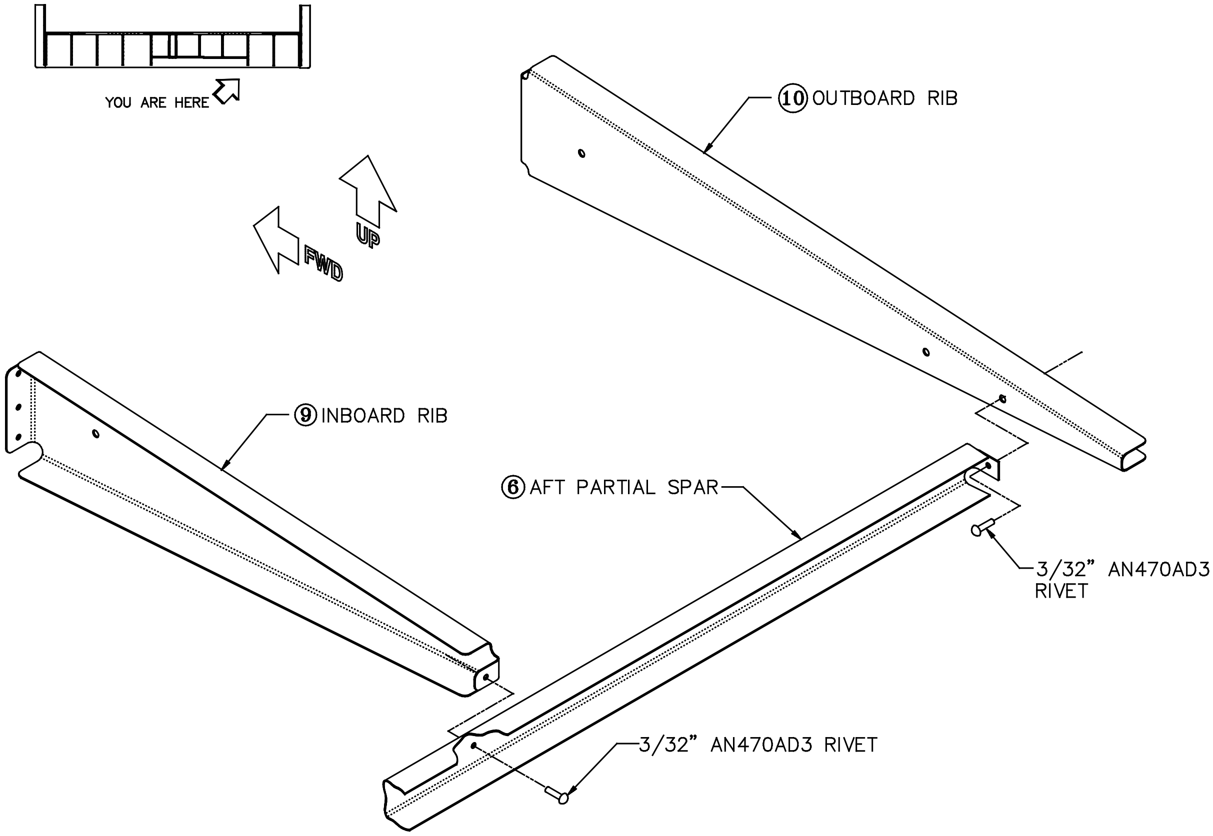

Figure 34: Riveting the Ribs to the Aft Partial Spar

Step 53: Rivet the Upper Skins to the Ribs *(Manual Trim Only)*

Electric Trim Option If you are installing electric trim, **skip this step and turn to the** ***Electric Trim Option Instructions.*** Return to **Step 54** in this *Assembly Manual* when the specified option steps have been completed.

☞

Rivet the upper skins to the ribs using 3/32" AN470AD3 universal-head rivets. In the areas where the ribs have been riveted to the partial spar, follow procedures for riveting control surface skins to their underlying framework: begin with a rivet in one corner, then a rivet in the opposite corner, then a rivet somewhere in the middle. Establish a pattern in which you are always riveting approximately in the middle of the remaining unriveted area. When you get to the outboard ribs that are not attached to the aft partial spar, pay careful attention to the orientation of the flanges, as shown in Figure 1. For each of the unattached outboard ribs, follow procedures for installing a line of rivets: rivet at the ends and the middle of the line, and then rivet in the middle of unriveted areas until the line is finished.

Note At this time **do not** rivet the skins to the aft partial spar. These rivets also secure the trim tab hinges, and will be driven in subsequent steps.

Completed: [ ]

Step 54: Rivet the Tip Ribs to the Outermost Ribs

Slide the tip ribs into position against the outermost ribs and rivet them in place with 3/32" AN470AD3 universal-head rivets, as shown in Figure 35.

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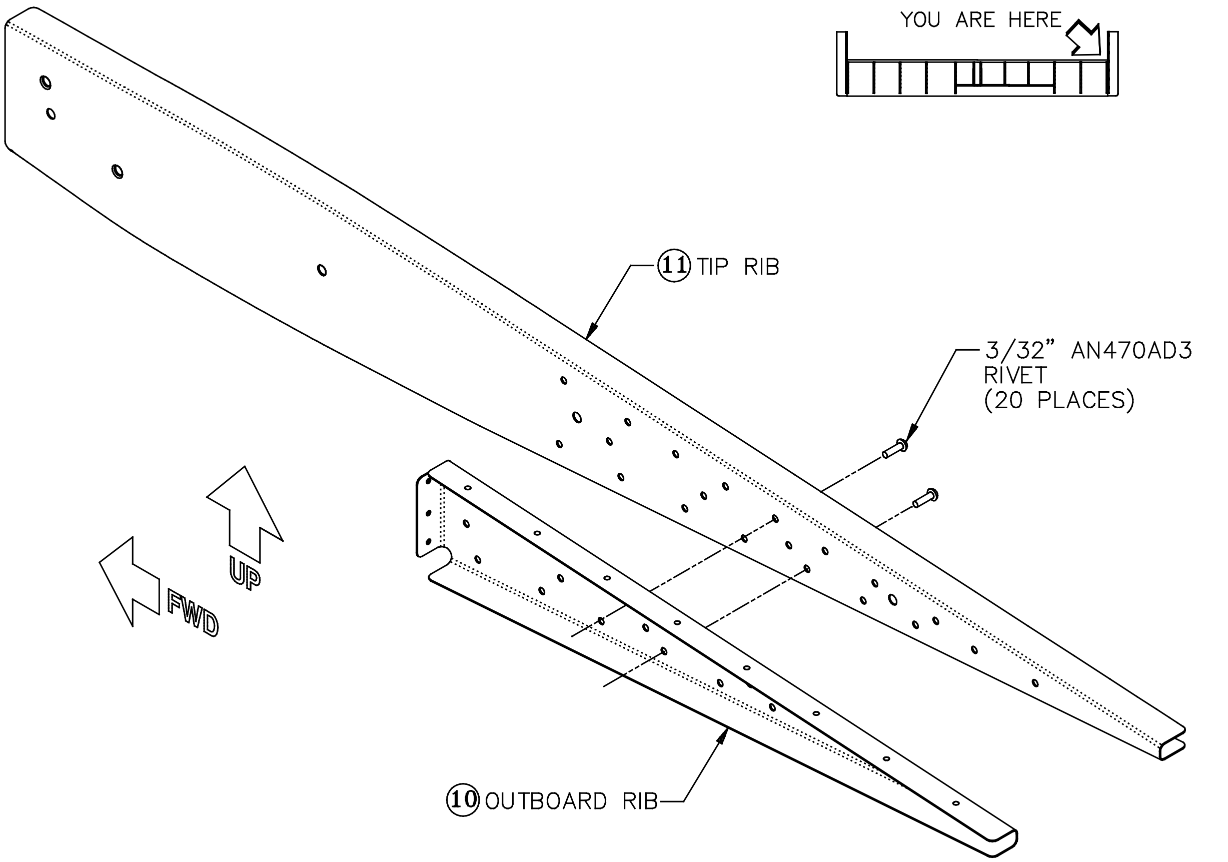

Figure 35: Riveting the Tip Ribs

Step 55: Rivet the Control Horn Assemblies and the Lower Skins to Ribs A and B

Use 1/8" AN470AD4 universal-head rivets to rivet the overlapped lower skins and the control horn assemblies to the forward ends of Ribs A and B. Refer to Figure 36 to ensure that you have the horn assemblies properly oriented.

> **Note** The forward-most hole in each attach angle goes through the skins and the forward spar. Since the spar will not be riveted into place for another few steps, rivet **only the aft four holes** on each attach angle at this time.

Riveting this area requires placing the bucking bar in a relatively tight space. You will have to reach inside the elevator structure to hold the bar in place with your fingertips. Remember, however, to use as heavy a bar as is practical. For each rib, follow standard procedures for installing a line of rivets.

Completed: [ ]

Step 56: Rivet the Lower Skins to the Aft Partial Spar and the Ribs

As shown in Figure 36, use 3/32" AN470AD3 universal-head rivets to rivet the skins to the remaining ribs at the first three holes on each rib. Rivet the remaining holes with 1/8" AAPQ-42 blind rivets. At the same time, use 3/32" AN470AD3 universal-head rivets to rivet the skins to the aft partial spar. Use a rivet squeezer here if you have one. Sequence the driving of these rivets as discussed in "SECTION II: TOOLS AND TECHNIQUES" under the heading "ALUMINUM SHEET METAL WORK, *Installing a Line of Rivets*": begin with a rivet in one corner of the area to be riveted, then a rivet in the opposite corner and one somewhere in the middle. Continue riveting approximately in the middle of unriveted areas until finished.

> **Note** Don't forget to blind rivet the unriveted aft holes in Ribs A and B.

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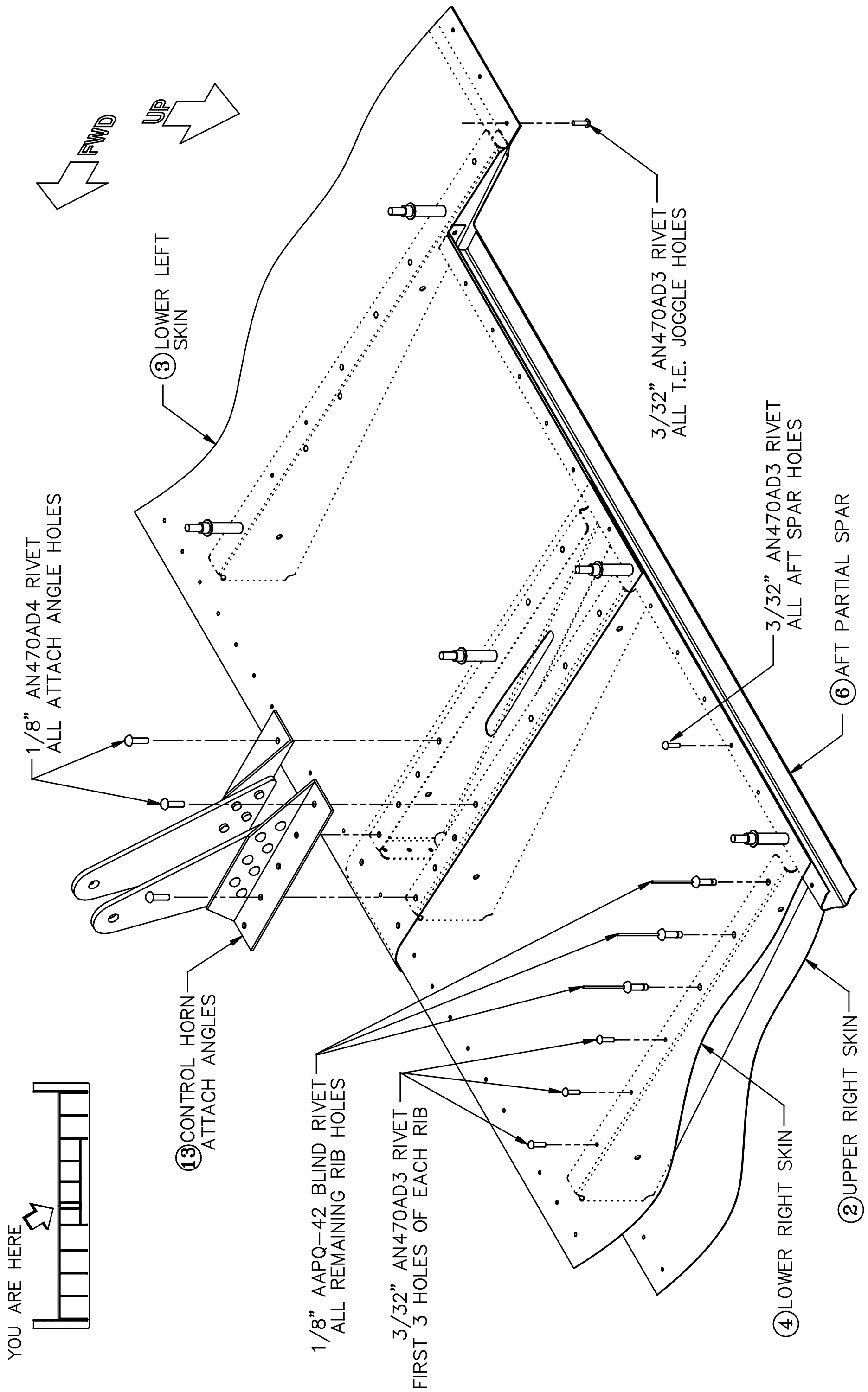

Figure 36: Riveting the Control Horn Assemblies and Lower Skins to the Ribs and Aft Partial Spar

Step 57: Rivet the Trailing Edge Joggles

Use 3/32" AN470AD3 universal-head rivets to rivet the upper and lower skins together along the trailing edge. As shown in Figure 36, the manufactured heads should be on the upper skin. Carefully avoid overdriving these rivets, as this will result in a wavy trailing edge

Again, be sure to sequence this riveting as outlined in "SECTION II: TOOLS AND TECHNIQUES."

Completed: [ ]

Step 58: Rivet the Forward Spar to the Ribs

Finish the basic elevator assembly by riveting the forward spar to the ribs with 1/8" AAPQ-42 blind rivets, as shown in Figure 37. The same length rivet is used whether you are riveting through both the spar and a hinge doubler or just through the spar. Be sure the spar is right-side up before you slide it between the upper and lower skins, and be careful to avoid crimping the skin leading edges.

Completed: [ ]

Step 59: Rivet the Lower Skins and Control Horn Attach Angles to the Forward Spar

Now that the forward spar is riveted in place, rivet the lower skins to the spar using 3/32" AN470AD3 universal-head rivets. Observe proper sequencing procedures in driving these rivets.

Note The two holes in this line that go through the control horn attach angles require **1/8"** AN470AD4 universal-head rivets.

Completed: [ ]

Step 60: Tape the Lightening Holes in the Forward Spar

Apply strips of **2"-wide aluminum tape** [24] to the web of the forward spar to seal the lightening holes.

Completed: [ ]

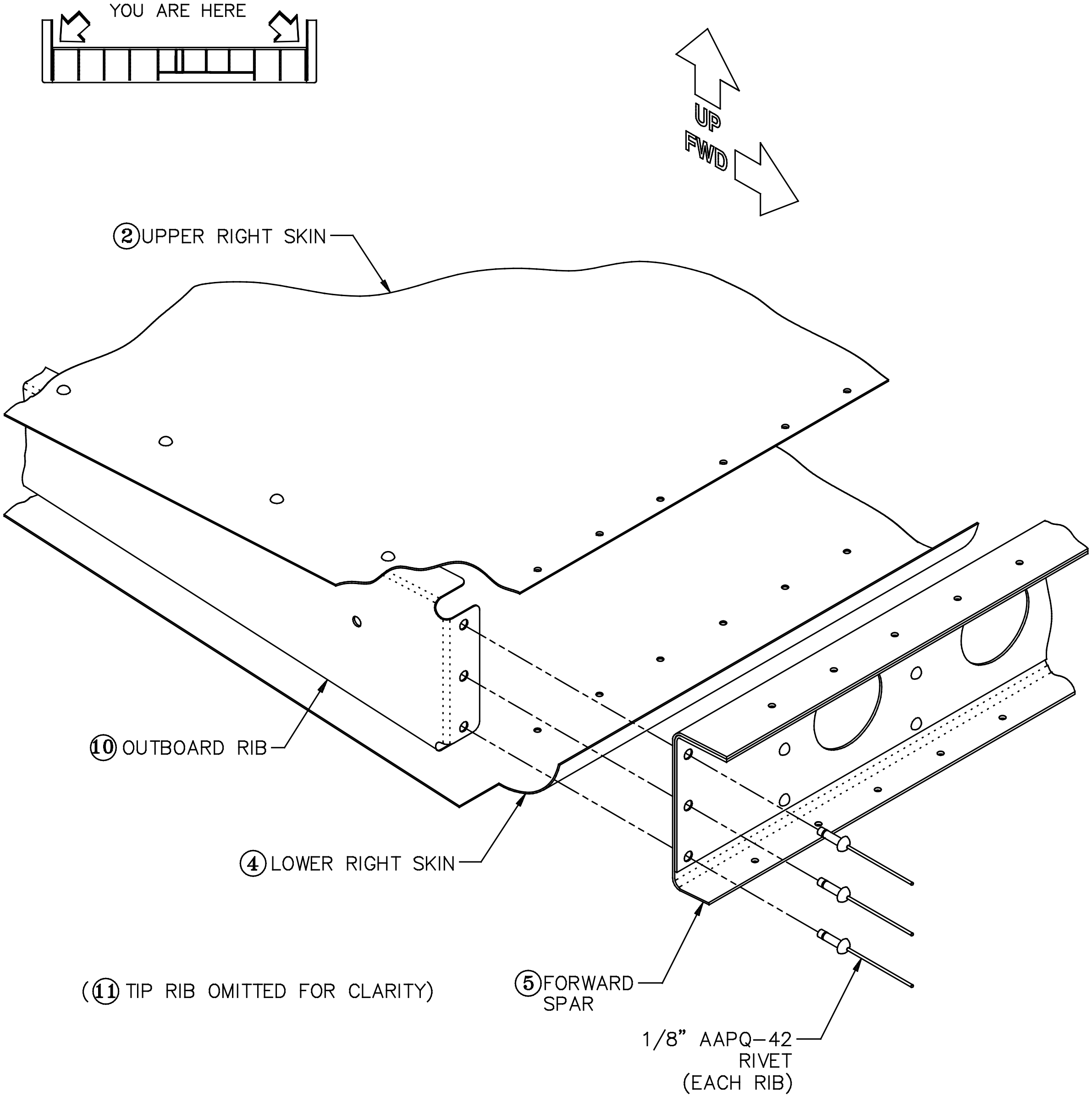

Figure 37: Riveting the Forward spar to the Ribs

TRIM TAB

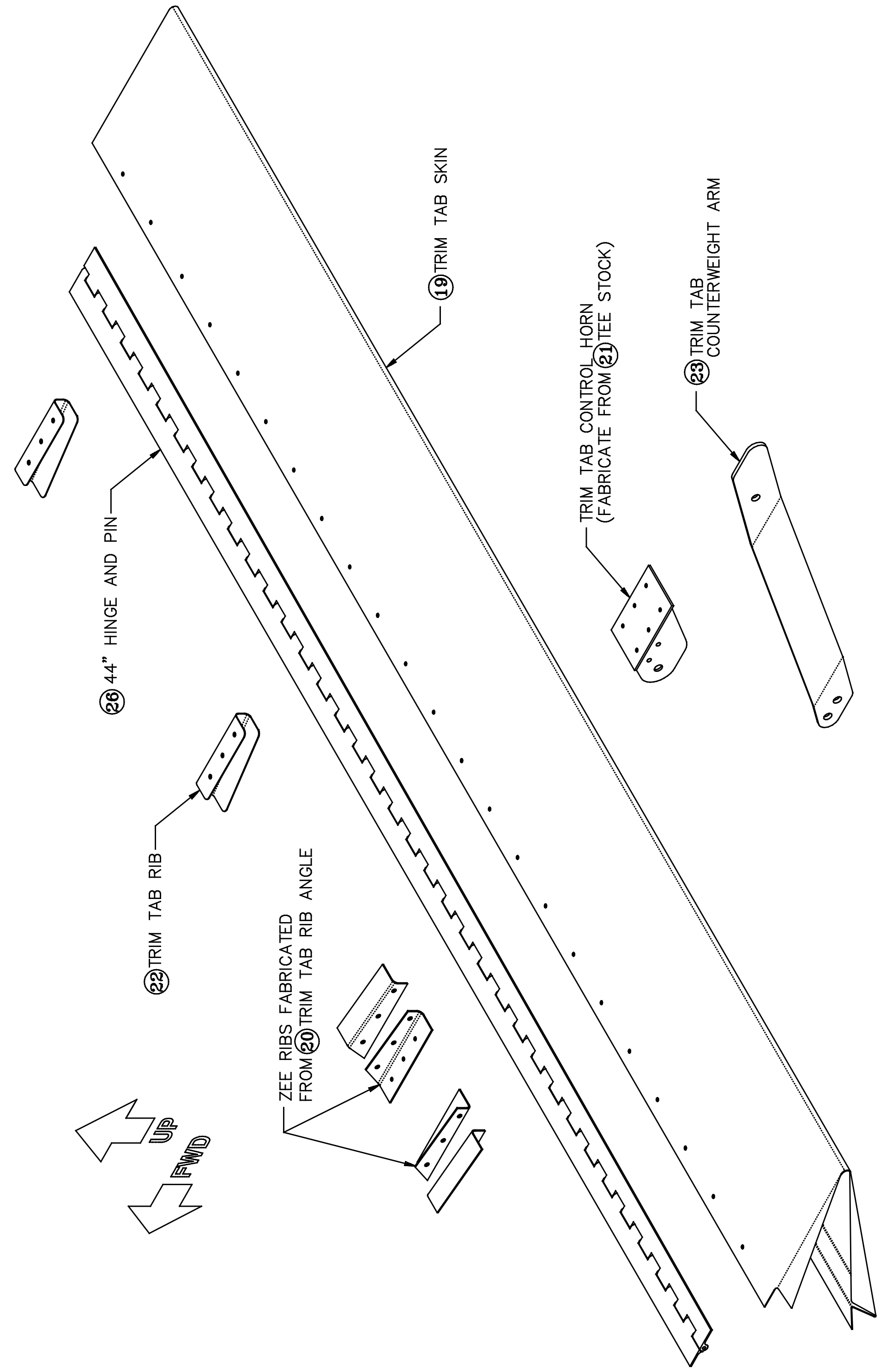

Figure 38: Trim Tab Assembly

Step 61: Fabricate the Trim Tab Zee Ribs, Control Horn and Counterweight Arm

The trim tab zee ribs are cut from the length of **trim tab rib angle** [20]. These ribs stiffen the trim tab as well as providing anchor points for the **trim tab control horn** [21]. Figure 39 shows the configuration of the finished ribs and the horn.

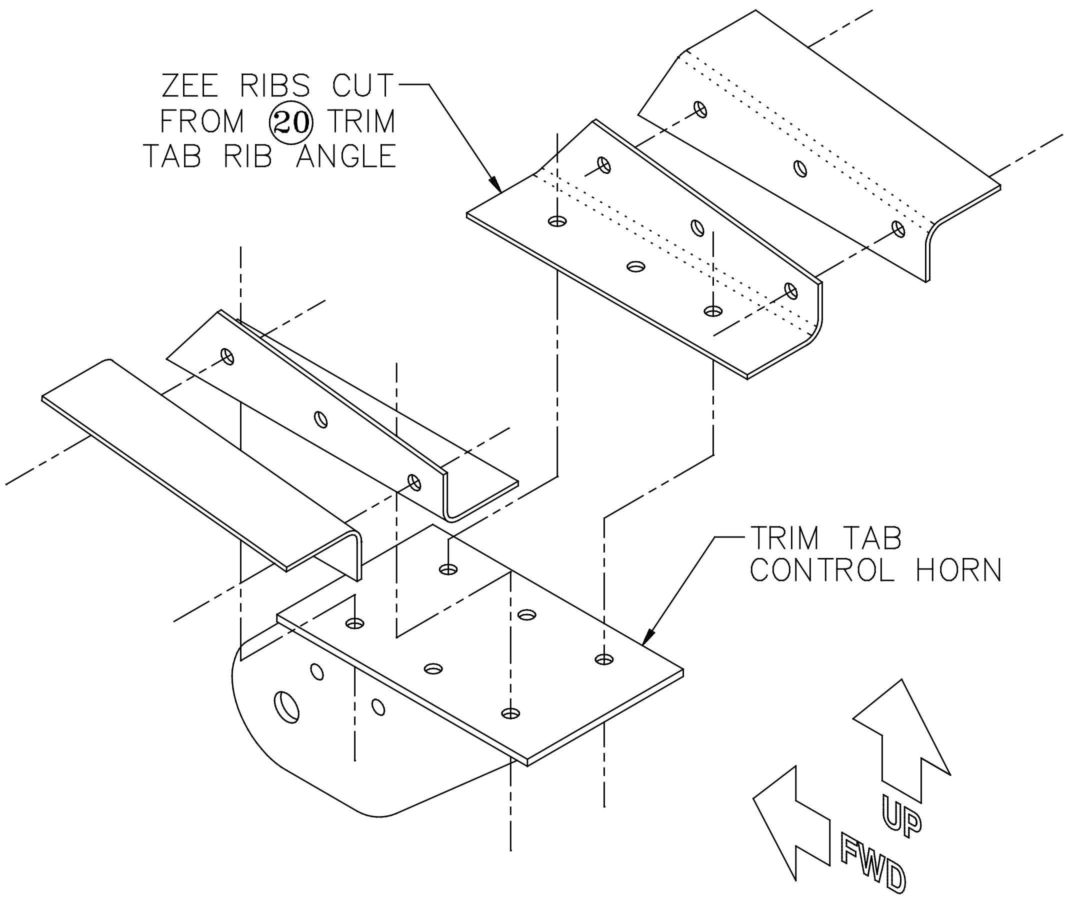

Figure 39: Configuration of Finished Trim Tab Zee Ribs and Control Horn

With a bandsaw or snips, cut the provided angle stock into four **2-1/4"** segments. Then cut each segment according to the dimensions shown in Figure 40 to produce the four rib halves. Use a file to smooth and deburr the cut edges.

Caution Be sure that you end up with two **mirror-image** sets of rib halves.

Next, fabricate the trim tab control horn from the 3-1/2" length of **.050" X 1-1/4" X 1-1/2" aluminum tee** [21] stock according to the dimensions shown in Figure 39.1a. Use a bandsaw to cut out the basic shape, and then finish the rough edges with a file and/or a belt sander.

Hint To hold the part perpendicular to the saw blade, place it over a scrap of 2X4 with the wider flange flat against the wood and the narrower flange hanging over the edge.

Mark and drill the six holes on the wider flange, as shown in Figures 39.1a and 39.1b; the single **#10** hole will accommodate the pushrod bolt, while the five **#40** holes will be used to rivet the **trim tab counterweight arm** [23] to the horn. Finally, mark but do not yet drill the six hole locations shown in Figure 39.1c. Be sure to mark them on the **underside** of the horn.

The counterweight arm comes pre-bent, but you must drill holes for the pushrod and counterweight attach bolts, as well as radius the corners of the arm. Figure 39.2 shows the locations of the three **#10** holes. Note that the **longer** of the two parallel faces of the arm is the **upper** one, and this is where the pushrod hole should be drilled.

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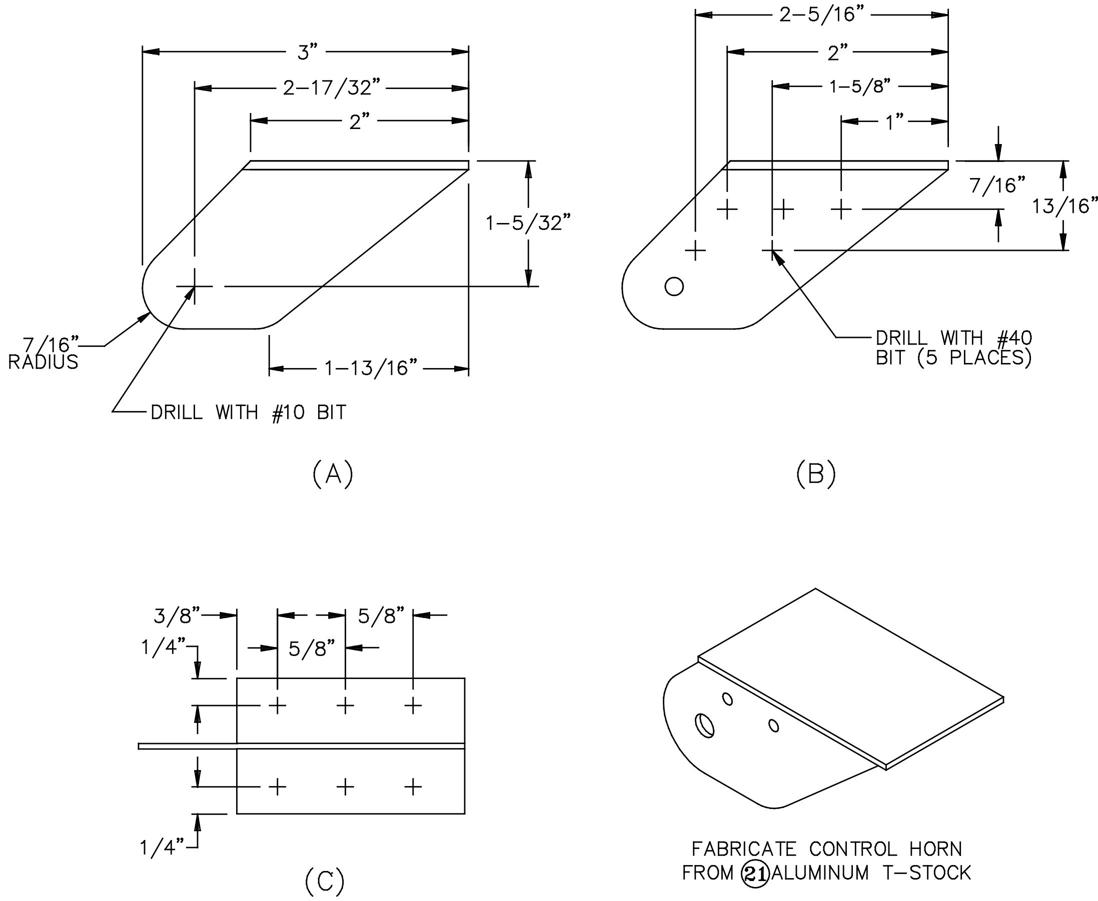

Figure 39.1: Fabricating the Trim Tab Control Horn

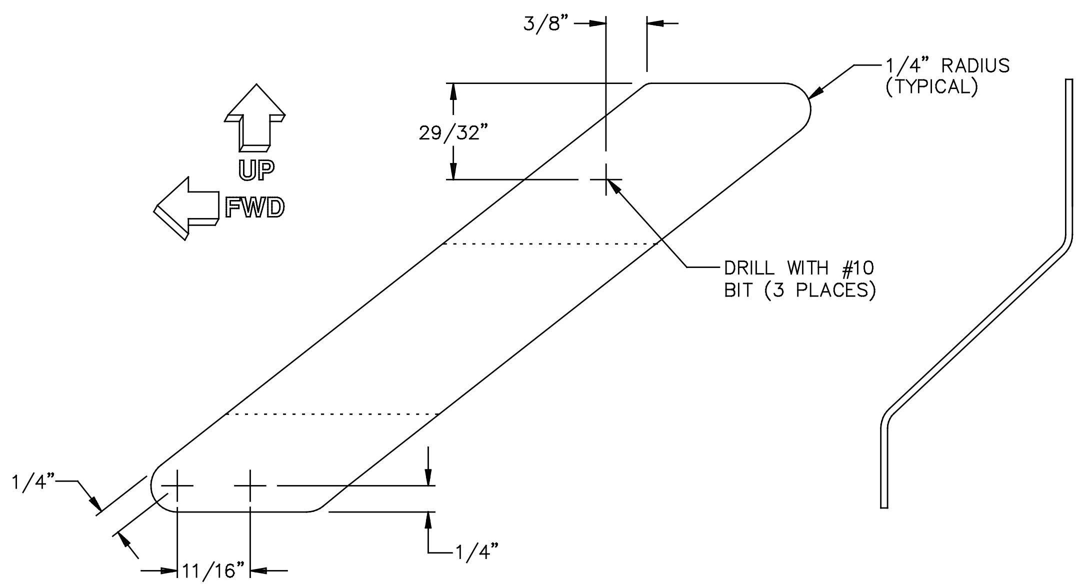

Figure 39.2: Fabricating the Trim Tab Counterweight Arm

Step 62: Mark and Drill the Rivet Holes in the Webs of the Upper Zee Rib Halves

Refer to Figure 39 to identify the **upper** half of each zee rib pair. Mark and lightly center punch three rivet hole locations on each one according to the dimensions given in the Figure 40.

Put each upper half together with its lower counterpart, aligning their forward, top and bottom edges, and clamp them together with a side-grip or C-clamp at each end, as shown in Figure 40.

Note Standard side-grips may be too wide to fit between the flanges of the zee rib halves at the narrow (aft) end. If necessary, relieve the interference by slightly filing down the jaws of one clamp.

Drill the center hole of each pair with a **#40** bit. Insert a Cleco in this hole, remove the side-grip or C-clamp from one end, and drill the hole at that end with a **#40** bit. Finally, Cleco this second hole, remove the remaining side-grip or C-clamp and drill the final hole with a **#40** bit.

After drilling, mark each pair of rib halves so that you can reunite them after disassembly. Then remove the Clecos and disassemble the halves.

Completed: [ ]

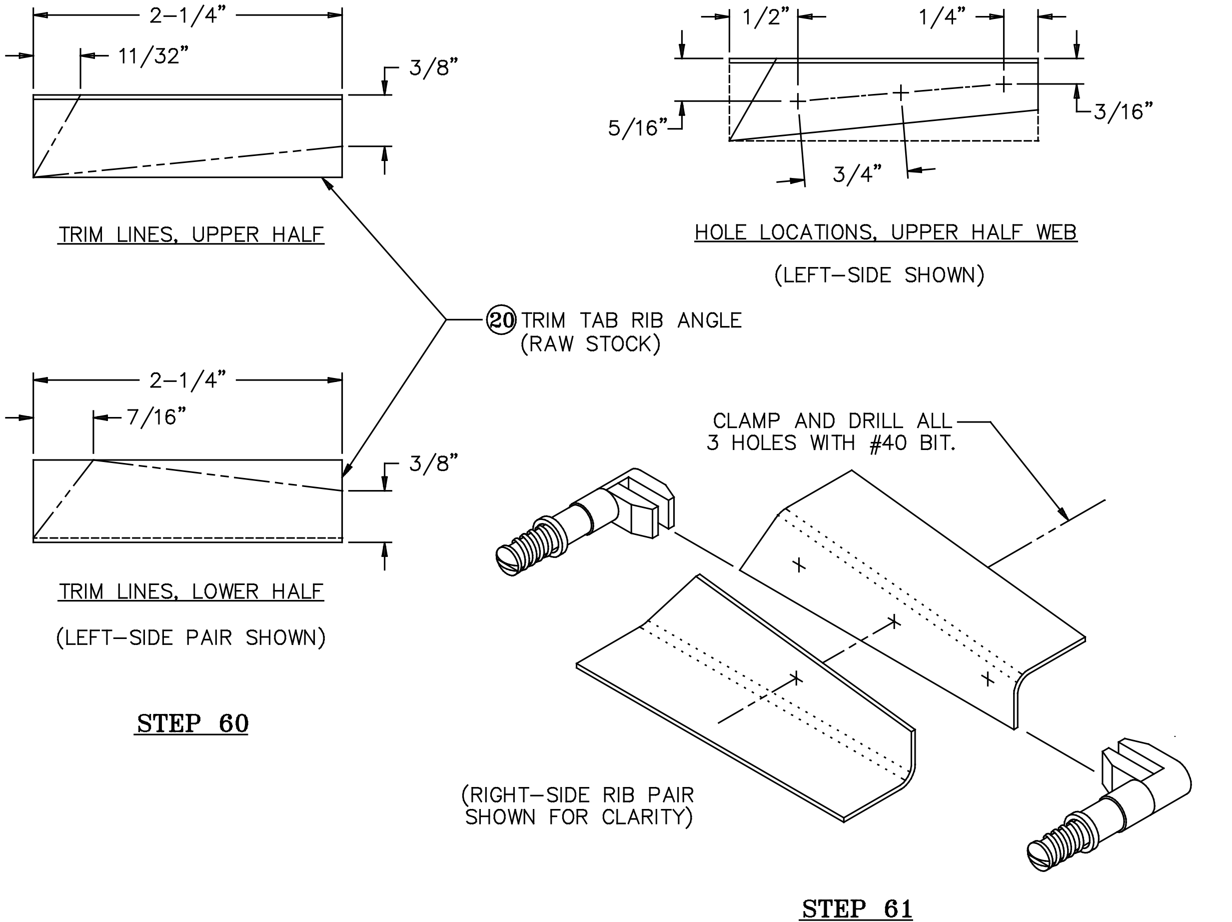

Figure 40: Marking and Drilling the Zee Ribs

Step 63: Mark Reference Lines and Hole Patterns on the Trim Tab Skin

Because there are no pre-punched rib holes in the **trim tab skin** [19], you have to lay out a number of reference lines and hole locations for the ribs as follows:

A) On the **inside** of the **upper** surface, mark a spanwise line **3/4"** aft of the leading edge.

B) On the **inside** of the **upper** surface, mark four chordwise lines: **8-9/32"**, **10-29/32"**, **22-1/4"** and **34-3/4"** from the left-hand end.

C) On the **outside** of the **upper** surface, mark four chordwise lines: **8-17/32"**, **10-21/32"**, **22"** and **34-1/2"** from the left-hand end.

D) On **each** of the four lines you marked in the last step on the **outside** of the **upper** surface, mark and lightly center punch hole locations **1"**, **1-5/8"** and **2-1/4"** aft of the leading edge.

E) On the **outside** of the **lower** surface, mark three chordwise lines: **8-31/32"**, **22"** and **34-1/2"** from the left-hand end.

F) On the **second** (22") and **third** (34-1/2") of the three lines you marked in the last step on the **outside** of the **lower** surface, mark and lightly center punch hole locations **1/2"**, **1-1/8"** and **1-3/4"** aft of the leading edge.

All these lines and hole locations and their dimensions are shown in Figure 41.

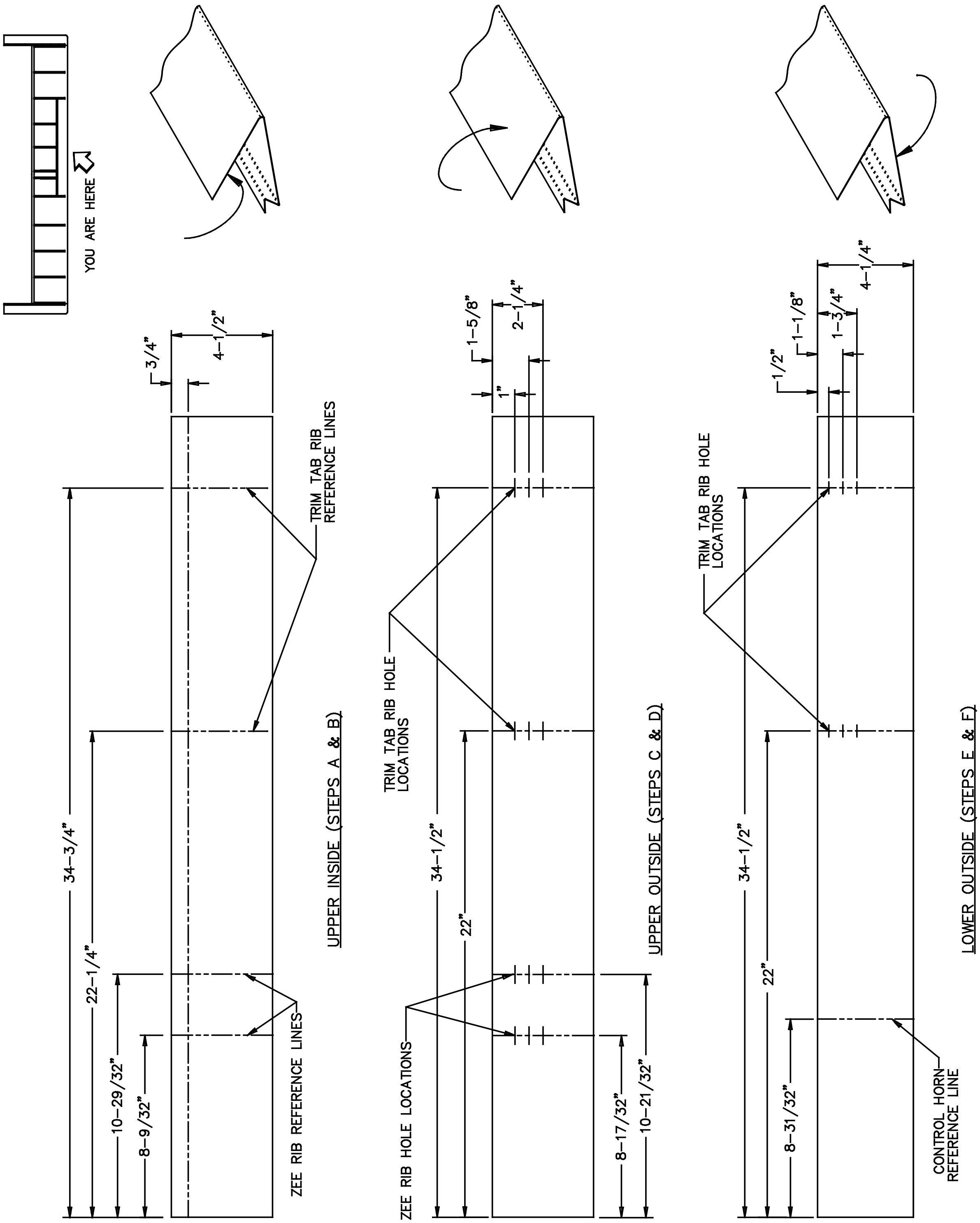

Figure 41: Trim Tab Skin Reference Lines

Step 64: Position and Drill the Upper Zee Rib Halves

Position the upper halves of the zee ribs inside the skin with their leading and outboard edges aligned on the reference lines inside the upper surface of the skin, as shown in Figure 42. Holding the halves in position with your fingers, drill through the flange and the skin with a #30 bit at each of the three locations you marked.

Hint A strip of duct tape will help hold the rib halves in position inside the skin. You'll still need to hold the rib halves in place while drilling , but the tape will make that easier. After the first hole is drilled in each half, use Clecos to hold them more securely.

When the holes have been drilled, reunite the halves of each zee rib pair and clamp them together with a pair of Clecos inserted from the outboard side. Then clamp each entire zee rib in place inside the skin using a couple of Clecos inserted from the outside through the holes you just drilled.

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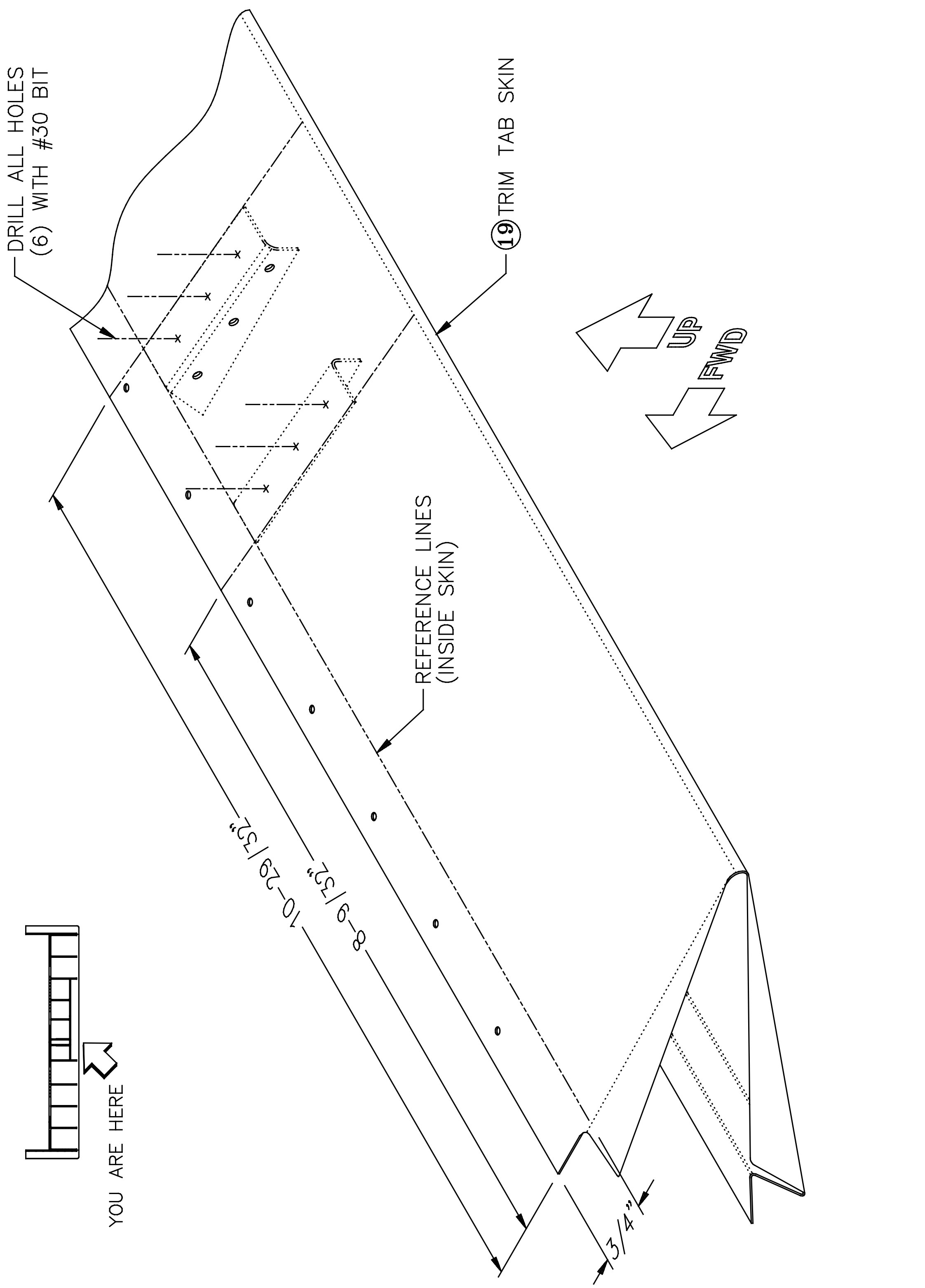

Figure 42: Positioning and Drilling the Upper Zee Rib Halves

Step 65: Position and Drill the Remaining Trim Tab Ribs

In addition to the zee ribs, the trim tab is stiffened with two formed **trim tab ribs** [22]. The orientation of these ribs is shown in Figure 43. Position these ribs by aligning their leading and outboard edges on the reference lines inside the upper surface of the skin, as shown in the figure.

Holding the ribs in position (Tape might again be helpful), drill through the skin and ribs at each of the six marked locations with a **#40** bit. Cleco as you go.

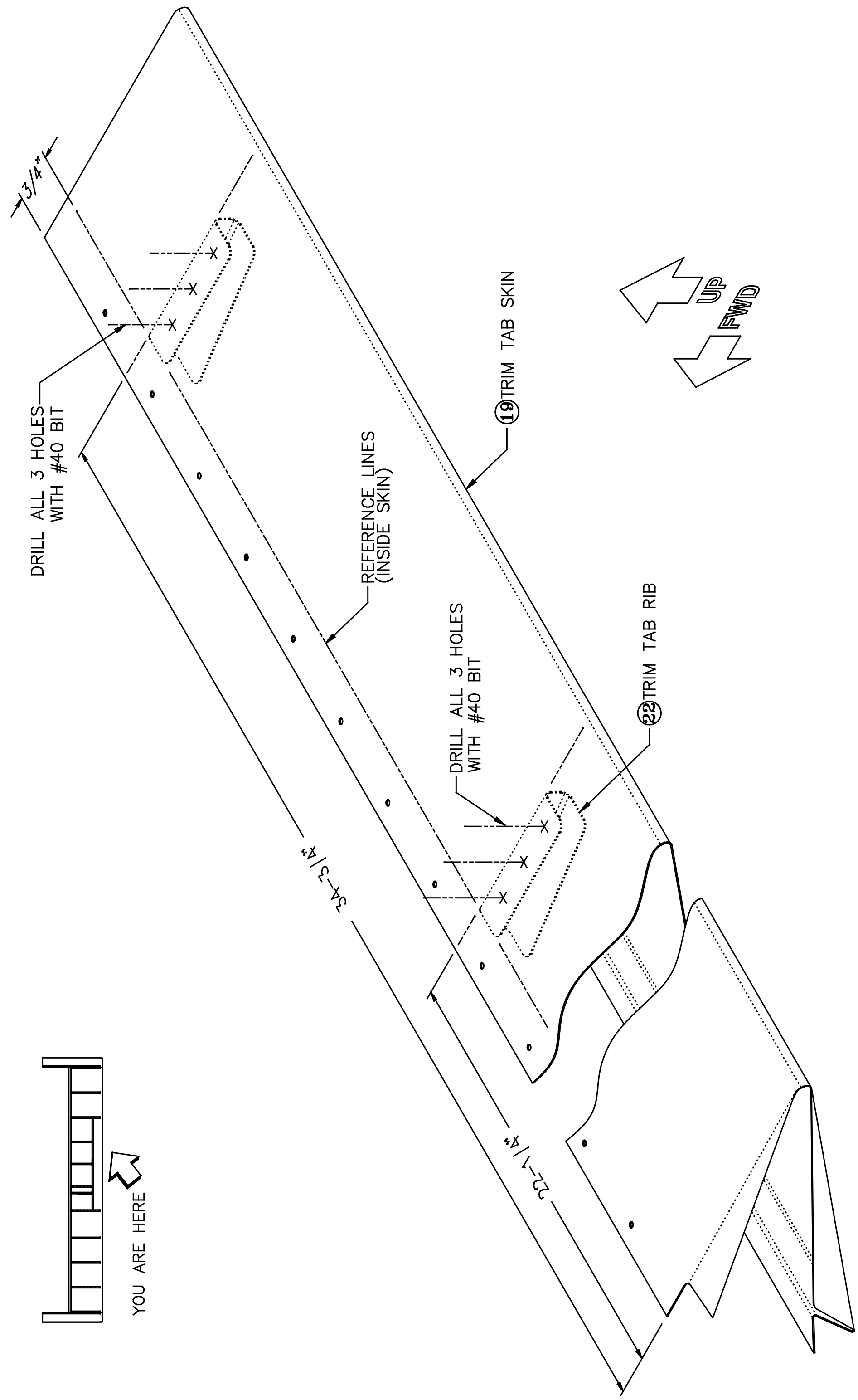

Figure 43: Positioning and Drilling the Trim Tab Ribs

In order to drill the lower-surface holes, the skin must be "closed" over the ribs. Closing the skin without kinking the trailing edge can be tricky. The best method, as shown in Figure 44, is to use a 2 X 4 as a bending brake to apply even pressure along the entire length of the skin. For best results, have a helper press on the 2 X 4 at two points while you clamp the upper and lower leading edges together with side-grip clamps.

> **Note** In closing the skin, you will have to bend the lower leading edge joggle forward to clear the leading edges of the four ribs. Also, make sure that the **upper** end tab on each end of the trim tab skin laps to the **outside** of the **lower** end tab. This will help the finished trim tab shed rain.

Once the skin is clamped shut, flip the assembly over and drill (**#30**) and Cleco the three lower-surface holes in each rib.

> **Note** Hold the trim tab on a flat surface to make sure that it remains straight while drilling the lower surface rivet holes.

Completed: [ ]

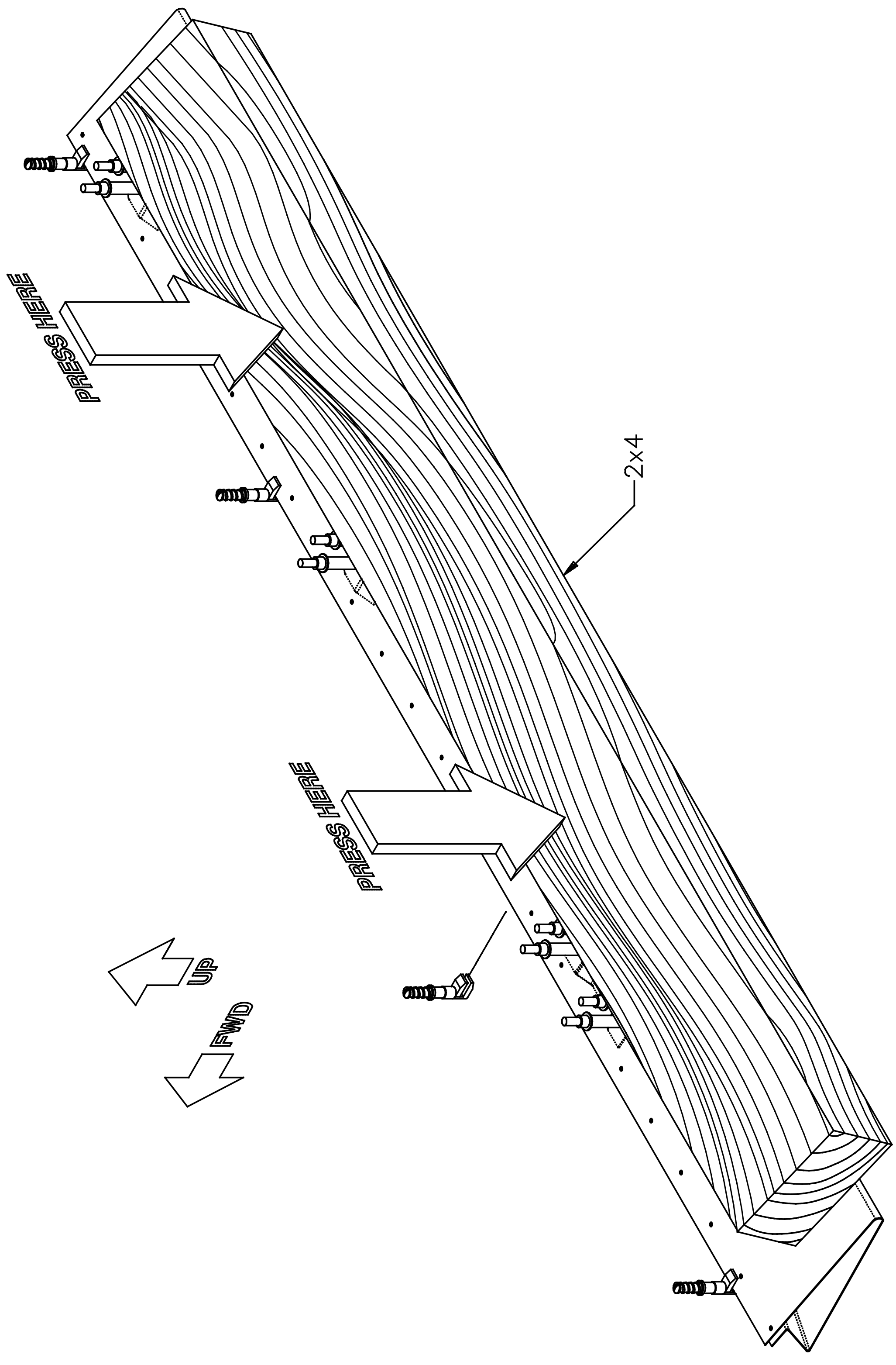

Figure 44: "Closing" the Trim Tab Skin

Note Step 66 and Figure 45 have been deleted by Revision C.

Step 67: Drill the Trim Tab Counterweight Arm

To eliminate the possibility of dangerous trim tab flutter in the event that the trim control linkage is severed, it is necessary that the tab be balanced by means of a counterweight hung forward of the hinge line. This weight is suspended from the **trim tab counterweight arm** [23], which is riveted to the trim horn.

Use a standard, hardware-store 3/16" hex bolt and nut to temporarily fasten the counterweight arm to the trim horn, as shown in Figure 46. Be certain to attach the arm to the **right** side of the horn. Pivot the arm around the bolt as necessary to make the top edge of the arm parallel to the flange of the horn, and then tighten the nut and bolt to secure it in place. Drill each of the five rivet holes through both the arm and the horn with a **#30** bit.

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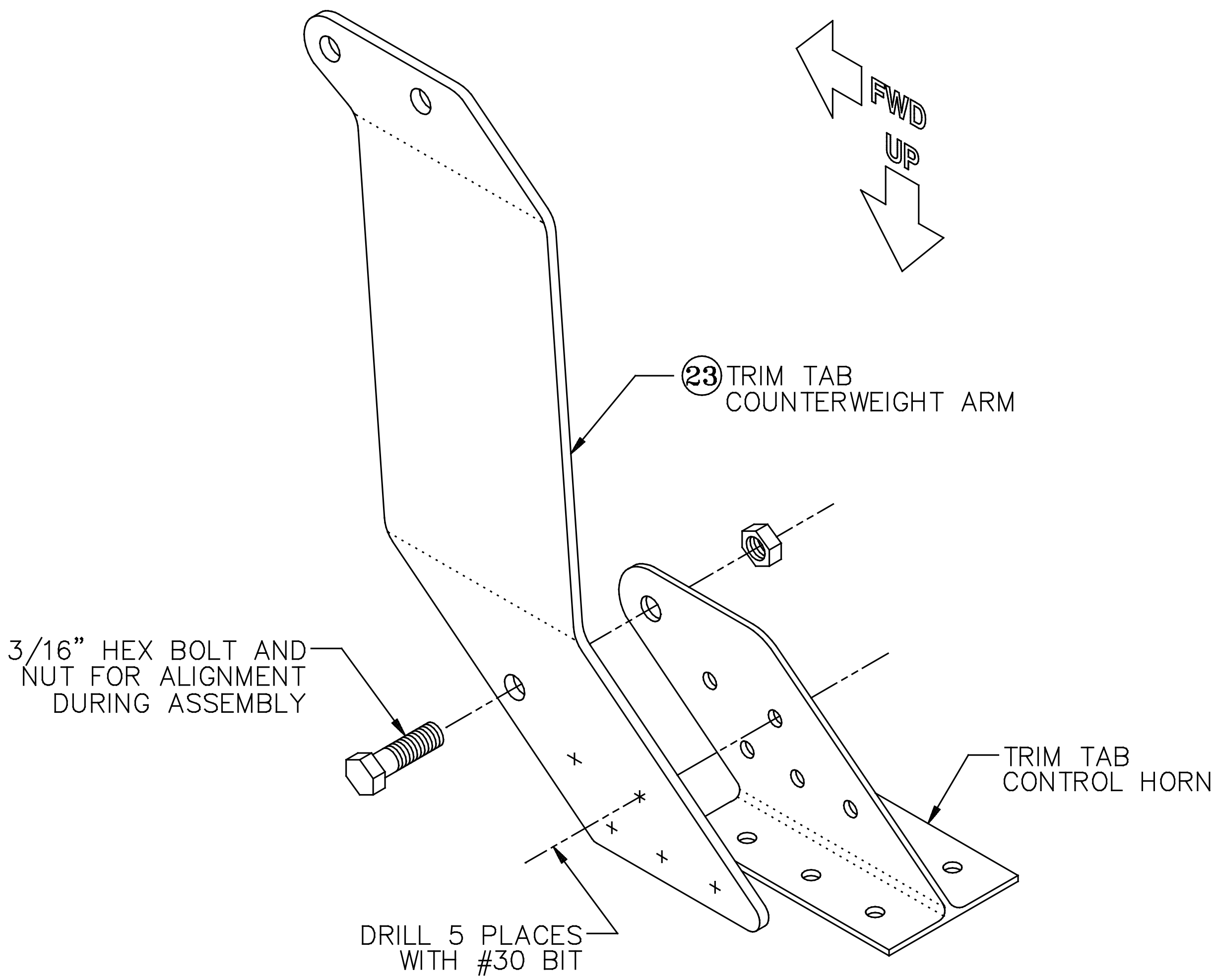

Figure 46: Drilling the Trim Tab Counterweight Arm

Step 68: Position and Drill the Trim Tab Horn and the Lower Zee Ribs

Position the trim tab horn with its leading edge even with the lower leading edge of the skin and its left-hand edge aligned on the control horn reference line, as shown in Figure 47.

> **Note** The control horn reference line is the one that was marked on the outside of the lower skin **8-31/32"** from the left-hand end. Refer to Step 63e and Figure 41.

Holding the horn in position with your fingers, drill through the horn flange, the skin and the underlying zee rib flange with a **#30** bit at each of the six marked locations, Clecoing as you go.

Completed: [ ]

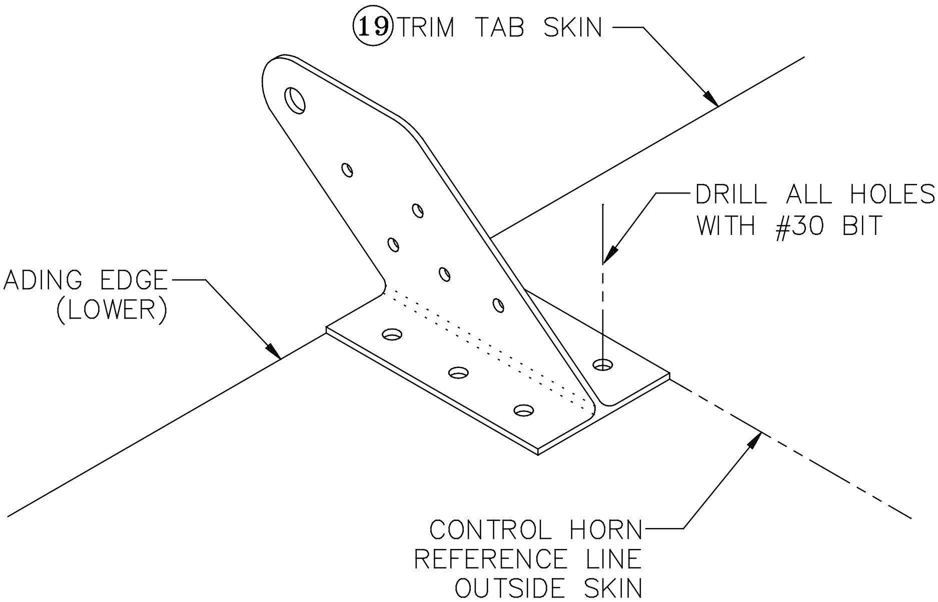

Figure 47: Positioning and Drilling the Trim Tab Control Horn

Step 69: Drill the End Tabs of the Trim Tab Skin

Re-Cleco the ribs inside the skin top and bottom. Mark and center punch three hole locations on each end of the trim tab, and drill each hole with a **#30** bit, as shown in Figure 48. The location of these holes is not critical—simply center them vertically and space them evenly along the width of the tab (while maintaining the standard minimum edge margin for rivet holes, of course).

> **Note** To make sure that the trim tab remains straight, hold it against a flat surface while drilling the end tab rivet holes. You will probably have to block the trim tab up to provide access for your drill and for inserting Clecos.

After drilling, clean and deburr the holes.

> **Note** The trim tab leading edge holes will be drilled when the hinge is drilled in a later step.

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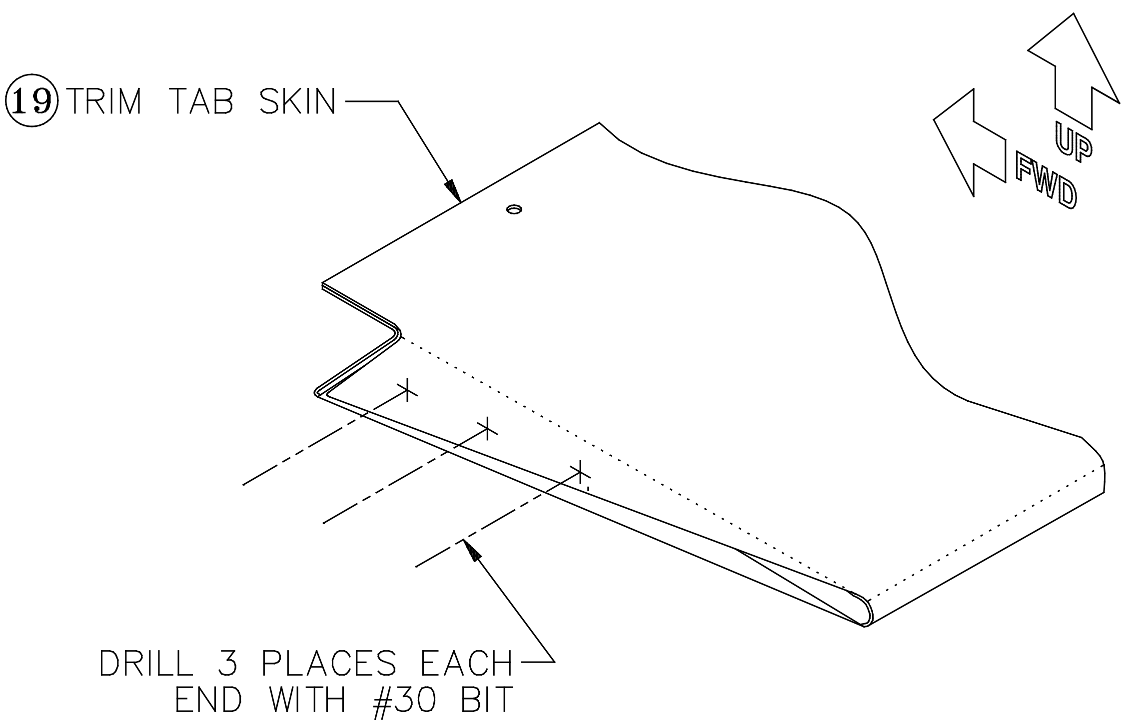

Figure 48: Drilling the End Tabs of the Trim Tab Skin

Step 70: Clean and Deburr All the Parts

Disassemble the trim tab and carefully clean and deburr all cut edges and all holes of all the parts.

Completed: [ ]

Step 71: Corrosion-Proof the Trim Tab Interior

Corrosion-proof all interior parts as you deem necessary (see "INTERIOR CORROSION PROTECTION" in "SECTION II: TOOLS AND TECHNIQUES"). Minimally, we recommend treating the rib flanges and the zee rib webs.

Completed: [ ]

TRIM TAB RIVETING

Step 72: Rivet the Zee Rib Halves

Use 3/32" AN470AD3 universal-head rivets to rivet the zee rib halves together. Check your marks to make certain that you are pairing the proper halves and refer back to Figure 39 to ensure that you have the halves oriented properly in relation to each other. The manufactured heads of the rivets can be on either side.

Completed: [ ]

Step 73: Rivet the Zee Ribs and the Control Horn to the Lower Surface

With 1/8" AN470AD4 universal-head rivets, rivet the zee ribs and the control horn to the lower surface of the trim tab skin. Be sure the horn is angled forward, as shown in Figure 49. The manufactured heads should be on the horn flange.

Completed: [ ]

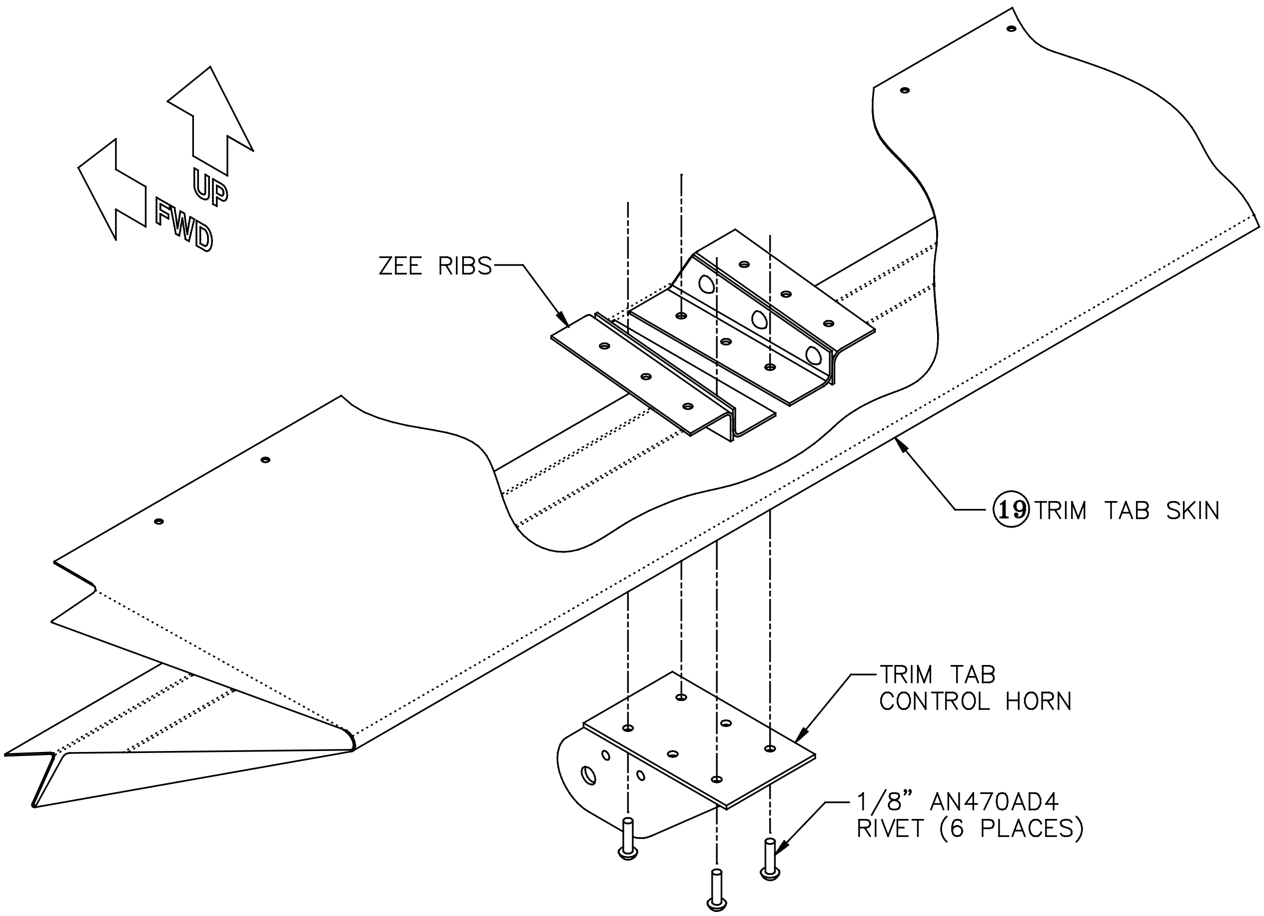

Figure 49: Riveting the Trim Horn and Zee Ribs

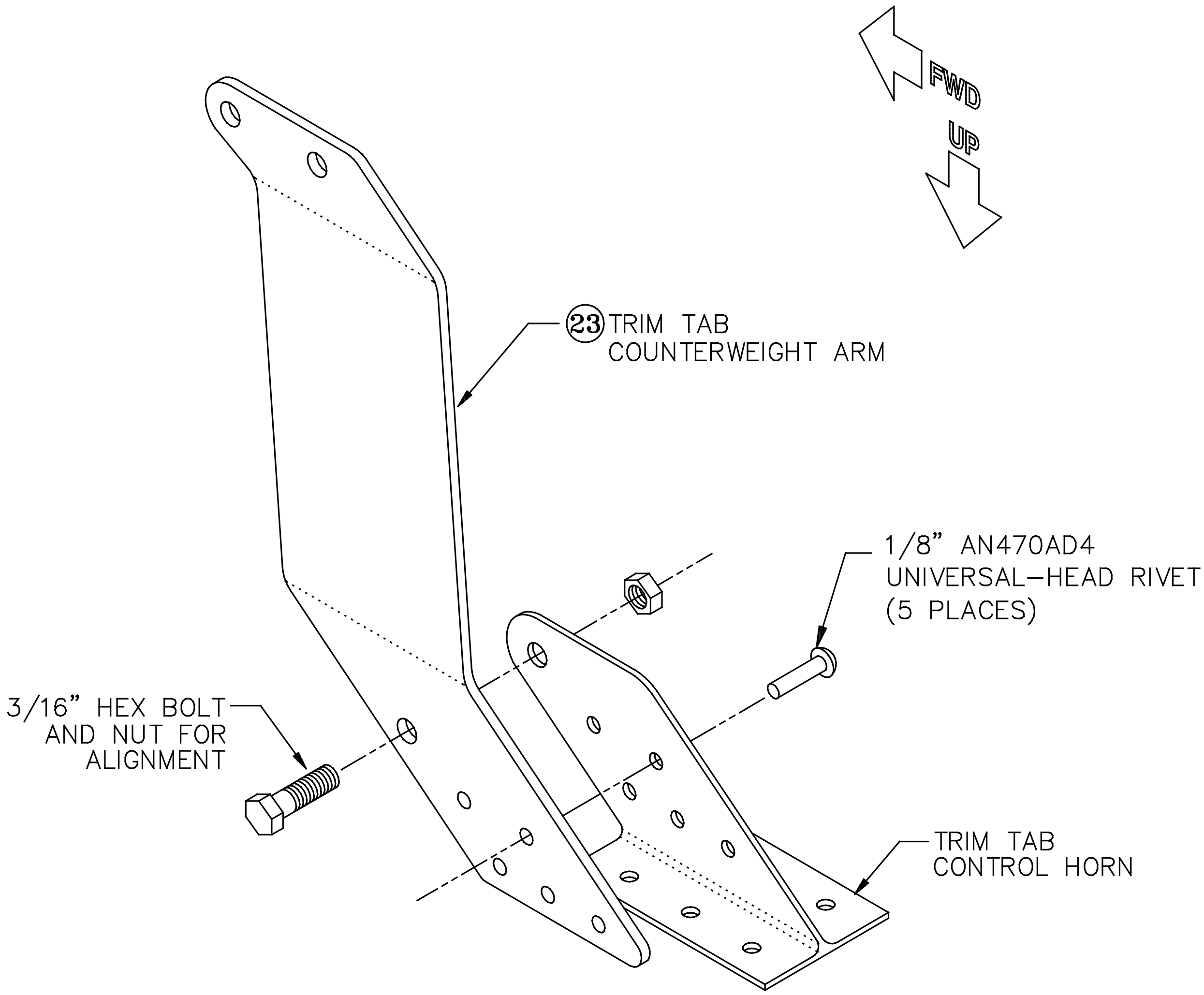

Figure 50: Riveting the Counterweight Arm to the Trim Horn

Step 74: Rivet the Trim Tab Ribs to the Upper Surface

Rivet the two outboard trim tab ribs to the upper surface of the skin with 3/32" AN470AD3 universal-head rivets.

Completed: [ ]

Step 75: Rivet the Remaining Rib/Skin Holes

> **Note** To make sure that it remains straight and untwisted, hold the trim tab against a flat surface while riveting in Steps 75 and 76.

Re-close the trim tab skin (again using the 2 X 4 brake if necessary) and hold it together with Cleco side-grips along the leading edge. Then use 1/8" AAPQ-42 blind rivets to rivet the remaining holes in the zee ribs (upper surface) and outboard ribs (lower surface).

Completed: [ ]

Step 76: Rivet the End Tabs of the Trim Tab Skin

Use 1/8" AAPQ-42 blind rivets to rivet the skin end tabs together through the three holes at each end.

Completed: [ ]

Step 77: Rivet the Counterweight Arm to the Trim Horn

With 1/8" AN470AD4 universal-head rivets, rivet the counterweight arm to the **right** side of the trim horn. As shown in Figure 50, the rivet heads should be on the horn side.

Completed: [ ]

ELEVATOR HINGES

Warning There are two types of piano hinge supplied in the GlaStar kit, "rolled" and "extruded"; they are **not** interchangeable. Make sure that you use the **rolled** hinge material for the **trim tab hinge** and the **extruded** hinge material for the **elevator hinges**. The two different types of hinge can easily be distinguished by noting the part numbers marked or stamped on them, or by observing the hinge knuckles. The **rolled** hinge is marked with P/N **MS20257**; furthermore, it will be obvious upon inspection that the hinge knuckle was formed by rolling up a flat piece of metal. The **extruded** hinge is marked with P/N **MS20001** and looks like the hinge shown in Figure 51: the knuckles flow smoothly into the flat part of the hinge without gaps.

Step 78: Cut the Elevator and Trim Tab Hinges to Length

Remove the pin from the **44" length of rolled hinge** [26] stock and separate the halves; the hinges will be cut one half at a time. As shown in Figure 51, each end of each hinge should fall roughly in the middle of one of the "knuckles." So, first, select one half of the hinge stock and cut off one end in the middle of the first "knuckle." From that freshly cut end, measure, mark and cut off a **40"** length. This will be the trim tab hinge.

Hint The hinge stock can be cut easily with a hacksaw if the stock is held in a bench vise. A bandsaw or scroll saw with a fine-toothed wood-cutting blade will also do a smooth job of cutting the aluminum hinge stock. But don't try using it on the hardened steel hinge pin—the pin will win!

Next, lay the 40" half flat on the bench and slide it together with its mate (the remaining 44" half), with the loops up on both halves. Mark the 40" length on the second half, using the cut 40" half as a guide. Cut the second half to the marked length.

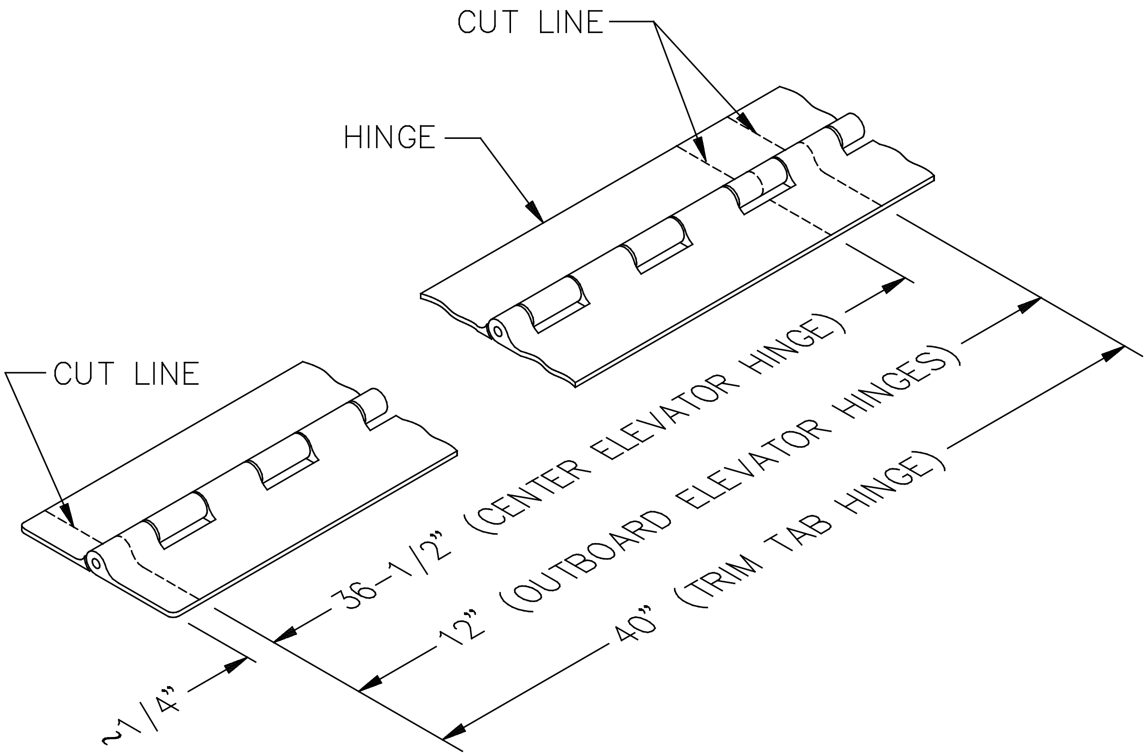

Figure 51: Cutting the Hinges

Repeat this process on the **72" length of extruded hinge stock** [25], cutting one **36-1/2"** hinge (elevator center) and two **12"** hinges (elevator outboard). (The 36-1/2" length will begin in the middle of the knuckle of one hinge half and end in the middle of the knuckle of the opposite half.) Be sure to mark both halves of both 12" pairs so that each half can be reunited with its original mate.

After all four hinge pairs have been cut to length, use a fine file to smooth the cut ends and, if necessary, a deburring tool to deburr the inside of the pin hole. Also, round each sharp corner slightly, as shown in Figure 51.

Completed: [ ]

Step 79: Cut and Bend the Hinge Pins

From the 44" length of hinge pin, cut a piece **41-1/2"** long. Use a pair of heavy-duty wire cutters to make the cut. From the 72" length, cut two pieces **13-1/2"** long and two pieces **19-1/4"** long. Use a fine file or a bench grinder to smooth the cut ends; bringing them to a slight point is fine and will make it easier to reinsert them into the hinges.

A 90° bend must be put in one end of each pin to fit the hinge-pin retainers. Tighten each pin securely in a bench vise with **3/4"** of it protruding perpendicularly above the jaws. Using a small hammer as close to the top of the jaws as possible, pound the end of the pin over until it is parallel with the floor. Try to keep the radius of the bend as small as possible, i.e. keep the bent end of the pin as straight as possible.

Completed: [ ]

Step 80: Position the Elevator Hinges and Drill Index Holes

In positioning the hinges there are a number of goals to be met, as follows:

A) Adequate edge margins must be maintained for all rivet holes with respect to the skins, the spar flanges, the doubler (in the case of the elevator) and the hinge stock.

B) The gap between the upper stabilizer skin and the upper elevator skin must be kept as small as is practical, but neither skin can come closer than **1/16"** to the hinge centerline (for a total minimum gap of **1/8"**). Gaps smaller than this will impede full elevator up travel.

Achievement of these two goals takes precedence over any particular dimension given in the manual.

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Make marks along the upper leading edge of the elevator **3/16"** from each end of the forward spar. These marks indicate the outboard end points of the outboard hinges. Make an additional mark **41-7/8"** from one end of the forward spar; it doesn't matter which end you measure from. This mark indicates the end point of the center hinge.

Figure 52 shows how the elevator hinges are aligned fore-and-aft, with the bottoms of the "knuckle" slots approximately **1/32"** aft of the leading edge of the elevator skin. Position half of each elevator hinge under the upper spar flange, aligning it spanwise on the reference mark you just drew and fore-and-aft on the leading edge of the skin, as shown in the figure. Clamp in place with a side-grip at each end, as shown in the figure.

Caution This is one of the most critical alignments in the entire GlaStar empennage. With the hinges clamped at each end, double check to make sure that they are all aligned as precisely as possible on the elevator leading edge and—even more importantly—with one another. You may find it useful to stretch a string along the hinge line to detect any small misalignments. Readjust the clamps as necessary.

When you are satisfied with the alignment of the hinges, use a **#30** bit to drill **one** hole near the center of each hinge, using the nearest pre-punched skin hole as a guide. Insert a Cleco in each hole and remove the side-grips.

With the elevator-side hinge halves Clecoed in place, mount the stabilizer-side hinge halves on their respective mates using the pins you cut in the preceding step.

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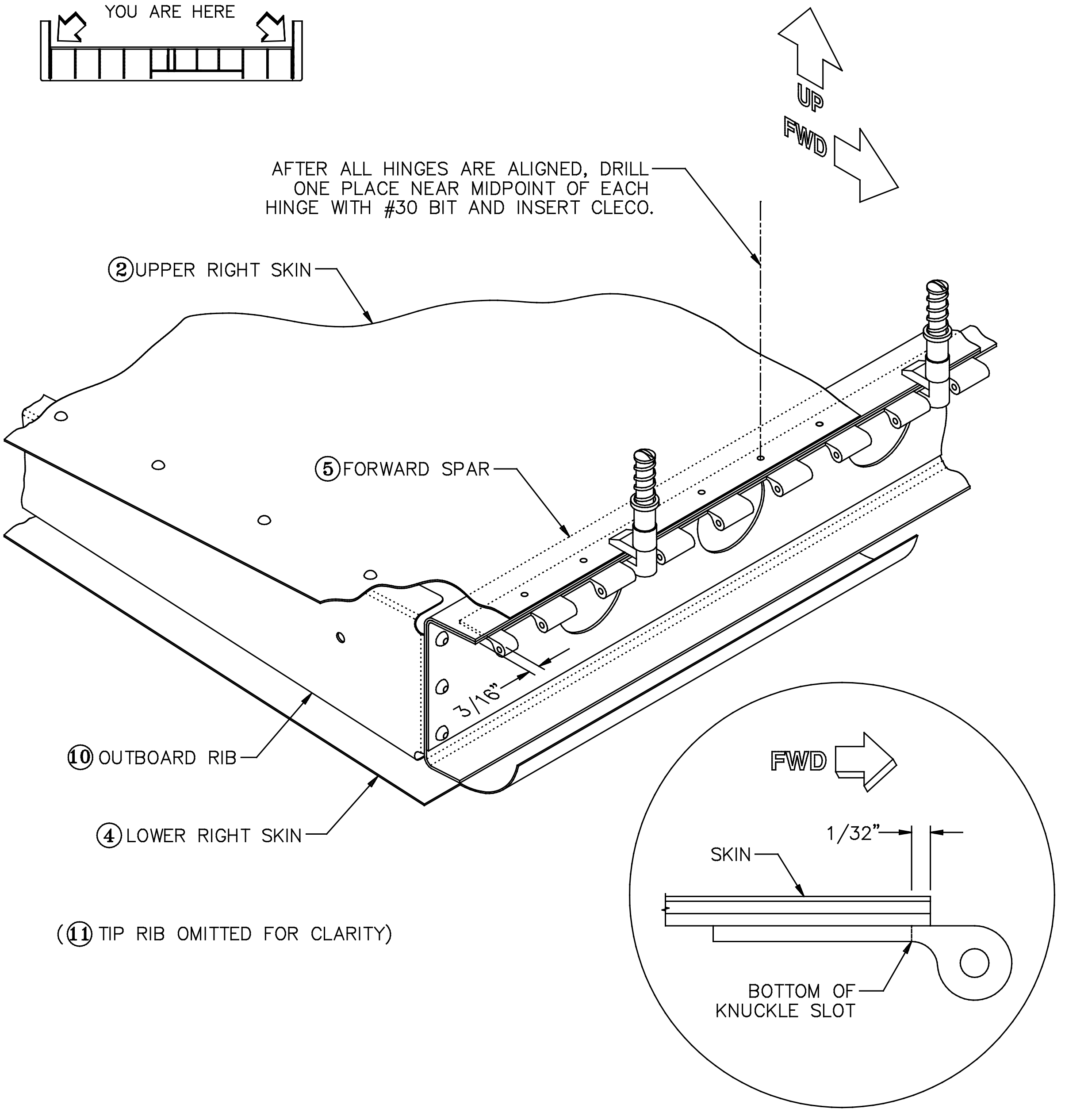

Figure 52: Aligning and Drilling the Elevator-Side Hinge Halves

Step 81: Position the Elevator Behind the Stabilizer and Align the Hinges on the Aft Spar

In this step, you will temporarily mount the elevator on the horizontal stabilizer. This and the subsequent couple steps are somewhat tricky, but the most important requirements are simply patience and diligence.

First, you need to arrange some supports that will hold the stabilizer and elevator flat and right-side up above the bench, providing clearance underneath for the elevator control horns. A pair of 24" long 2 X 6s—one at each end of the stabilizer—oriented chordwise will do the trick nicely. It's not important that the stabilizer be precisely level, only that it be firmly supported a couple inches off the bench top.

With the stabilizer supported on the bench, ease the elevator into position behind the stabilizer with the elevator tip ribs projecting forward alongside the outermost stabilizer ribs. Note that the elevator is 3/8" longer than the stabilizer. However, because you set the outboard elevator hinges 3/16" from each end, the outboard ends of the hinges should align with the outboard ends of the stabilizer. As shown in Figure 53, place the flanges of the stabilizer-side hinge halves against the **underside** of the stabilizer upper aft spar flange.

Make final adjustments as necessary to bring all three hinges into precise alignment with the trailing edge of the stabilizer. As on the elevator side, the bottoms of the stabilizer-side "knuckle" slots will, ideally, fall approximately **1/32" forward** of the trailing edge of the upper skin of the stabilizer, thus leaving a gap between the stabilizer and elevator of approximately **3/16"**.

Hint A good way to align the hinges is to insert a 3/16" piece of wood or metal into the gap between the stabilizer and elevator just outboard of the outboard hinges and then push the elevator forward until the gap closes tightly on the pieces at both ends. Also, the stabilizer hinge halves must be held tightly against the underside of the spar flange for drilling the initial index holes (described in the following step). One way to do this is to cut small blocks of wood just the right length to wedge between the hinge halves and the lower spar flange. Place the blocks near the center of each hinge.

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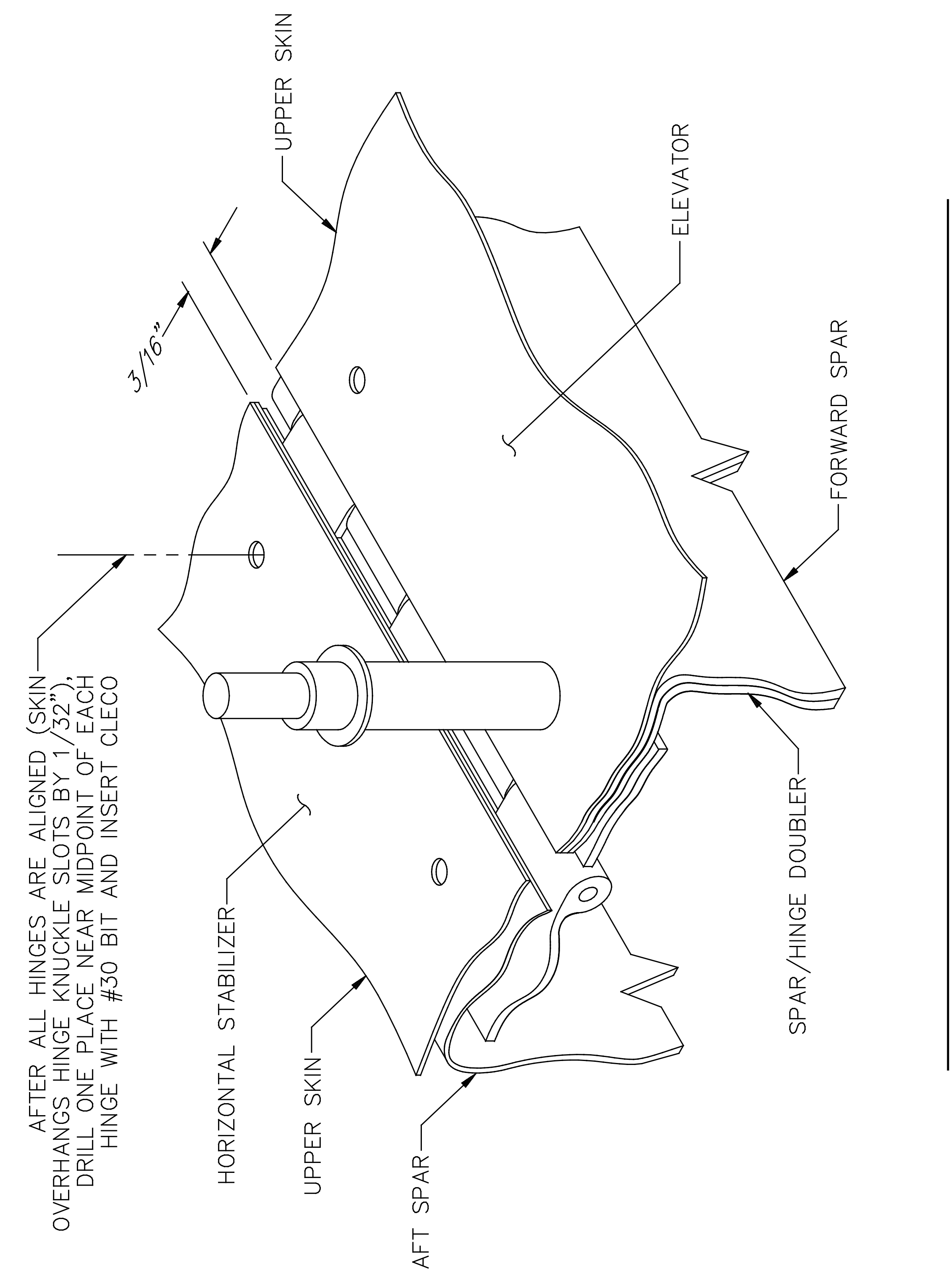

Figure 53: Aligning and Drilling the Stabilizer-Side Hinge Halves

Step 82: Drill Index Holes in the Stabilizer-Side Hinge Halves

When you are satisfied that the outboard hinges are aligned, use a **#30** bit to drill **one** hole through the skin, hinge and spar near the center of each hinge. Make sure that the location you pick is staggered at least a Cleco's width from its opposite number on the elevator-side.

Completed: [ ]

Step 83: Drill the Final Hinge Alignment Holes

With each hinge held to the stabilizer with one Cleco, fold the elevator upward until it is in a near-vertical position (approximately perpendicular to the stabilizer. This motion will cause the hinges to pivot minutely around the Clecos as necessary to bring the hinges into final alignment.

With the elevator in this vertical position, drill **one** stabilizer-side hole at **each** end of each hinge with a **#30** bit. Cleco after drilling. With Clecos at each end of each hinge on the stabilizer side, you can lower the elevator to rest on supports.

Note Firm contact must be maintained between the hinge halves and the underside of the spar flange while drilling these holes. Have a helper insert a wooden stick into the hinge gap from below and push against the stabilizer hinge half to support it while drilling. Or use the wedges described in the hint in Step 81 to support the hinge halves against the pressure of your drill.

Completed: [ ]

Step 84: Drill the Remaining Holes

With each hinge Clecoed at three points on the stabilizer side and one point on the elevator side, they are effectively locked into position. Now you can go ahead and drill all the remaining holes along the stabilizer trailing edge and the elevator leading edge with a **#30** bit. Don't forget to redrill the holes you drilled previously at each rib location; these were drilled with a #40 and must now be brought up to final size. Cleco these holes as you go.

When all the drilling is completed, remove the Clecos, separating the elevator from the stabilizer and removing both halves of each hinge from their respective assemblies. Thoroughly clean and deburr all the holes in the hinge parts and in the stabilizer and elevator assemblies.

Completed: [ ]

TRIM TAB HINGE

Step 85: Position the Trim Tab Hinge and Drill an Index Hole

The main goals in positioning the trim tab hinge are as follows:

A) It is most important to maintain proper edge margins for all rivet holes with respect to all parts.

B) The gap between the upper elevator skin and the trim tab skin must be as small as is practical, but neither skin can come closer than **1/16"** to the hinge centerline (for a total minimum gap of **1/8"**). Gaps smaller than this will impede full trim tab travel.

C) The trim tab must be held straight and untwisted while drilling the hinge rivet holes.

Achievement of these three goals takes precedence over any particular dimension given in the manual.

As shown in Figure 54, make a mark along the upper leading edge of the trim tab **3/4" outboard** of the **third hole from the right-hand end**. This mark indicates the outboard end point of the trim tab hinge.

The trim tab hinge is aligned just like the elevator hinge. Position half of the hinge under the upper surface overhang, as shown in Figure 54, aligning it spanwise with its outboard end on the reference mark and fore-and-aft with the bottom of its "knuckle" slots about **1/32" aft** of the leading edge of the skin. Clamp in place with side-grips or small C-clamps near each end. Double check to make sure that the hinge is aligned as precisely as possible on the trim tab leading edge. Readjust the clamps as necessary.

When you are satisfied with the alignment of the hinge, use a **#40** bit to drill **one** hole near the center of the hinge. Insert a Cleco in the hole and remove the side-grips or C-clamps.

With the trim tab-side hinge half Clecoed in place, mount the elevator-side half on its mate using the pin you cut previously.

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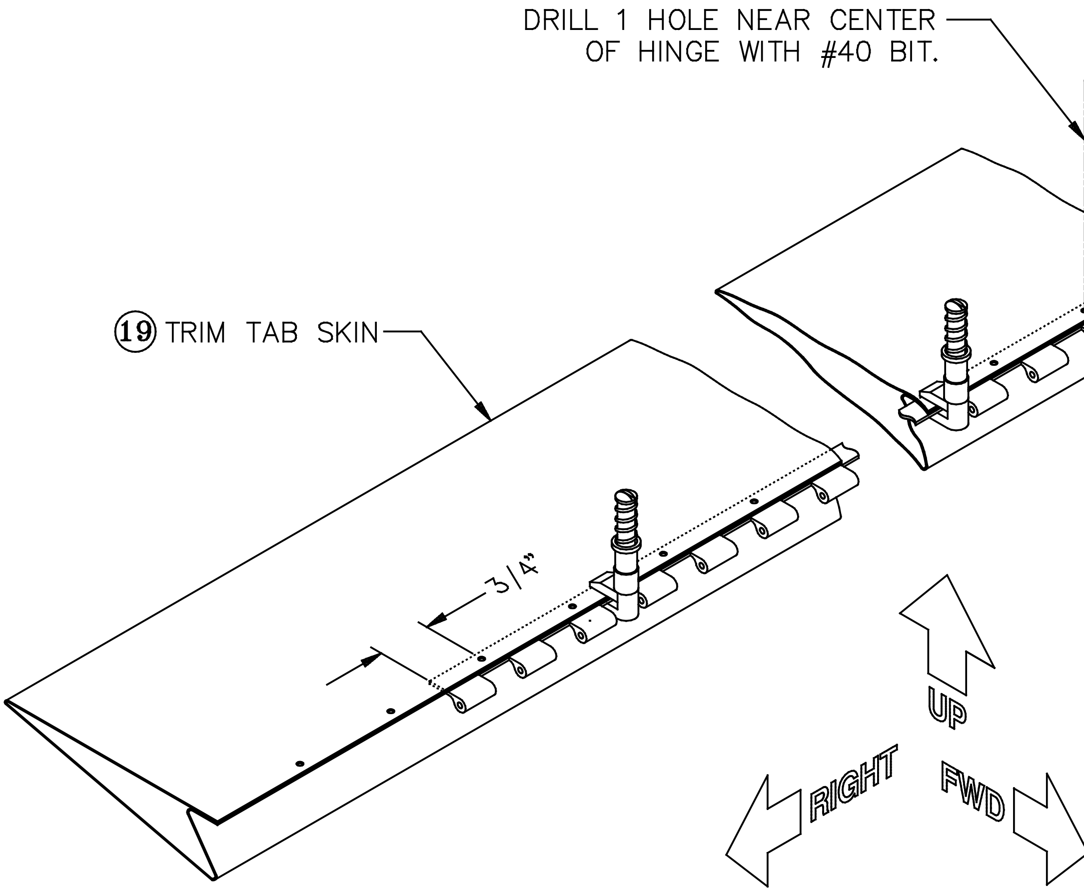


Figure 54: Aligning and Index Drilling the Trim Tab Hinge

Step 86: Align the Hinge on the Elevator Side and Drill an Index Hole

To align the elevator-side trim tab hinge half for drilling an index hole, insert the flange of the hinge **between** the upper skin and the upper flange of the aft partial spar. (This is not where the hinge will ultimately go—it will be riveted to the **underside** of the partial spar flange—but the clamping action provided by the upper elevator skin makes final adjustment of the hinge much easier.) Adjust the hinge as necessary to even the gap. Once again, the bottoms of the “knuckle” slots will, ideally, fall approximately **1/32"** forward of the trailing edge of the upper skin of the elevator, leaving a total gap of about **3/16"**.

When you are satisfied that the hinges are aligned, use a **#40** bit to drill through the skin, spar and hinge at **one** location near the center of the hinge, using the nearest pre-punched hole for a guide. As with the elevator, make sure that the location you choose is offset at least a Cleco's width from the trim tab-side Cleco. After drilling, insert a Cleco in the hole.

Completed: [ ]

Step 87: Drill the Final Alignment Holes

With the hinge held to the elevator with one Cleco, fold the trim tab upward until it is in a near-vertical position (approximately perpendicular to the elevator), just as you did with the elevator.

With the trim tab in this vertical position, drill **one** hole near **each** end of the hinge with a **#40** bit. Cleco these holes and then lower the trim tab.

Completed: [ ]

Step 88: Drill the Remaining Holes

With the hinge Clecoed to the elevator in three places, it is locked into position. You can now drill all the remaining holes with a **#40** bit. Cleco these holes as you go. Also, with the same bit, drill the remaining holes along the aft partial spar outboard of the hinge ends. Finally, drill the holes through the leading edge of the trim tab that fall outboard of the hinge.

Note Early GlaStar elevator skins lacked the pre-punched aft spar rivet holes in the area of the skin overlap. You marked the locations of the missing holes in Step 37; if your original marks have been erased, lay out the hole locations on the **left** skin and drill them through both skins, the hinge half and the aft spar with a **#40** bit. Use the same hole spacing as the rest of the rivet line, adjusting as necessary to maintain the standard minimum edge distance (**3/16"**) in both the left and right skins.

When all the drilling is completed, remove the Clecos, separating the trim tab from the elevator and removing both halves of each hinge from their respective assemblies. Thoroughly clean and deburr all the holes in the hinge parts and in the elevator and trim tab assemblies.

Note The hinges are made of anodized aluminum; they require no additional corrosion protection, although you may paint them if you wish. Do **not** acid-etch or alodize the hinges, however.

Completed: [ ]

HINGE RIVETING

Step 89: Rivet the Elevator Hinge Halves to the Stabilizer

Use 1/8" AN470AD4 universal-head rivets to rivet the stabilizer-side halves of the elevator hinges to the upper flange of the stabilizer aft spar. Also, use rivets of the same diameter (but different length, as appropriate) to rivet the upper stabilizer skins to the spar flange between the hinges, **with the following exceptions: do not** put a rivet in the holes immediately inboard of the outboard hinges or on either side of the center hinge (see Figure 55). These holes will accommodate the hinge pin retainers.

Sequence the riveting as discussed in "SECTION II: TOOLS AND TECHNIQUES."

Note In this and the subsequent three steps, note that the thickness of the stack-up is less between the hinges than it is on the hinges. Be sure to choose rivet length accordingly, as discussed in "SECTION II: TOOLS AND TECHNIQUES."

Completed: [ ]

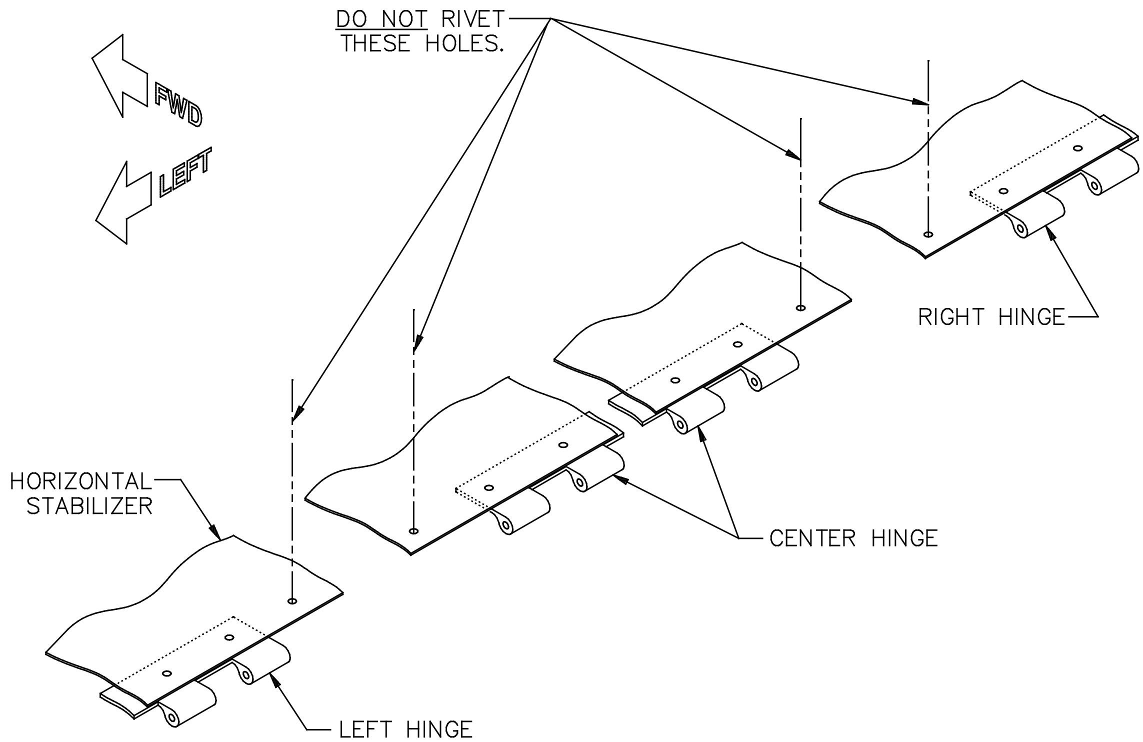


Figure 55: Stabilizer-Side, Hingeline Rivet Holes to Be Left Empty

Step 90: Rivet the Elevator-Side Hinge Halves to the Elevator

With 1/8" AN470AD4 universal-head rivets, rivet the elevator-side halves of the elevator hinges to the upper flange of the elevator forward spar. Also, rivet the upper elevator skins to the spar flange between the hinges using rivets of the same diameter but appropriate length.

Completed: [ ]

Step 91: Rivet the Trim Tab Hinge Half to the Elevator

Rivet the elevator-side half of the trim tab hinges to the upper flange of the elevator aft spar with 3/32" AN470AD3 universal-head rivets. In the holes outboard of the hinge, use rivets of the same diameter but appropriate length to rivet the upper elevator skins to the aft partial spar flange, **with the following exception: do not** put a rivet in the outermost hole at the right end of the aft partial spar, as shown in Figure 56. This hole will accommodate the hinge pin retainer.

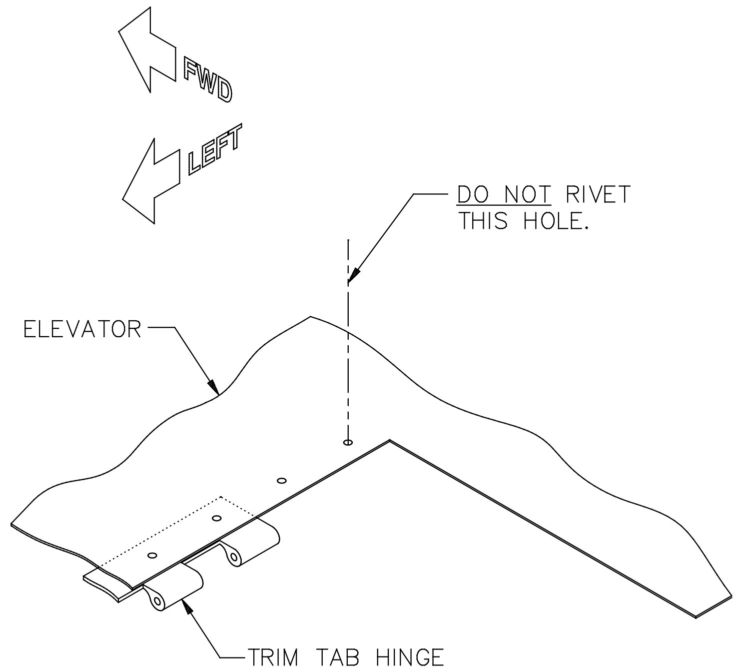


Figure 56: Elevator-Side, Hingeline Rivet Holes to Be Left Empty

Completed: [ ]

Step 92: Rivet the Trim Tab Hinge Half to the Trim Tab

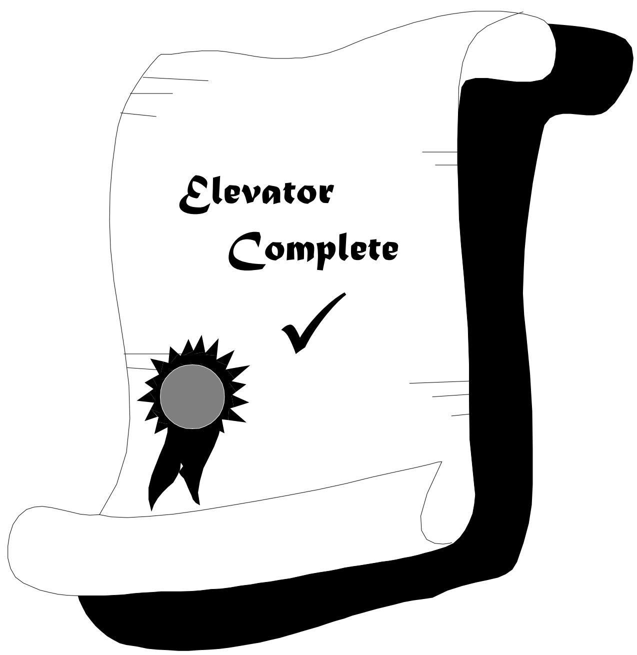
Using 3/32" AN470AD3 universal-head rivets, rivet the trim tab-side half of the trim tab hinge to the trim tab leading edge overhang. Using rivets of the same diameter but appropriate length, rivet the upper and lower surfaces of the trim tab hinge together outboard of the hinge.

Completed: [ ]

Note Steps 93 through 108, which described balancing the trim tab and elevator and installing the stabilizer and elevator tip fairings, have been deleted by Revision C. These procedures are now described in Steps 166 through 176 of "SECTION X: FINAL ASSEMBLY." For this reason, pages 109–130 of Revisions B and earlier are now **obsolete** and should be discarded.

CONGRATULATIONS!

You've completed the elevator assembly, and with it, the entire empennage! Your GlaStar is really beginning to take shape. Now, it's time to apply all you've learned on a bigger project—the wing!



SECTION VI: WING ASSEMBLY

PARTS LIST

Key No.:	Part Name:	Qty:	Part No.:
1	Rib, root main, left	1	201-00001-01
2	Rib, root main, right	1	201-00001-02
3	Rib, outboard main, left-flange	5	201-00002-01
4	Rib, outboard main, right-flange	5	201-00002-02
5	Rib, root nose, left	1	201-00003-01
6	Rib, root nose, right	1	201-00003-02
7	Rib, outboard nose, left-flange	16	201-00004-01
8	Rib, outboard nose, right-flange	16	201-00004-02
9	Rib, flap cove root, left	1	201-00005-01
10	Rib, flap cove root, right	1	201-00005-02
11	Rib, flap cove, left-flange	13	201-00006-01
12	Rib, flap cove, right-flange	13	201-00006-02
13	Rib, aileron cove, left-flange	9	201-00007-01
14	Rib, aileron cove, right-flange	9	201-00007-02
15	Hat section, upper	34	201-00008-01
16	Hat section, lower	32	201-00009-01
17	Skin, leading edge, inboard, left	1	201-00011-01
18	Skin, leading edge, inboard, right	1	201-00011-02
19	Skin, leading edge, center, left	1	201-00012-01
20	Skin, leading edge, center, right	1	201-00012-02
21	Skin, leading edge, outboard, left	1	201-00013-01
22	Skin, leading edge, outboard, right	1	201-00013-02
23	Skin, upper inboard, left	1	201-00014-01
24	Skin, upper inboard, right	1	201-00014-02
25	Skin, upper center, left	1	201-00015-01
26	Skin, upper center, right	1	201-00015-02
27	Skin, upper outboard, left	1	201-00016-01
28	Skin, upper outboard, right	1	201-00016-02
29	Skin, lower inboard, left	1	201-00017-01

30	Skin, lower inboard, right	1	201-00017-02
31	Skin, lower center, left	1	201-00018-01
32	Skin, lower center, right	1	201-00018-02
33	Skin, lower outboard, left	1	201-00019-01
34	Skin, lower outboard, right	1	201-00019-02
35	Stiffener channel, lower center skin	8	201-00027-01
36	Cap strip, 72"	4	201-00028-01
37	Cap strip, 36"	4	201-00029-01
38	Doubler, lower inboard skin	2	201-00030-01
39	Doubler, root rib, upper, left	1	201-00031-01
40	Doubler, root rib, upper, right	1	201-00031-02
41	Doubler, root rib, lower, left	1	201-00032-01
42	Doubler, root rib, lower, right	1	201-00032-02
43	Gusset, lower center skin	1	201-00034-01
44	Spar, forward, left	1	201-01001-01
45	Spar, forward, right	1	201-01001-02
46	Doubler, forward spar root, left front	1	201-01002-01
47	Doubler, forward spar root, right front	1	201-01002-02
48	Doubler angle, forward spar root	2	201-01003-01
49	(Part deleted by Revision C)		
	Doubler, forward spar root, rear	2	201-01004-01
51	Doubler, forward spar/strut beam	2	201-01005-01
52	Spar, aft, left	1	201-02001-01
	Spar, aft, right	1	201-02001-02
	Doubler, aft spar root, front	2	201-02002-01
53	Doubler angle, aft spar root	2	201-02003-01
56	(Part deleted by Revision C)		
57	Doubler, aft spar root, rear	2	201-02004-01
58	Doubler, aft spar/strut beam	2	201-02005-01
	Bracket, flap bellcrank	4	201-02006-01
	Angle, flap bellcrank attach, upper	2	201-02008-01
	Angle, flap bellcrank attach, lower	2	201-02008-02
	Bracket, aileron bellcrank	2	201-02010-01
	Bracket, aileron bellcrank, opposite	2	201-02010-02
	Angle, aileron bellcrank upper attach, left	1	201-02012-01

65	Angle, aileron bellcrank upper attach, right	1	201-02012-02
66	Angle, aileron bellcrank attach, lower	2	201-02013-01
	Beam, strut, left-flange	2	201-04001-01
	Beam, strut, right-flange	2	201-04001-02
	Angle, strut beam attach, forward	4	201-04002-01
	Angle, strut beam attach, aft	4	201-04003-01
	Arm, strut attach, left	1	201-04004-01
	Arm, strut attach, right	1	201-04004-02
	Flap track	4	201-05001-01
	Rib, flap track, left-flange	4	201-05002-01
	Rib, flap track, right-flange	4	201-05002-02
	Pulley, flap bellcrank	2	201-05501-01
	Arm, flap bellcrank, upper left/lower right	2	201-05502-01
	Arm, flap bellcrank, lower left/upper right	2	201-05502-02
	Bearing housing, flap bellcrank	2	201-05503-01
	Spacer, flap bellcrank	4	201-05505-01
	Arm, aileron hinge	4	201-06001-01
	Doubler, bearing arm	8	201-06002-01
	Rib, aileron hinge, left-flange	4	201-06003-01
	Rib, aileron hinge, right-flange	4	201-06003-02
	Angle, aileron hinge attach, left-flange	3	201-06004-01
	Angle, aileron hinge attach, right-flange	3	201-06004-02
	Angle, inboard aileron hinge attach, left	1	201-06005-01
	Angle, inboard aileron hinge attach, right	1	201-06005-02
89	(Part deleted by Revision C)		
90	Angle, flap pulley bracket	1	602-01001-03
91	Angle, outboard aileron pulley bracket	1	602-04101-03
	Bellcrank, aileron	2	602-06001-01
	Bellcrank, aileron, opposite	2	602-06001-02
	Bearing	8	017-00001-01
	Angle, 6061-T6, .063" X 1/2" X 1/2"	60"	100-0640-002
	Angle, 6061-T6, .063" X 1" X 1"	44"	100-0640-003
	Angle, 6061-T6, .063" X 1" X 1-1/4"	24"	100-0640-008
	Bearing, bellcrank	2	170-0134-001
	Pulley	4	AN210-3A

	Pulley	8	AN210-4A
	Bolt	16	AN3-4A
	Nut, castle	10	AN310-4
	Nut, nylon lock	16	AN364-1032A
	Nut, nylon lock	52	AN364-428A
	Nut, nylon lock	6	AN364-624A
	Pin, cotter	10	AN380-2-2
	Bolt	6	AN4-15
	Bolt	2	AN4-20
	Bolt	2	AN4-21
	Bolt	52	AN4-6A
	Bolt	6	AN6-13A
112	(Part deleted by Revision C)		
113	Washer	30	AN960D10
114	Washer, thin	2	AN960D10L
	Washer	76	AN960D416
	Washer, thin	60	AN960D416L
	Washer	12	AN960D616
	Spacer	2	NAS42DD8-20
	Spacer	2	NAS42DD8-43
	Bushing, aft spar root	2	NAS75-7-012
	Bushing, forward spar root	2	NAS75-8-014
	Bushing, flap bellcrank bracket	4	NAS77-4-005

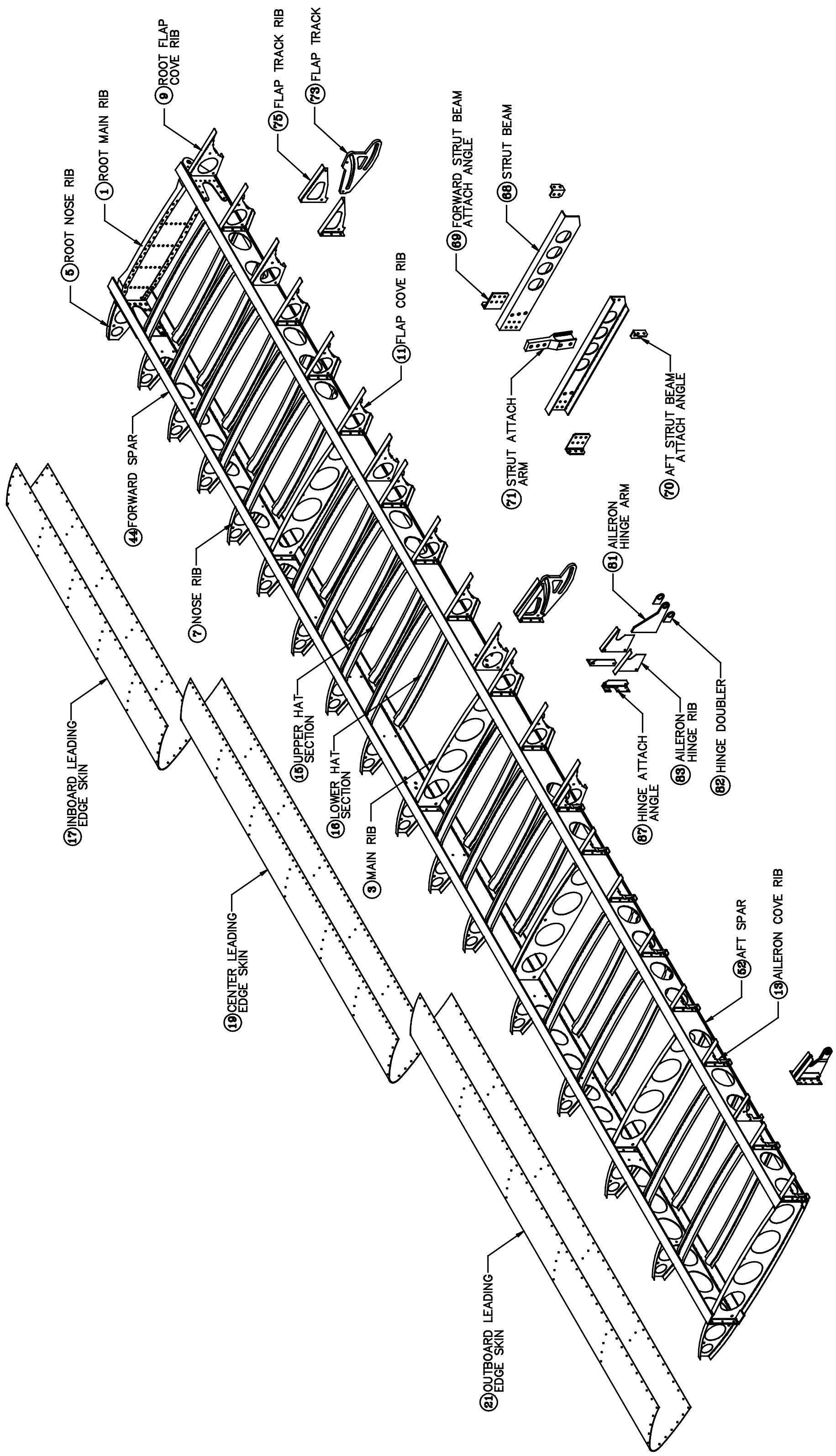


Figure 1: Wing Assembly (Left Shown)

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TOOL LIST

1. Measuring tape, 16' minimum
2. Carpenter's framing square
3. Level
4. String line, 16' minimum
5. Try square
6. Fine-point marking pen (permanent ink recommended)
7. Crosscut saw or electric circular saw (for wing jig)
8. Electric drill with screwdriver bit (for building the wing jig)
9. Plumb bob
10. Flat and round files or edge deburring tool
11. Sheet metal hand shears (offset type recommended)
12. 12" decimal/fractional rule
13. Clecos, 3/32", 1/8", 5/32" and 3/16" (approximately 200 to 250 each of the 1/8" and 3/32"; approximately 15 each of the 5/32" and 3/16"). Also needed are about a half-dozen **extended-grip** 1/8" Clecos for securing the root ribs in the spar root area.
14. Cleco side-grip clamps or small C-clamps (15 to 20)
15. Cleco pliers
16. Duck bill pliers
17. Center punch
18. Electric drill or air drill with 3/16", 1/4", 11/32", 3/8", 1/2", 9/16", D, U, #40, #30, #21 and #10 bits (#40 and #30 are used most; at least 3 to 4 each of these two sizes will be needed)
19. Right-angle drill or adapter with #40, #30 and 1/4" bits
20. Hole deburring tool
21. Dimple dies, 3/32" and 1/8"
22. Microstop countersink tool with #30 and #21 pilots
23. Riveting frame (highly recommended)
24. Rivet gun, air compressor and bucking bars
25. Flush head rivet set
26. Universal-head rivet sets, 1/8" and 3/32"
27. Rivet squeezer with flush-head set and 3/32" and 1/8" universal-head sets (highly recommended)
28. Blind rivet puller
29. Wrenches, sizes 3/8" to 3/4"

Tool List (Continued)

30. Straightedge, at least 4' long
31. Hole saws (for cutting aluminum) or adjustable fly cutter: 1", 1-1/4", 2-5/8", 3" and 3-5/8" diameters. Must be the type with a central pilot drill.
32. Scotch Brite wheel for a drill motor (recommended)
33. Straight reamers, .540", .5625", .600", .6255"
34. Arbor press (recommended) or bench vise
35. Band saw or hacksaw
36. Large C-clamps or spring clamps
37. Torque wrench (optional)
38. Milled, curved tooth file (optional). This file, also called a "body file" or a "panzer file," has widely spaced, curved teeth for easy chip clearance. It removes material rapidly and leaves a smooth finish. Used for trimming the leading edge skins.
39. Transit (optional)
40. Cabinetmaker's web clamps (optional)

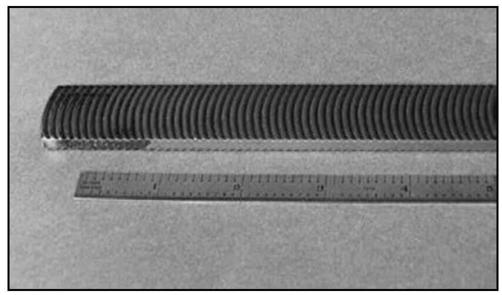

Figure 1.1: "Panzer" File

> **Note** Some of the tools, such as the arbor press, are used infrequently and need not be purchased if access to them can be obtained. Be sure to read through the entire wing section before making tool purchases.

ADDITIONAL MATERIALS

1. Lumber for wing jig table
2. Sheetrock screws or wood screws to assemble jig and mount jig brackets
3. 3/16" X 2" X 2" aluminum angle, 4' long, for jig brackets. Steel angle would also work fine. See text for details.
4. Three 1/4" X 2" lag screws (hardware store variety) for wing jig aft spar supports
5. 2 X 4 scraps to support spars while drilling lightening holes
6. Sand bags or lead shot bags to stabilize spars while drilling lightening holes
7. Corrosion-proofing materials
8. 1/2" diameter bolt (approximately 1-1/4" grip length) and 7/16" diameter bolt (approximately 3/4" grip length) for securing the spars to the wing jig brackets. Hardware-store quality is acceptable for these.
9. 1"-square pieces of 1/16" thick scrap aluminum (24-30) or wide masking tape. Used to clamp the main wing skins during drilling.
10. Loctite bearing retaining compound (either Loctite 609 low viscosity or Loctite 680 medium viscosity, high strength, or equivalent)

WORKSPACE

The wing jig occupies a space 16' long by 2' wide. For convenient access you will need at least enough additional room to walk all around the wing jig.

PRELIMINARIES

Note Minor blemishes, such as small scratches or machine tool marks, may be present on some metal wing components when you receive them, and there may be areas where the spars have been filed to remove small scratches. Such minor blemishes are acceptable; all of the parts for the GlaStar are carefully inspected, and none are shipped without meeting our rigid quality standards. If we were to ask our vendors to provide parts absolutely free of such minor blemishes, the cost of the GlaStar kit would increase dramatically. Any minor blemishes you might find on metal parts have been judged acceptable by our quality control personnel, so you can be confident that you can use the parts safely. If you wish to achieve a flawless exterior finish on your GlaStar, you can wet sand any blemished areas locally with 600 grit sandpaper.

The wings are built one at a time. Basic assembly procedures are identical for the left and right wings, and they can be built in either order.

Note The instructions and illustrations in this section all refer to the **left** wing. The basic structure of the **right** wing is a mirror-image of the left.

The wings are built on a simple jig that holds the assembly in a vertical position with the span parallel and the chord perpendicular to the floor (leading edge up). This arrangement allows easy access to both the top and the bottom of the wing without ever requiring that the assembly be flipped over. So, the first step in building the wing is to build the jig.

The outline of the complete assembly procedure is as follows:

1. Fabricate the wing jig.

2. Assemble the wing spars.

3. Mount the spars in the jig.

4. Mount the ribs and the strut beam assembly on the spars.

5. Fit-up and drill the wing skins.

6. Install the hat section stiffeners, forward spar cap strips and lower center skin stiffener channels.
7. Dimple the skins and countersink the forward spar flanges.
8. Assemble the aileron hinges.
9. Assemble the aileron bellcrank and mount the hinges and the bellcrank.
10. Fabricate and mount the aileron pulley brackets.
11. Assemble and mount the flap tracks.
12. Assemble and mount the flap bellcrank.
13. Fabricate and install the flap pulley brackets.
14. Rivet the ribs and the leading edge and lower skins.

The "WING ASSEMBLY" section of the *Manual* concludes before assembly of the wings is completely finished. After the basic fuselage structure has been completed ("SECTION VIII: FUSELAGE ASSEMBLY"), the partially finished wings will be mounted on the fuselage temporarily to enable installation of the flight control system. Procedures for routing the control cables and installing the fuel tanks and vent lines (as well as optional lighting and pitot systems) will be described in "SECTION IX: SYSTEMS INSTALLATION." Finally, after the flight control and other systems have been installed, the wings will be returned to the jig for riveting the upper skins and the flap and aileron cove skins ("SECTION X: FINAL ASSEMBLY").

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FABRICATE THE WING JIG

The wing jig consists mainly of two vertical posts, one at either end of the wing. Support brackets are attached to these posts, and the forward and aft wing spars are in turn temporarily fastened to the support brackets. The wing is then built around the spars. Several additional supports for the aft spar are needed to keep the wing assembly from sagging.

There are many possible jig designs that would all serve equally well for the jig's main task, which is to keep the spars in one place while the wing is being assembled. The only **essential** features of a suitable jig are that the support brackets be installed precisely the proper vertical distance apart and that they be absolutely plumb (i.e., level and aligned with one another).

You'll have to live with whatever jig you build through many hours of work, however, so there are some other, non-essential considerations that are worth some thought. For example, it's very important that you build your jig at a height that's most comfortable for you—too low and you'll spend hours stooping or working on your knees; too high and you'll get a lot of practice perching on stools or paint cans. So, by all means, treat the dimensions given below as general suggestions and tailor them to your needs.

Another consideration is how best to organize the workspace under and around the wing. Our experience suggests that the most serviceable jig consists of a long, narrow work table extending between the uprights. This provides a convenient place to set your tools, as well as providing an easy way to anchor the posts and the center supports. It might also catch some of those rivets you'll drop so you won't have to search for them on the floor! Keep the work surface narrow, however, so that you don't have to lean over a large overhang to work on the wing.

Note Whatever jig design you settle on, once the spars are mounted and plumbed, it's vital that they remain that way. Therefore, the jig must be **securely** attached to the floor so that normal bumping and jostling won't move the wing assembly out of true. A good way to do this is to use a little body putty (Bondo) between the legs of the jig and the floor. Be sure, however, that you don't glue the jig to the floor until **after** you've trued it!

A suggested jig design is shown in Figure 2. The exact dimensions, materials and construction techniques can be tailored to suit, but in general it's better to build a jig that's too sturdy than one that's too flimsy. Additionally, it's important that the wood you select for the posts be as straight as possible, which probably means avoiding the cheaper grades of construction lumber and checking the pieces carefully for bows or twists. Time spent selecting good, straight posts will be repaid with the relatively easy time you'll have truing the mounting brackets.

Step 1: Fabricate the Jig Framework

Construct a framework for a base table using the suggestions in Figure 2 or an equivalent structure of your own design. Sheetrock screws work well for assembling the jig framework. Once you have assembled the base table, install the end posts as shown in Figure 2. Be as precise as possible in spacing the posts horizontally, and use a plumb bob to check for vertical alignment. When you're satisfied, secure the posts to the framework. To help keep the posts plumb, you can support them with diagonal braces.

Make the table top by ripping a single 4' X 8' sheet of 3/4" particle board lengthwise into two 2' X 8' pieces (most lumber yards can do this for you). Cut square holes or notches in the ends of the table top to fit around the 4 X 4 posts. Install the table top using sheetrock screws.

Completed: [ ]

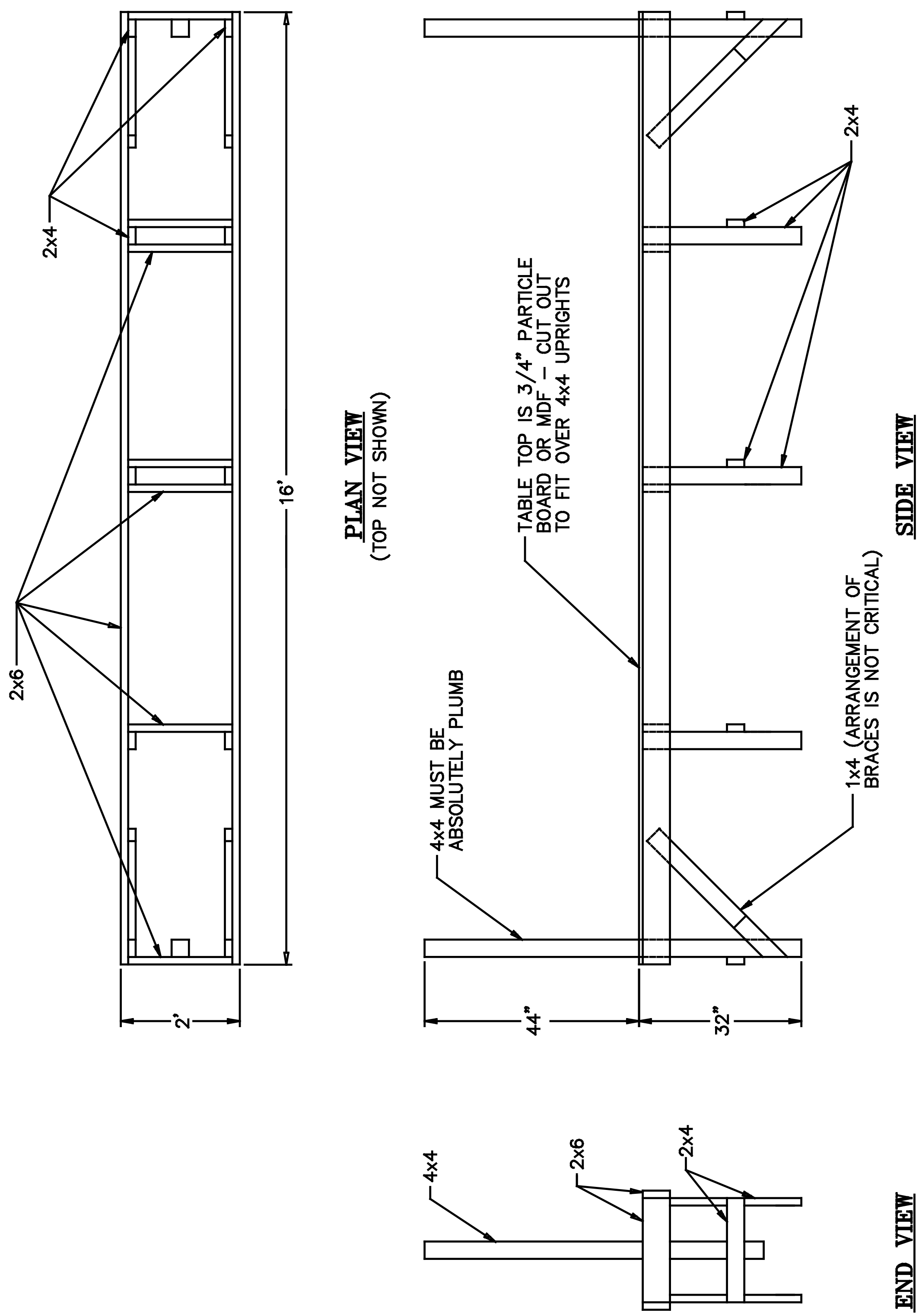

Figure 2: Suggested Wing Jig Framework

Step 2: Fabricate the Wing Jig Spar Brackets

Fabricate the **inboard forward spar bracket**, the **outboard forward spar bracket**, the **inboard aft spar bracket** and the **outboard aft spar bracket** for the wing jig, as shown in Figures 3 through 6. The recommended material (not supplied) is 2" X 2" extruded aluminum angle with a thickness of 3/16", although 1/8" thick material would probably be adequate. You will need a 4' length to make all the brackets for both wings. You may substitute any other material, such as steel angle, that is readily available, as long as it has the strength to support a complete wing panel without deforming and is large enough to provide room for laying out and drilling all the spar support holes shown in the illustrations.

The critical dimensions in the brackets are the locations of the spar attach holes and the plumb bob holes. To accurately lay out these dimensions, be careful to cut one end of each bracket square and then make all measurements from the square end. Make all measurements in the other direction from the corner of the angle, as shown, rather than from the edges of the legs.

> **Note** The wing attach holes in the front and rear spars are not on the same axis. The rear spar attach hole is centered 1/2" inboard and .057" above the forward spar attach hole (when the airplane is level longitudinally and laterally).

The sizes and locations of the holes for fastening the brackets to the jig posts are not critical; these can be adjusted, if necessary, to suit your particular circumstances.

> **Note** Figures 3–6 show the jig brackets for the **left** wing. The **right**-wing brackets are mirror images. The “OUTBRD” and “UPPER” arrows apply only to the **top view** of each bracket (i.e., the view in the upper right corner of each figure).

Completed: Left [ ] Right [ ]

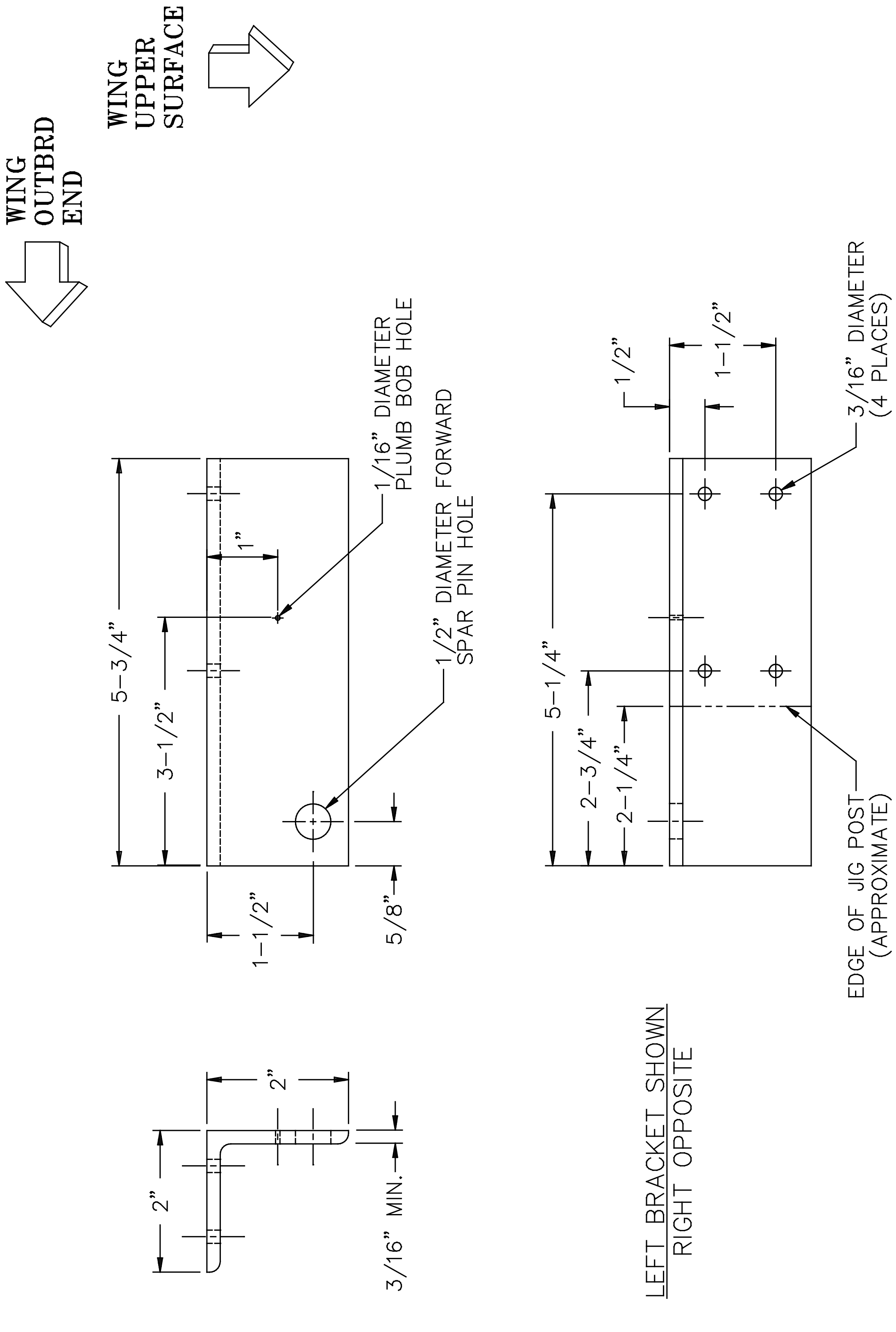

Figure 3: Inboard Forward Spar Bracket

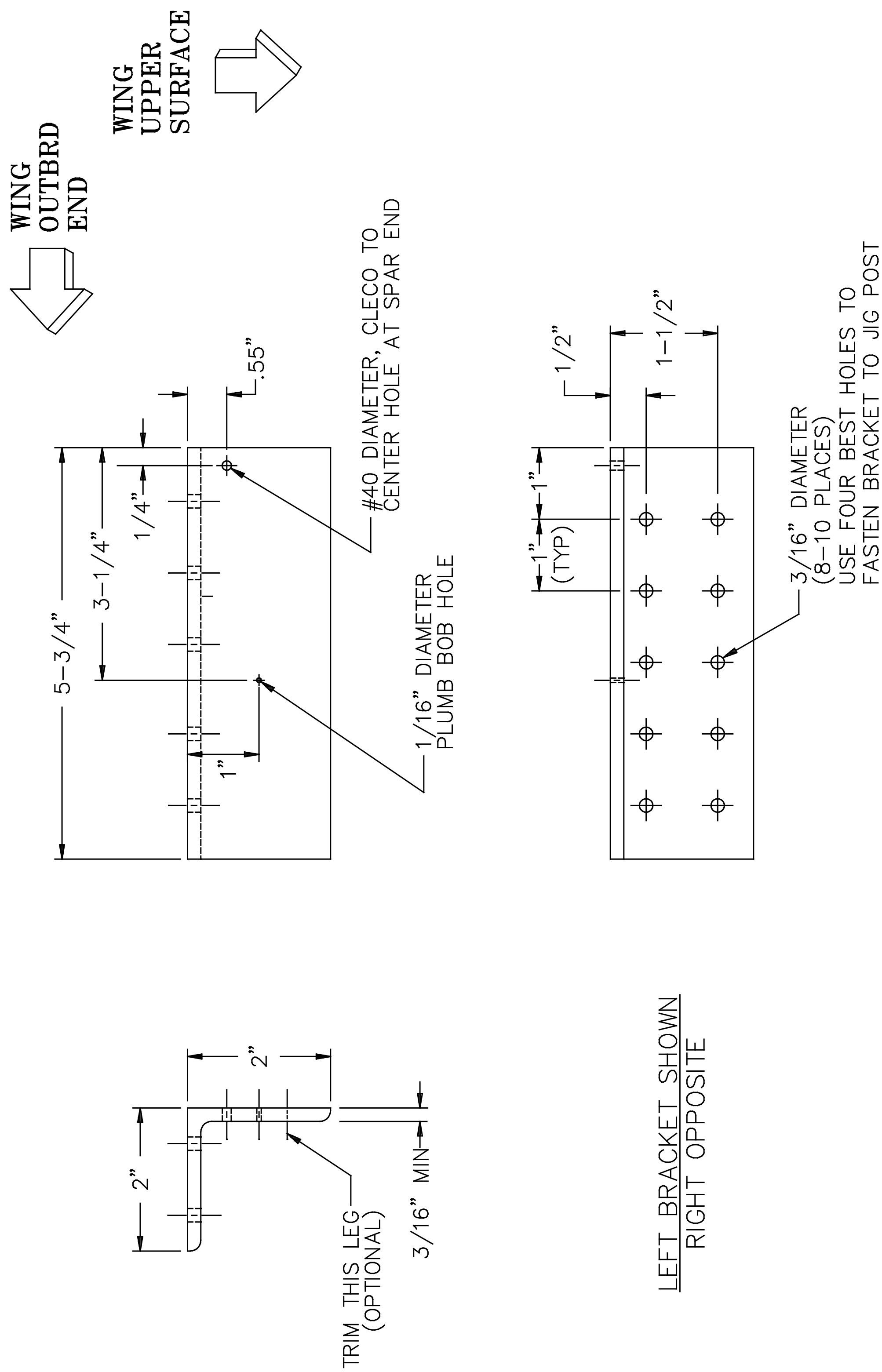

Figure 4: Outboard Forward Spar Bracket

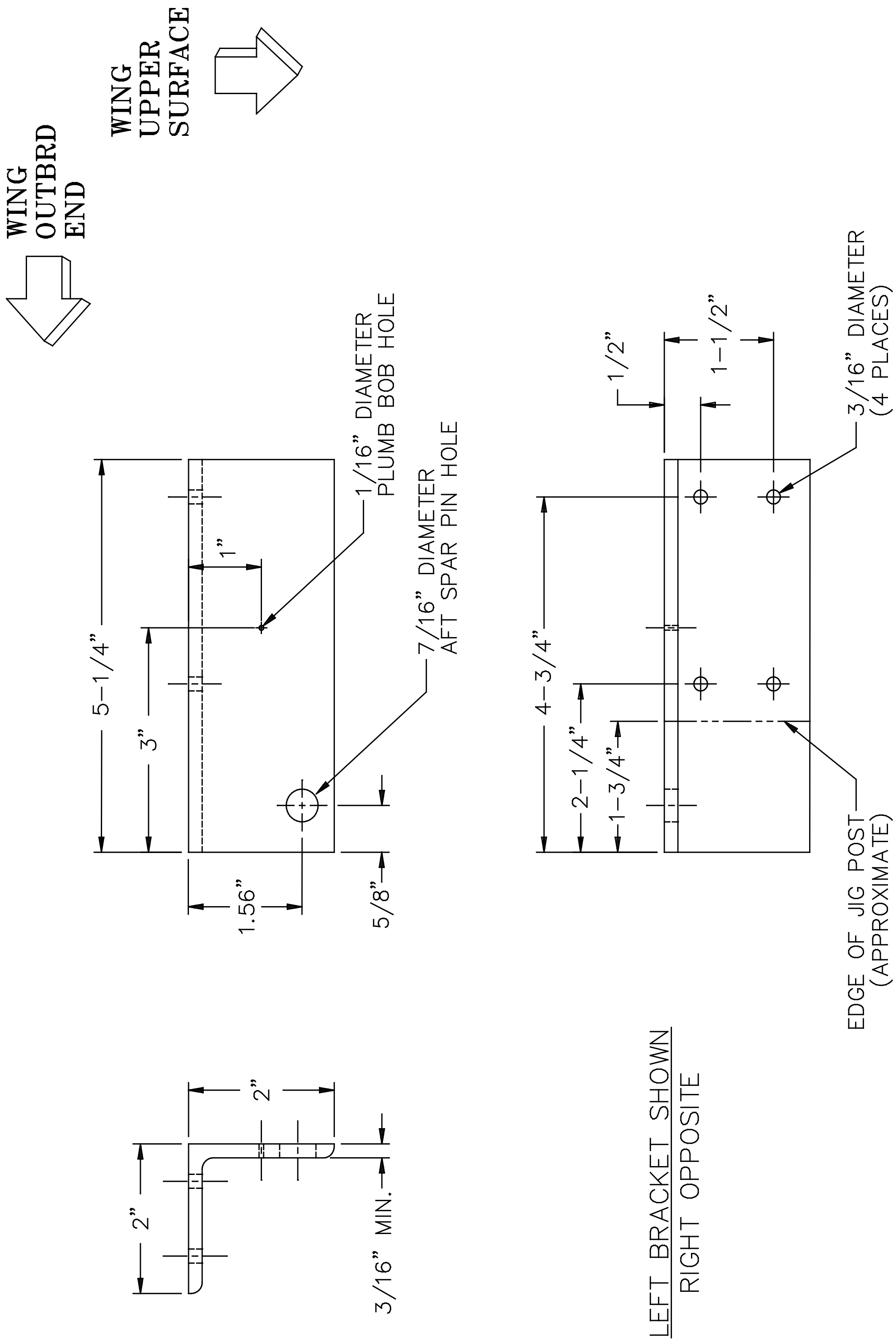

Figure 5: Inboard Aft Spar Bracket

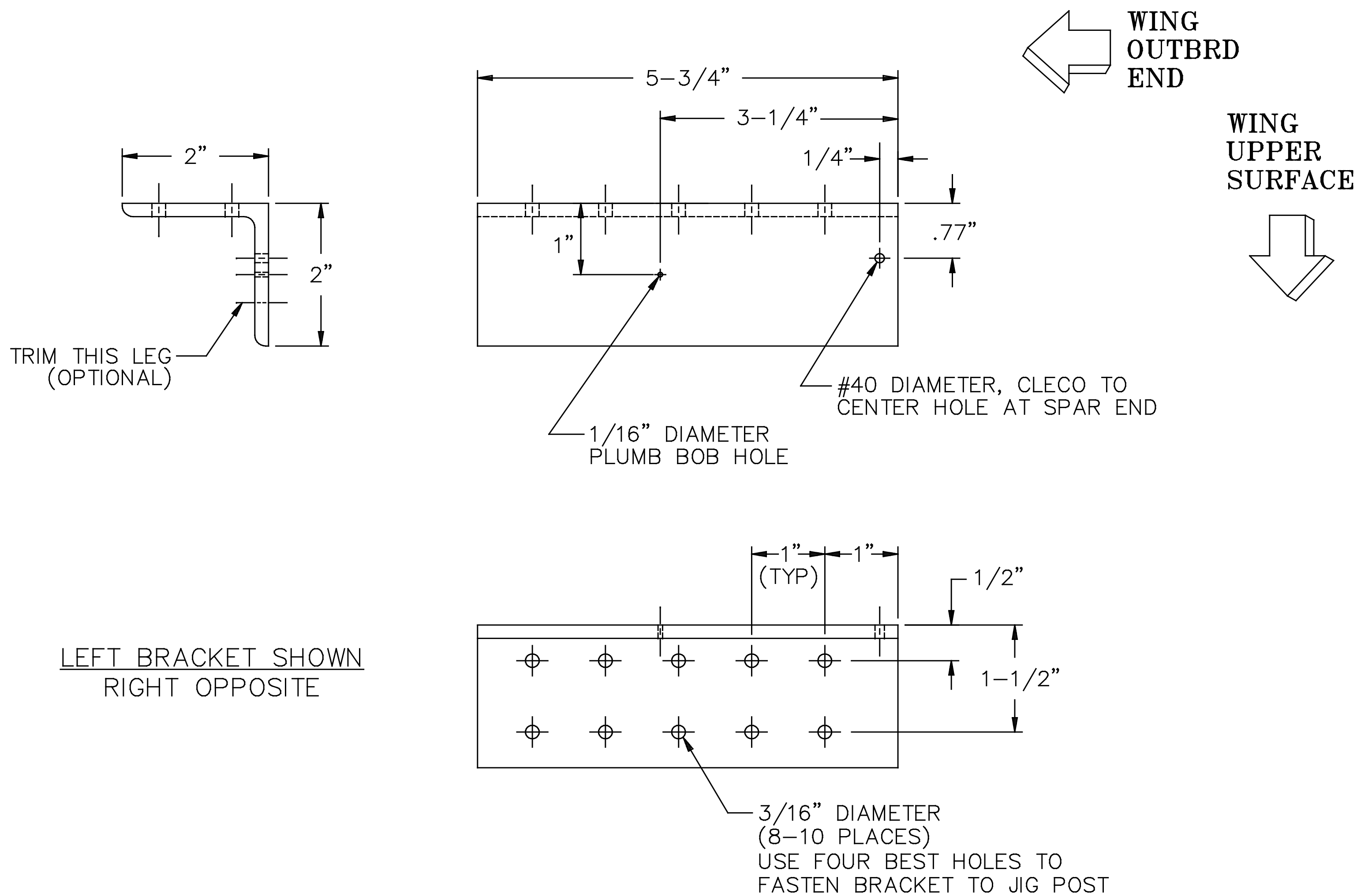

Figure 6: Outboard Aft Spar Bracket

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Step 3: Install the Inboard Spar Brackets

After the jig posts are erected and secured, use four sheetrock screws to mount the **inboard forward spar wing jig bracket** fabricated in the previous step on one of the posts **40.95"** above the jig table, as shown in Figure 7. (Mount the inboard bracket for the **left** wing on the **right** post, when facing either side of the jig. Mount the inboard bracket for the **right** wing on the **left** post.) Use a small carpenter's level to make sure that the top of the bracket is level. (If you carefully plumbed the posts, the top of the bracket should be perpendicular to the edge of the post.)

> **Note** Refer to Figure 28.1 for another view of the inboard wing jig brackets. Do not mount the outboard brackets yet. This will be done in a subsequent step.

Measuring down the post **21.95"** from the top of the newly-installed forward spar bracket, mark the location of the upper edge of the **inboard aft spar wing jig bracket**, as shown in Figure 7.

Hang a plumb bob from the plumb bob hole in the forward spar bracket. While holding the upper edge of the aft spar bracket on its marked height line, align the plumb bob hole in the **aft bracket** with the point of the plumb bob to position the aft bracket in the spanwise direction. (If the post is truly plumb, the aft bracket will be positioned correctly in the other direction when it is secured to the post.) Use four sheetrock screws to secure the aft spar bracket to the post, again using a level or a square to make sure that the bracket is level.

> **Note** It's a good idea to check your jig for plumb and true periodically, especially before any major drilling operation. The lumber in the jig can shrink or warp as it ages, and the jig can get jostled enough, while working, to knock it out of alignment. Leave the plumb bob in place so that you can easily check and adjust the jig's alignment.

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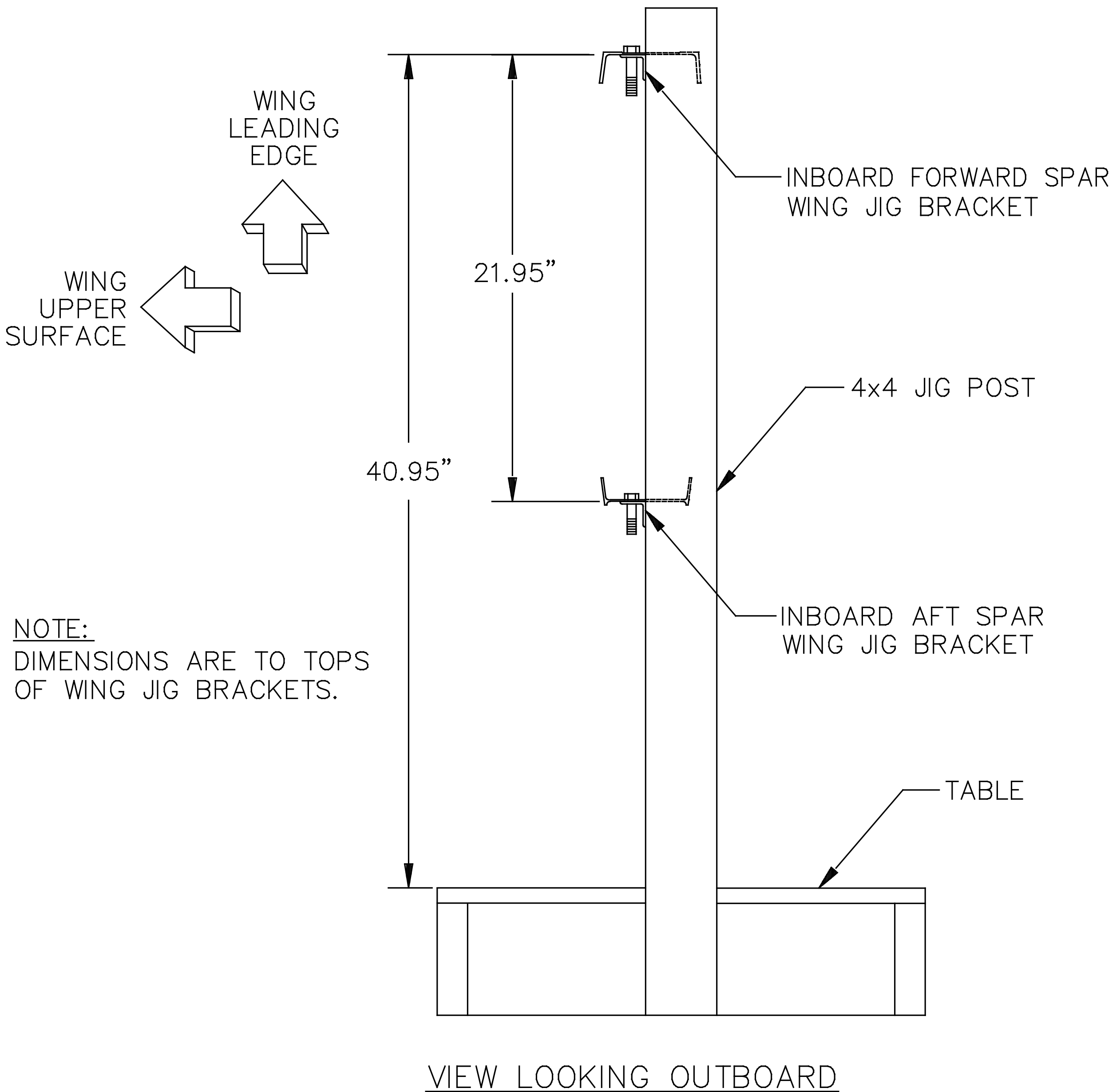

Figure 7: Mounting the Inboard Wing Jig Brackets

ASSEMBLE THE WING SPARS

Step 4: Cut Lightening Holes in the Spars

Jump-Start Spar Option If you ordered the pre-assembled spar option (P/N 038-02100P01), **skip to Step 14**.

The locations of the lightening holes in the spar webs are marked by 3/16" pilot holes at the dimensions shown in Table 1.

Note The locations of the lightening holes are given in "butt line" (BL) dimensions, which are measured in inches from the **longitudinal centerline of the airplane, not** from the end of the spar. Notice that the wing attach hole in the **forward spar** is centered at **BL 22.5**; the wing attach hole in the **aft spar** is centered at **BL 22.0**.

All lightening holes in the **aft spar** [52] are **3"** in diameter. In the **forward spar** [44], all lightening holes are **2-5/8"** in diameter **except** for the six outboard holes, which are **3-5/8"**.

Caution It is important to avoid scarring the spar when cutting the lightening holes. Scars or scratches in the spar provide places where stresses concentrate, which can reduce the strength and fatigue-resistance of the spar. A spar with a scratch deeper than 10% of the material thickness generally cannot be used or must be repaired.

Note Minor blemishes may be present on the spars when you receive them, or there may be areas where the spars have been filed or sanded to remove small scratches. Such minor blemishes are acceptable; each spar is thoroughly inspected, and is not shipped unless it meets our rigid quality standards. If you find minor blemishes or repaired areas on your spars, we recommend wet sanding the area locally to a 600 grit surface finish.

FORWARD SPAR LIGHTENING HOLES		AFT SPAR LIGHTENING HOLES	
LOCATION:	DIAMETER:	LOCATION:	DIAMETER:
BL 35.48	2-5/8"	BL 35.75	3"
BL 39.98	2-5/8"	BL 40.75	3"
BL 44.45	2-5/8"	BL 52.25	3"
BL 48.95	2-5/8"	BL 57.00	3"
BL 53.38	2-5/8"	BL 61.63	3"
BL 57.90	2-5/8"	BL 84.00	3"
BL 62.38	2-5/8"	BL 88.50	3"
BL 66.88	2-5/8"	BL 152.50	3"
BL 71.30	2-5/8"	BL 156.88	3"
BL 147.86	2-5/8"	BL 162.31	3"
BL 152.08	2-5/8"	BL 166.75	3"
BL 156.32	2-5/8"	BL 174.00	3"
BL 161.66	2-5/8"	BL 180.73	3"
BL 165.43	2-5/8"	BL 185.25	3"
BL 169.23	2-5/8"	BL 195.25	3"
BL 176.14	3-5/8"	BL 199.75	3"
BL 180.71	3-5/8"		
BL 185.28	3-5/8"		
BL 189.88	3-5/8"		
BL 194.46	3-5/8"		
BL 199.03	3-5/8"		

Table 1: Lightening Hole Locations

Note To distinguish between the forward and aft spars, notice that, first, the forward spar is larger than the aft spar and, second, the forward spar web is not of uniform thickness but is relieved in the center. To orient the spars, the large wing-attach hole in each spar is on the **inboard** end and near the **upper** flange. The forward spar flanges are oriented **aft** and the aft spar flanges are oriented **forward.**

Here are some hints to help you drill the lightening holes:

A) Support the spars at a comfortable height for working, if you'll be using a hand drill; if the spars are either too high or too low, you are more likely to become fatigued while cutting a hole, which could result in damage. The wing jig table is a good height for most adults.

Figure 7.1: Drilling the Lightening Holes

B) Use hole saws of the proper diameters to cut the lightening holes. Use the type of hole saw with a central pilot drill. Not only will the pilot drill center the saw properly at the beginning of the cut, but it will also help keep the saw from jumping sideways out of the cut while drilling. We strongly recommend mounting the hole saw in either a drill press or a mill rather than a hand drill, although the latter will work if you don't have access to either of the stationary tools. Do **not** try using a fly cutter in anything but a drill press or a mill.

C) Place several 2 X 4s under the spar along its length, with one right under the hole being cut (in contact with the web on the underside). Place sand bags or bags of lead shot on the spar (over the 2 X 4 supports) to stabilize the spar. Place a couple of the bags within a few inches on both sides of the hole being cut, as well as at the inboard and outboard ends of the spar, to provide maximum stability.

D) Cutting oil is not needed, as long as only **light** downward pressure is used. If you're using a hand drill, a **small, gentle** circular rocking motion will make the cut easier and smoother.

E) Be sure to finish the cut completely and even cut into the wood support a bit, and then turn off the drill before withdrawing the saw from the hole. If the saw is spinning when you withdraw it from the hole, it is much more likely to go sideways and grab metal in the area around the hole.

Note Before you drill, identify and double-check all lightening holes and their sizes with an obvious pen mark. Drill **only** the locations identified by a 3/16" diameter pilot hole.

When all the holes have been drilled, use a deburring tool to deburr their edges. Also, use a half-round file and/or sandpaper to remove any marks left by the hole saw on the interiors of the holes.

Warning To prevent cracks caused by stress concentrations, the lightening holes **must be smooth and free of burrs, saw marks or scratches** when finished.

Hint A Scotch Brite wheel mounted in a drill motor is a good tool for removing hole saw marks from the insides of the lightening holes.

Completed: Left [ ] Right [ ]

Step 5: Drill the Forward Spar Root Doublers

Each of the wing spars is reinforced at the root and in the strut attach area to carry the loads from the fuselage into the wing.

> **Note** In general, it's very important to keep the large wing attach holes in the doublers centered on the wing attach hole in the spar. The small, pre-drilled pilot holes in some of the doublers may not align perfectly with the corresponding holes in the spar when the wing attach holes are centered on each other. This is acceptable; the small holes are undersized and their locations can be shifted somewhat when they are drilled up to final size.

To prepare the **forward spar root** reinforcements, follow these procedures:

A) Position the **forward spar root doubler angle** [48] against the aft side of the forward spar, as shown in Figure 8. Use C-clamps or Cleco side-grip clamps to clamp the doubler angle tightly to the underside of the spar's upper flange and to the aft face of the spar web.

> **Note** It is very important to make sure that the doubler angle is clamped **very tightly** to the spar flange. There **must not be any gaps** between the angle flange and the spar flange.

With the doubler angle clamped in position, the first task is to drill a **9/16"**-diameter wing attach hole in the angle to match the hole in the spar. Mark and punch the center of the hole and start drilling with a **1/4"** bit. Enlarge the hole in **1/16"** increments while shifting the hole center as you go, if necessary, to keep the hole centered with respect to the hole in the spar. You might find that a Unibit is more useful for enlarging the hole while shifting its center. **Be very careful not to enlarge or elongate the hole in the spar.** After drilling, insert a 9/16" drill bit into the hole through the two parts to maintain alignment. Finally, use the three small pilot holes nearest the wing-attach hole in the spar as a guide to drill matching **#40** holes through the doubler angle, as shown in the figure. (These three holes are where the **root ribs** are installed.)

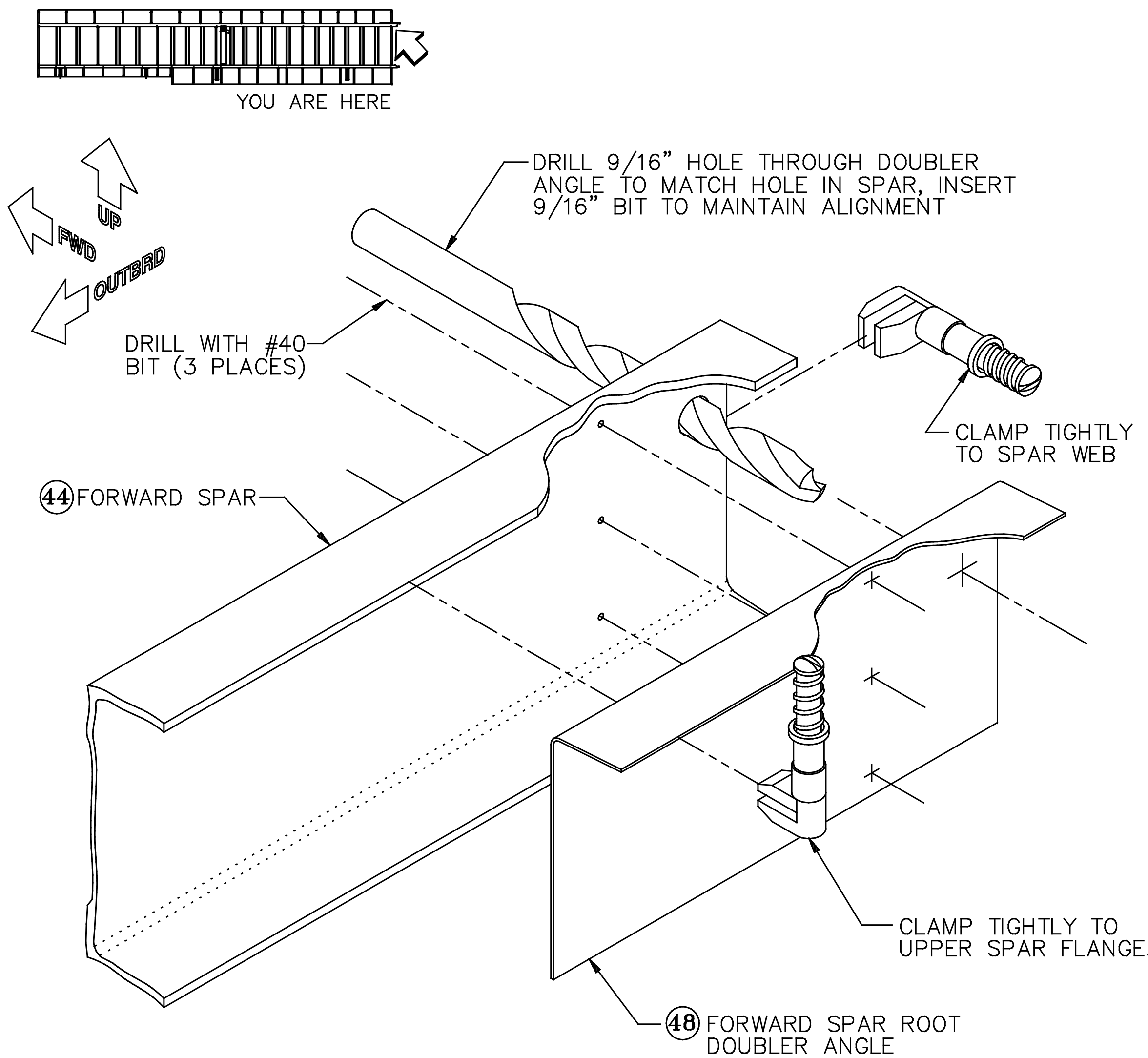

Figure 8: Forward Spar Root Doubler Angle

Note The doubler angles shipped with early GlaStar kits had the wing attach holes pre-drilled. For these parts, clamp the angle to the spar, as described above, while aligning the holes in the two parts as closely as possible. If the holes are not perfectly aligned when the angle is clamped up, use a **9/16"** bit to pass drill the hole in the **doubler angle**, using the hole in the spar as a guide. When the hole is finished, insert the drill bit through the hole in the two parts to maintain alignment and drill the #40 rivet holes, as described above.

B) Use the 9/16" drill bit to align the wing attach hole in the **rear-side forward spar root doubler** [50] with the wing attach holes in the forward spar/doubler angle assembly, as shown in Figure 9. Use the three #40 holes drilled in Step A to Cleco the rear-side forward spar root doubler to the assembly.

> **Note** If the three #40 pilot holes in the rear-side root doubler are not well aligned with the corresponding holes in the spar/doubler angle assembly, shift the rear-side doubler around the 9/16" drill bit in the wing attach hole until the three #40 holes are aligned as closely as possible; clamp the rear-side doubler to the assembly. Use the holes in the spar as a guide to pass drill **#40** holes through the rear-side doubler, and insert Clecos.

Use the two holes near the outboard end of the rear-side forward spar doubler to drill **#40** holes through the spar/doubler angle assembly, as shown in Figure 9.

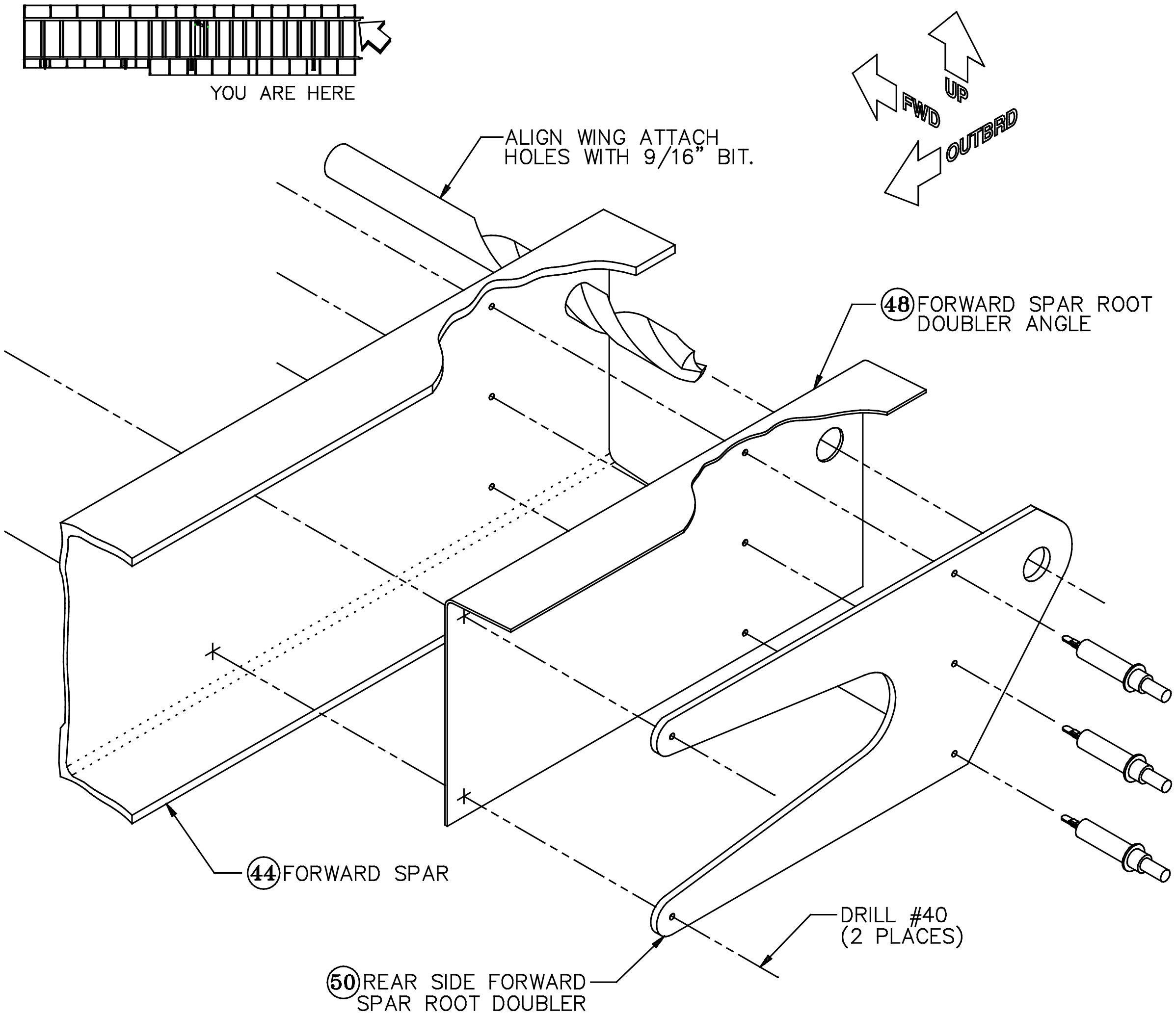

Figure 9: Rear-Side Forward Spar Root Doubler

c) Use the 9/16" drill bit to align the wing attach hole in the **front-side forward spar root doubler** [46] with the wing attach holes in the other three parts of the forward spar root assembly, as shown in Figure 10. Use the five #40 holes drilled so far to Cleco the front-side root doubler to the assembly. Make sure you use the correct front-side doubler—the **aft** face of the front-side doubler is machined to fit the contour of the spar web.

Note If the applicable five pilot holes in the front-side doubler are not well aligned with the corresponding holes in the spar root assembly, shift the front-side doubler around the 9/16" drill bit until the five holes are aligned as closely as possible; clamp the front-side doubler to the assembly. Use the five holes in the rear-side doubler as a guide to pass drill **#40** holes through the front-side doubler, and insert Clecos.

Using the pilot holes in the front-side doubler as a guide, drill the remaining twenty-one **#40** holes through the spar, the doubler angle and the rear-side doubler.

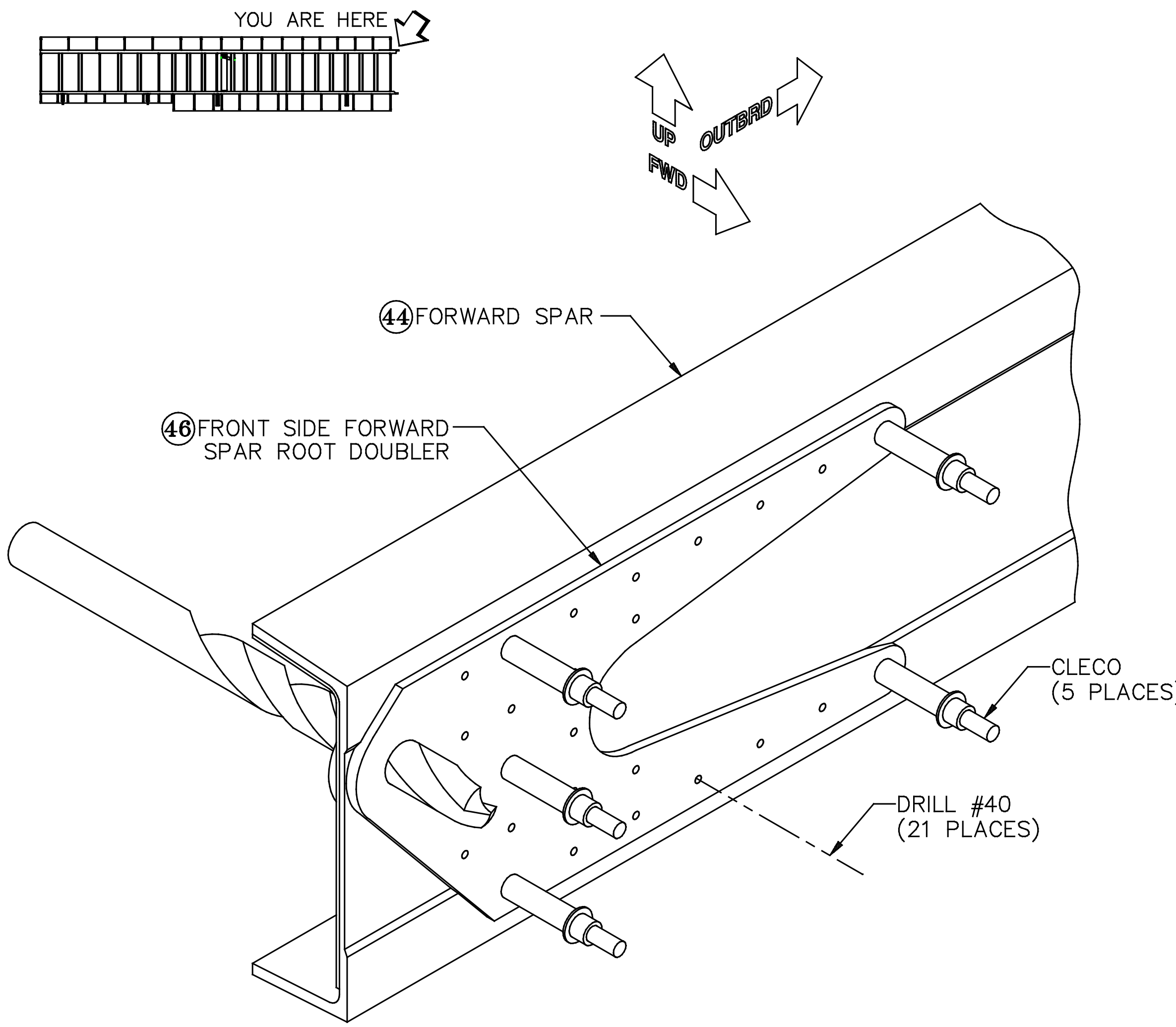

Figure 10: Front-Side Forward Spar Root Doubler

D) **Except for the five holes where the root ribs attach** (the second vertical line of holes from the wing-attach hole), drill all the holes in the assembly up to **#21** diameter for 5/32" rivets, as shown in Figure 11. Cleco as you go. The five holes in the rib line will be enlarged to #30 diameter later during rib fit-up.

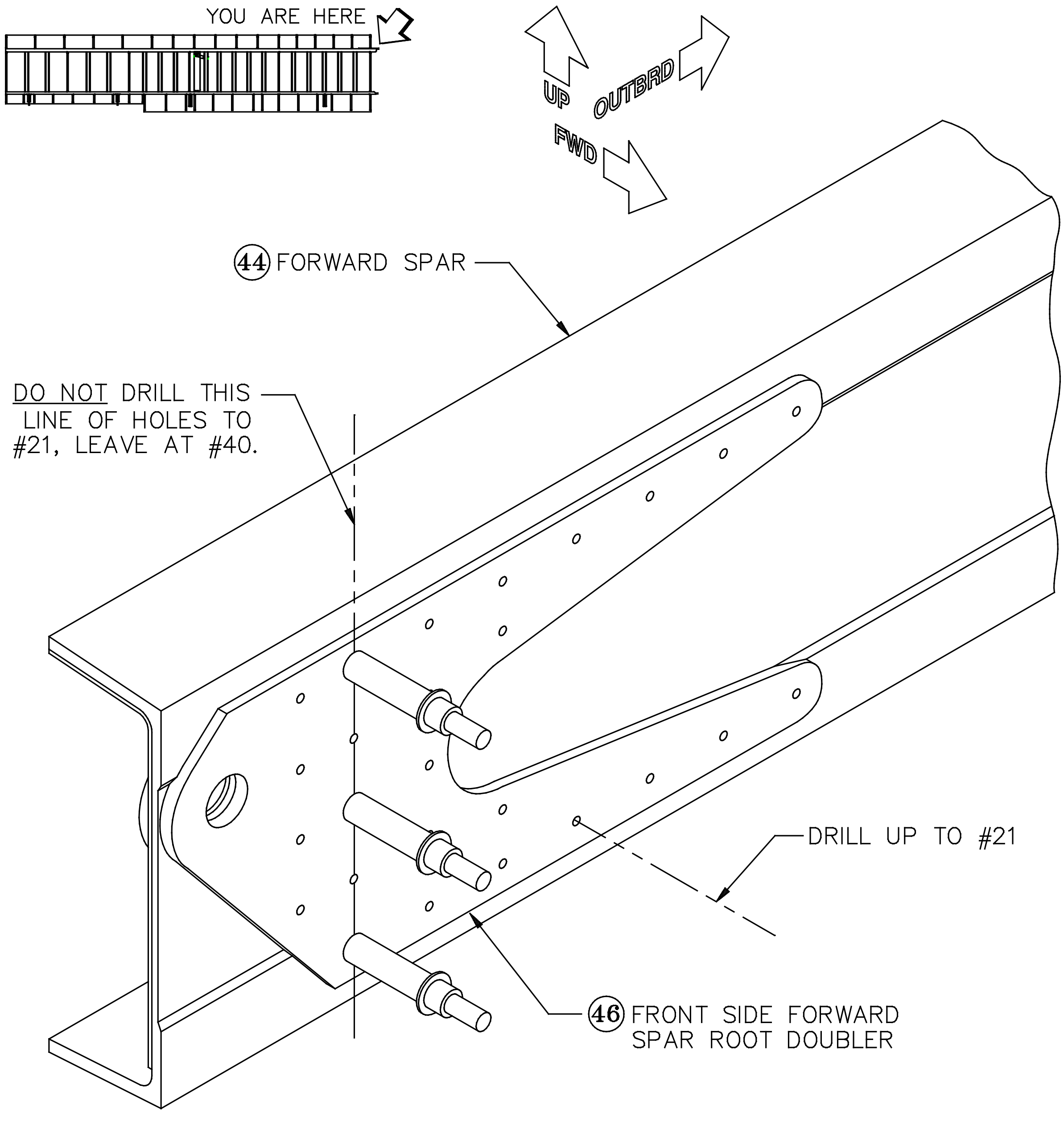

Figure 11: Drilling the Forward Spar Root Doublers

E) Disassemble all the parts and deburr all the holes. Countersink the 5/32" diameter holes on the **aft face** of the **rear-side forward spar root doubler** for (AN426AD5) flush head rivets. (Flush head rivets are used here to provide clearance for the fuel tank, which fits between the forward and aft spars.) **Do not countersink the five holes where the root ribs attach.**

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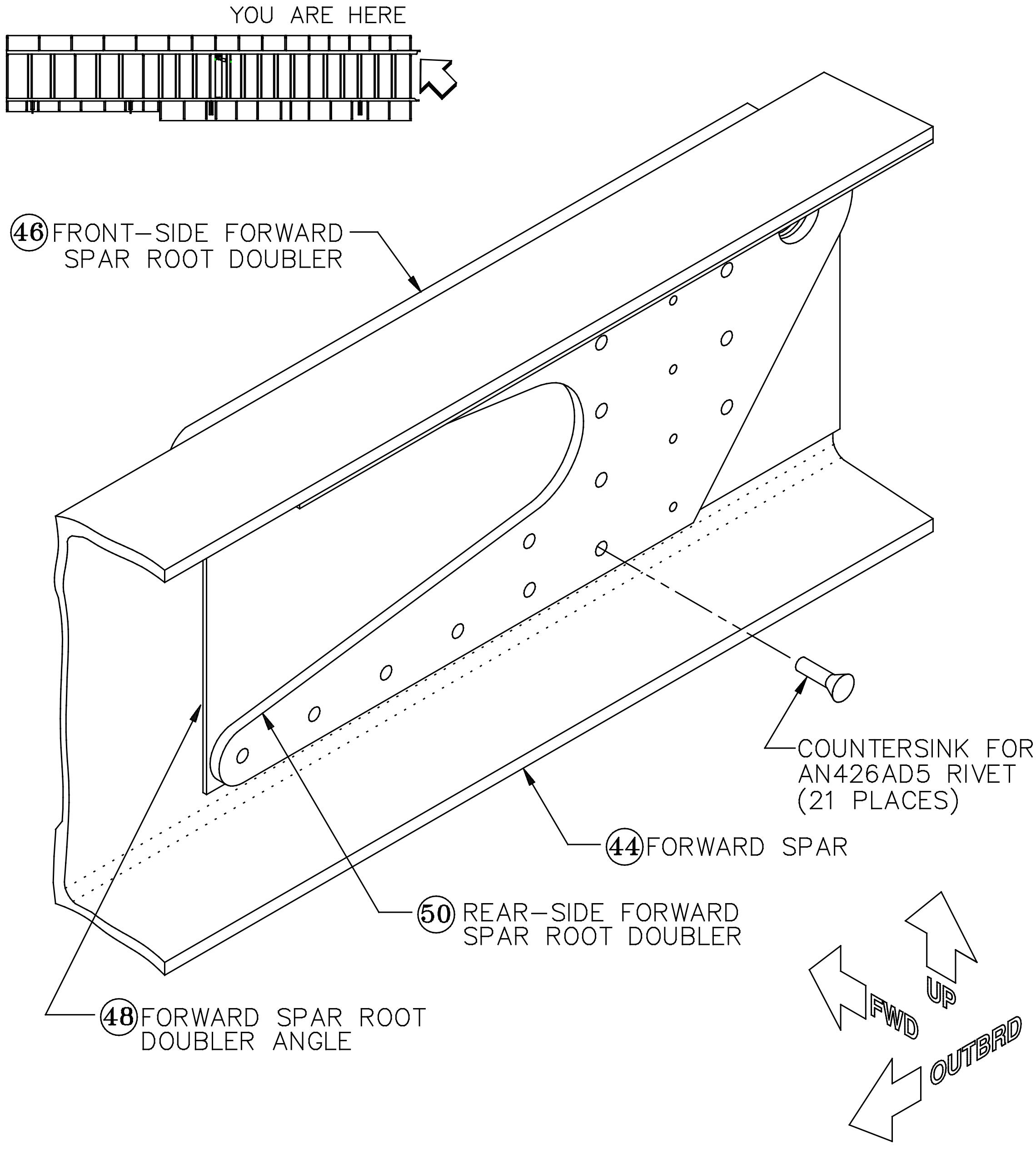

Figure 12: Countersinking the Rivet Holes

Step 6: Drill the Forward Spar Strut Beam Doubler

Position the **forward spar web/strut beam doubler** [51] on the aft side of the forward spar web, as shown in Figure 13, using four 3/16" Clecos inserted through the large holes in the two parts to align them. (The six large holes are for securing the strut beam assembly.) Also, Cleco the three #40 holes for the nose rib at BL 110.60, as shown in the figure.

Use the pilot holes in the doubler as guides to drill **#30** holes through the spar/doubler assembly (30 places). Insert Clecos as you go.

Note Do not enlarge the three pre-drilled holes for the nose rib yet; these three holes will be drilled to size when the rib is fit to the spar in a later step.

Remove the doubler from the spar and deburr the rivet holes in both parts.

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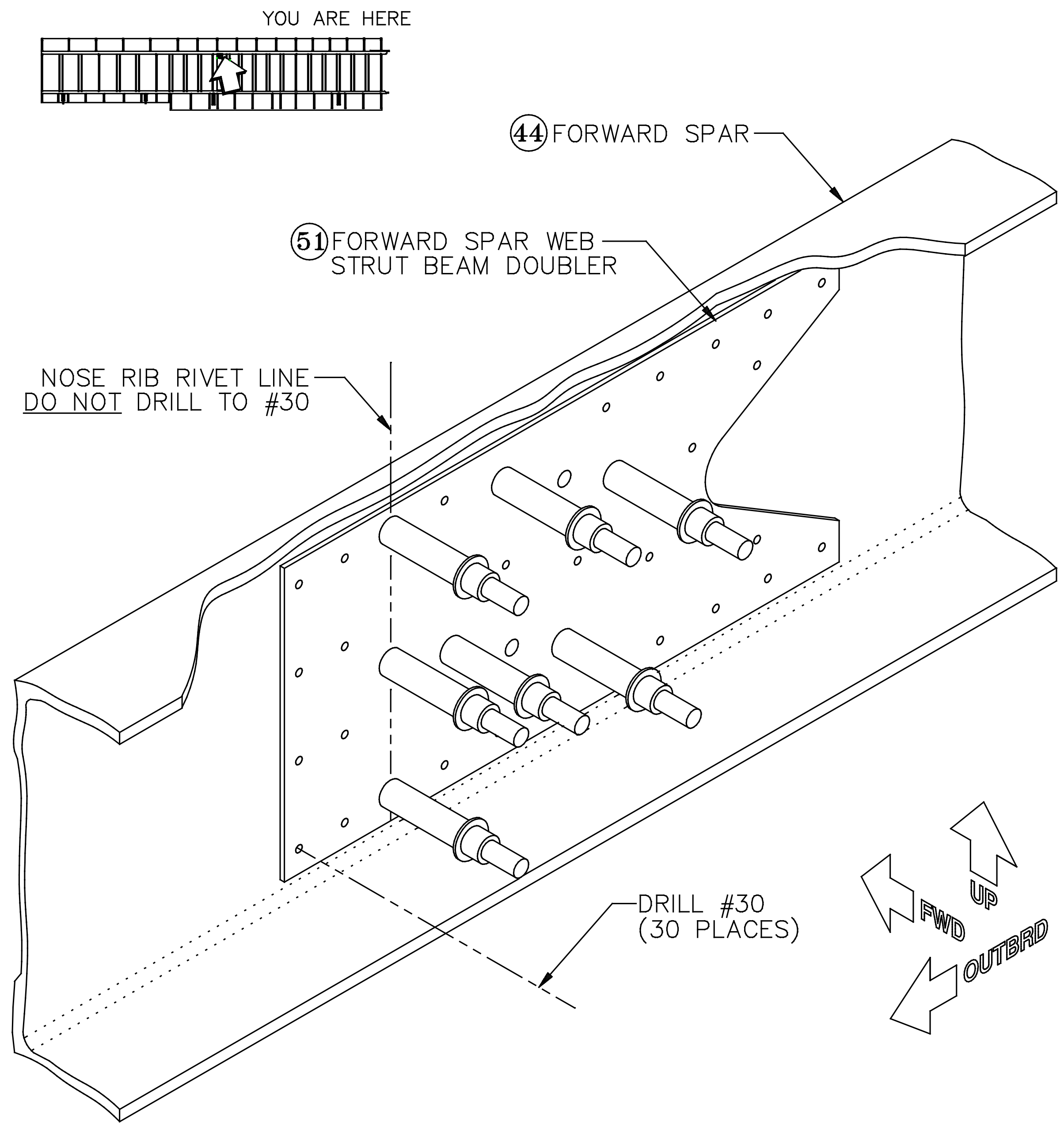

Figure 13: Drilling the Forward Spar Web/Strut Beam Doubler Assembly

Step 7: Drill the Aft Spar Root Doublers

> **Note** As with the forward spar root doublers, it's most important to keep the large wing attach holes in the doublers aligned on the wing attach hole in the aft spar. Minor misalignments among the small, pre-drilled pilot holes in the doublers are acceptable because they are undersized.

To reinforce the aft spar root, follow these procedures:

A) Position the **aft spar root doubler angle** [55] against the **forward** side of the aft spar web, as shown in Figure 14. Use C-clamps or Cleco side-grip clamps to clamp the doubler angle tightly to the underside of the spar's upper flange and to the front face of the spar web.

> **Note** It is very important to clamp the doubler angle **very tightly** to the spar flange. There **must not be any gaps** between the angle flange and the spar flange.

With the doubler angle clamped in position, first drill a **1/2"**-diameter wing attach hole in the angle to match the hole in the spar. To do this, mark and punch the center of the hole and start drilling with a **1/4"** bit. Enlarge the hole in **1/16"** increments while shifting the hole center as you go, if necessary, to keep the hole centered with respect to the hole in the spar. You might find that a Unibit is more useful for enlarging the hole while shifting its center. **Be very careful not to enlarge or elongate the hole in the spar.** After drilling, insert a 1/2" drill bit into the hole through the two parts to maintain alignment. Finally, use the three small pilot holes nearest the wing-attach hole in the spar as a guide to drill matching **#40** holes through the doubler angle, as shown in the figure. (These three holes are where the **root ribs** are installed.)

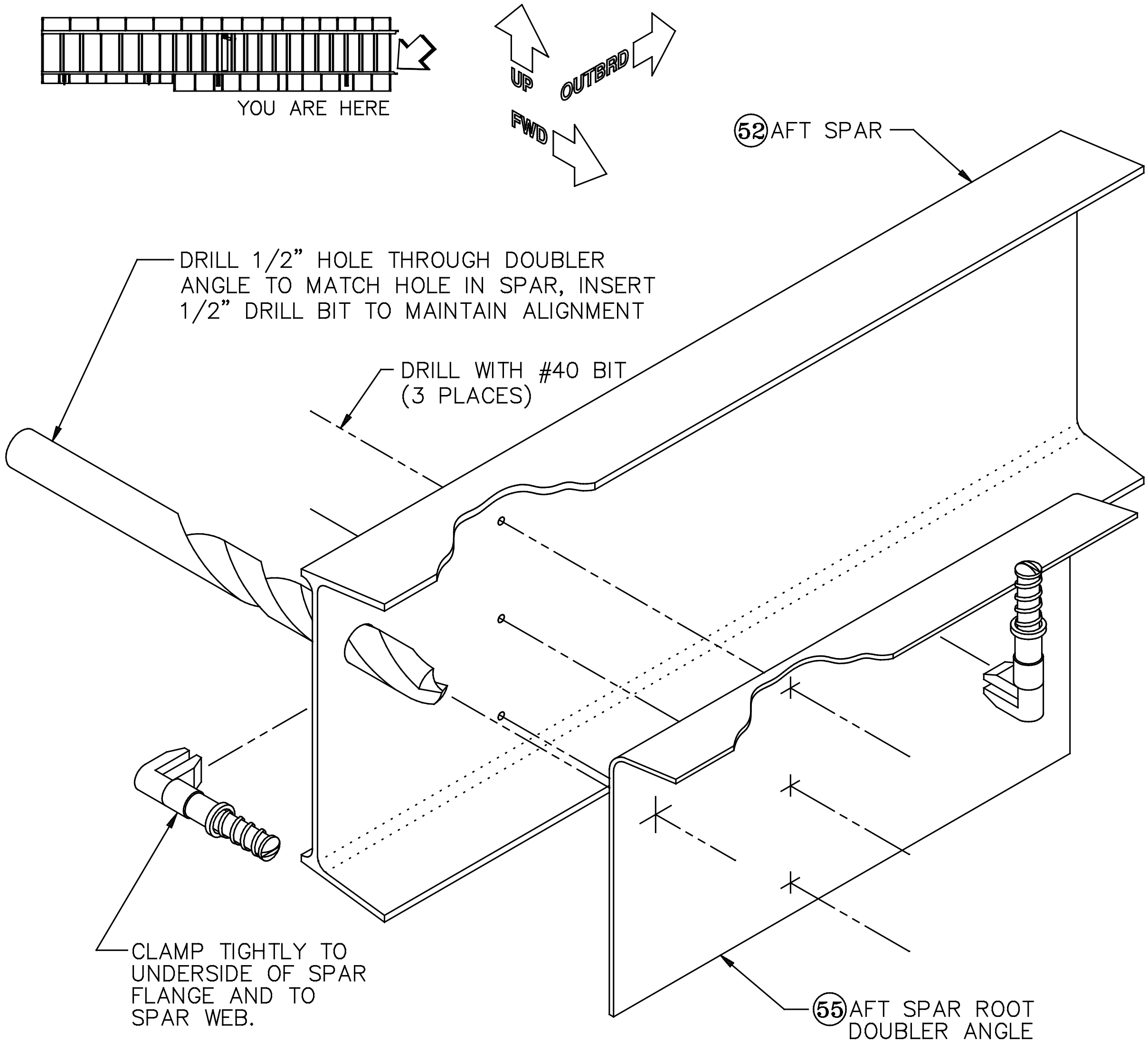

Figure 14: Aft Spar Root Doubler Angle

Note The doubler angles shipped with early GlaStar kits had the wing attach holes pre-drilled. For these parts, clamp the angle to the spar, as described above, while aligning the holes in the two parts as closely as possible. If the holes are not perfectly aligned when the angle is clamped up, use a **1/2"** bit to pass drill the hole in the **doubler angle**, using the hole in the spar as a guide. When the hole is finished, insert the drill bit through the hole in the two parts to maintain alignment and drill the #40 rivet holes.

B) Use the 1/2" drill bit to align the wing attach hole in the **front-side aft spar root doubler** [54] with the wing attach holes in the aft spar/doubler angle assembly, as shown in Figure 15. Use the upper and lower of the three holes drilled in Step A to Cleco the front-side doubler to the assembly.

> **Note** If the two #40 pilot holes in the front-side doubler are not well aligned with the corresponding holes in the spar/doubler angle assembly, rotate the front-side doubler around the 1/2" drill bit in the wing attach hole until the two #40 holes are aligned as closely as possible; clamp the front-side doubler to the assembly. Use the holes in the spar as a guide to pass drill **#40** holes through the front-side doubler, and insert Clecos.

Use the two holes near the outboard end of the front-side doubler to drill **#40** holes through the aft spar/doubler angle assembly, as shown in Figure 15. Use the middle hole drilled in Step A as a guide to drill a **#40** hole through the front-side doubler.

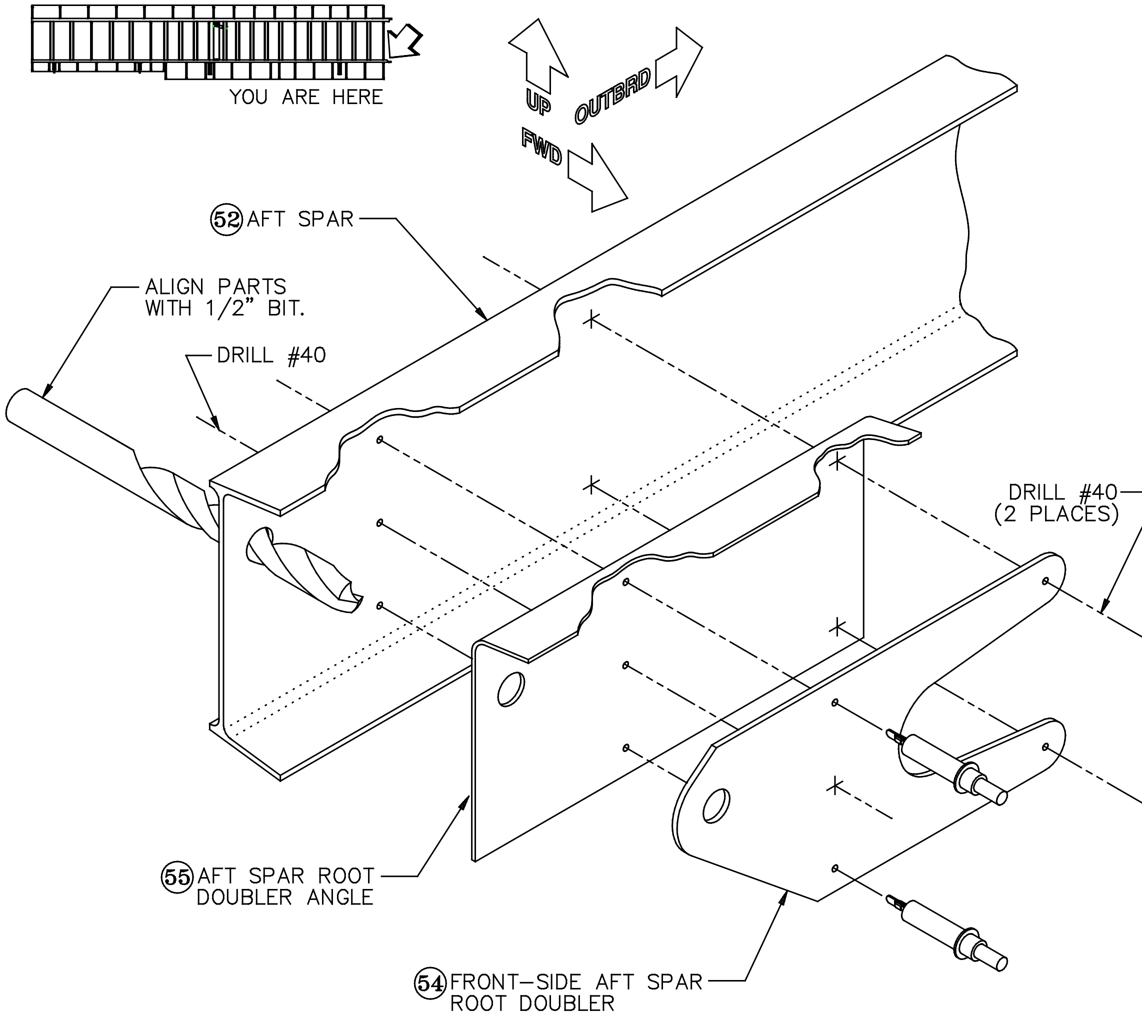

Figure 15: Front-Side Aft Spar Root Doubler

c) Use the 1/2" drill bit to align the wing attach hole in the **rear-side aft spar root doubler** [57] with the wing attach holes in the other three parts of the aft spar root assembly, as shown in Figure 16. Use the five #40 holes drilled so far to Cleco the rear-side root doubler to the assembly.

> **Note** If the applicable five pilot holes in the rear-side doubler are not well aligned with the corresponding holes in the spar root assembly, shift the rear-side doubler around the 1/2" drill bit until the five holes are aligned as closely as possible; clamp the rear-side doubler to the assembly. Use the five holes in the front-side doubler as a guide to pass drill **#40** holes through the rear-side doubler, and insert Clecos.

Using the pilot holes in the rear-side doubler as a guide, drill the remaining eighteen **#40** holes through the spar, the doubler angle and the front-side doubler.

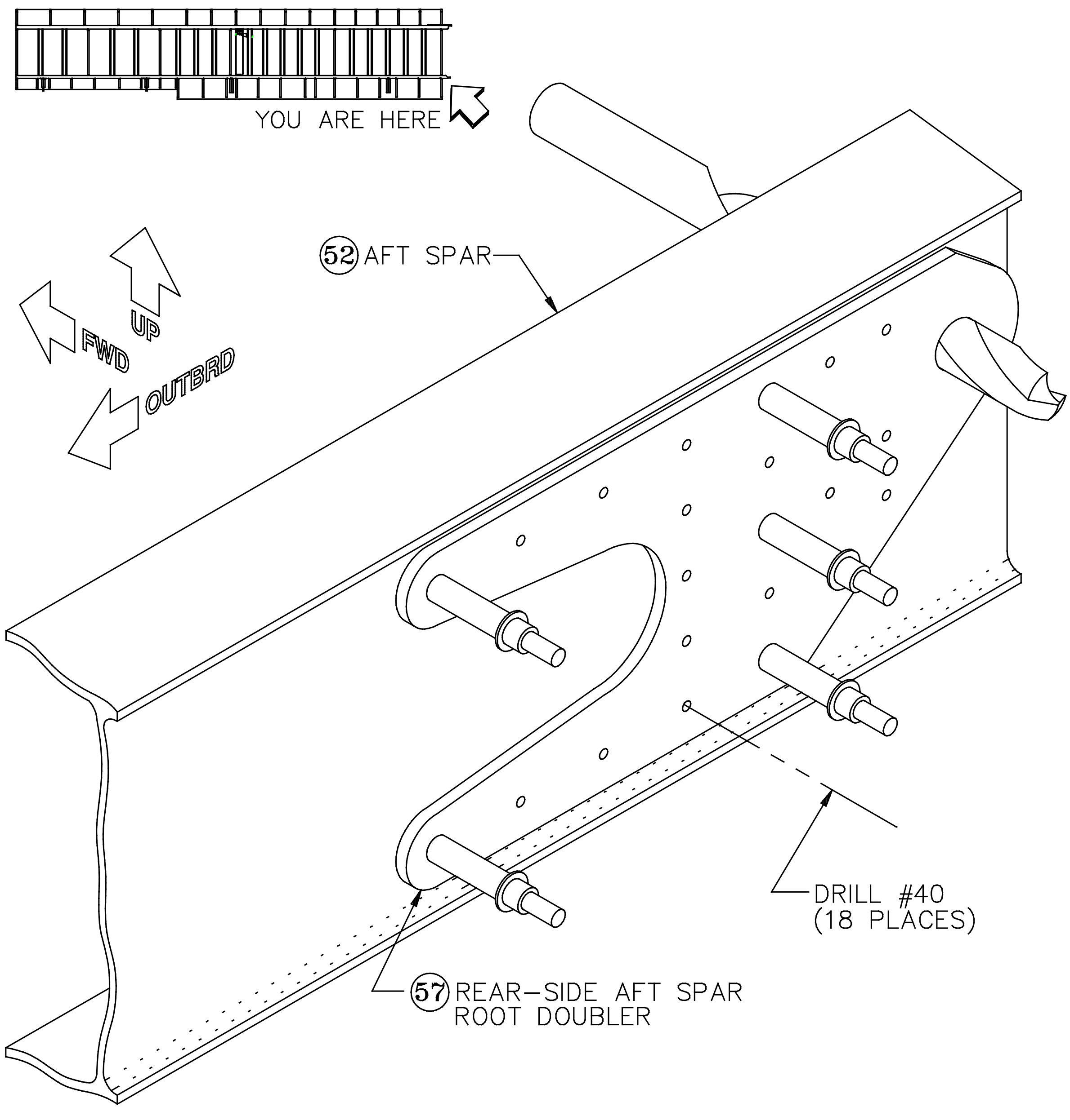

Figure 16: Rear-Side Aft Spar Root Doubler

D) **Except for the line of holes where the root ribs attach** (the third vertical column of holes from the wing-attach hole, as shown in Figure 17), drill all the holes in the assembly up to **#21** diameter for 5/32" rivets. Cleco as you go. The five holes in the rib line will be enlarged to #30 diameter later when the ribs are fit to the spar.

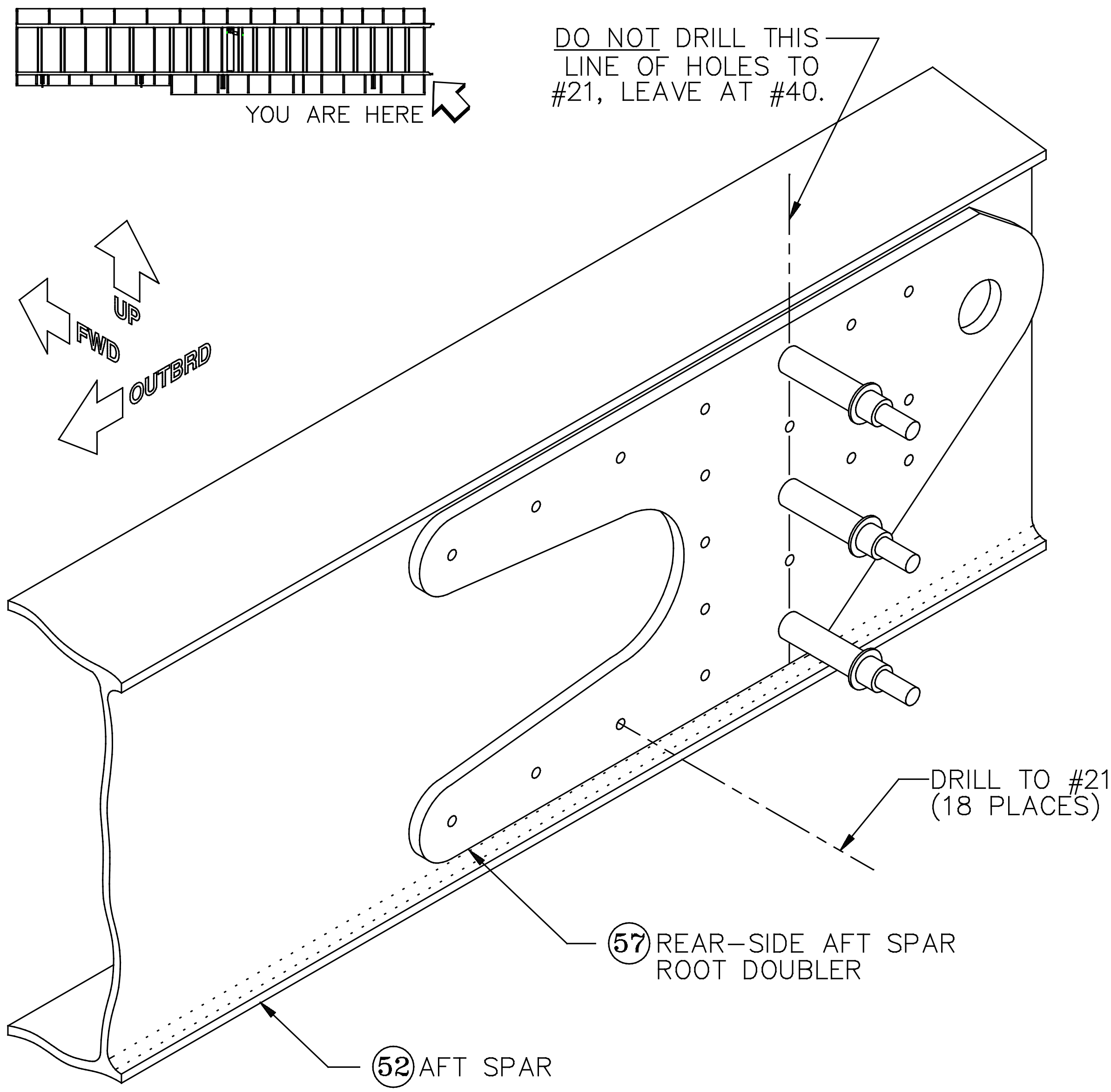

Figure 17: Drilling the Aft Spar Doublers to Final Size

E) Disassemble all the parts and deburr all the holes. Countersink the 5/32" diameter holes on the **forward face** of the **front-side aft spar root doubler** for (AN426AD5) flush head rivets, as shown in Figure 18. (Flush head rivets are used to provide clearance for the fuel tank.) **Do not countersink the five holes where the root ribs attach.**

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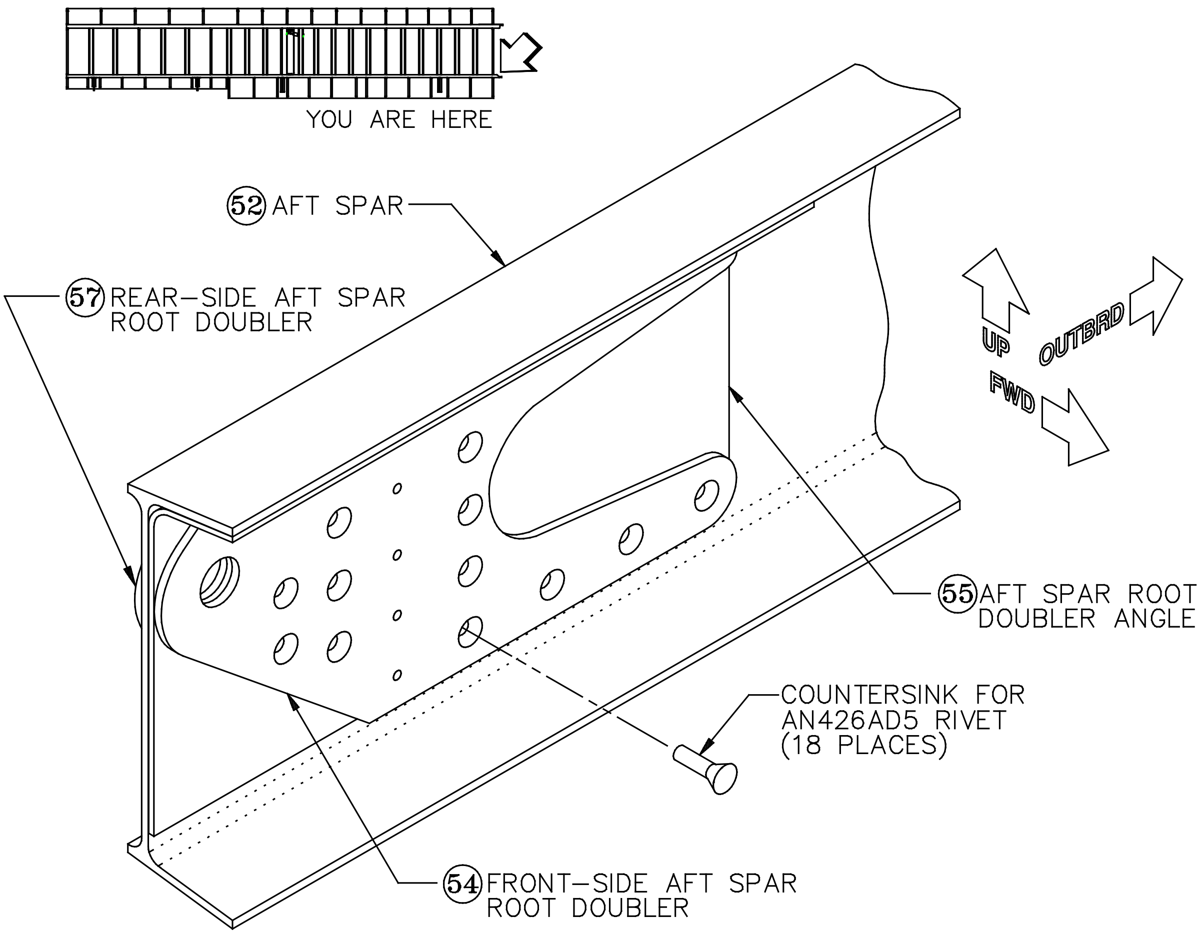

Figure 18: Countersinking the Rivet Holes

Step 8: Trim and Drill the Aft Spar Strut Beam Doubler

Mark trim lines on **both ends** of the **aft spar web/strut beam doubler** [58], as shown in Figure 19. Use a band saw to cut just outside the trim lines and then finish the cut by filing or belt-sanding down to the lines. Use sandpaper to smooth all rough edges and saw marks.

> **Note** Just trim the doubler at this time. The rivet hole pattern shown in Figure 19 will be laid-out and drilled after the rib and strut beam mounting holes have been transferred from the spar to the doubler, as described below.

Position the doubler on the front side of the aft spar with the doubler flange under the **upper** aft spar flange, as shown in Figure 20. Position the **inboard** end of the doubler about **3/8"** inboard of the rivet holes for Flap Cove Rib 9 (BL 91.37); position the **outboard** end of the doubler about **3/8"** outboard of the rivet holes for Flap Cove Rib 13 (BL 123.64). Clamp the doubler both to the spar web (using large C-clamps padded to prevent damage to the aluminum) and to the spar's upper flange (using small C-clamps or Cleco side-grip clamps).

> **Note** It is vitally important that the doubler flange fit tightly against the underside of the spar flange along the entire length of the doubler. Before drilling any holes, make sure that there are no gaps between the doubler and the spar flange. Use enough clamps to achieve a good fit.

> **Note** Look ahead to *"Step 19: Mount the Ribs on the Spars"* for a description of the rib numbering convention used in this section of the *Manual.* Step 19 also has tables of the locations and flange orientations of all the ribs.

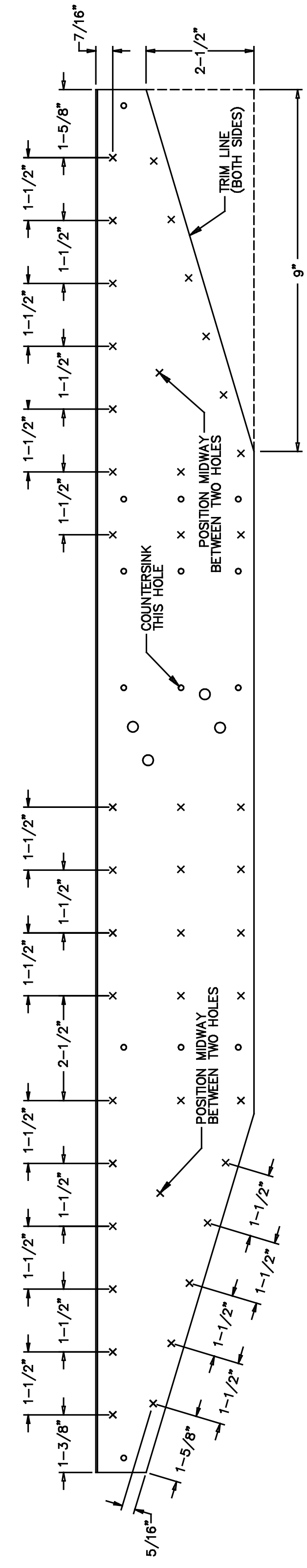

Figure 19: Aft Spar/Strut Beam Doubler Preparation

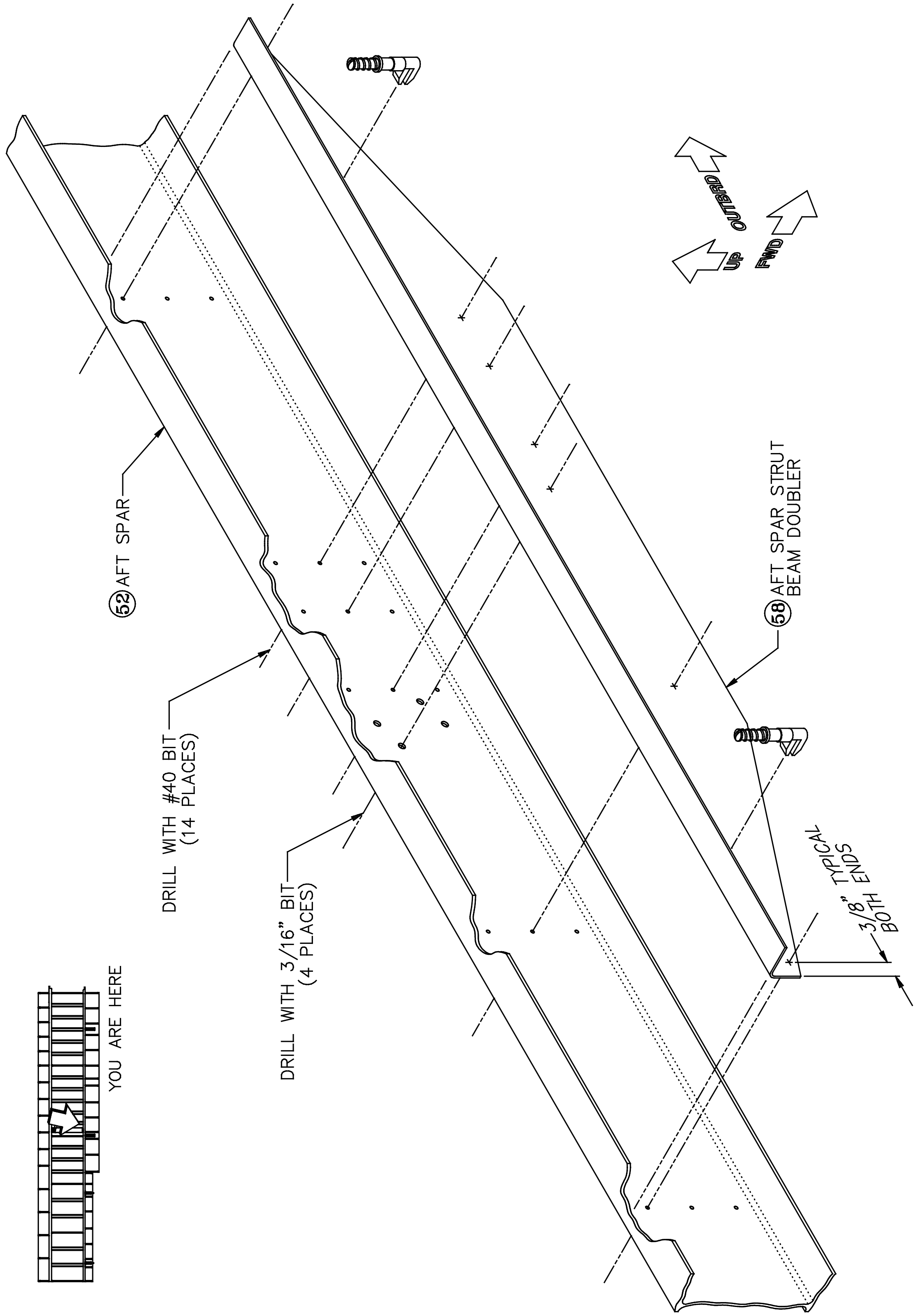

Figure 20: Aft Spar/Strut Beam Doubler Installation

As shown in Figure 20, use the pre-drilled holes in the spar web to drill matching holes through the aft spar web/strut beam doubler—use a **3/16"** bit to drill the four holes for mounting the strut beam; use a **#40** bit to drill the fourteen holes for mounting the ribs.

Note Figure 19 specifies that you countersink the center rivet hole for the rib closest to the strut beam. This hole will be countersunk when the ribs are fit to the spars in Step 19.

Remove the doubler from the spar. Lay out and center punch the rivet pattern shown in Figure 19 onto the **forward** side of the doubler. Reference the rivet pattern to the holes just drilled, as shown.

Clamp the doubler to the spar once again, using Clecos to align the rib and strut beam holes drilled previously. Use the center punched rivet pattern on the doubler to drill **#30** rivet holes through the doubler and the spar. (Do not drill the fourteen holes where the ribs mount; these holes will be enlarged to #30 diameter when the ribs are installed later.) As always, Cleco to maintain alignment as you proceed.

Remove the doubler from the spar and deburr all of the holes in both parts.

Completed: Left [ ] Right [ ]

Step 9: Trim the Ends of the Spars

Cleco the forward and aft root doublers and doubler angles to both the forward and aft spars.

Mark the trim lines shown in Figures 21 and 22 onto the forward and aft spar webs, respectively. Notice that the **spar web** trim lines at the upper edges of the spars are centered on the wing attach holes; the **spar web** trim lines at the lower edges of the spars are **1-1/8" inboard** of the root rib rivet line. Elsewhere, the spar web trim lines follow the inboard edges of the root doublers. Mark generous radii, as shown, at all the corners of all the trim lines. Use a band saw or a hacksaw to trim the spar webs and root doubler angles. At the same time, cut the **flanges** off square, as shown by the **dashed lines** in the top and bottom views of Figures 21 and 22. Cut outside the trim lines first, and then finish the cuts with files and sandpaper to remove the saw marks.

> **Warning** This is an extremely important area of the wing. Poor workmanship at the spar attach points could seriously compromise the structural integrity of the airplane. **Be very careful not to reduce the edge distances** to the wing attach holes when trimming the ends of the spars. (The inboard edges of the root doublers mark the limit for trimming the spar.) Also, the trimmed edges **must be smooth**, with no saw marks or file marks remaining when you are finished.

After the spar webs have been trimmed, mark the **spar flange** trim lines onto both the upper and lower flanges of both spars, as shown in Figures 21 and 22. Make sure to maintain the full width of both the upper and the lower spar flanges at the root rib doubler locations, so that the spar flanges can be riveted to the doublers. (Look ahead to Steps 18 and 19 and Figures 30 and 32 for clarification.) Trim the spar flanges and smooth the cut edges with files and sandpaper.

Square off the outboard ends of the forward and aft spars between **1/4"— 5/16"** outboard of the centers of the tip rib rivet holes, as shown in Figure 23. Use a hacksaw or a band saw to make the cuts and, again, remove any saw marks or rough edges with files and sandpaper.

Completed: Left [ ] Right [ ]

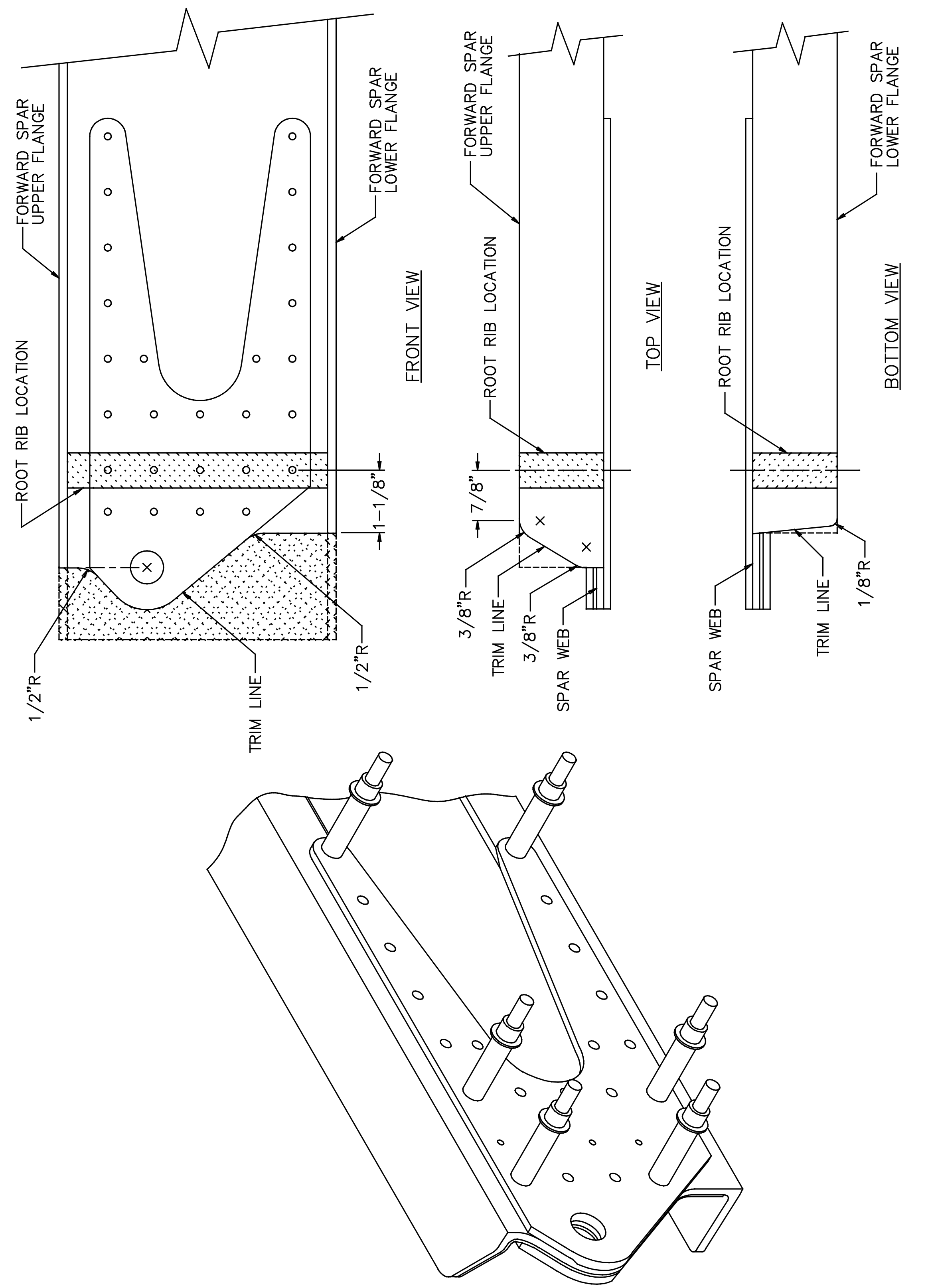

Figure 21: Trimming the Inboard End of the Forward Spar

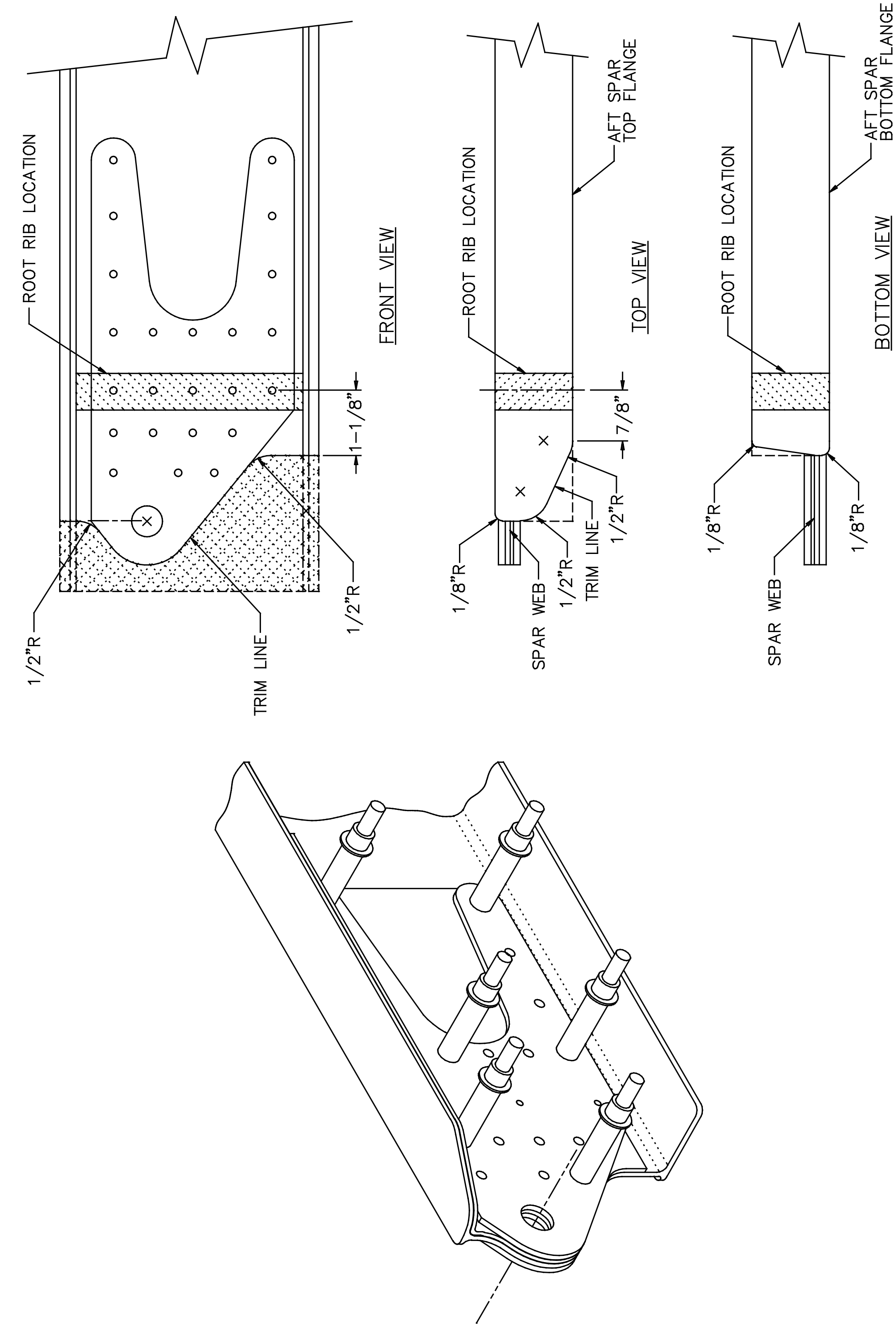

Figure 22: Trimming the Inboard End of the Aft Spar

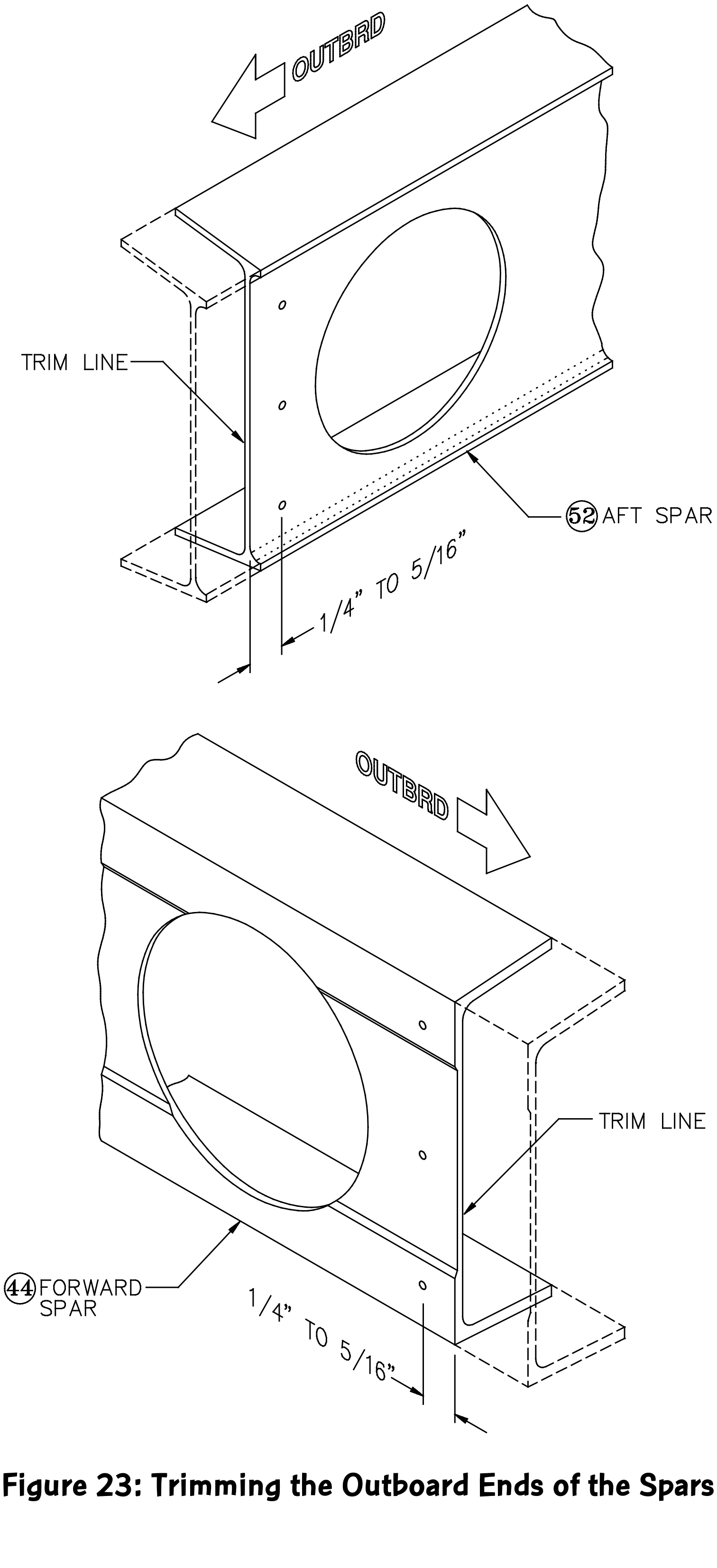

Figure 23: Trimming the Outboard Ends of the Spars

Step 10: Apply Corrosion Protection to the Spar Components

Completely disassemble the forward and aft spars. Deburr any rivet holes that have not yet been deburred. Apply corrosion protection to all of the spar components.

> **Note** We recommend the GlaStar Corrosion Protection Option Kit (P/N 962-01000-01), which includes a special, water-based primer and instructions. Contact our Order Desk for ordering and shipping information.

Completed: Left [ ] Right [ ]

Step 11: Rivet the Spar Assemblies

Now that the spar components have been corrosion proofed, you are ready to rivet the spar assemblies together, as follows:

A) Rivet the forward spar root doublers and doubler angle to the forward spar using 5/32" (AN426AD5) flush head rivets. Position the heads of the rivets in the countersinks on the aft side of the spar root doubler. **Do not rivet in the holes where the root rib attaches** (these are the five holes that were not drilled up to 5/32" diameter). See Figure 12.

> **Note** 5/32" rivets are the largest rivets in the GlaStar kit, and they require more gun pressure to adequately drive them. Practice on some scrap pieces with rivets of the same length. Remember that the driven tail should be 1-1/2 times the shank diameter when finished. If you have trouble driving the 5/32" rivets, try "back-riveting" them: hold the bucking bar against the head, and drive the tails with a flush rivet set. Use C-clamps to hold the pieces tightly together while riveting.

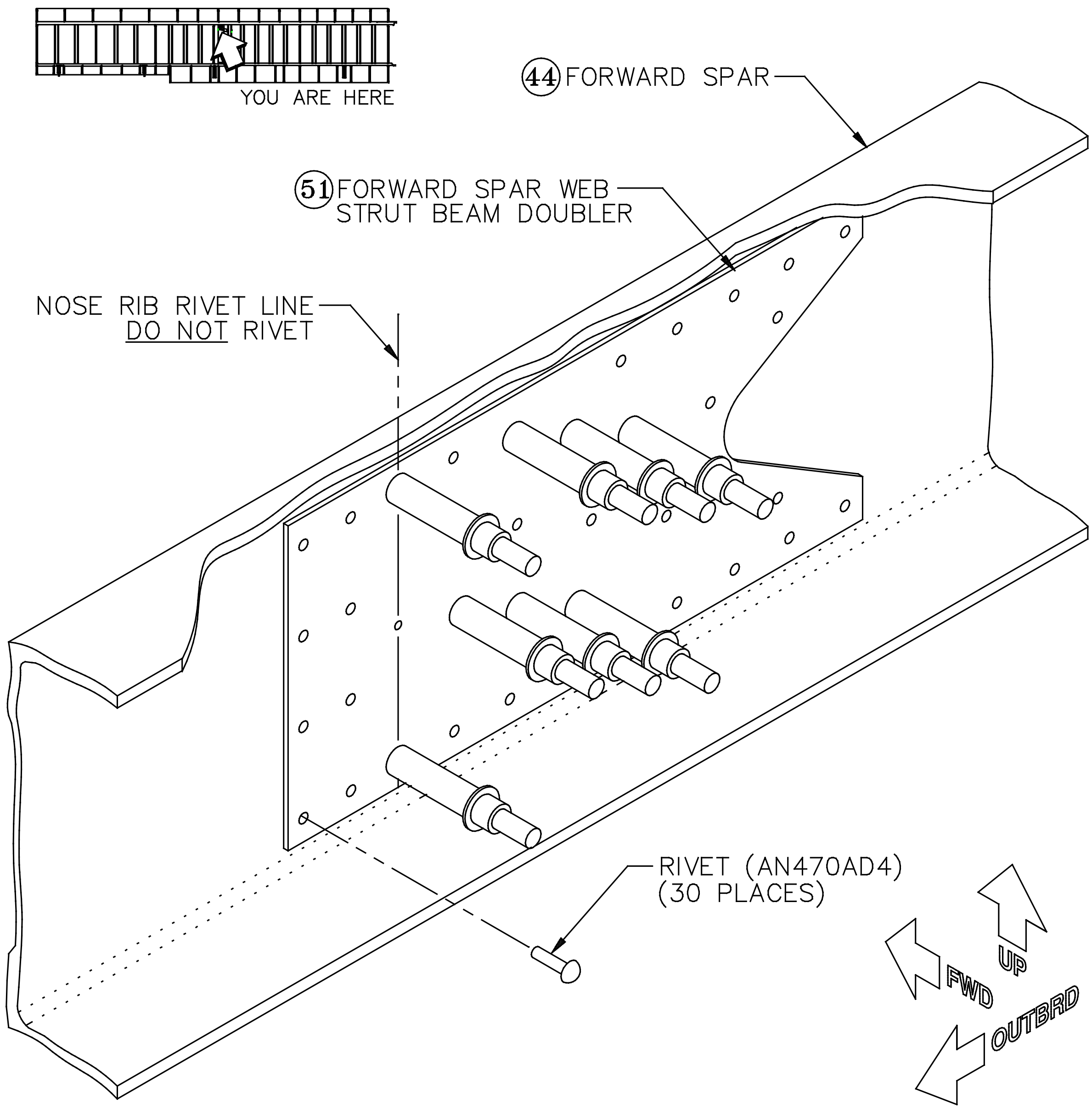

Figure 24: Riveting the Forward Spar Web/Strut Beam Doubler

B) Rivet the forward spar web/strut beam doubler to the forward spar with 1/8" (AN470AD4) universal head rivets. Position the rivet heads on the aft side of the assembly, as shown in Figure 24. **Do not** rivet in the three holes where the nose rib will mount (these are the holes that were left undrilled previously).

c) Rivet the aft spar root doublers and doubler angle to the aft spar using 5/32" (AN426AD5) flush head rivets. Place the heads of the rivets in the countersinks on the forward side of the doubler. **Do not rivet the holes for the root ribs** (these are the five holes that were **not** drilled up to 5/32"). See Figure 18.

D) Rivet the aft spar web/strut beam doubler to the aft spar with 1/8" (AN470AD4) universal head rivets. Place the heads of the rivets on the **forward** side of the doubler. **Do not rivet** any holes where ribs will be installed.

Completed: Left [ ] Right [ ]

Step 12: Ream the Wing Attach Holes

> **Note** Bushings in the forward and aft spar roots provide attach points for the wing. In view of their importance, the holes for these bushings must be reamed very precisely. While this operation is certainly not beyond the competence of the homebuilder, it does require special tools and special care. You may prefer to have a local machine shop perform this task.

Ream the forward spar wing attach hole to a **final diameter** of between **.6255" and .6245"**. We recommend achieving this by first drilling the hole with a **19/32"** bit, then with a **.600"** step ream, and finally with a **.625"** straight ream.

Ream the aft spar hole to between **.5625" and .5615"**. Start with a **17/32"** bit, continue with a **.540"** step ream, and finish with a **.562"** straight ream.

> **Note** For best results, run the reams at very low speeds. Keep the ream well lubricated and perpendicular to the spar. Use a mill or a drill press, if you have access to one. (Now is a good time to start promising rides!) Otherwise, use a heavy-duty drill motor and have someone help you line it up. After reaming, keep the ream turning in the forward direction while you withdraw it from the hole.

After the holes have been reamed, deburr them in preparation for pressing in the bushings.

Completed: Left [ ] Right [ ]

Note Stoddard-Hamilton has several sets of step reamers sized for this procedure that are available on a rental basis. Contact our Order Desk for information on terms and availability. Order the Wing Spar Attach Hole Reamer Set, P/N 981-02000-01.

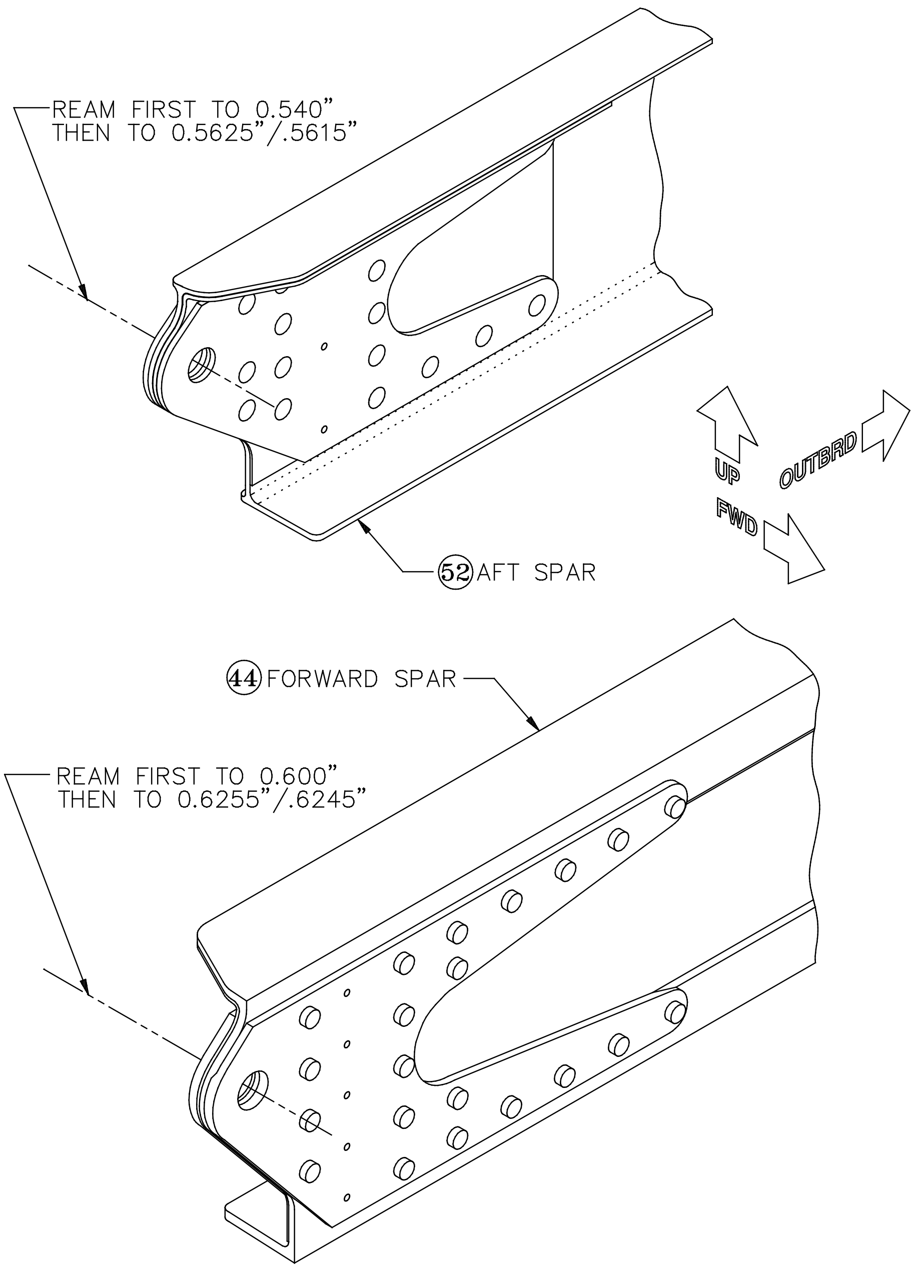

Figure 25: Reaming the Wing Attach Holes

Step 13: Press in the Wing Attach Bushings

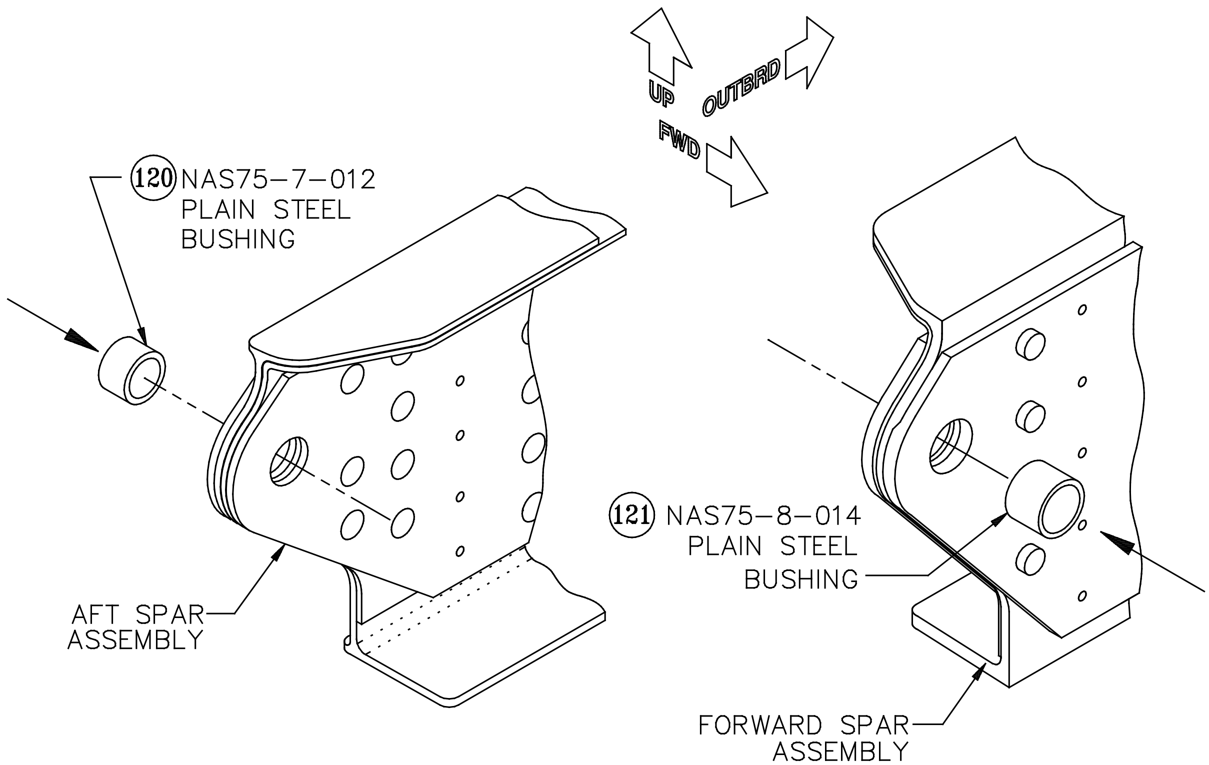

Figure 26: Pressing in the Wing Attach Bushings

If you have access to one, use an arbor press to press the NAS75-8-014 **plain steel bushing** [121] into the forward spar wing attach hole. Similarly, press the NAS75-7-012 **plain steel bushing** [120] into the aft spar wing attach hole.

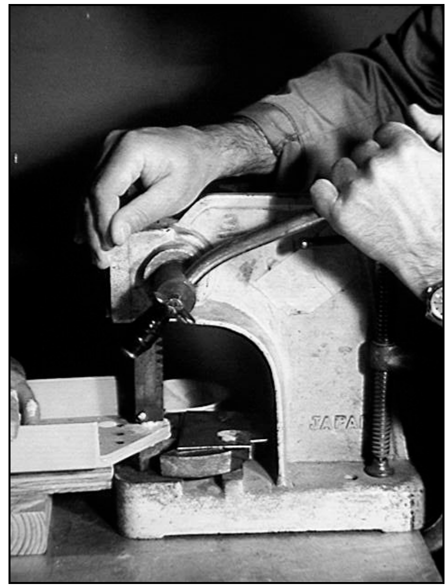

Figure 26.1: Pressing in the Wing Attach Bushing

Make sure that the spar is resting on a solid, flat surface when you press in the bushings; otherwise the pieces in the spar-root sandwich will tend to separate. Also, it is important to keep the bushing straight while pressing it into the hole. Apply Loctite to the bushings before assembly. Besides retaining the bushing after assembly, the Loctite lubricates the bushing slightly, which reduces the force needed to press it into place and helps prevent damage to the parts.

If you don't have access to an arbor press, use a bench vise to press in the bushings. Pad the vise jaws with pieces of aluminum sheet to prevent damage to the spar and the bushings. You could even use a hammer to drive in the bushings if you're **very** careful to start the bushings straight. If you choose this method, don't hammer directly on the bushings, but use a thick piece of scrap aluminum between the bushing and your hammer.

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Step 14: Mark Rivet Lines on Forward Spar Flanges

Rivet lines need to be drawn on the forward spar flanges, and these are easier to make when the spars are lying flat on the bench than when they are installed in the jig. The first rivet line is **3/8"** forward of the aft edge of the spar flange; the second rivet line is **1-1/8"** forward of the aft edge of the spar flange, as shown in Figure 27.

As on the stabilizer and elevator spars, the wing spars may be slightly bowed. Keep the rivet lines parallel to the spar flange edges, not necessarily straight. You will straighten the spars in the fore-and-aft direction when they're placed in the jig.

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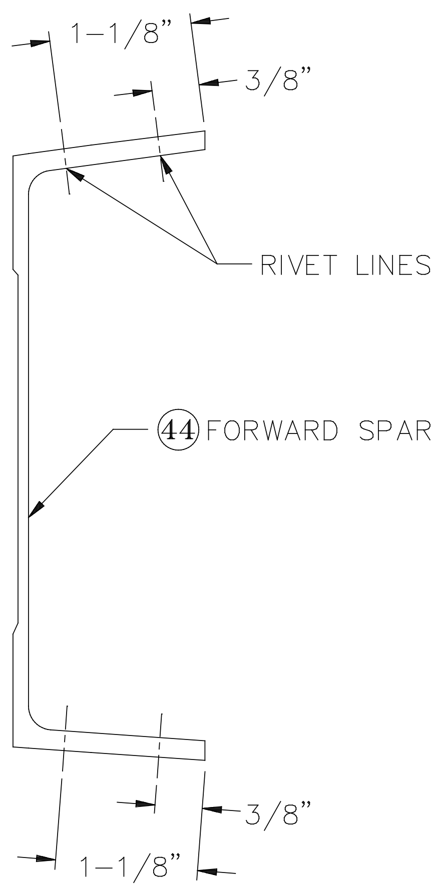

Figure 27: Forward Spar Rivet Line Dimensions

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Mount the Spars in the Jig

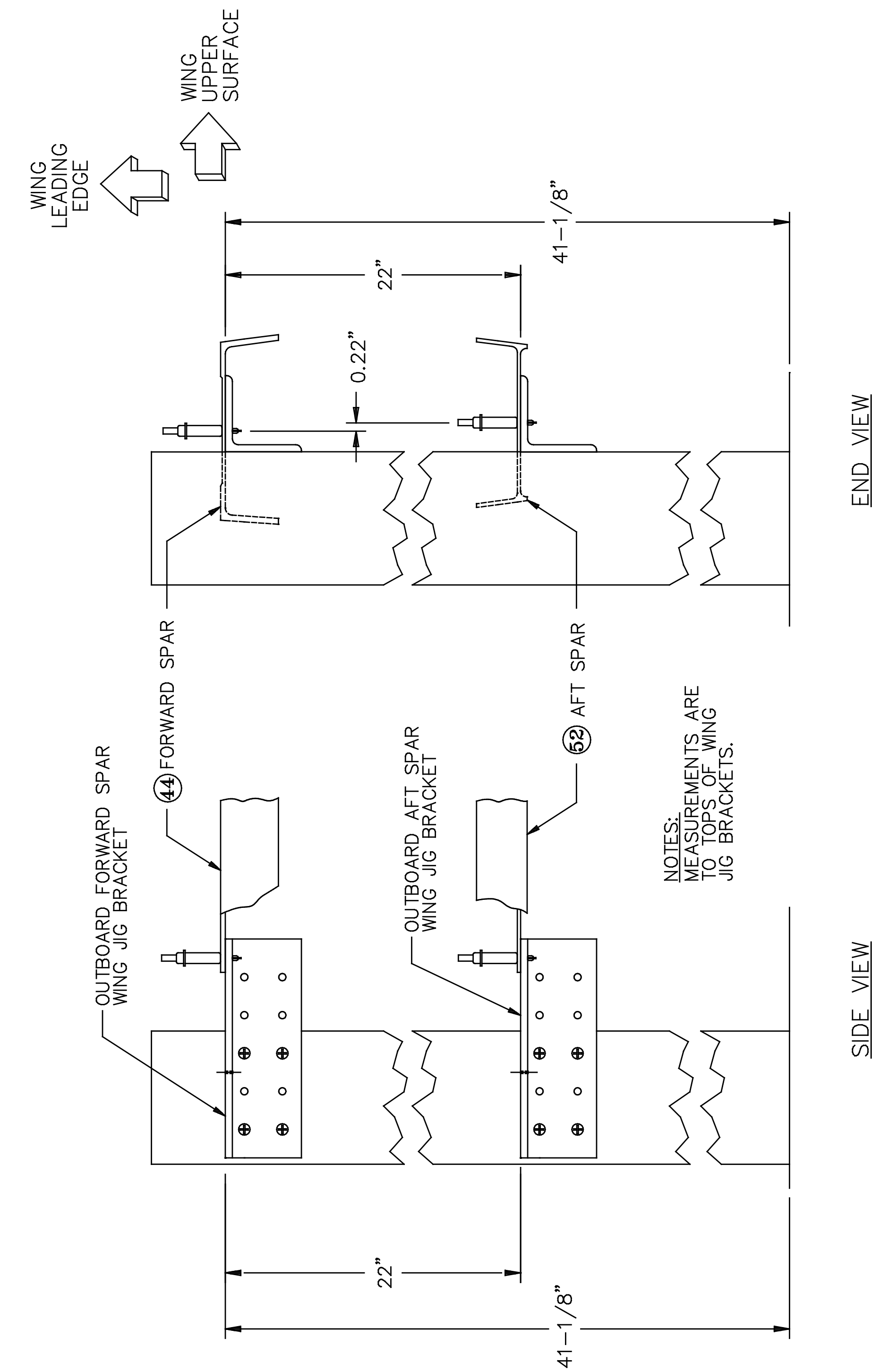

Figure 28: Mounting the Outboard Spar Brackets

Step 15: Fasten the Spars to the Jig Brackets

Using one Cleco inserted through the **center** rivet hole at the outboard end of the forward spar, mount the **outboard forward spar wing jig bracket** to the spar, as shown in Figure 28. Mount the forward spar on the **inboard forward spar jig bracket**, which was attached to the jig post in Step 3, by resting the spar on the bracket and inserting a 1/2" bolt through the wing-attach hole.

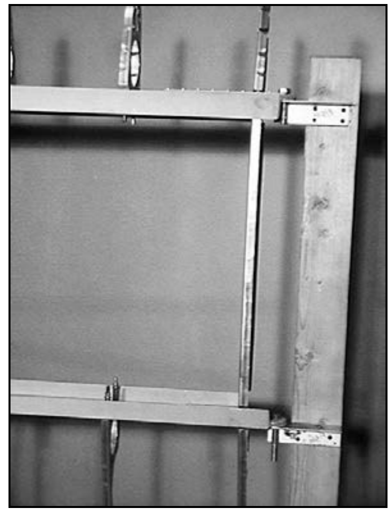

Figure 28.1: Inboard End of the Wing Jig

Note You don't need a special bolt for this purpose; any 1/2" hardware-store bolt with a grip length of about 1-1/4" will do.

Note As mentioned previously, the forward spar flanges point aft (down, when the wing is in the jig) and the upper flange of the spar is oriented away from the jig post (toward you when you are facing the jig).

Hold the outboard forward spar wing jig bracket against the outboard jig post and level the spar in the spanwise direction. When you're satisfied that the spar is level from root to tip, fasten the outboard jig bracket to the post with sheetrock screws.

Note To level the spar, use a water level or a transit or, if you're sure the jig table is level from end to end, simply measure up from the table **41-1/8"** as shown in Figure 28. (A water level is simply a length of clear, flexible tubing partially filled with water. It has to be long enough to run down from the top of one jig post, across the floor and up to the top of the other jig post. As long as the ends of the tube are open to the air, the level of the water will be the same at both ends when the ends are held up along the jig posts. So, you can measure up or down at each end to equalize the distance from the spar to the water.) Since the spars sag from their own weight when in the jig, you won't be able to use a carpenter's level. Supports to keep the spars from sagging are described in the next step.

Measure down **22"** from the top of the **outboard forward spar wing jig bracket** and mark a line on the jig post for the top edge of the **outboard aft spar jig bracket**, as shown in Figure 28. Use a Cleco to fasten the outboard aft spar jig bracket to the center rivet hole at the outboard end of the aft spar. Rest the root end of the aft spar on the inboard aft spar jig bracket and insert a 7/16" bolt (hardware-store quality is okay; grip length about 3/4") through the wing attach hole. Hold the top edge of the outboard aft spar jig bracket on the line just marked and secure the bracket to the jig post with sheetrock screws.

Note It's possible that, if either of your jig posts is **twisted**, the forward spar will not be held in the correct relationship to the aft spar, even when the plumb bob holes in the jig brackets are properly aligned. This could induce an unwanted twist in the wing. **The GlaStar wings are intended to be straight with no twist (wash-in or wash-out).** To double-check that the wing is not twisted in the jig, have one helper hold a straightedge from the upper forward spar flange to the upper aft spar flange at the wing root. Have another helper do the same at the wing tip. When viewed from either end of the wing, the two straightedges should be parallel. (Alternatively, measure with a digital level across the upper spar flanges at the root and the tip to verify an untwisted condition.) Another situation that will result in a twisted wing is inadvertently swapping the positions of the two outboard jig brackets. We recommend checking for twist and making any necessary jig adjustments before each major skin drilling or riveting operation.

Note It may be helpful from now on to remember that, as long as the wing assembly is in the jig, “forward” is up, and “aft” is down. In general, remember that all directional references in the text are keyed to the completed aircraft in a level-flight attitude, irrespective of what position the parts are in when jigged.

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Step 16: Fabricate the Aft Spar Center Supports

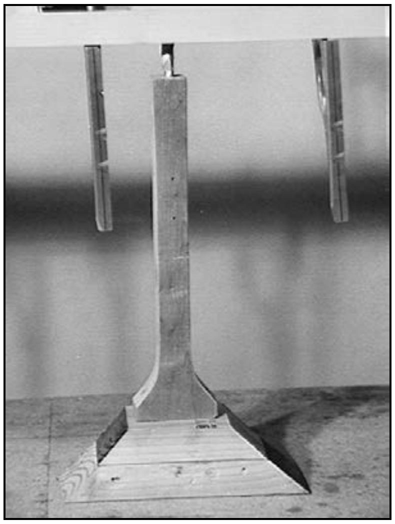

Figure 28.2: Aft Spar Support

Until the wing skins are riveted in place, it's necessary to support the center of the wing assembly to prevent the spars from sagging. To accomplish this, build **three** adjustable supports and install them between the wing jig table and the aft spar. A suggested design is shown in Figure 29.

Place the supports, spaced equidistantly, under the aft spar and adjust them until the bow in the spar disappears. To check this, simply sight along one of the corners of the aft spar or stretch a string tautly from one end of the spar to the other. When the string contacts the spar along its entire length, the spar is straight. A transit could also be used if you have access to one, but it's really not necessary since either of the "low-tech" methods mentioned above works just fine. When you're satisfied that the spar is straight, secure the supports to the jig and lock the height adjustment in place. If you've used something similar to the design suggested in Figure 29, then we suggest using sheetrock screws to secure the support to the jig table and hot-melt glue to lock in the bolt.

Note Do not place the supports in areas where they will interfere with installing wing ribs or other components. Such locations are marked by pilot holes in the spar. If you place them near main ribs, however, they will offer support to both the forward and the aft spars.

Note In addition to checking your jig for plumb and true periodically, also check the straightness of the spars and adjust as necessary.

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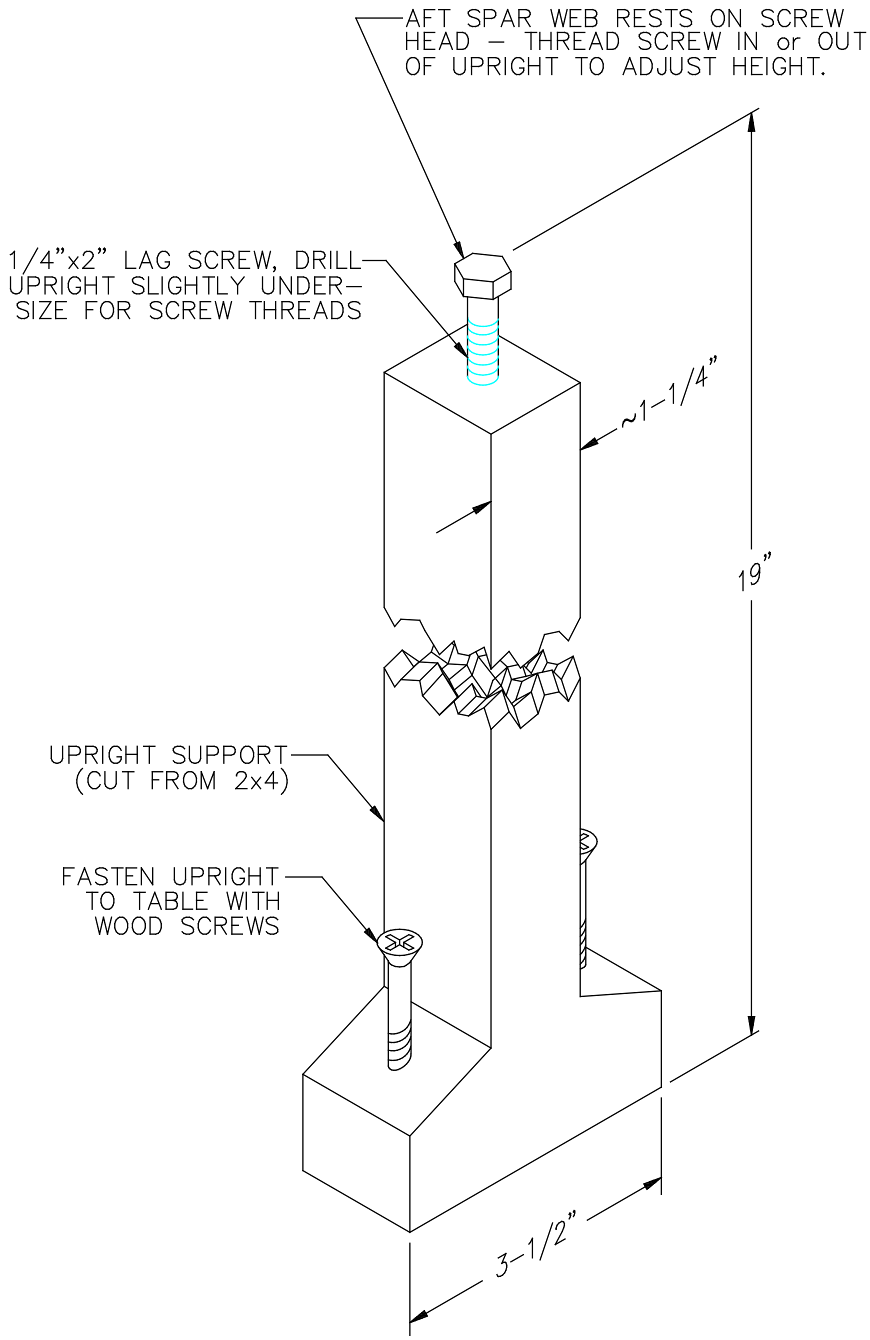

Figure 29: Suggested Aft Spar Center Support Design

MOUNT THE RIBS AND STRUT BEAM ASSEMBLY TO THE SPARS

Step 17: Square the Rib Flanges and Mark the Rivet Lines

Using a try square, check that all the nose rib, main rib, flap cove rib and aileron cove rib flanges are perpendicular to the rib faces. If necessary, square the flanges up with duck bill pliers.

Use a fine point felt-tip marking pen to mark centerlines (rivet lines) on all the rib flanges.

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Step 18: Reinforce the Root Main Rib

The **root main rib** [1] must be reinforced with the **upper root rib doubler** [39], the **lower root rib doubler** [41] and the **root rib web doubler angles** (cut from the **.063 X 1/2 X 1/2 angle** [95]), as shown in Figure 30.

Fit the upper and lower doublers to the outboard side of the root rib, as shown, trimming the corners of the ribs, as necessary, to allow the doublers to fit tightly against them.

Cleco the root rib into place between the spars. Slide the upper and lower rib doublers into place from the outboard side of the rib, nesting them against the rib. Trim the ends of the rib doublers the **minimum** amount necessary to allow them to fit into place under the spar flanges. **Be careful not to trim too much**; you will need room to install rivets through the doubler flanges later. You also may have to trim the corners of the ribs additionally to allow the doublers to fit relative to the spars.

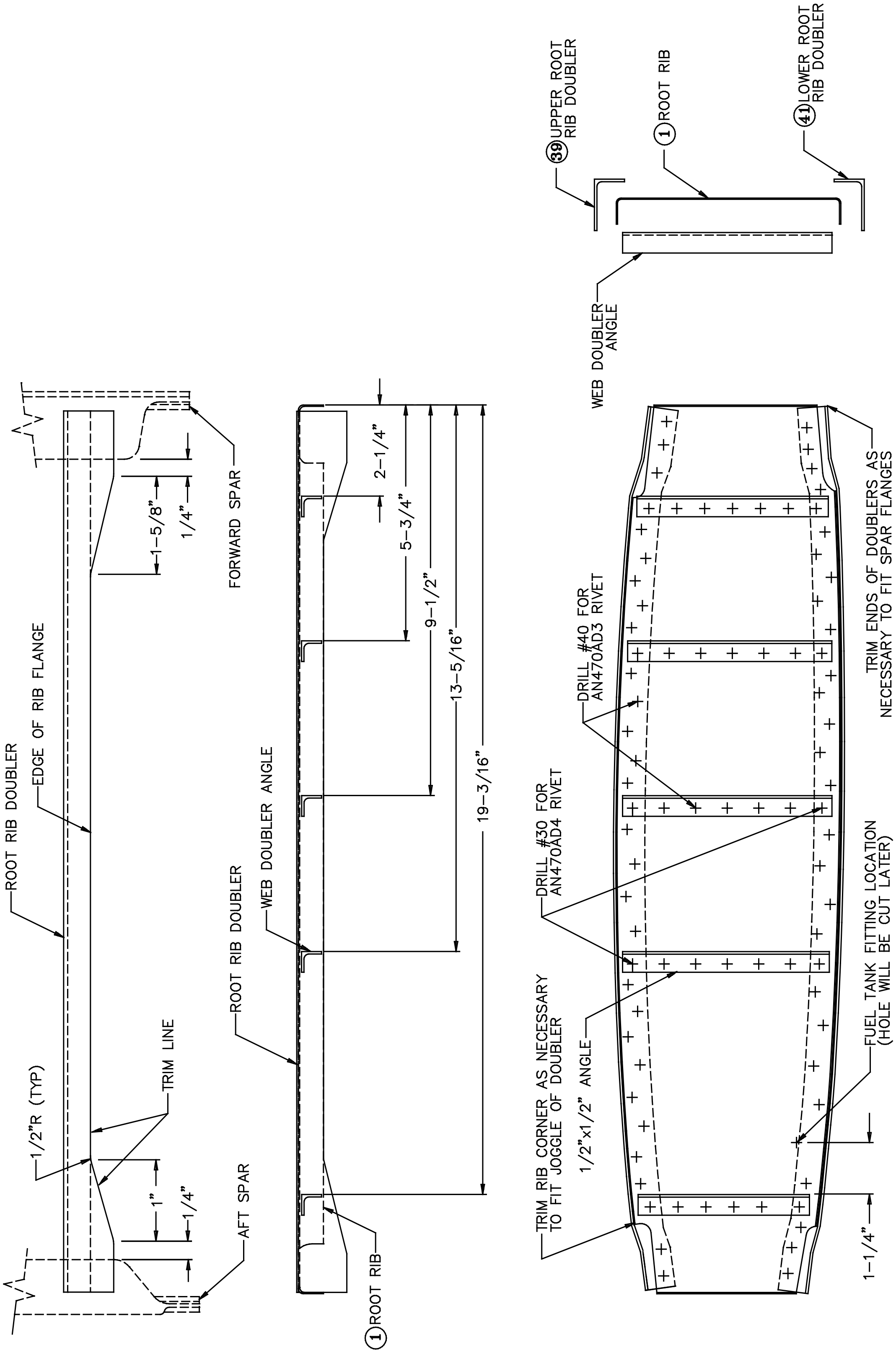

Figure 30: Root Rib Reinforcement

When the rib/doubler assembly is fitting satisfactorily between the forward and aft spars, mark trim lines onto the **flanges** of the root rib doublers, as shown in Figure 30. Notice that the trim lines are referenced to the edges of the spar flanges and that, for most of their length, the doubler flanges are trimmed even with the inboard edges of the rib flanges. The trim lines are the same for both the upper and the lower doubler flanges. Use a band saw or a hack saw to trim the doublers, and then finish the cuts with files and sandpaper. When finished, clamp the doublers to the rib once again.

Cut the **root rib web doubler angles** from the **.063" X 1/2" X 1/2" angle** [95] as shown in Figure 30. Make the angles just long enough to fit inside the rib flange bend radii at both ends (about **1/8"–3/16"** from the rib flange itself on each end). Lay out and center punch the rivet patterns shown onto one leg of each angle. Clamp the web doubler angles into position against the rib/doubler assembly. Drill one **#30** hole at each end of each web doubler angle through the doubler angle, the rib web and the rib doubler, as shown. Insert Clecos into the holes. Drill the rest of the holes through the web doubler angles and root rib to **#40** diameter.

Also, lay out and drill the remaining rivet holes through the rib web and the rib doublers to **#40** diameter, as shown in Figure 30. When laying out the rivet holes, maintain a minimum distance of **3/16"** (twice the rivet diameter) from the centers of the holes to the edges of all the parts; also, position the holes to provide adequate space for access with a rivet set on the inboard side of the rib. Don't place rivets in the area of the fuel tank fitting at the lower, aft edge of the rib, as shown in Figure 30.

Disassemble the root rib assembly, deburr the rivet holes and corrosion-proof the parts.

Cleco and then rivet the root rib/doubler/web doubler angle assembly together. Use 1/8" AN470AD4 universal-head rivets in the rivet holes at both ends of each doubler angle, as shown (these are the rivets that go through all three parts); use 3/32" AN470AD3 universal-head rivets for all the other rivet holes in the assembly.

Note Rivet the entire root rib assembly **except** for the rivets through the upper and lower root rib doublers **forward** of the **forwardmost** web doubler angle and **aft** of the **aftmost** web doubler angle (i.e., the rivets at the extreme ends of the upper and lower doublers). Then double-check the fit of the assembly between the spars. If the fit is satisfactory, go ahead and finish riveting, but you may find it necessary to trim a bit more off the upper and/or lower doublers to get a good fit. Do so, and then finish the riveting.

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Step 19: Mount the Ribs to the Spars

Cleco the **root nose rib** [5], the reinforced **root main rib** [1] and the **root flap cove rib** [9] to the spars.

> **Note** You will need extended-grip Clecos for the root ribs. If necessary, drill up to **#30** diameter and use 1/8" extended-grip Clecos.

The flanges of these three ribs point inboard. Use two Clecos through the forward spar to secure the nose rib and the forward end of the main rib; use two Clecos through the aft spar to secure the flap cove rib and the aft end of the main rib. Use the holes in the spar that were **not** drilled up to #21 when installing the spar root doublers in Steps 5 and 7.

> **Note** To orient the main ribs, position the wider ends of the ribs forward and position the center tooling holes in the ribs toward the upper surface of the wing, as shown in Figure 31. The root main and root nose ribs can be distinguished from the outboard ribs by the absence of the flanged lightening holes in the root ribs. The root flap cove rib is slightly shorter than the other flap cove ribs to accommodate the rear-side aft spar root doubler.

Five #40 pilot holes for mounting the ribs were drilled through the spar assemblies earlier, but only two holes exist in the end flanges of the ribs. Drill the additional holes through the rib flanges at this time. First, remove the root nose rib and root flap cove rib, and use the three extra holes in each spar to drill **#40** holes through the end flanges of the root main rib. Then, remove the main rib, reinstall the nose and flap cove ribs and use the three extra holes in the spar to drill holes through the nose and cove rib flanges. Reinstall the main rib.

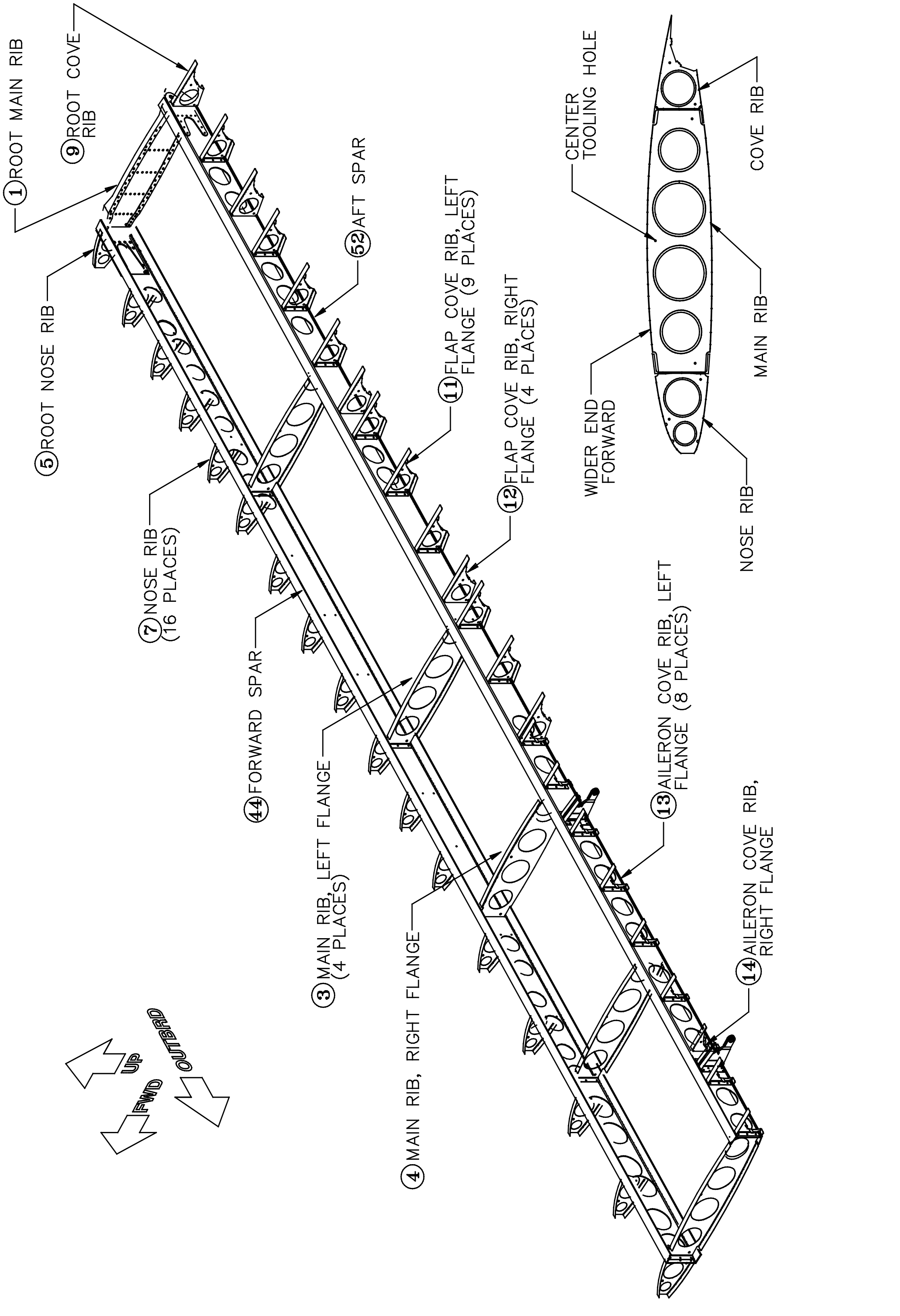

Figure 31: Rib Installation

Note We will use numbers to refer to specific ribs throughout this section of the manual, with the **furthest inboard** rib of any particular type called "Rib 1" and the other ribs of that type numbered sequentially outboard from Rib 1. For example, when we refer to "Flap Cove Rib 3," we mean the third flap cove rib from the root, counting the root flap cove rib as number one.

Cleco the sixteen **outboard nose ribs** [7], and the five **outboard main ribs** [3 and 4] to the spars, paying careful attention to the orientation of the flanges (see Figure 31 and Tables 2 and 3). (All nose and main rib flanges are oriented **outboard**, except for the root nose rib, the root main rib and Main Rib 4, the flanges of which are oriented **inboard**.) Fasten the main ribs in place with two Clecos at each end using the pre-drilled holes in the spars. Fasten each of the nose ribs with two Clecos, also. For Main Ribs 1, 2 and 6, the same Clecos fasten both the main and the nose ribs.

Note The extra thickness of the aft spar strut beam doubler under the aft end of Main Rib 3 will cause the rib to buckle or deform if it is forced into place. Because tooling does not exist for forming a shorter rib, Main Rib 3 must be modified to eliminate this problem. Use procedures similar to those described for the center main horizontal stabilizer ribs in Step 18 of "SECTION IV: HORIZONTAL STABILIZER ASSEMBLY," as follows: Cut two pieces of **.063" X 1/2" X 1/2" 6061-T6 aluminum angle** [95] to the same length as the aft flange of the rib. Cut off the existing aft flange of the rib as close to the bend as possible. With the other main ribs installed between the spars to hold the spars the correct distance apart, clamp the 1/2" angle in place between Main Rib 3's web and the aft spar. Use the existing rivet holes in the aft spar to drill **#40** holes through one flange of the angle; lay out and drill three **#30** holes through the rib and the other flange of the angle. Deburr the holes and apply corrosion protection to the rib and the angle. Rivet the angle to the rib with three 1/8" AN470AD4 universal-head rivets. The modified rib can now be Clecoed into place using the #40 holes in the angle; it will be riveted to the spar later, at the same time as the other ribs.

Cleco the **flap cove ribs** [11 and 12] and the **aileron cove ribs** [13 and 14] to the aft spar, with the flange orientations shown in Figure 31 and Tables 4 and 5. Counting outboard with the root flap cove rib number one, the flanges of Flap Cove Ribs 1, 3, 7, 11 and 14 are oriented **inboard**; the flanges of the remaining flap cove ribs are oriented **outboard**. Counting from the furthest inboard location, the flange of Aileron Cove Rib 7 is oriented **inboard**; all other aileron cove rib flanges are oriented **outboard**.

Note Holes are **not** pre-drilled in the aft spar for Aileron Cove Rib 1. To mount Aileron Cove Rib 1, butt its inboard side against the outboard side of Flap Cove Rib 14 (the flanges of the two ribs are oriented in opposite directions), making sure that the upper flanges of the two ribs are aligned with each other. Clamp the aileron cove rib to the aft spar and use the holes in its forward flange to drill **#40** holes through the spar.

Note When using the tables for the rib locations remember that the wing attach hole in the **forward spar** is located at **BL 22.5** and the wing attach hole in the **aft spar** is located at **BL 22.0**.

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MAIN RIBS		
RIB:	**LOCATION:**	**FLANGE:**
Main Rib 1	BL 24.25	Inboard
Main Rib 2	BL 69.00	Outboard
Main Rib 3	BL 112.53	Outboard
Main Rib 4	BL 141.75	Inboard
Main Rib 5	BL 171.75	Outboard
Main Rib 6	BL 201.75	Outboard

Table 2: Main Rib Locations and Orientations

NOSE RIBS		
RIB:	**LOCATION:**	**FLANGE:**
Nose Rib 1	BL 24.25	Inboard
Nose Rib 2	BL 33.20	Outboard
Nose Rib 3	BL 42.15	Outboard
Nose Rib 4	BL 51.10	Outboard
Nose Rib 5	BL 60.05	Outboard
Nose Rib 6	BL 69.00	Outboard
Nose Rib 7	BL 79.30	Outboard
Nose Rib 8	BL 89.17	Outboard
Nose Rib 9	BL 99.89	Outboard
Nose Rib 10	BL 110.60	Outboard
Nose Rib 11	BL 120.48	Outboard
Nose Rib 12	BL 130.75	Outboard
Nose Rib 13	BL 144.95	Outboard
Nose Rib 14	BL 159.15	Outboard
Nose Rib 15	BL 173.35	Outboard
Nose Rib 16	BL 187.55	Outboard
Nose Rib 17	BL 201.75	Outboard

Table 3: Nose Rib Locations and Orientations

FLAP COVE RIBS		
RIB:	**LOCATION:**	**FLANGE:**
Flap Cove Rib 1	BL 24.25	Inboard
Flap Cove Rib 2	BL 33.64	Outboard
Flap Cove Rib 3	BL 43.03	Inboard
Flap Cove Rib 4	BL 49.97	Outboard
Flap Cove Rib 5	BL 59.36	Outboard
Flap Cove Rib 6	BL 69.00	Outboard
Flap Cove Rib 7	BL 76.94	Inboard
Flap Cove Rib 8	BL 81.56	Outboard
Flap Cove Rib 9	BL 91.37	Outboard
Flap Cove Rib 10	BL 101.17	Outboard
Flap Cove Rib 11	BL 109.75	Inboard
Flap Cove Rib 12	BL 114.25	Outboard
Flap Cove Rib 13	BL 123.64	Outboard
Flap Cove Rib 14	BL 134.25	Inboard

Table 4: Flap Cove Rib Locations and Orientations

AILERON COVE RIBS		
RIB:	**LOCATION:**	**FLANGE:**
Aileron Cove Rib 1	BL 134.88	Outboard
Aileron Cove Rib 2	BL 141.75	Outboard
Aileron Cove Rib 3	BL 149.95	Outboard
Aileron Cove Rib 4	BL 159.45	Outboard
Aileron Cove Rib 5	BL 168.95	Outboard
Aileron Cove Rib 6	BL 178.45	Outboard
Aileron Cove Rib 7	BL 187.95	Inboard
Aileron Cove Rib 8	BL 193.08	Outboard
Aileron Cove Rib 9	BL 201.75	Outboard

Table 5: Aileron Cove Rib Locations and Orientations

Note The outboard wing jig brackets interfere with installing the tip ribs. Relieve the ends of the jig brackets, if necessary, to clear the rib webs. Fit the forward end of Main Rib 6 between the forward spar wing jig bracket and the forward spar; fit the forward end of Aileron Cove Rib 9 between the aft spar wing jig bracket and the aft spar. This raises both spars by the thickness of the rib material, which is acceptable.

When all of the ribs have been mounted to the spars, use a **#30** bit to drill up all the rib-to-spar web rivet holes to final diameter for 1/8" rivets.

Note Before drilling, check that the rib is centered vertically on the spar. The rib can be adjusted up or down slightly and clamped with C-clamps while drilling to optimize the skin match-up between the rib flanges and the spar flanges.

Note **Do not** drill the holes where Main Rib 3 attaches to the aft spar. These holes share rivets with the flap track ribs and will be drilled when the flap tracks are installed. Also, **do not** drill the **middle** rivet holes for Flap Cove Rib 14 and Aileron Cove Rib 1; rivets installed in these holes would interfere with the aileron pulley brackets (see Step 51 in this WING ASSEMBLY section). To drill the center holes through the tip ribs, clamp the spar/rib assemblies to the jig brackets and remove the 3/32" Clecos. Drill up to **#30** size through the ribs, spar webs and jig brackets, and then use 1/8" Clecos to secure the spar/rib assemblies to the jig brackets. Remove the temporary clamps.

Lay out and center punch the locations for the two inboard rivets that fasten each end of the upper and lower root rib doublers to the spar flanges, as shown in Figure 32. The doublers fit under the spar flanges, so the rivet locations must be laid out on the spars. For both the forward and the aft spar, the rivet holes are located a minimum of **5/16"** outboard of the inboard edge of the doubler flange. For the forward spar, the holes are located **5/16"** and **3/4"** from the aft edge of the spar flange; for the aft spar the holes are located **5/16"** and **5/8"** from the forward edge of the spar flange. Use a **#30** bit to drill the holes through the spar flanges and both the upper and the lower root rib doublers. Countersink these holes on the **spar flanges** for 1/8" AN426AD4 flush-head rivets. Insert a Cleco through the spar into each end of each doubler flange.

Note In order to maintain the minimum 5/16" edge margin (2-1/2 rivet diameters) and the 3/8" minimum between rivets (3 rivet diameters), you can arrange the rivets diagonally with respect to each other instead of in line as shown in Figure 32.

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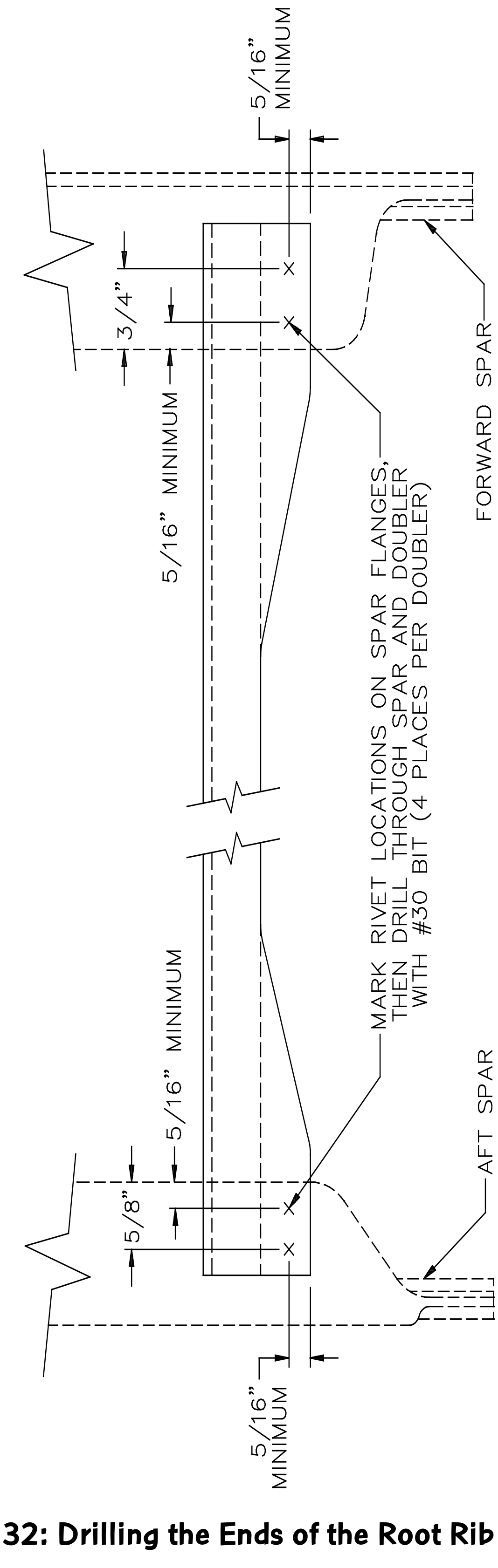

Figure 32: Drilling the Ends of the Root Rib Doublers

Step 20: Mark the Ribs

Choosing a standard notation (for example, "LM1" through "LM6" for the left main ribs, "LN1" through "LN17" for the left nose ribs, and so on), mark each rib, noting its order relative to the other ribs. Also mark the spar with the same notation at each rib location. The spar/rib assembly will be disassembled and reassembled multiple times, and **it's vital that each rib be returned to its original position** at each reassembly.

> **Hint** Use a grease pencil or a marking pen with permanent ink to mark the ribs, or attach a tag to each part. Don't use a lead pencil as this can lead to dissimilar metal corrosion.

Completed: Left [ ] Right [ ]

Step 21: Assemble the Strut Beam

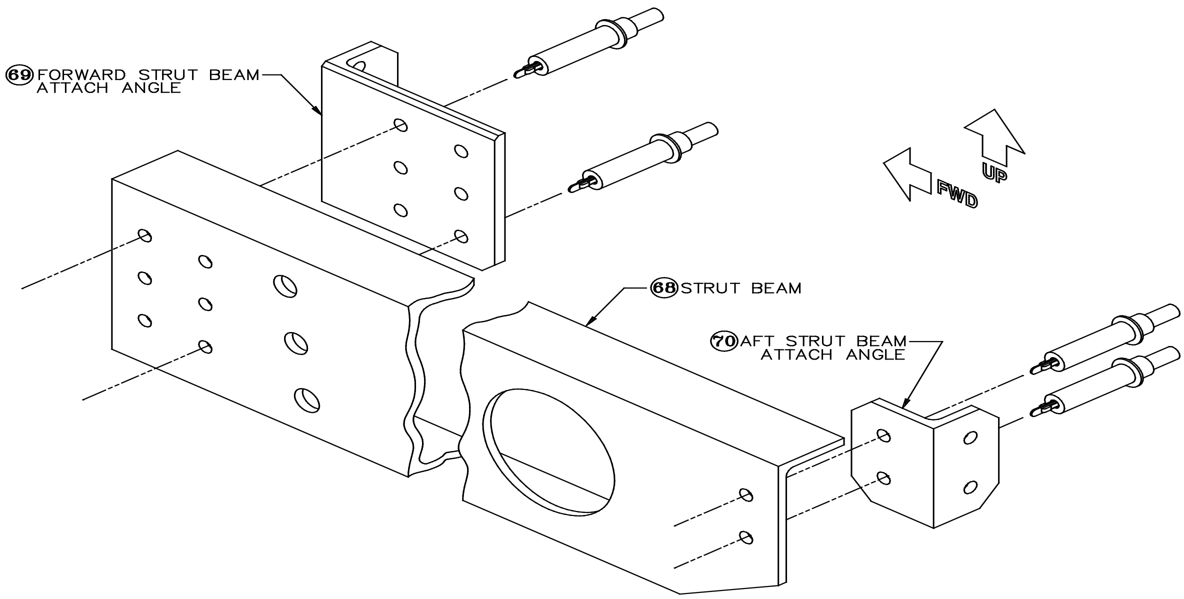

Figure 33: Fastening the Attach Angles to the Strut Beams

Use 3/16" Clecos to fasten a **forward strut beam attach angle** [69] and an **aft strut beam attach angle** [70] to both the **left-flange strut beam** [67] and the **right-flange strut beam** [68], as shown in Figure 33. (The longer leg of the aft strut beam attach angle fastens to the strut beam.)

To distinguish between the **left** and **right strut attach arms** [71 and 72], refer to Figure 34. Notice that, for the **left** arm, the **outboard** end (the thin end that fastens between the strut beams) is rotated about **4° counterclockwise** relative to the inboard end when viewed from the outboard end. For the **right** arm, the **outboard** end is rotated about **4° clockwise** relative to the inboard end when viewed from the outboard end.

Use a 3/8" AN6-13A **bolt** [111] to pin the **strut attach arm** [71] between the two strut beams through the one 3/8" diameter hole in all three parts. Orient the flanges of the two beams away from each other, as shown in Figure 34. Pin the attach arm to the beam assembly with an 11/32" drill bit through one of the other two holes.

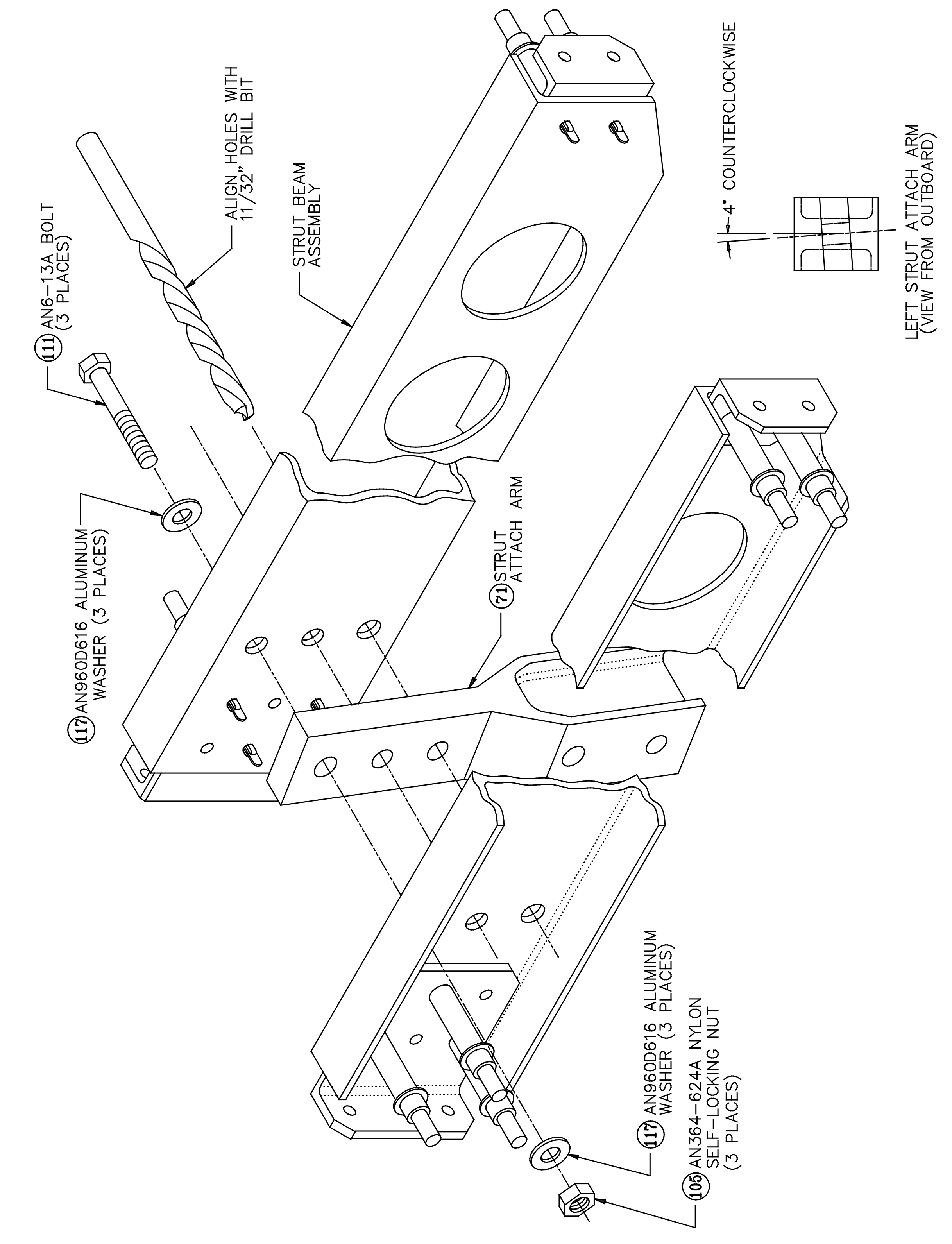

Figure 34: Strut Attach Arm Installation

Position the strut beam assembly (including the strut attach arm) between the forward and aft spars, as shown in Figure 35, and Cleco it in place with at least two 3/16" Clecos per end. The tapered corners at the aft ends of the strut beams are positioned inboard and toward the lower surface of the wing; the strut attach arm is oriented inboard, down and slightly aft.

With the strut beam assembly Clecoed between the spars, use a 1/4" reamer or a 1/4" or letter "E" drill bit to enlarge the holes through the forward and aft attach angles and the strut beams to final size. Be very careful to hold the bit perpendicular to the surface. Insert a 1/4" AN4-6A **bolt** [110] into each hole after drilling to maintain alignment. You probably won't be able to ream all the holes (unless you have a right-angle drill) because the spar flanges overhang areas where you are working; ream as many of the holes as you can with the strut beam assembly installed between the spars.

Note Each 1/4" bolt should be a medium "push fit" into its hole. This means that the bolt should offer some resistance during insertion, but excessive force (such as hammering) shouldn't be required to insert it. If the first bolt feels loose or just "falls" into place, change to a letter "D" bit to drill the remaining holes. Another strategy to help produce accurately sized holes is to "step drill" the holes, which means drilling the holes to final size in increments, instead of all at once. So, for these holes, you would first drill to **3/16**", then to **7/32**", then to **15/64**" (or letter "**A**"), and finally to **1/4**".

In a similar manner, enlarge each mounting hole through both spars and the forward and aft strut beam attach angles to **1/4"** diameter (ten places total). Use the same size ream or drill bit used previously for drilling through the attach angles and the strut beams. Insert a 1/4" AN4-6A bolt through each hole after drilling to maintain alignment.

Note Drill through the forward spar and forward strut beam attach angles from the front side of the forward spar; drill through the aft spar and the aft strut beam attach angles from the rear side of the aft spar. One of the strut beam mounting holes through the **aft** spar interferes with Flap Cove Rib 11. Drill a **1/4"** hole through the **rib flange** to match the bolt hole in the spar web; then form a notch in the flange, centered on the 1/4" hole, just big enough (about **9/16"**-diameter) to eliminate interference with the washer under the head of the strut beam mounting bolt.

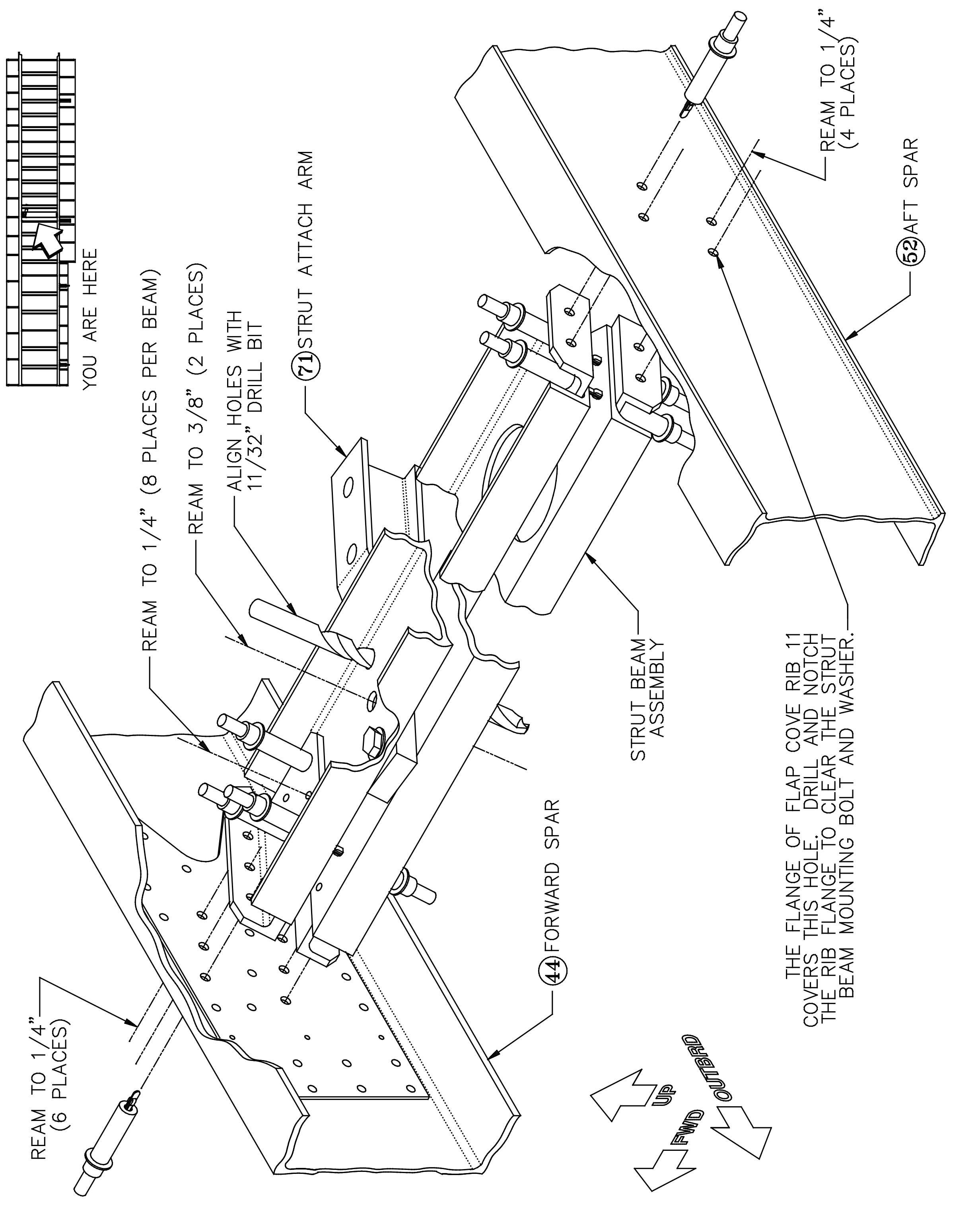

Figure 35: Reaming the Holes in the Strut Beam Assembly

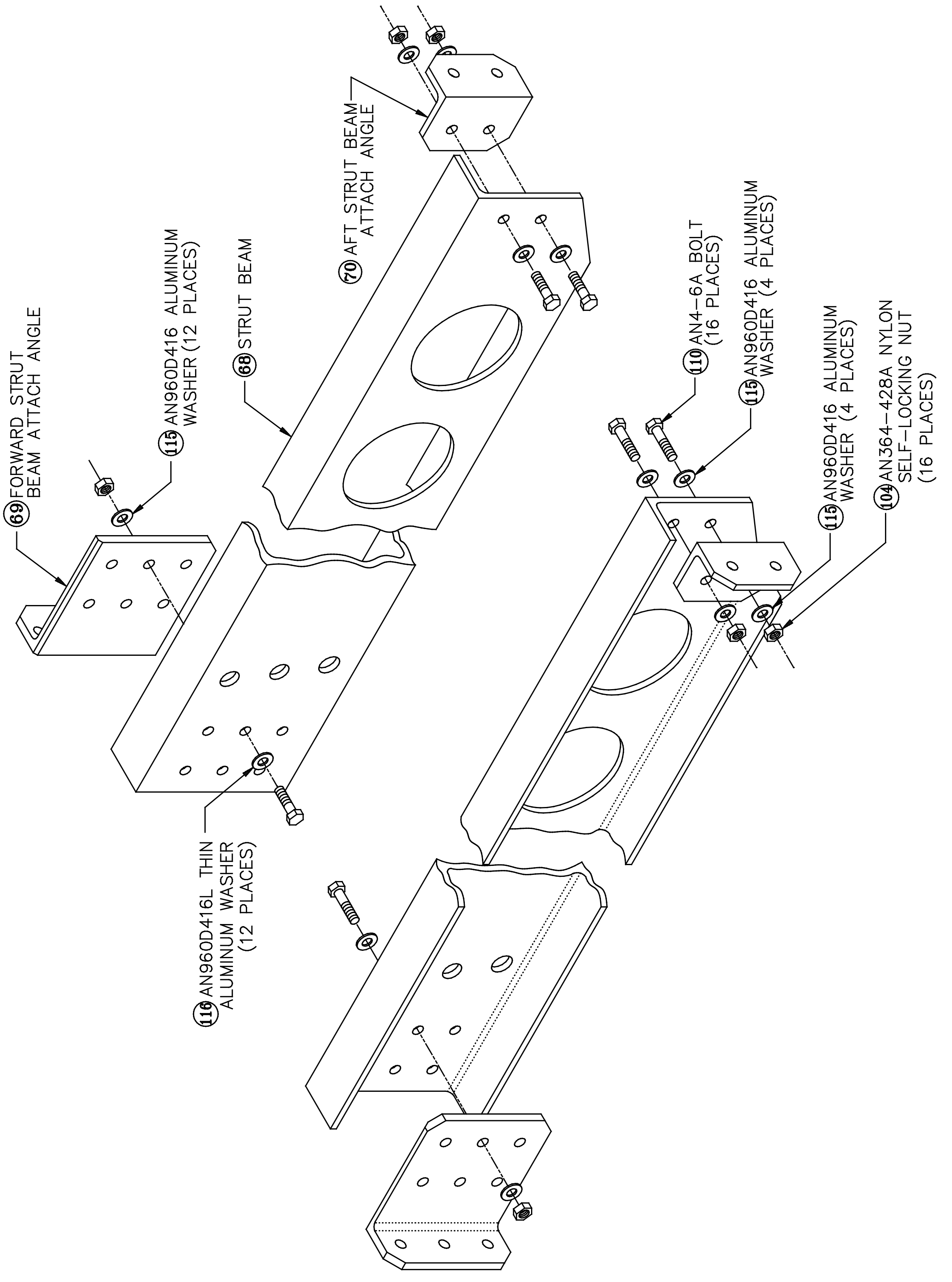

Figure 36: Strut Beam Assembly

The strut attach arm is pinned between the two strut beams with a 3/8" bolt through one hole and an 11/32" drill bit through one of the other holes, as shown in Figure 35. Ream the empty hole through all three parts to 3/8" diameter.

> **Note** Use a 3/8" reamer or drill bit to ream the hole. Trial fit an AN6-13A bolt in the hole just reamed; it should be a medium push fit. If the bolt is too loose, try step drilling first with either a 23/64" or letter "U" bit and then drill up to 3/8".

Insert a 3/8" AN6-13A bolt through the hole just reamed, remove the 11/32" drill bit and ream the last hole.

After all the holes have been reamed, remove the strut beam assembly from between the spars. Using nuts and bolts to maintain alignment, ream any holes you were unable to reach before. Disassemble the strut beams and deburr the holes in all the parts. Corrosion-proof the strut beams, the attach angles and the strut attach arm.

> **Note** The strut attach arms have been anodized for corrosion resistance, so only the bolt holes that you reamed require additional protection. Do **not** use an alodine treatment on the strut attach arms as this can damage the anodized finish.

Secure a forward strut beam attach angle to each strut beam using six AN4-6A bolts and AN364-428A **nylon lock nuts** [104]. Install (AN960D416L) **thin aluminum washer**s[116] under the bolt heads and (AN960D416) **washers** [115] under the nuts, as shown in Figure 36. Torque the fasteners to the proper value, as described in "SECTION II: TOOLS AND TECHNIQUES, AIRCRAFT FASTENERS, *Torque Values*."

> **Note** Washers are used under the bolt heads only to adjust the length of the bolt shank. The shank length of AN bolts can vary slightly, so you may have to use different washers than those specified. In general, don't use a washer under bolt heads unless the shank extends all the way through the last piece in an assembly. Threads should not contact the interiors of holes in structural pieces.

Secure an aft strut beam attach angle to each strut beam using two AN4-6A bolts and AN364-428A nylon self-locking nuts, as shown in Figure 36. Install an AN960D416 aluminum washer under both the bolt head and the nut.

Install the strut attach arm between the strut beams using AN6-13A bolts, AN960D616 **aluminum washers** [117] and AN364-624A **nylon self-locking nuts** [105], as shown in Figure 34. Place the bolt heads on the upper side. Place washers under both the bolt heads and the nuts.

Completed: Left [ ] Right [ ]

Step 22: Mount the Strut Beam Assembly

Install the strut beam assembly between the spars, and fasten it to the forward spar using six AN4-6A bolts and AN364-428A nylon self-locking nuts, as shown in Figure 37. The washer for the **upper, outboard** bolt head must be ground to fit the contour of the spar; use a file or a bench grinder to modify an AN960D416 aluminum washer to fit, as shown in the detail in Figure 37. The other five bolts use an AN960D416L thin aluminum washer on the forward side under the bolt head. All six bolts use AN960D416L thin aluminum washers under the nut.

Fasten the strut beam assembly to the aft spar with four AN4-6A bolts and AN364-428A nylon self-locking nuts. Use AN960D416L thin aluminum washers under the bolt heads and standard AN960D416 aluminum washers under the nuts.

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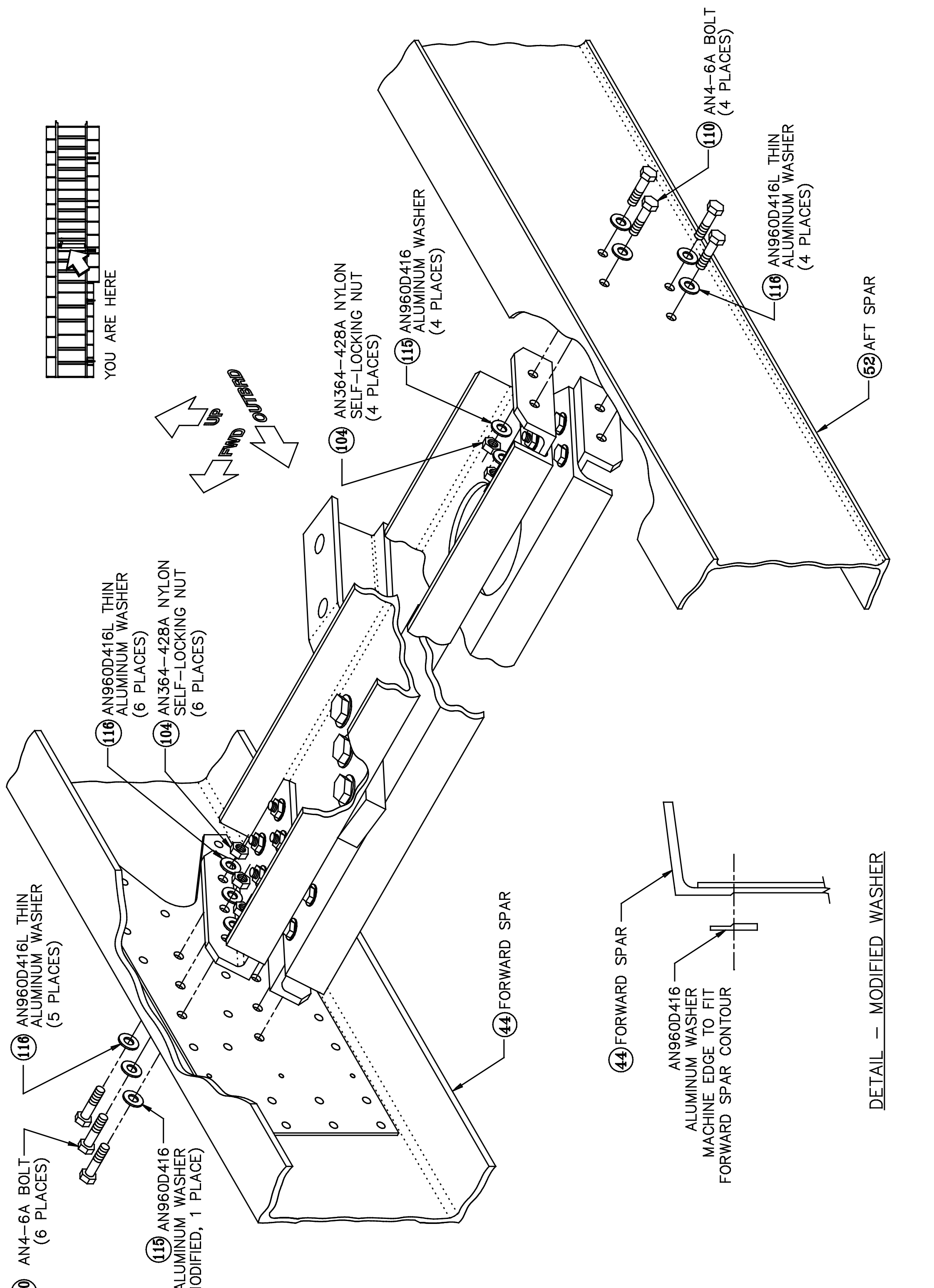

Figure 37: Strut Beam Assembly Installation

FIT-UP AND DRILL THE WING SKINS

Step 23: Position, Clamp and Index Drill the Outboard Leading Edge Skin

Note The **inboard** leading edge skin is **45-7/16"** long, the **center** leading edge skin is **62-1/2"** long and the **outboard** leading edge skin is **71-3/4"** long. The **inboard** skin has pilot holes for drilling rivet holes through the nose ribs at **both** ends (in addition to the holes for the intermediate ribs, of course); the other two skins **do not** have nose rib pilot holes at the **inboard** ends. (The outboard end of each skin overlaps the inboard end of the adjacent skin. If any of the skins, other than an inboard skin, has pilot holes for a rib at the inboard end, **something is wrong**! Make sure that you have selected the correct skin for the location.) It is very difficult to distinguish between the upper and lower surfaces of the leading edge skins visually. When you wrap the skin around the nose ribs, however, it will very obviously fit if it is right side up and equally obviously not fit if it is upside down. Refer to Figure 38 for help identifying and orienting the leading edge skins.

Note Before beginning to fit your wing skins (as before any major fitting and drilling operation) check that your wing jig posts are still plumb and true and that the spars are still straight. Make any necessary adjustments. Any twist or misalignment will be locked permanently into the structure once the wing skins are drilled.

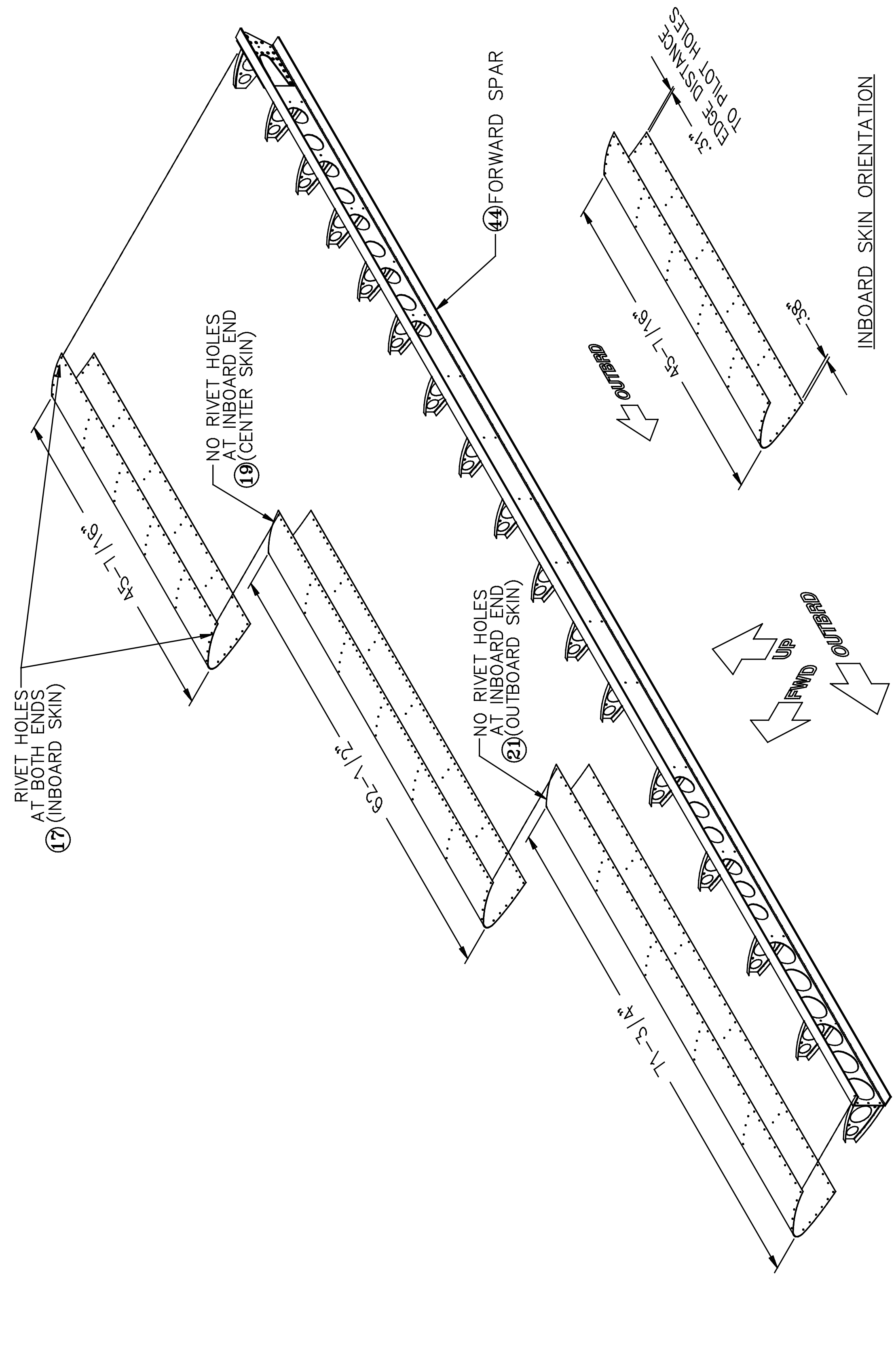

Figure 38: Leading Edge Skins

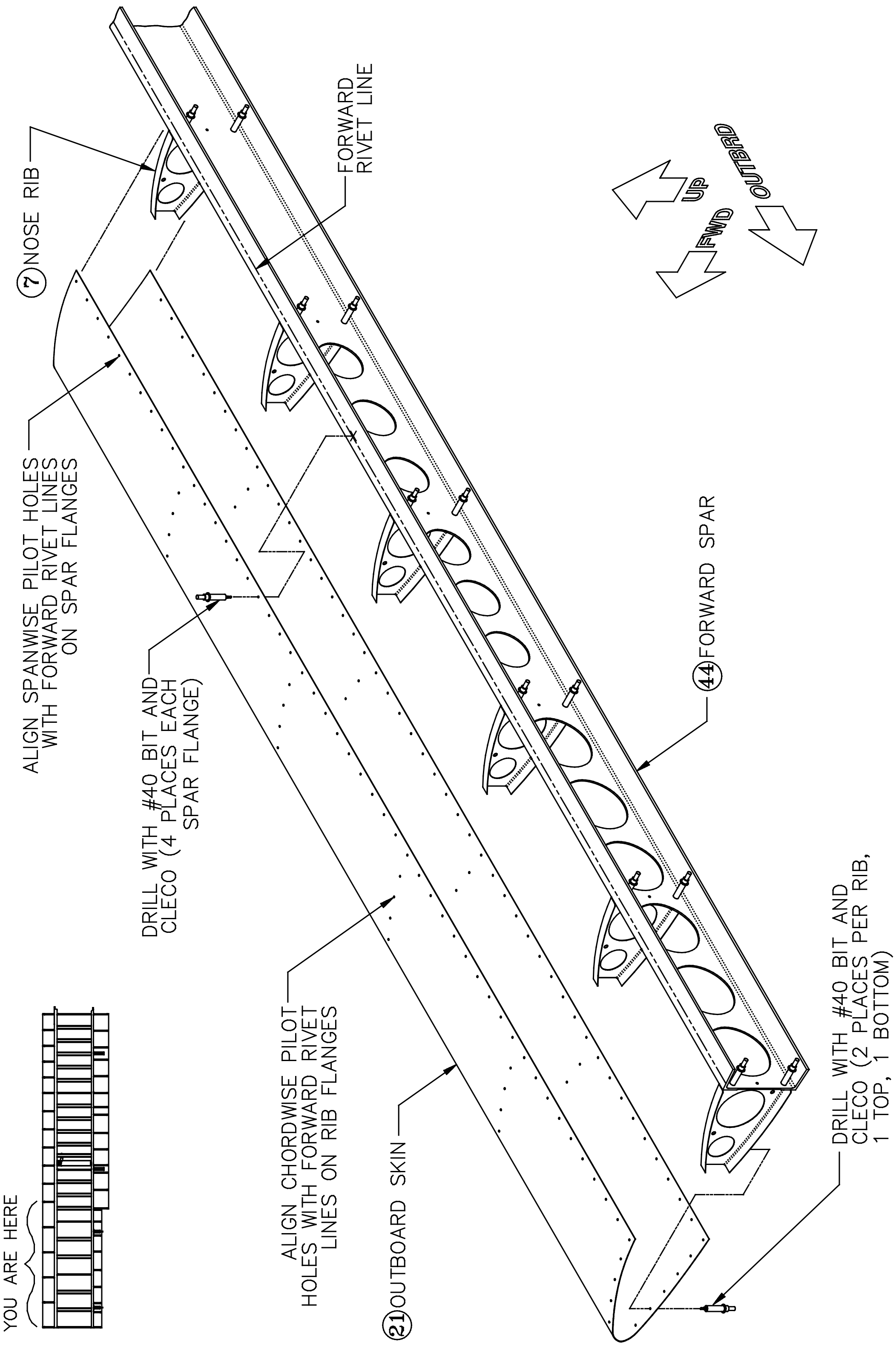

Figure 39: Leading Edge Skin Installation

Note We recommend transferring the rivet lines marked on the nose rib flanges to the forward spar flanges. This will help you to position the leading edge skins correctly in the spanwise direction.

Slide the **outboard leading edge skin** [21] over the nose ribs and forward spar, as shown in Figure 39, aligning the chordwise row of pilot holes in the skin with the centerline marked on the outermost nose rib. When the rib is held perpendicular to the spar and the marked line is aligned under the pilot holes, the outboard edge of the skin will extend **just slightly** (approximately 1/16") beyond the outboard end of the spar and the outboard edge of the rib flanges. Hold the skin tightly against the nose ribs and spar and shift its position forward and aft around the leading edge, as necessary, until the **forward** rivet lines you drew on the spar flanges in Step 14 appear centered in the pre-punched pilot holes in the skin on both the top and the bottom.

Hint If you don't have a helper available for this procedure, you can use cabinetmaker's web clamps to pull the leading edge skin into position. Place wooden blocks against the spar web at each clamp position so that the clamps don't deform the spar flanges when tightened. Also, position the straps over nose ribs to avoid deforming the skins. Be careful not to pull the straps too tight.

It will be easier to fit the skin into position if you make sure the nose ribs are all straight so that the rivet lines you marked on the rib flanges appear in the pilot holes in the skin. To align the ribs you can use a sharp scribe or an awl inserted through the skin pilot holes to lever the ribs into position or use the rib alignment probe described in "ALUMINUM SHEET METAL WORK, *Clamping Parts Together*" in "SECTION II: TOOLS AND TECHNIQUES."

Once you have the skin positioned satisfactorily, use Cleco side-grip clamps or C-clamps to secure it to the spar flange and to the outboard rib flange.

With the outboard leading edge skin clamped in position, use the pilot holes in the skin as a guide to drill one **#40** index hole through the skin and the spar flange near each end of each spar flange rivet line. Insert a Cleco into each hole to hold the skin in place. Drill and Cleco a few more **#40** holes along the spar flange between the ends on both the top and the bottom.

Note For the holes near the ends of the skin, use holes a few inches inboard or outboard of the ends. This way, if a skin's position has to be shifted slightly, it won't affect a hole common to another skin. Don't drill all the rivet holes until the other leading edge skins have been positioned, aligned and index drilled.

Adjust the nose rib alignment, if necessary, and then use the pilot holes in the skin as a guide to drill two **#40** holes (one on the upper surface and one on the lower surface) through each nose rib **except for the rib under the inboard end of the skin** (Nose Rib 12). The outboard skin does not have pilot holes for drilling Nose Rib 12; these holes will be drilled after the center skin, which overlaps the outboard skin, has been positioned.

Since the inboard end of the outboard skin hides the rivet line marked on the flange of Nose Rib 12, the rivet line must be transferred to the outside surface of the skin so that it will be visible through the pilot holes punched at the outboard end of the center skin. Use a fine-point marking pen to mark rivet lines onto the outboard skin parallel to and **3/8"** from the inboard end of the skin, as shown in Figure 40.

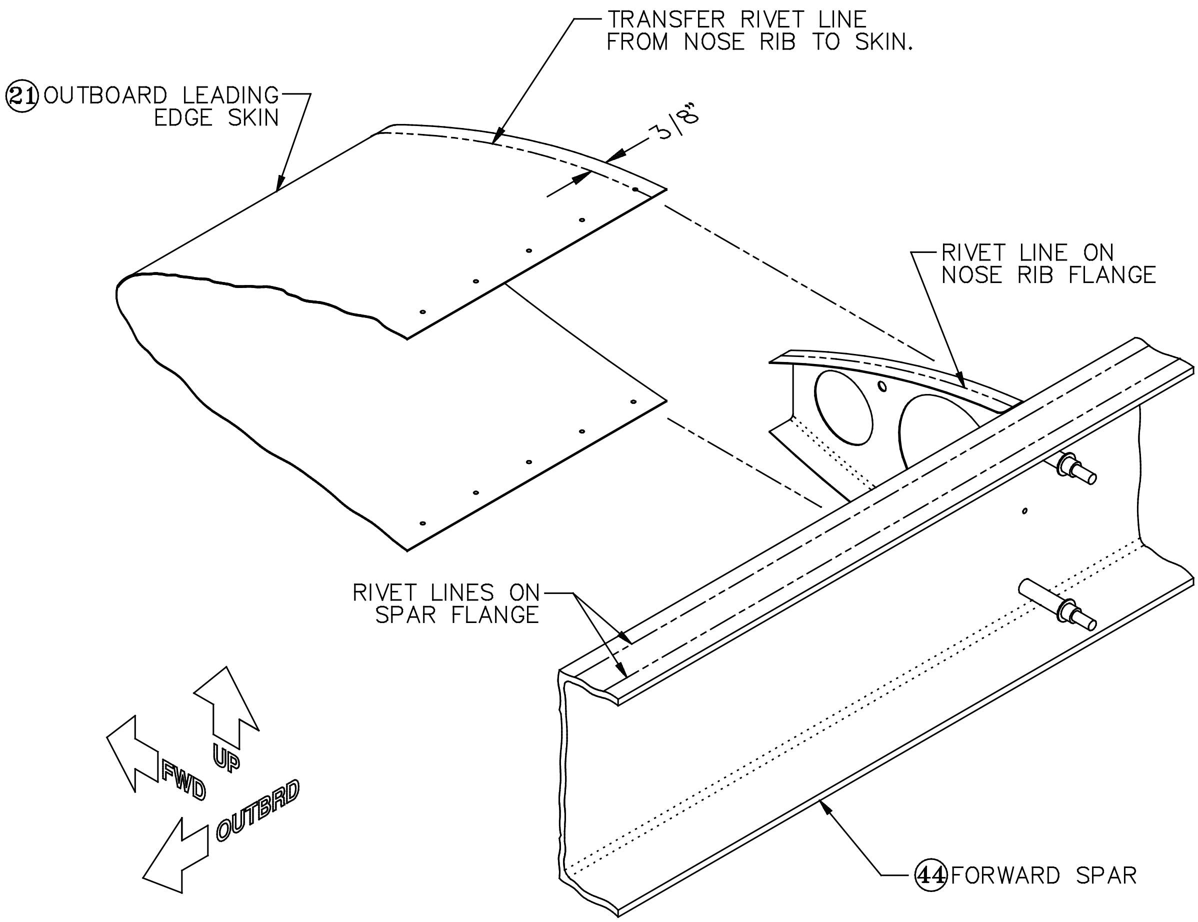

Figure 40: Transfer Nose Rib Rivet Line to Skin

Note Since there are no pilot holes in the outboard skin, you can't tell if Nose Rib 12 is properly aligned when drilling. We recommend removing Nose Rib 12 until a couple of holes have been drilled in the overlap between the center and outboard skins. Then you can reinstall Nose Rib 12 and see the rivet line on its flange to align it for drilling. Use the same procedure for Nose Rib 6, which lies under the overlap for the center and inboard skins.

Completed: Left [ ] Right [ ]

Step 24: Position, Clamp and Index Drill the Center and Inboard Leading Edge Skins

Caution Since the **inboard** leading edge skins are nearly symmetrical, it is very easy to install them on the wrong side (right skin on left wing and vice versa). To distinguish between the left and right skins, notice that the edge distance to the center of the first chordwise row of pilot holes at the **inboard** end of each skin is **.31"** and the edge distance to the first row of pilot holes at the **outboard** end is **.38"**, as shown in Figure 38. After making sure that the inboard skin is right side up, therefore, check to make sure that the end with the smaller edge distance to the pilot holes is installed inboard. As a general rule for **all** of the wing skins, take your time and be **absolutely certain** that you have chosen the correct skin for each location before drilling any holes. After you have drilled rivet holes, mark each skin with its location and orientation.

Repeat the process described in the previous step for the **center** [19] and the **inboard leading edge skins** [17], in that order. Refer to Figures 38, 39 and 40. The outboard end of each skin overlaps the inboard end of the adjacent skin. Position the **center** leading edge skin in the spanwise direction so that the pilot holes for the nose rib rivets are best centered over the rivet lines marked on Nose Ribs 7 through 12. (The Nose Rib 12 rivet line is actually marked on the outside of the outboard skin.)

Since the outboard end of each skin overlaps the previous skin, the spanwise rows of pilot holes for the rivets into the spar flanges will be pulled forward slightly, away from the rivet lines marked on the spar flanges, as shown in Figure 41. This means that the lines of rivet holes will not be perfectly parallel to the marked rivet lines, which is acceptable. Adjust the skins so that the pilot holes on the upper and lower surfaces are offset an equal distance from the rivet lines at their outboard ends. In other words, try to distribute the misalignment caused by the overlap of the skins equally between the upper and the lower surface.

Note Peel off the protective plastic coating from the underlying skin at the overlap. This will reduce the misalignment and result in a tighter fitting skin when finished.

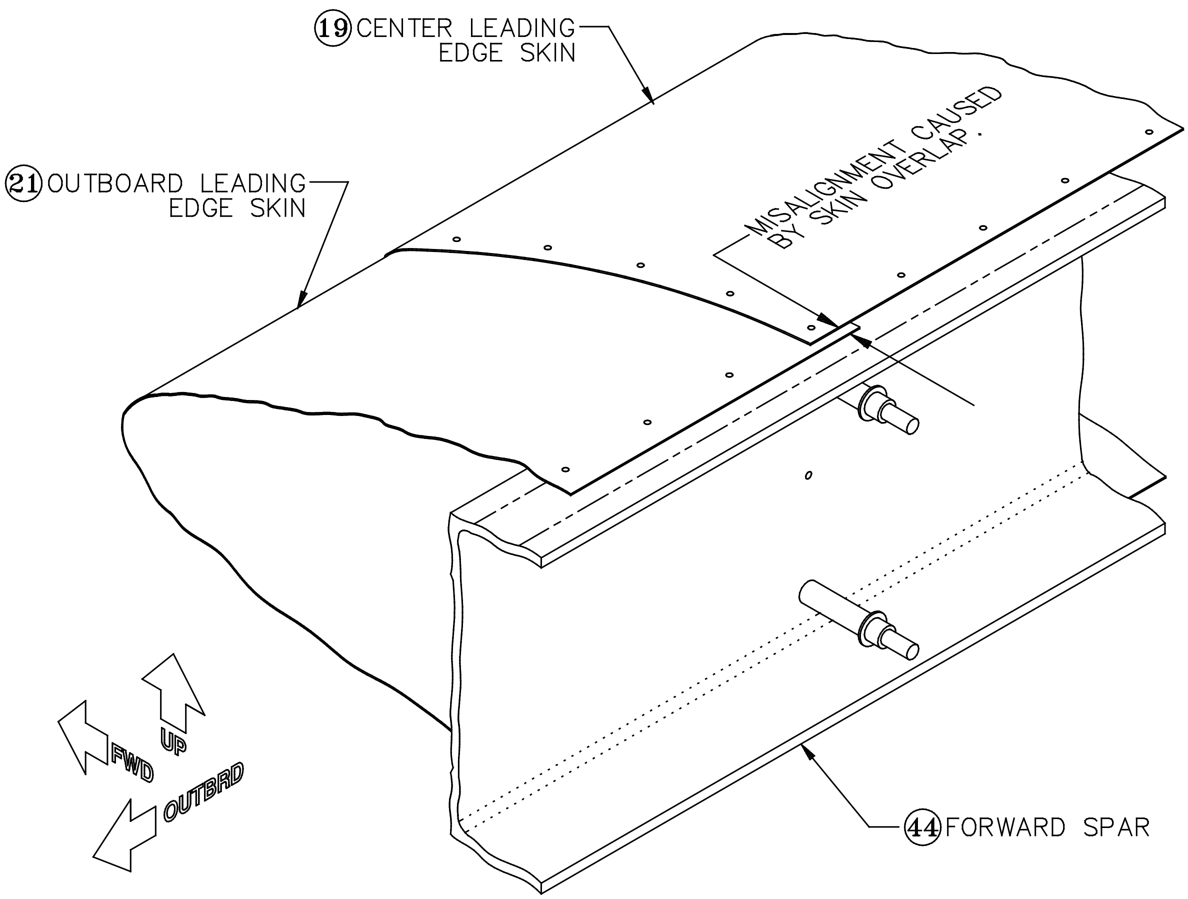

Figure 41: Rivet Line Misalignment Caused by Skin Overlap

Use two tightly stretched strings along the leading edge of the wing (one about 2" back from the nose on the upper surface, the other the same distance back on the lower surface) or a long straightedge to monitor alignment of the leading edge (or simply sight down the leading edge). Adjust the positions of the skins, by shifting their upper and lower trailing edges in opposite directions (fore and aft) relative to the forward spar flange, until the entire wing leading edge is a straight line from root to tip, without dips or jogs (other than those resulting from the skin overlaps) where the skin sections meet. You'll find that small corrections in the skins' positions at the spar result in relatively large changes in the alignment of the leading edge. (To accomplish a straight leading edge, it may be necessary also to adjust the position of the outboard leading edge skin. This is acceptable since only a few holes have been drilled at this time and the holes through the spar flange are undersized to accommodate adjustment.)

When the positions of the center and inboard leading edge skins have been set, drill and Cleco several index holes, first through the spar flanges and then through the nose ribs for each skin in turn, as was done with the outboard skin.

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Step 25: Finish Drilling the Leading Edge Skins

With all three leading edge skins satisfactorily positioned, you are ready to finish drilling all of the rivet holes. Before doing so, however, mark each skin for its location and orientation, remove the skins, brush off all chips resulting from the index drilling and reassemble. Removing drill chips will help prevent gaps between the skins and the structural framework while drilling.

Note Once again, before beginning to drill, check your jig for plumb and true and check that the spars are straight. This is also your last chance to check that the pilot holes in the skins are well aligned with the rivet lines marked on the rib and spar flanges and to make any minor adjustments.

Except for the rivet holes through the lower spar flange for the inboard leading edge skin, first drill **#40** holes through the spar flanges, using the pilot holes in the skins as guides. Drill every hole, inserting a Cleco into every second or third hole to maintain alignment and to keep the skins clamped tightly to underlying structure while drilling.

Note The **inboard skin lower spar flange** rivet holes (except for the few #40 alignment holes drilled during initial skin fit-up) will be drilled when the lower inboard skin is installed in a subsequent step.

When you have finished drilling all the holes through the spar flange on one side (either upper or lower first is fine), repeat the process on the other side. Then, use the pilot holes in the skins as guides to drill **#40** holes through all the nose ribs. Again, pin every second or third hole as you go.

Hint When drilling the skins, make sure they're clamped securely along their edges. 2"-wide masking tape works well in addition to Clecos. Rather than starting at one end of a line of holes and drilling to the other end, drill holes at the ends and then in the middle of the line; then drill halfway between the holes already drilled, continuing in this fashion until all the holes are finished.

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Step 26: Deburr the Leading Edge Skins and the Nose Ribs

Remove the leading edge skins and nose ribs and deburr the rivet holes according to the instructions in "SECTION II: TOOLS AND TECHNIQUES". Be sure also to brush off any chips or shavings that might be clinging to the parts away from the holes. When everything is clean, reassemble in the original order.

Completed: Left [ ] Right [ ]

Step 27: Position and Drill the Upper Main Skins

Note The **inboard** upper skin is **45-7/16"** long, the **center** upper skin is **73-1/2"** long (and also has a jog in the trailing edge at the flap-aileron juncture) and the **outboard** upper skin is **60-11/16"** long. The jog in the center skin is near the **outboard** end. The **inboard** skin has full rows of pilot holes for the main rib rivets at **both ends**; the other two skins have just a few pilot holes for the main rib rivets at the **inboard** ends. Refer to Figure 42. To distinguish between the left and right upper skins, notice that the protective plastic coating is installed on the **outside** of the wing (the side that's visible after assembly). To distinguish the upper skins from the lower skins, notice that each of the **upper** skins is longer in the chordwise direction than the corresponding lower skin. (The center and outboard **lower** skins also have inspection hole cutouts.) The single chordwise lines of pilot holes in all main skins are for riveting to the wing ribs; the double lines of holes are for riveting the hat section stiffeners.

Caution It is very easy to install the **inboard** skins on the wrong sides; the skins are nearly symmetrical so that the rivet holes in them can appear to be properly aligned with the ribs when they're not. To distinguish between the inboard and outboard ends of the inboard skins, notice that the spacing between the two rows of pilot holes for drilling **Flap Cove Ribs 1 and 2** is about **9-3/8"** and the spacing between the holes for **Flap Cove Ribs 5 and 6** is about **9-5/8"**, as shown in Figure 42. When installing the inboard skin (as with all skins), check very carefully to verify that the pilot holes align correctly with the rivet lines marked on the ribs before drilling any holes. Although our Quality Assurance Department makes every effort to be accurate in stamping part numbers on the parts, you should not rely **solely** on the stamped part numbers to identify the wing skins. If you have any questions at all about whether you have chosen the proper skin for a particular location, refer back to the distinguishing features and dimensions discussed above **before** drilling any holes!

Note Once again, check your wing jig for plumb and true and check your spars for straightness before beginning the procedures described in this step.

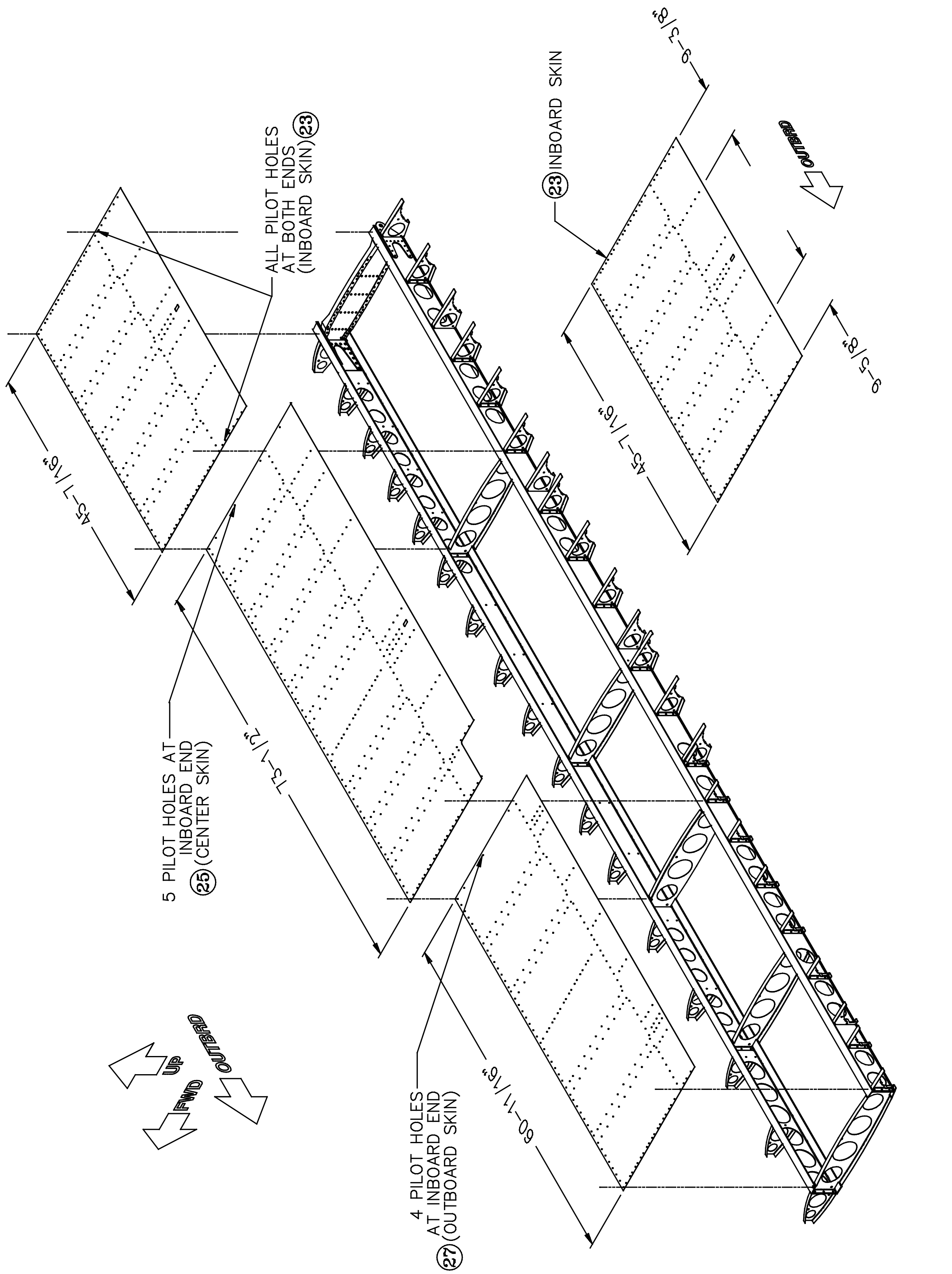

Figure 42: Upper Main Skins

Begin with the **upper outboard skin** [27]. As shown in Figure 43, align the outboard end of the skin with the outboard edge of the outboard main rib flange; align the forward spanwise line of pilot holes in the skin with the aft rivet line on the forward spar flange.

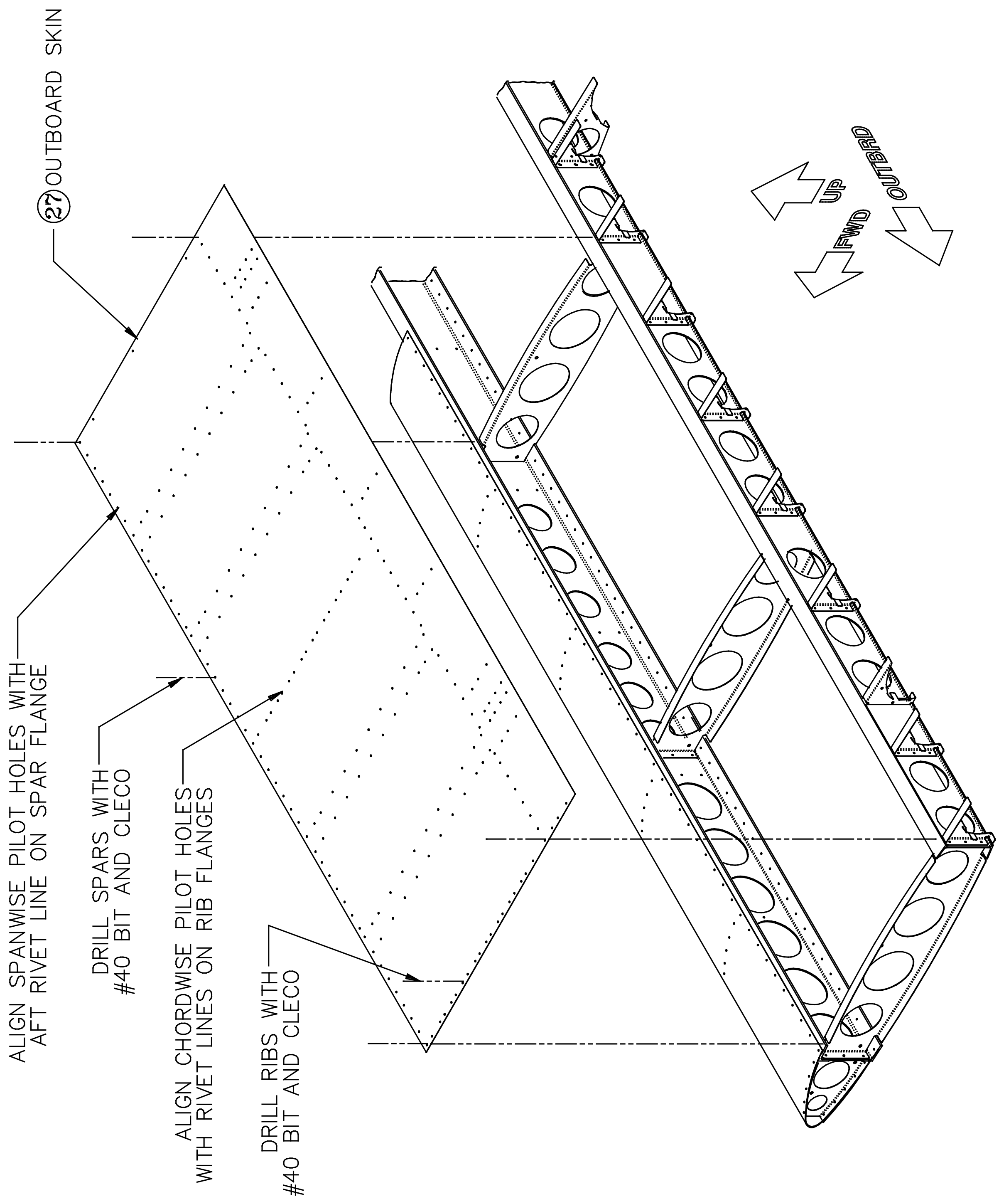

Figure 43: Upper Outboard Skin Installation

Note The forward edge of the upper outboard main skin overlaps the aft edge of the leading edge skin, as shown in Figure 44. This is acceptable for now. The skins will be trimmed in a later step to eliminate the overlap.

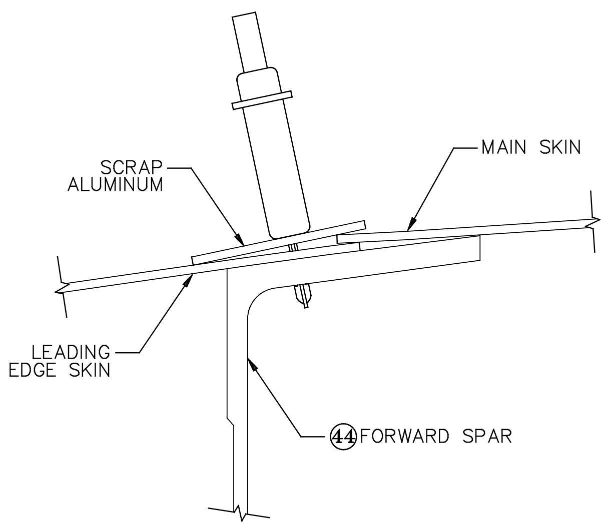

Figure 44: Clamping Method for Main Skins

Use Cleco side-grip clamps or C-clamps to clamp the upper outboard skin to the Main Rib 4 and 6 flanges. Use the method shown in Figure 44 to clamp the skin along its leading edge. To use this method, drill #30 holes in some small, square pieces of 1/16" scrap aluminum sheet, and Cleco these pieces to the wing assembly using the same Clecos securing the leading edge skins. The Clecos exert pressure against the aluminum scraps, which in turn clamp the main skin against the spar flange.

Hint 2" wide masking tape also works well to secure the edges of the main skins.

When the skin is fitted satisfactorily (pilot holes aligned over the rivet lines on the spar and rib flanges), use the pilot holes in the skin as guides to drill three or four **#40** holes through the forward spar, and Cleco the skin in place. Also, using a **#40** bit, drill and Cleco the skin to the main ribs in one or two places per rib, to the aft spar in three or four places and to the aileron cove ribs in one place per rib, in that order.

Repeat this process first for the **upper center skin** [25] and then for the **upper inboard skin** [23]. As with the leading edge skins, lap the outboard ends of the center and inboard skins over the inboard ends of the adjacent skins.

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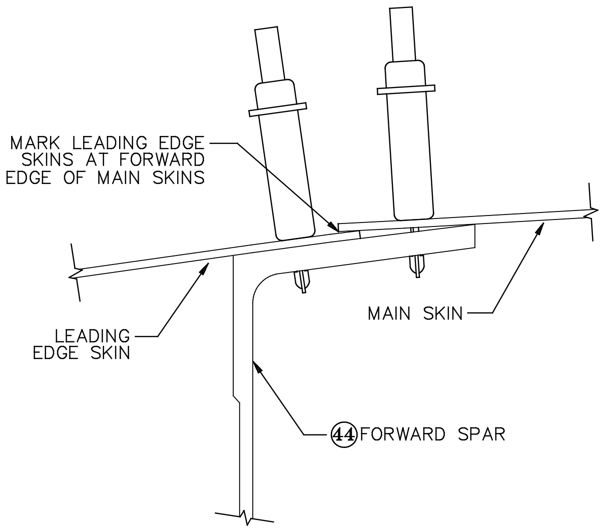

Figure 45: Marking the Leading Edge Skins for Trimming

Step 28: Mark and Trim the Leading Edge Skins

With all three upper main skins drilled in several places and secured with Clecos as described in the previous step, use a fine point pen to mark along the forward edges of the main skins onto the leading edge skins, as shown in Figure 45.

Remove all the skins and trim the leading edge skins to the marked lines. To do this, first use a pair of offset shears to trim just aft of the line and then file forward to the line.

Note There is no absolute requirement that **only** the leading edge skins be trimmed. You could just as well trim half the necessary width off both the leading edge skins and the main skins. You might want to do this, for example, if the main skins have become nicked along their forward edges or if trimming just the leading edge skins would reduce the edge distance to the centers of the leading edge skin rivet holes to less than the required minimum dimension (5/16" or 2-1/2 times the rivet diameter for countersunk rivets). Since the edges of the skins tend to spread out slightly when riveting, you might want to leave just the slightest gap (.010" or so) between the skins when you have finished trimming them to avoid buckling when riveting.

Hint To simplify trimming the leading edge skins, use a **milled curved-tooth file**. This file, also called a “body file” or a “panzer file,” has widely spaced, curved teeth for easy chip clearance. It removes material rapidly and leaves a smooth finish.

Deburr the edges of the leading edge skins when you have finished trimming them.

Completed: Left [ ] Right [ ]

Step 29: Finish Drilling the Upper Main Skins

Brush off all chips and shavings and reinstall the leading edge and main skins to the wing structure. Make sure that the main skins no longer overlap the leading edge skins anywhere; trim the leading edge skins further, if necessary.

When the skins are fitted satisfactorily, use the pilot holes in the main skins as guides to drill all the rivet holes through the spars and the ribs. First drill **#40** holes through the forward spar flanges, and insert a Cleco into every second or third hole. Then drill and Cleco **#40** holes through the main ribs. Next, drill and Cleco **#40** holes through the aft spar. Finally, drill and Cleco **#40** holes through the flap and aileron cove ribs.

Note The rivet holes through the spars will be enlarged to #30 diameter as a final step after all of the skins, the forward spar cap strips and the hat section stiffeners have been installed.

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Step 30: Position and Drill the Lower Outboard and Center Main Skins

Use the same procedures described for the **upper** skins in Steps 27 through 29 to position and drill the **lower outboard skin** [33] and the **lower center skin** [31], in that order.

Note The procedures for installing the **lower inboard skin** [29] and the **lower inboard skin doubler** [38] are different, and will be described below in Steps 32 and 33.

Caution As described for the other wing skins in previous steps, make sure that you have chosen the correct skin for each location before drilling any holes. In particular, notice that, like the other skins, the **inboard** ends of the **center** and **outboard** skins have just a few pilot holes for indexing to the ribs (instead of full rows of pilot holes).

Completed: Left [ ] Right [ ]

Step 30.1: Trim the Aileron Cove Ribs (Early Kits Only)

The flap and aileron cove skins, which will be installed in Steps 82–85 of "SECTION X: FINAL ASSEMBLY," are riveted to the aft edges of the lower main skins, which extend aft beyond the cove ribs. On the earliest GlaStar kits, the **lower outboard main skin** and the aileron portion of the **lower center main skin** are too narrow to accommodate installation of the aileron cove skins. To determine if your skins are affected, measure the width of the lower outboard main skin (the distance from the leading edge to the trailing edge) and the length of the **outboard edge** of the lower center main skin. If this distance is about **22-1/4"**, you have the narrow skins and must modify the aileron cove ribs, as described below. If your skins are about **22-1/2"** wide, they are okay; no modification is needed.

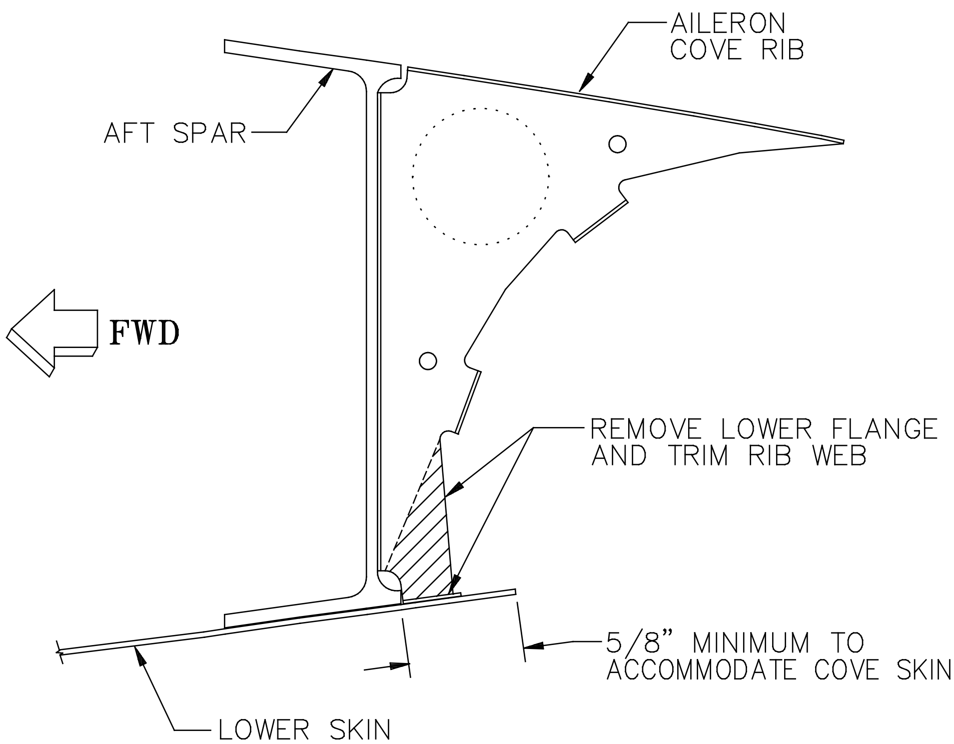

Figure 45.1: Trimming the Aileron Cove Ribs (Early Kits Only)

If you have the narrow skins, use sheet metal snips to remove the **lower flange** and trim the **web** of each **aileron cove rib**, as shown in Figure 45.1. Smooth the cut edges with files and/or sandpaper. The lower skins must extend aft at least **5/8"** beyond the trimmed cove ribs and the aft spar to accommodate the cove skins.

In addition, if the lower outboard main skin and the aileron portion of the lower center main skin are not of equal width (measured from the leading edge to the trailing edge), trim the trailing edge of the wider skin to match the narrower.

Completed: Left [ ] Right [ ]

Step 31: Install the Lower Center Skin Gusset

A small, triangular gusset is installed under the **forward, inboard corner** of the lower center skin to reinforce this area. Use sheet metal shears to cut the 6" square **lower center skin gusset** [43] into two pieces along one of its diagonals. This makes two triangular gussets, one for each wing.

Remove the lower center skin and position the triangular gusset against the **inside** surface of the lower center skin with the **forward** and **inboard** edges of the gusset and the lower skin aligned. Use a felt pen to mark the five inboard rivet holes in the forward edge of the lower center skin onto the gusset. Separate the gusset from the skin and trim the gusset's angled, outboard edge so that only four marked rivet holes remain. Make sure to maintain a minimum edge distance of 2-1/2 rivet diameters to the center of the furthest outboard hole. After trimming the gusset, deburr the cut edge.

Clamp the gusset in position against the inside surface of the lower center skin. Use the **#40** rivet holes in the forward edge of the lower center skin as guides to drill matching holes through the gusset. Be careful not to enlarge or elongate the rivet holes in the main skin.

Use Clecos to reinstall the lower center skin, with the gusset sandwiched between the skin and the spar, as shown in Figure 46. The holes through the inboard edge of the gusset (and the lower center main skin) will be drilled when the lower inboard skin is installed in the next step.

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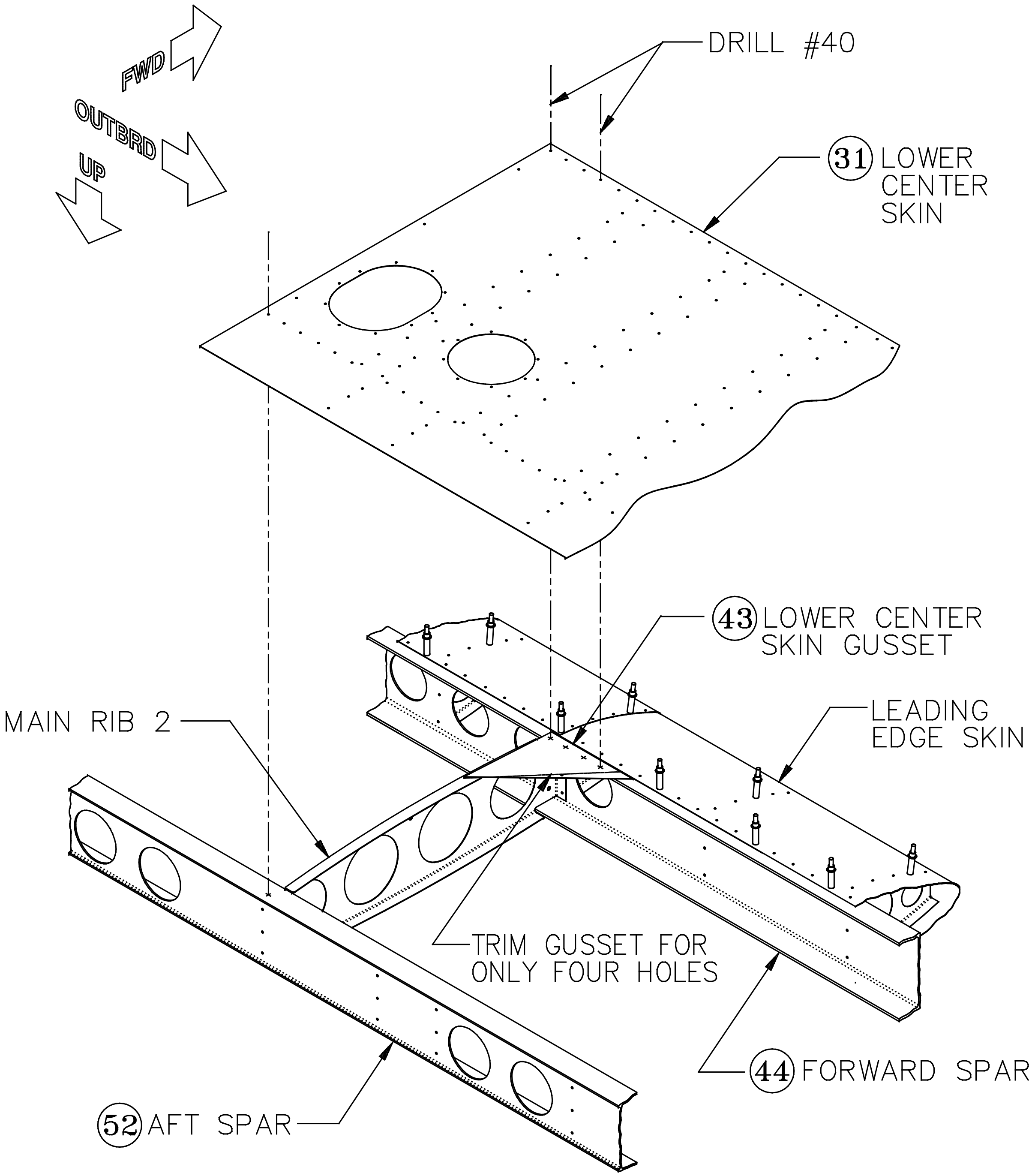

Figure 46: Lower Center Skin Gusset

Step 32: Position and Drill the Lower Inboard Main Skin

The **lower inboard main skin** [29], unlike the other main skins, is overlapped by the leading edge skin and is secured by a double row of rivets to the lower forward spar flange. The lower inboard skin comes pre-drilled with one row of pilot holes for the forward spar flange rivets; these pilot holes are positioned over the **aft** rivet line marked on the forward spar flange. (See Figure 47.) The second row of rivets is the same one that secures the leading edge skin.

> **Caution** Distinguishing between the left and right lower **inboard** skins is the same as for the upper inboard skins: the spacing between the pilot holes for **Flap Cove Ribs 1 and 2** is about **9-3/8"**, and the spacing for **Flap Cove Ribs 5 and 6** is about **9-5/8"**.

Remove the inboard leading edge skin. Position the lower inboard main skin on the wing structure with its outboard end overlapping the inboard ends of both the center leading edge skin and the lower center main skin, as shown in Figure 48. Align the forward, spanwise line of pre-drilled pilot holes in the lower inboard main skin with the **aft** rivet line marked on the lower forward spar flange, as shown in Figure 47. Align the chordwise lines of pilot holes in the skin with the rivet lines marked on the rib flanges. Use the pilot holes in the lower inboard skin as guides to drill several **#40** rivet holes through the forward spar, the main ribs, the aft spar and the flap cove ribs, in that order. Cleco as you go.

Transfer the **forward** rivet line on the lower spar flange to the outside surface of the inboard lower main skin. Reinstall the inboard leading edge skin with its lower aft edge overlapping the forward edge of the inboard lower main skin, as shown in the detail in Figure 47. Cleco the leading edge skin to the **upper** spar flange and to the nose ribs through the holes drilled earlier in Step 25. Position the pilot holes in the lower aft edge of the leading edge skin over the rivet line marked on the lower inboard main skin.

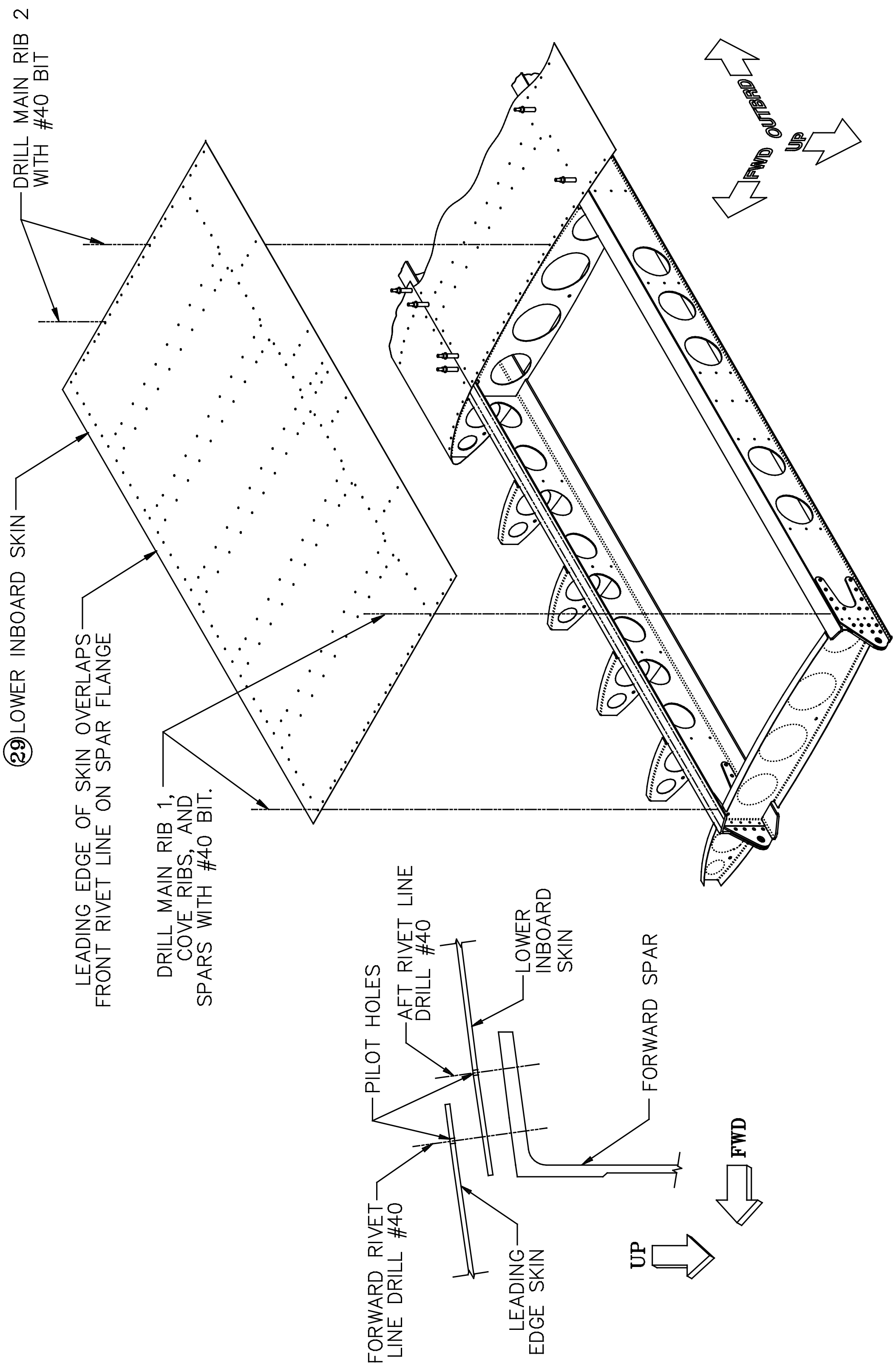

Figure 47: Lower Inboard Main Skin Installation

Use the pilot holes in the lower aft edge of the **leading edge skin** as guides to drill the **forward** line of **#40** rivet holes through the lower inboard main skin and the lower forward spar flange, as shown in Figure 48. Cleco as you go. Use the forward, spanwise row of pre-drilled pilot holes in the **lower inboard main skin** to drill the **aft** line of **#40** rivet holes through the forward spar flange, as shown in Figure 47. (These #40 holes will be enlarged to #30 diameter as a final step after the forward spar cap strips and the hat section stiffeners have been installed.)

Once all the holes through the forward spar have been drilled and Clecoed, use the pilot holes in the outboard end of the lower inboard main skin to drill **#40** rivet holes through the inboard end of the lower center skin, the inboard end of the lower center skin gusset and Main Rib 2. Finally, use the pilot holes in the lower inboard skin as guides to drill **#40** rivet holes through Main Rib 1, the aft spar and the flap cove ribs, in that order. (The #40 holes through the spars and Main Ribs 1 and 2 will be enlarged to #30 diameter in a later step.)

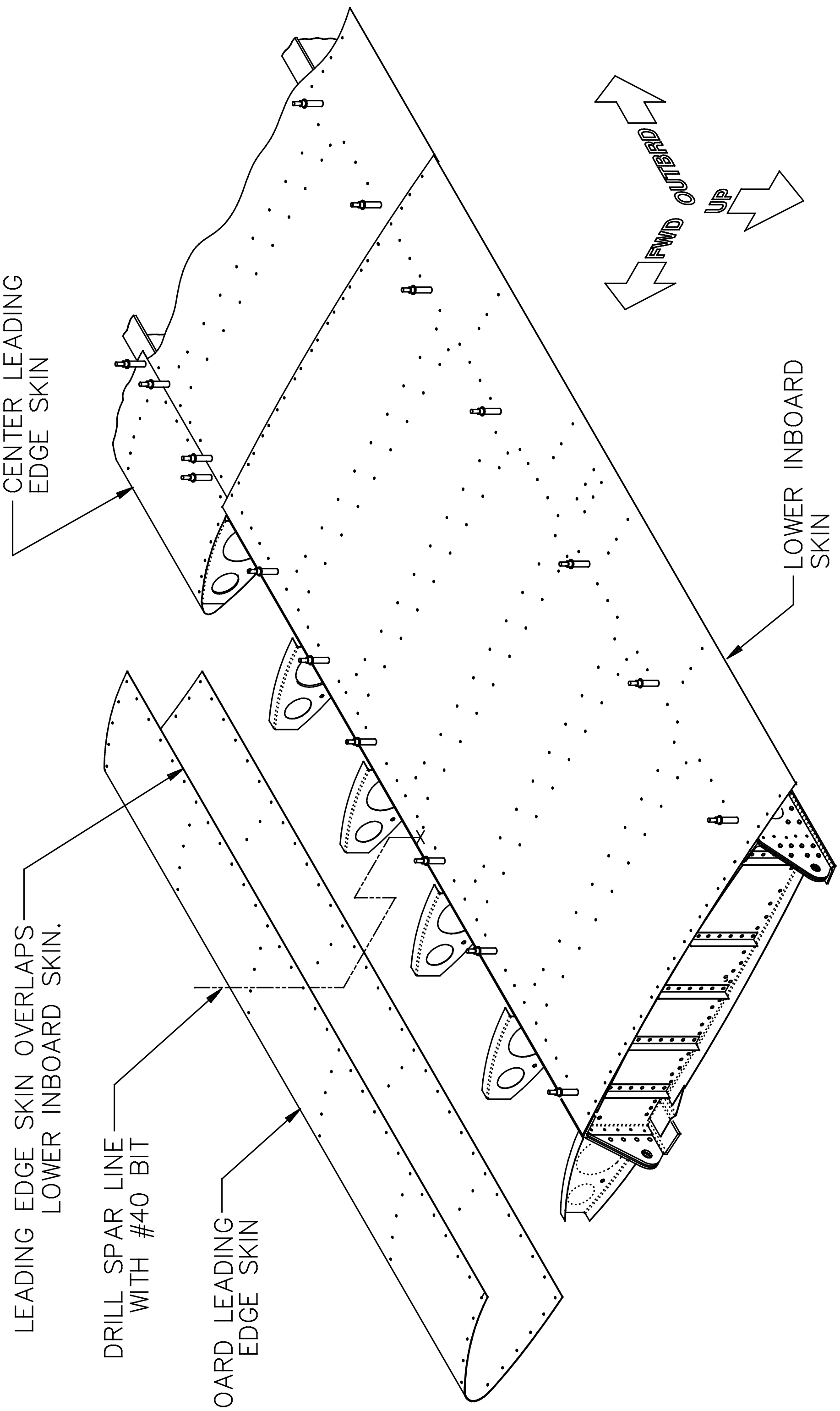

Figure 48: Fitting the Leading Edge Skin over the Lower Inboard Skin

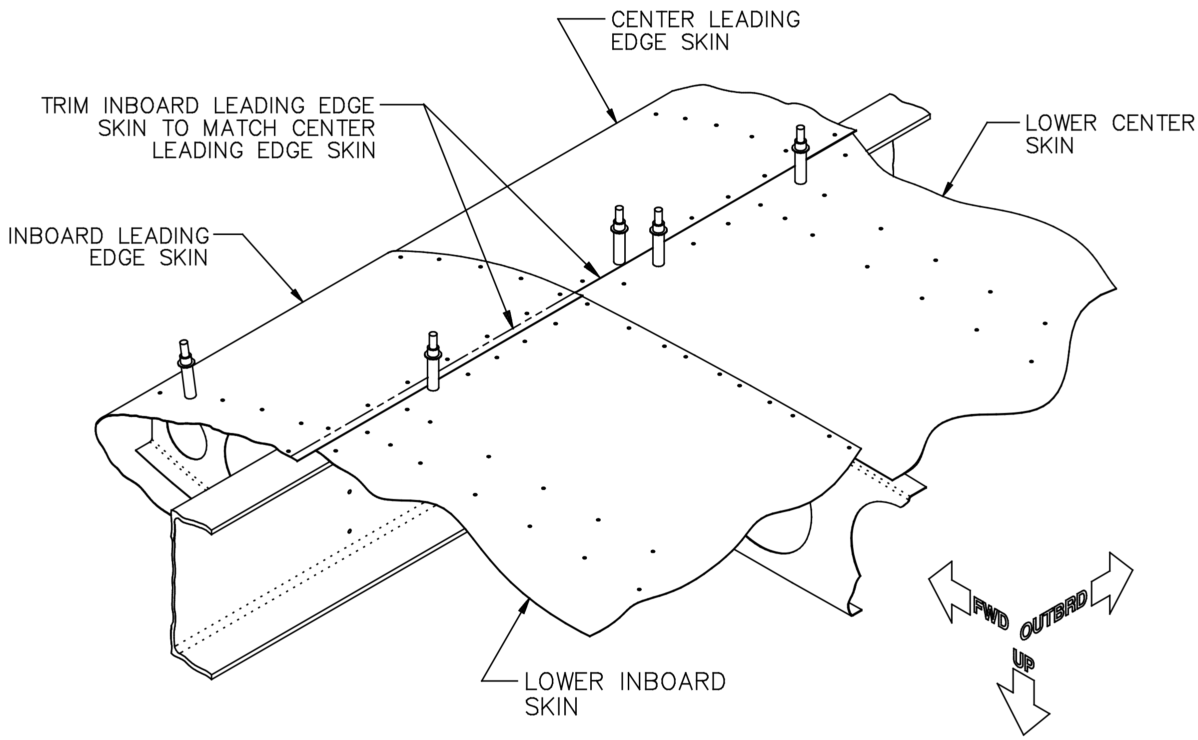

Figure 49: Inboard Leading Edge Skin Lower Trim Line

The trim line for the lower aft edge of the inboard leading edge skin is an extension of the center leading edge skin trim line, as shown in Figure 49. Use a long straightedge to mark the trim line onto the lower edge of the inboard leading edge skin. Remove the leading edge skin and trim its lower aft edge as was done for the other leading edge skins.

Note The only real reason to trim the inboard leading edge skin as described here is aesthetics—the unbroken split line between the skins from root to tip looks better. As long as you maintain the minimum edge distance for the rivets (5/16" or 2-1/2 times the rivet diameter) and as long as there is room to set the spar rivets just aft of the leading edge skin, you can trim the leading edge skin anywhere, or even leave it untrimmed.

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Step 33: Drill the Lower Inboard Skin Doubler

Remove the lower inboard main skin from the wing and place it on a table with the lower (outside) surface up. Place the **lower inboard skin doubler** [38] against the **outside** surface of the lower inboard main skin, aligning the **aft** and **inboard** edges of the two skins. (The long dimension of the doubler is oriented in the chordwise direction.) Clamp the skin and the doubler together, turn the assembly over, and use the pre-drilled holes in the lower inboard main skin to drill matching holes through the lower inboard skin doubler. Drill **#40** rivet holes for the spar flanges, Main Rib 1, the flap cove ribs and the hat section stiffeners. Also, at the outboard aft corner of the doubler, lay out and drill **three #40** rivet holes through the skin and doubler **5/16"** inboard of the doubler's edge and in line with the three rows of cove rib holes in the skin. Cleco as you go. Be careful not to elongate or enlarge the existing holes in the inboard lower skin.

Use Clecos to reinstall the lower inboard skin and lower inboard skin doubler onto the wing structure, with the doubler on the **outside**. Install the inboard leading edge skin and mark its lower aft edge onto the inboard skin doubler. Remove the doubler and trim its forward edge to the marked line.

Note The forward edge of the doubler butts against the aft edge of the leading edge skin; there should be no overlap.

Reinstall the doubler and the leading edge skin after trimming the doubler.

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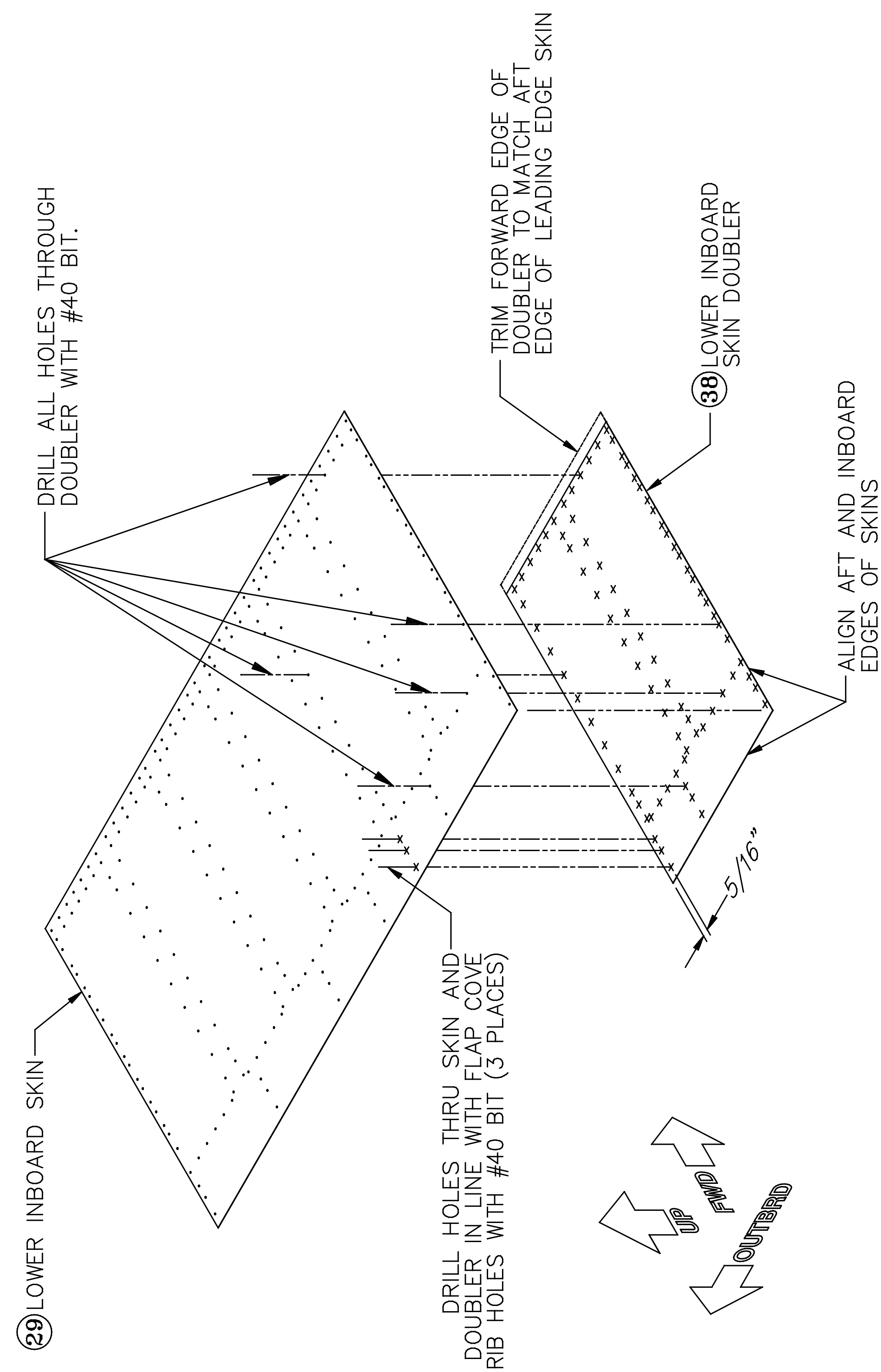

Figure 50: Inboard Lower Skin Doubler

Install the Hat Section Stiffeners, Forward Spar Cap Strips and Lower Center Skin Stiffeners

Step 34: Adjust the Flanges of the Stiffeners

In place of the many wing ribs in most designs, the GlaStar relies on **upper** [15] and **lower hat section stiffeners** [16] to reinforce the wing skins and to give them their airfoil shape. The stiffeners are referred to as "hat sections" because of their cross-sectional shape.

Double rows of pilot holes oriented in the chordwise direction have been pre-drilled in the wing skins (between the main ribs) for the hat section stiffeners. The two rows in each double row are spaced 1-1/2" apart. There are a total of sixteen stiffeners for the lower skins and seventeen for the upper skins of each wing panel.

To be effective in providing the necessary rigidity, these stiffeners must lie flat against the wing skins. The stiffeners have been stamped to fit the curvature of the airfoil, but you need to inspect them to make sure that the flanges are flat. If they're not, the skin will dimple when it's riveted.

Check for flatness by placing the stiffeners convex side down on a flat surface. Beginning at one end, rock the stiffener on the surface over its entire length, watching to see if the flanges lie flat on the surface at all points (see Figure 51). Alternatively, hold a straightedge against the flanges and slide it along the length of the stiffener to check for gaps. If the flanges do not lie flat on the surface, adjust them with a pair of duck bill pliers (or even with your fingers—the aluminum should bend easily).

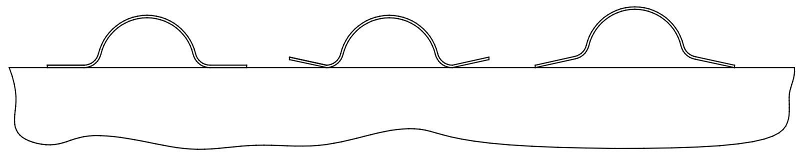

Figure 51: Adjust Stiffener Flanges to Lie Flat

Note This is an area where you can spend a lot of unnecessary time trying to achieve absolutely perfectly flat flanges. Especially if your goal is a good utility airplane rather than a Grand Champion, just do the best you can to get the flanges flat without fretting over them too much. Even with minimal efforts to flatten the flanges, the GlaStar wing will be straighter and have fewer peaks and valleys than most production airplanes.

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Step 35: Trim Stiffener Flanges and Mark Rivet Lines

As with the wing ribs, you need to mark rivet lines on the hat sections so that the flanges can be centered under the pilot holes in the wing skins. Mark the first rivet line onto the flange with the pre-drilled pilot hole, centering the rivet line on the pilot hole, as shown in Figure 52. Then mark a second rivet line onto the other flange **1-1/2"** from the first line. Mark both rivet lines on the **convex side** of the stiffener (the side that contacts the wing skin) so that they will be visible through the pilot holes in the wing skin.

Note When the hat section stiffeners are formed, the flanges tend to flare out at the ends, as shown by the dashed lines in Figure 52. The flared edges will be trimmed off straight, but not until **after the rivet holes have been drilled**, as described in the next step, to make sure that the minimum edge distance for the rivets is maintained.

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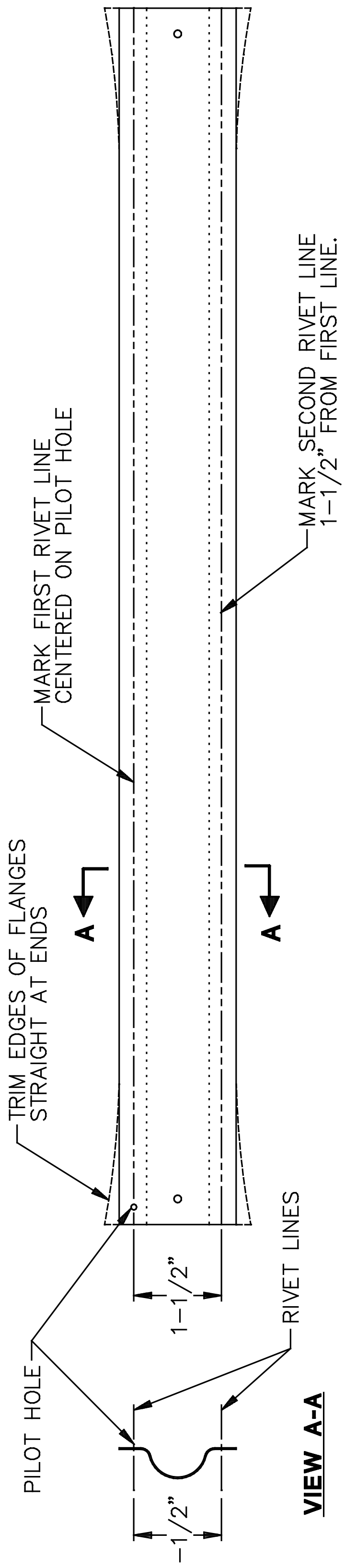


Figure 52: Rivet Lines on Stiffener Flanges

Step 36: Position and Drill the Lower Skin Stiffeners

Note You will need a helper to drill the rivet holes in the hat sections, but by now you should have many friends who are all amazed at how fast your GlaStar is coming together and who would be more than willing to help! Your helper adjusts the position of the stiffener and holds it securely while you drill holes and insert Clecos.

Remove the upper main wing skins to provide access to the interior of the wing for positioning the lower hat section stiffeners.

Note To orient the upper and lower stiffeners, refer to Figure 53. The single hole drilled through one flange on each stiffener is at the **forward** end of the stiffener. Also, the joggle in the stiffener flange for fitting over the spar flange is shorter at the **forward** end than at the aft end. To distinguish between the upper and lower stiffeners, refer to their stamped part numbers or hold them next to the main rib flanges and compare the contours of the stiffeners to the contours of the rib flanges. The upper stiffeners are formed to a sharper curvature than the lower stiffeners.

Using the pre-drilled pilot hole in the forward end, Cleco each stiffener to the wing skin and the forward spar, as shown in Figure 53, through one of the holes drilled in Steps 30 and 32 when the lower main skins were installed.

With the first corner Clecoed, adjust the position of the stiffener until the rivet lines marked on the flanges appear in the pilot holes in the skin. Hold the aft end of the stiffener tightly against the aft spar flange.

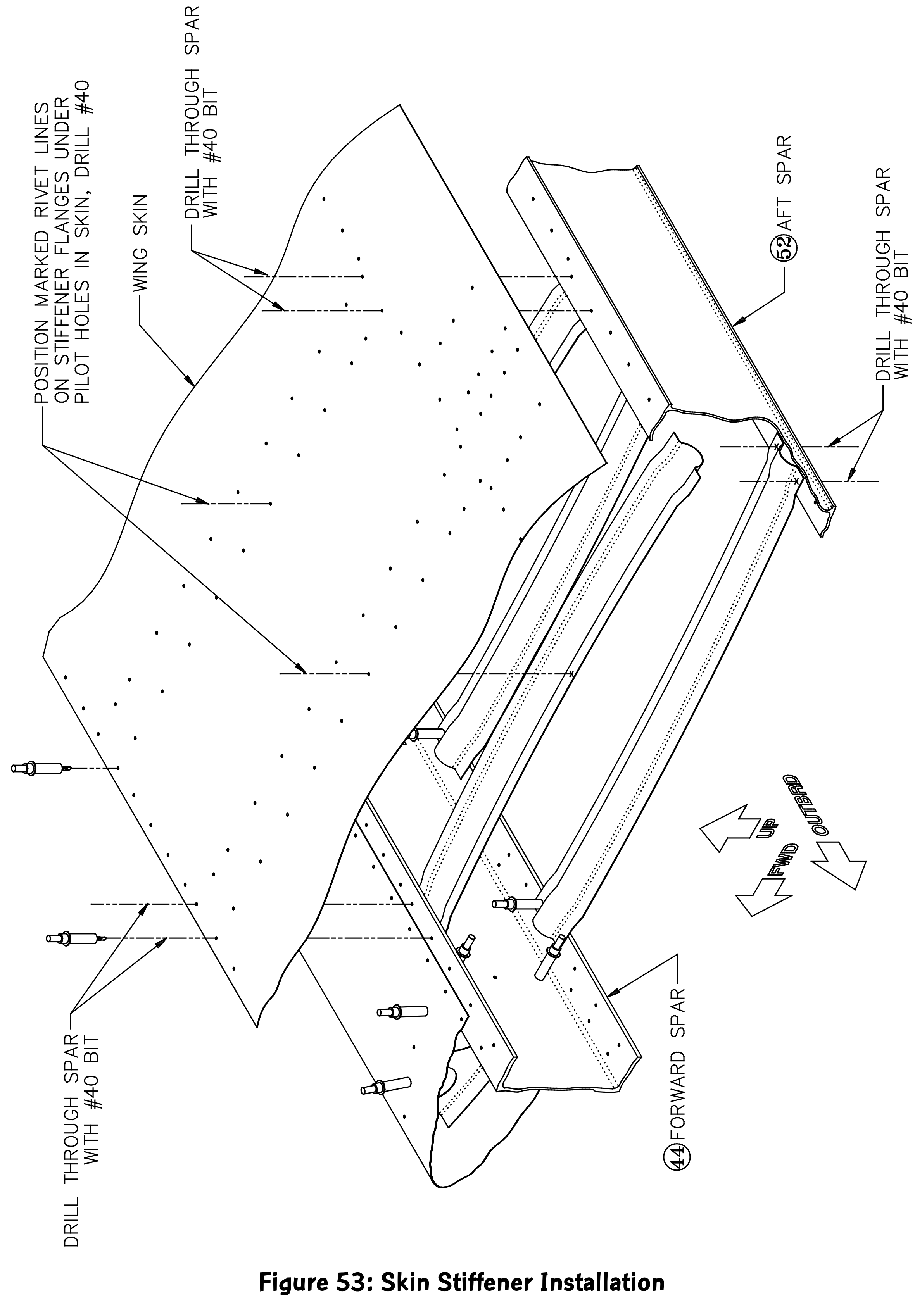
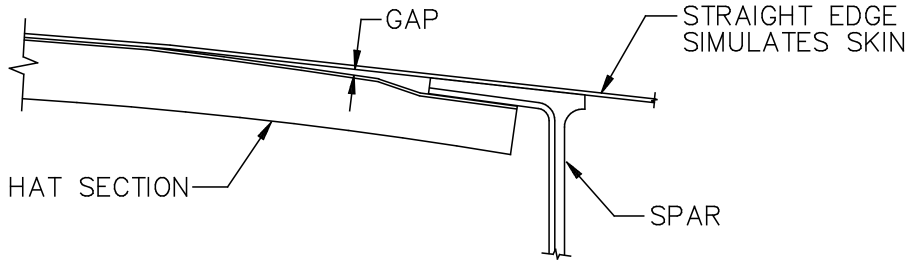


Figure 53: Skin Stiffener Installation



CHECK FIT OF HAT SECTION

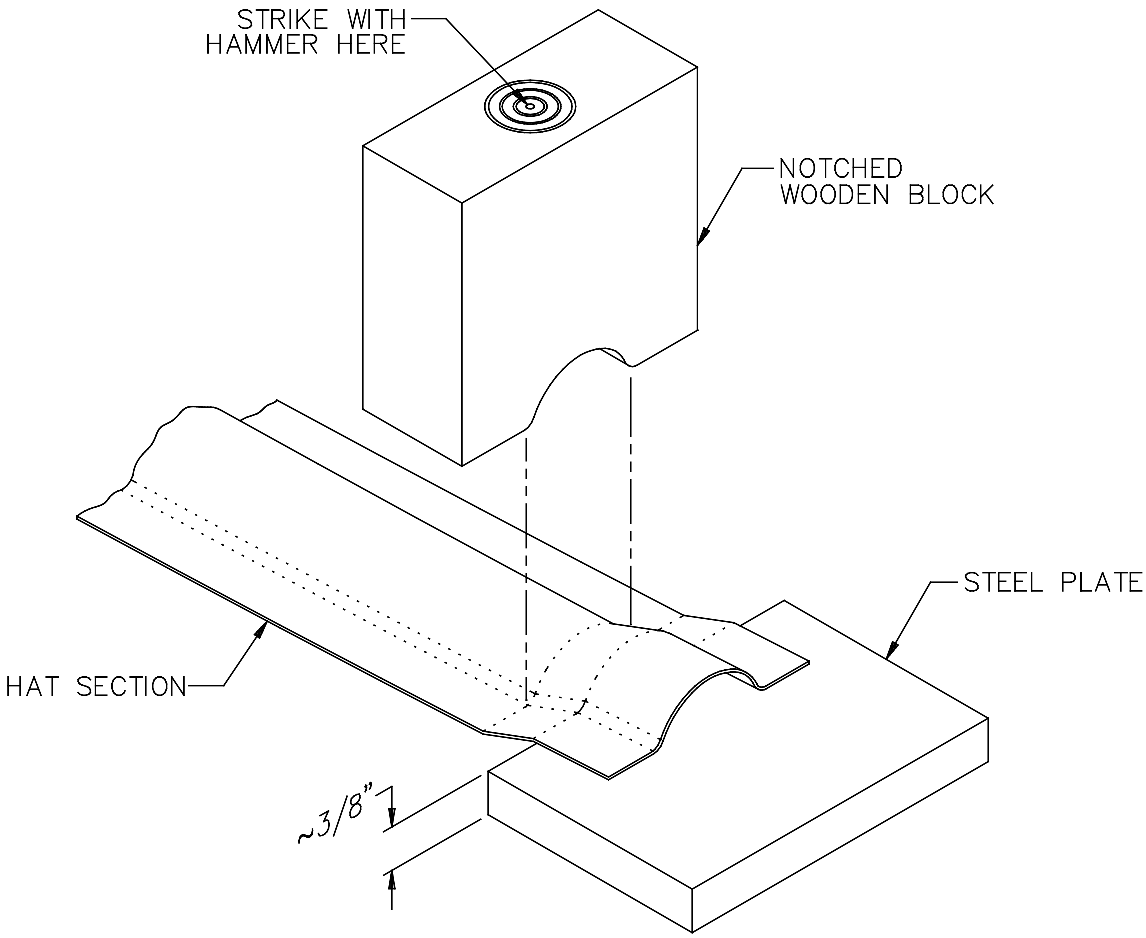


Figure 53.1: Adjusting the Hat Section Stiffeners

Check for gaps between the hat sections and the wing skins at each end of each hat section, as shown in Figure 53.1. The depth of the joggles at the ends of the hat sections may have to be increased to eliminate gaps between the skin and the hat sections and to achieve a smooth transition of the skin from the hat sections to the spar flanges. If you feel that adjustment is necessary, remove the offending hat section and clamp the hat section joggle to an approximately **3/8"** thick steel plate, as shown in Figure 53.1. Then use a **hardwood** block with a semi-circular notch cut in it to hammer on the hat section next to the joggle, as shown. Two or three sharp blows with a hammer should do the job. After adjustment, fit each hat section back into place and re-check the fit. Repeat as needed until you are satisfied with the fit of all the hat sections.

With any adjustments completed, re-Cleco the hat section to the forward spar and have your helper hold the stiffener tightly against the inside of the spar flanges while you drill some rivet holes. Drill two **#40** holes through each spar flange, and insert a Cleco in each after drilling.

With the stiffeners pinned to the spar flanges, use the pilot holes in the skins to drill **#40** holes through the skin-stiffener assembly. Drill the first hole in the center of the stiffener, halfway between the spars, and then continue drilling halfway between already drilled holes until all holes have been drilled. Have your helper apply back pressure to the stiffener with a piece of scrap 2 X 4 where you are drilling. Cleco each hole as you proceed to make sure the stiffener is held tightly to the skin while drilling.

The five hat section stiffeners for the **lower inboard** main skin (between Main Ribs 1 and 2) need additional rivets, as shown in Figure 54. Lay out the locations of the extra hat section stiffener rivet holes in line with and halfway between the existing holes, as shown. Also, lay out four lines of five extra rivet holes, oriented in the spanwise direction, to fasten the lower inboard skin doubler to the lower inboard skin, as shown in Figure 54. The four lines of rivet holes are located **6-7/8"** and **14"** from the forward end of the lower skin doubler.

Drill all the extra rivet holes through the lower inboard skin doubler, the lower inboard skin and the hat section stiffeners to **#40** diameter.

After all the stiffeners have been drilled, mark each one for position and orientation so that it can be returned to its original location after disassembly.

With all the **lower** skins and hat sections in position, take the time now to enlarge all the rivet holes through both the **forward spar** and the **aft spar** to **#30** diameter, using the #40 holes in the main skins as a guide. Also, enlarge all the rivet holes through **Main Ribs 1 and 2** to **#30** diameter. Leave the holes through the other main ribs, the hat section stiffeners and the flap and aileron cove ribs at #40 size.

> **Note Do not** enlarge the spar rivet holes through the **leading edge skins** at this time. These holes will be drilled up to #30 diameter after the forward spar cap strips have been installed.

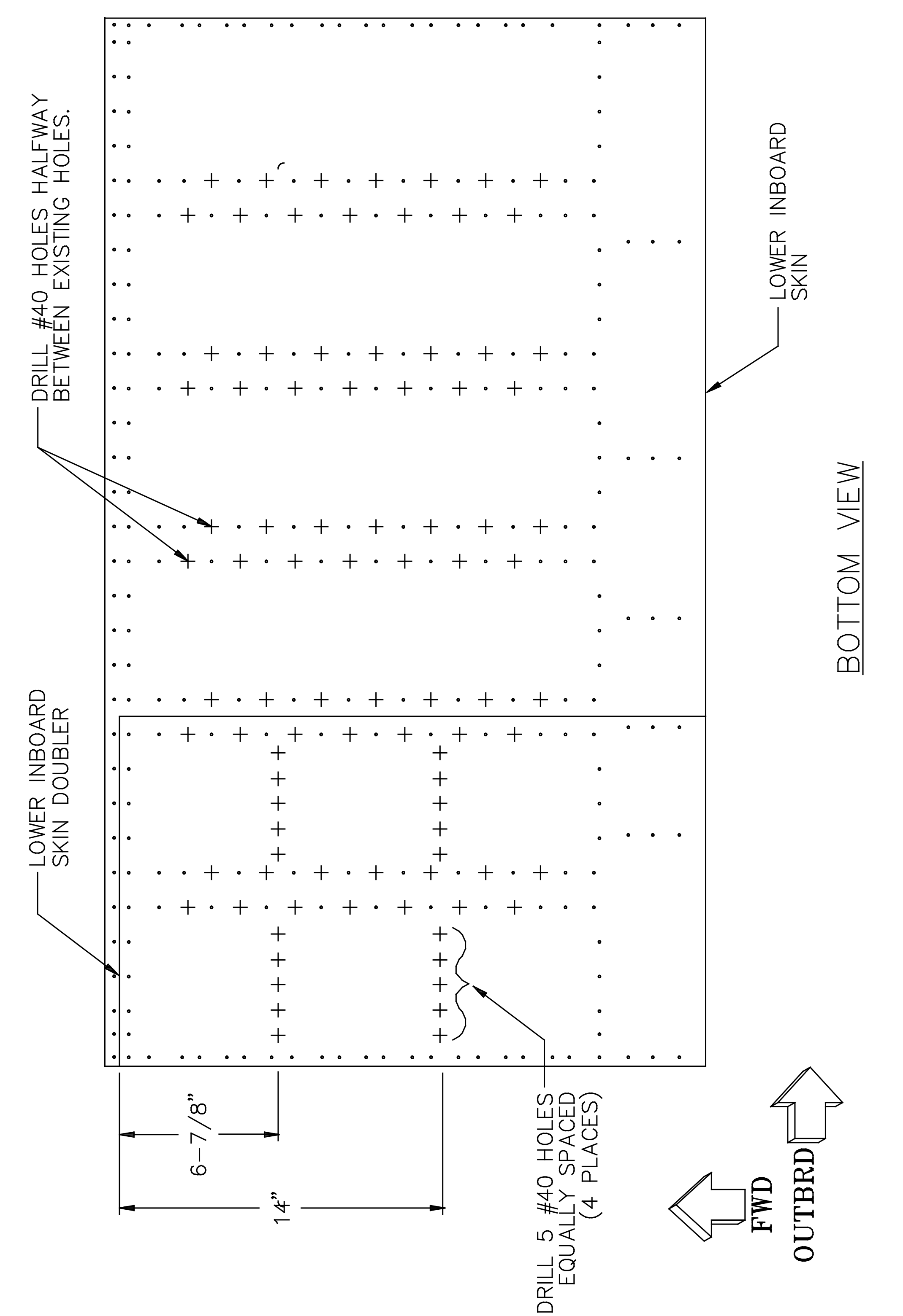


Figure 54: Additional Rivets for Lower Inboard Main Skin

As shown in Figure 55, relieve the **aft** ends of the stiffener flanges, where necessary, to eliminate interference with adjacent rivets through the spar flanges. Be sure to provide enough clearance to form shop heads on adjacent rivets.

Also, trim the edges of the flanges straight, as shown in Figure 52 and as mentioned in the note in Step 35, being careful to maintain the minimum edge distances for the rivets (twice the rivet diameter).

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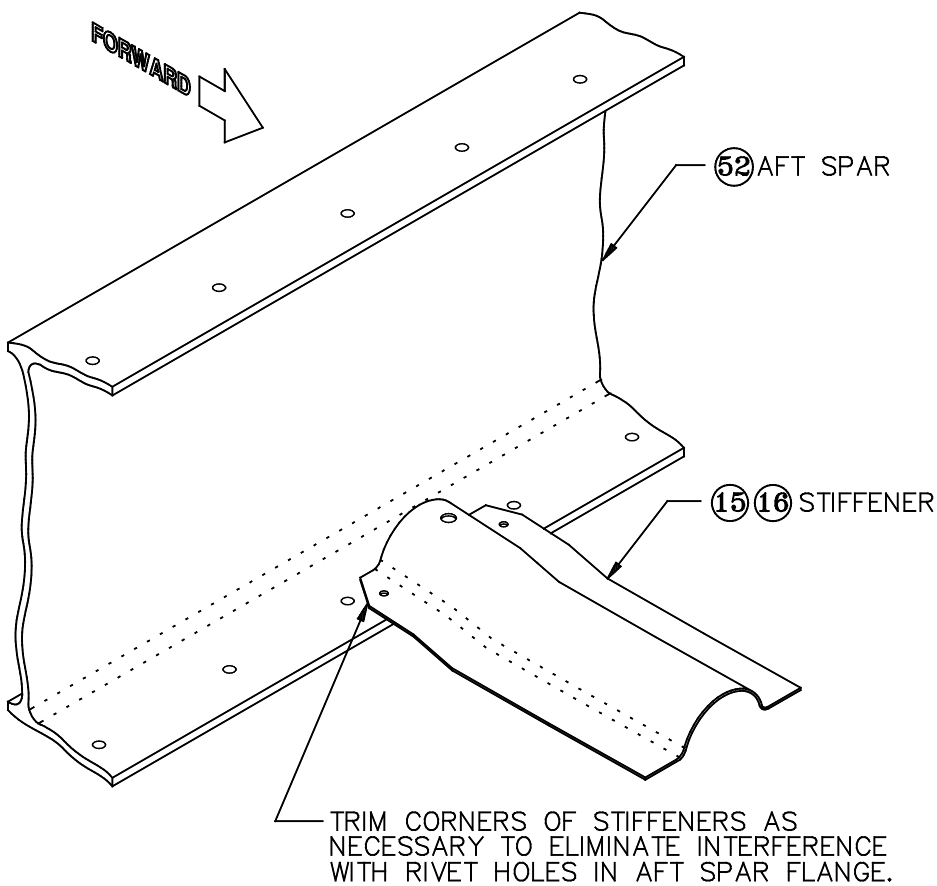

Figure 55: Relieve Stiffener Flanges for Rivet Clearance

Step 37: Position and Drill the Upper Skin Stiffeners

Remount the upper skins to the rib/spar assembly. Remove the lower skins and stiffeners to provide access to the interior of the wing.

Repeat the procedures described in Step 36 to mount, drill and mark the **upper hat section stiffeners** [15].

Note The hat section joggle adjustments described in Step 36 and shown in Figure 53.1 are most likely to be needed in the area of the aft spar strut beam doubler.

Note The additional rivets described in Step 36 for the lower inboard skin stiffeners (between Main Ribs 1 and 2) are **not** needed for the **upper** inboard skin stiffeners.

With all the **upper** skins and hat sections in position, enlarge all the rivet holes through both the **forward spar** and the **aft spar** to **#30** diameter, using the #40 holes in the main skins as a guide. Also, enlarge the holes through **Main Ribs 1 and 2** to **#30** diameter. Leave the holes through the other main ribs, the hat section stiffeners and the flap and aileron cove ribs at #40 diameter.

Note **Do not** enlarge the spar rivet holes through the **leading edge skins** at this time. These holes will be drilled up to #30 diameter after the forward spar cap strips have been installed.

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Step 38: Deburr the Skins and the Stiffeners

Remove the main skins and all the stiffeners, and deburr all the rivet holes as described in "SECTION II: TOOLS AND TECHNIQUES." Once again, remember to brush off any metal chips or shavings that might be clinging to the parts away from the holes. Do not remount the main skins at this time.

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Step 39: Position and Drill the Forward Spar Cap Strips

Cap strips are fastened to both the upper and the lower flanges of the **forward spar** to reinforce the spar in the strut attach area, as shown in Figure 56. Two lengths of cap strip are supplied: the **72" cap strip** [36]—which must be radiused to fit against the radius on the inside of the spar extrusion—and the **36" cap strip** [37], which fits against the longer cap strip. Both cap strips are centered in the spanwise direction on the strut beam bolt array.

Form a **1/8" radius** along one corner of each 72" long forward spar cap strip, as shown in the end view detail of Figure 56. Use a belt sander, if you have one, to start the radius; then, clamp the cap strip to the edge of your jig table and file to finish, while removing the roughness left by the sanding belt. If you don't have a belt sander, a milled, curved tooth "panzer" file will accomplish the job with the least effort. Use long strokes, parallel to the length of the strip to achieve a uniform radius. Since the lower cap strips are spaced 1/16" away from the spar web, as shown in the detail in Figure 56, you don't need to file away as much of the lower strip. Make sure, after the radii are finished, that the cap strips fit into position, as shown; the radii must be large enough to allow the cap strips to fit snugly against the insides of the spar flanges without gaps.

Mark the centerline of the strut beam bolt array onto the spar, as shown in the detail in Figure 56, and mark the spanwise centers of all the cap strips. Place the cap strips on the insides of the spar flange, as shown in the end view detail of Figure 56, with the centers of the strips positioned on the strut beam bolt array centerline.

> **Note** You'll have to remove Main Ribs 3 and 4 to fit the cap strips into position.

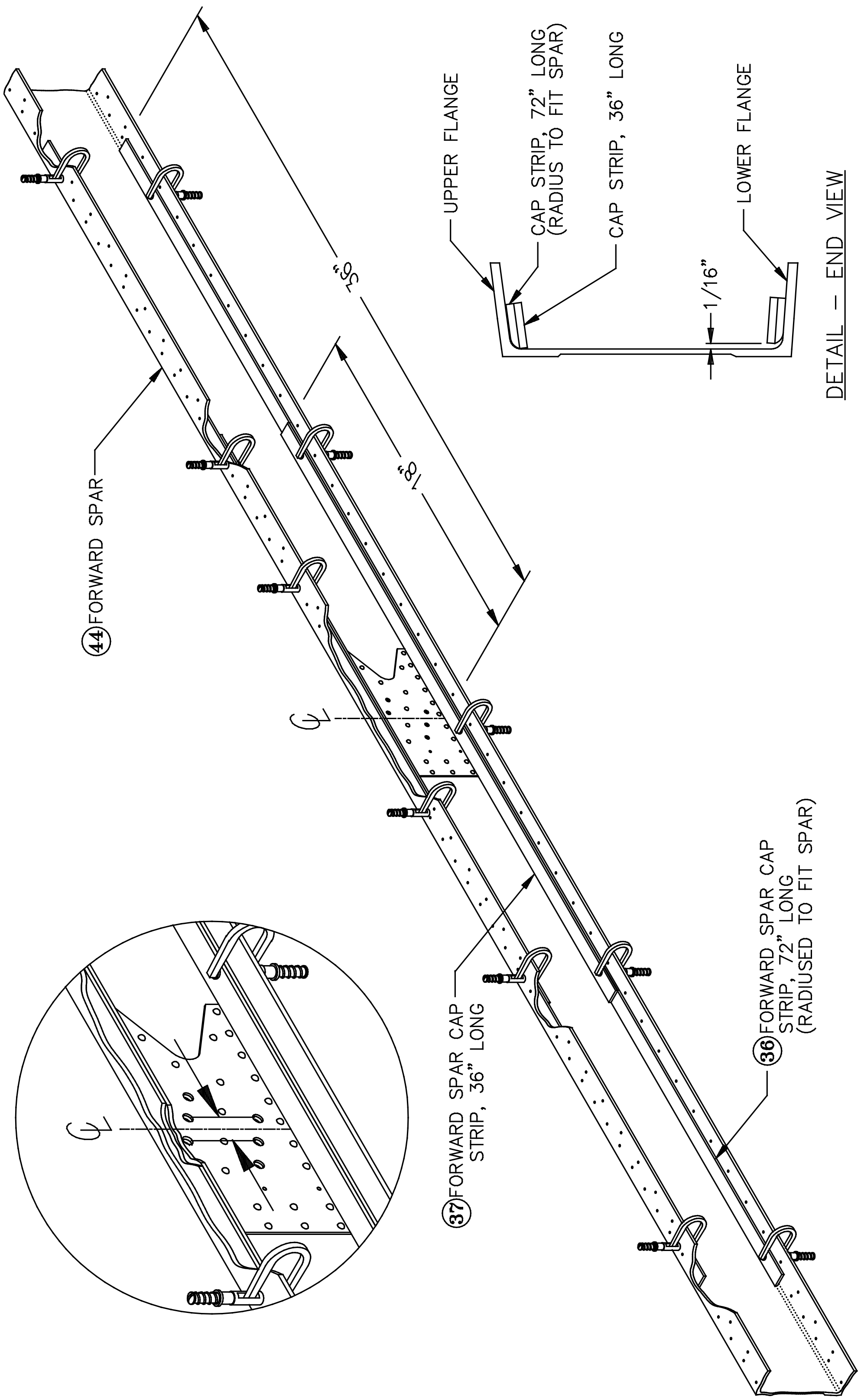

Figure 56: Forward Spar Cap Strips

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Shift each cap strip in the spanwise direction the minimum distance necessary to equalize the edge distance to the rivet holes at the ends of the strip. For example, if the rivet hole at one end is right at the end of the strip, when the cap strip is centered, and the rivet hole at the other end has an edge distance of about 1/2", shift the cap strip so that the edge distance to the rivet holes at both ends is about 1/4".

When positioning the **lower** cap strips, space them **1/16"** away from the spar web, as shown in Figure 56. This is necessary to avoid interference with the forward spar web/strut beam doubler. (The **upper** cap strips normally fit between the doubler and the spar flange, but some builders have encountered interference here, as well. Also space the upper cap strips 1/16" from the spar web, if necessary.) The easy way to do this is to place the centers of the cap strips up tight against the strut beam doubler and use small pieces of 1/16" thick scrap aluminum as temporary spacers at intervals along the rest of their length.

Note The hat section stiffeners also could possibly interfere with the cap strips. Cleco the stiffeners into position and check for clearance. If necessary, shift the cap strips as far forward as possible. You can also relieve the forward ends of the hat sections as long as you maintain the minimum **1/4"** edge distance to the rivet holes.

When both the cap strips have been positioned satisfactorily, clamp them securely and use the leading edge skin rivet holes in the spar flange as guides to drill **#40** holes through the cap strips. Place a clamp right next to each hole while drilling to achieve good alignment with the existing holes in the spar flanges and to prevent chips from getting between the parts. Insert Clecos as you go.

Repeat these procedures for the cap strips on both the upper and the lower forward spar flanges.

Note Reposition Main Ribs 3 and 4, which you removed earlier, and check for interference with the cap strips. Trim the notches in the corners of the ribs as necessary to eliminate interference. File or sand smooth any cuts you make in the ribs, making sure to leave no sharp corners or edges.

Reinstall the lower inboard main skin and all of the leading edge skins along with the spar cap strips. Cleco both the skins and the cap strips securely to the spar flanges. Use the #40 holes in the **leading edge skins** as guides to drill all the rivet holes common to the spar flanges to **#30** diameter on both the upper and the lower sides. (These are the rivet holes that go through both the leading edge skins and the spar flanges; the holes that go through the lower inboard main skin, the leading edge skin and the spar flange; and the holes that go through the leading edge skins, the spar flanges and the cap strips.) Also, enlarge the #40 holes through the leading edge skins and **Nose Ribs 6 and 12** to **#30**-diameter. (Nose Ribs 6 and 12 are at the joints where the leading edge skins overlap.) **Do not** enlarge the rivet holes for the rest of the leading edge ribs.

Remove the leading edge skins and cap strips, and deburr all the rivet holes in them.

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Step 40: Position and Drill the Lower Center Skin Stiffener Channels

Two rows of spanwise pilot holes 4-1/2" apart have been pre-drilled in the **lower** center skin between the oval cut-out for the lift strut and the large round inspection hole. These pilot holes are for riveting on the **strut area stiffener channels,** which reinforce the skin, as shown in Figures 57 and 58. The strut area stiffener channels are cut from the **lower center skin stiffener channel** [35].

To position and drill the stiffener channels, the lower center wing skin must be installed on the wing structure. Main Rib 3 and the hat section stiffener on the inboard side of the strut area must also be installed and Clecoed to the skin and to the spars. Remove the upper center wing skin, if necessary, to provide access to the interior of the wing.

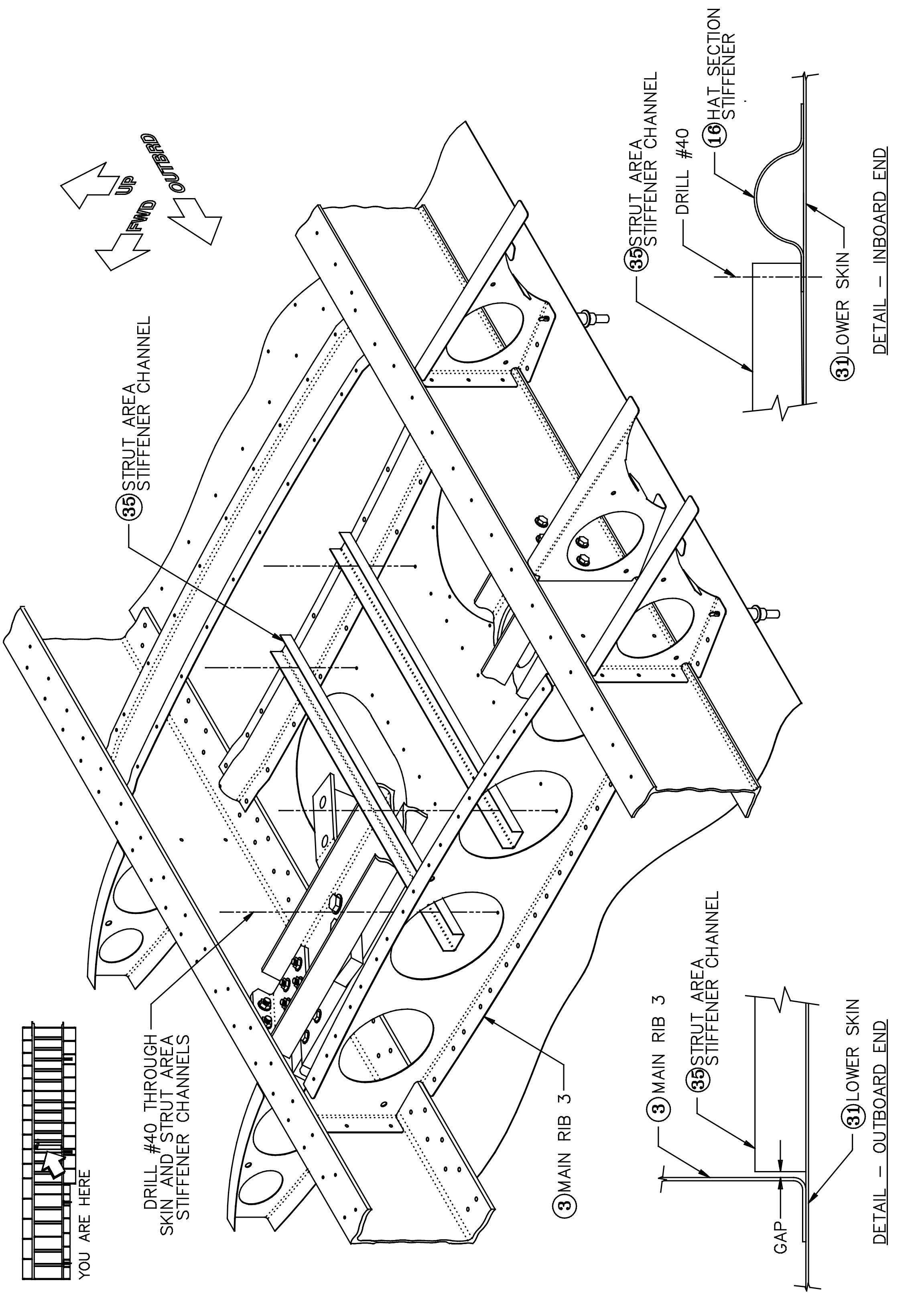

Figure 57: Strut Area Stiffener Channels

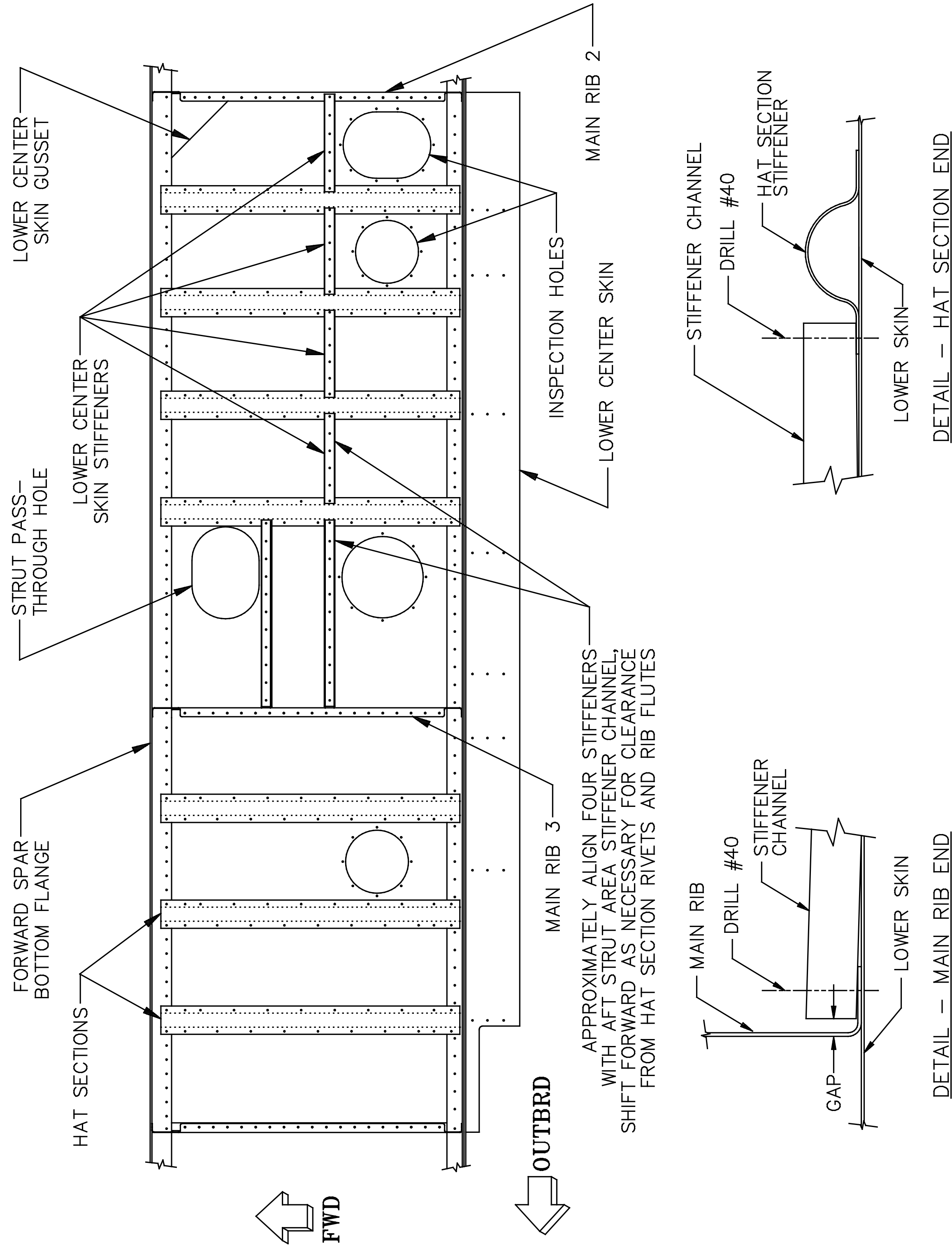

Figure 58: Lower Center Skin Stiffeners

The strut area stiffeners lie on the skin with the bottom of the "U"-channel down, as shown in Figure 57. Mark a centerline on the bottom of each channel.

Have your helper position each stiffener channel on the inside of the wing with its inboard end resting on the hat section flange and its outboard end close to (but not touching) Main Rib 3. Position the channel so its marked centerline is visible through the line of pilot holes. You can use a C-clamp (padded to prevent deformation of the skin) inserted through the holes in the skin to clamp the channels near their inboard ends, but your helper will need to hold them near their outboard ends for drilling.

Drill **#40** holes through the skin and the stiffener channels, using the holes in the skin as a guide. As always, Cleco as you go. When you've finished drilling, remove the channels and deburr the holes in both the wing skins and the channels.

Additional "U"-shaped stiffener channels are installed against the lower center wing skin, extending inboard from the **aft** strut area stiffener channel to Main Rib 2, as shown in Figure 58. Like the strut area stiffener channels, the stiffeners are installed with the "U" bottoms down against the inside of the lower center skin. The stiffeners are to be aligned as closely as possible with the **aft** strut area stiffener channel, but will have to be shifted **forward** slightly to avoid interference with pre-drilled rivet holes in the hat sections and flutes in Main Rib 2. Moving the three outermost channels forward about **1/4"** and the innermost channel forward about **1/2"** alleviates this interference.

Cut pieces from the supplied **lower center skin stiffener channel** [35] to fit the four locations shown in Figure 58 and described in the previous paragraph. Each stiffener section laps onto the hat section stiffener flanges (and Main Rib 2 flange, for the inboard channel) at its ends. When cutting the stiffener that fits next to Main Rib 2, make sure to leave a small gap (1/32" minimum) between the stiffener and the web of the rib.

Mark the rivet pattern shown in Figure 58 onto the inside of each stiffener (six rivets per stiffener, equally spaced; the two end rivets for each stiffener pass through the hat section and rib flanges).

Pitot/Static System Options If you are installing either of Stoddard-Hamilton's Pitot/Static System Options (Heated, P/N 912-02000-01, or Non-Heated, P/N 912-01000-01), **turn to the options instructions now**. Return to this *Assembly Manual* when the specified option steps have been completed.

☞

Hold each lower center skin stiffener in position and use the marked rivet pattern to drill **#40** holes through the stiffener and the lower center wing skin. Install Clecos as you go.

When all the holes have been drilled, remove the stiffeners and deburr the rivet holes in both the wing skins and the stiffeners.

Completed: Left [ ] Right [ ]

DIMPLE THE SKINS AND COUNTERSINK THE FORWARD SPAR FLANGES

Step 41: Dimple the Wing Skins and the Nose Ribs

Note At this time, double check that all the rivet holes in the wing structure have been drilled to the correct sizes, as follows:

1. All rivet holes through the **forward and aft spars**, through **Main Ribs 1 and 2**, and through **Nose Ribs 6 and 12**, on both the upper and the lower surfaces, should be **#30** diameter.
2. All other rivet holes (for **Nose Ribs 1–5, 7–11 and 13–17**, **Main Ribs 3–6**, the **flap** and **aileron cove ribs**, the **hat section stiffeners**, the **lower center skin stiffener channels** and the holes for the extra rivets that fasten the **lower inboard skin doubler** to the lower inboard skin) should be **#40** diameter.

Completely disassemble the wing. Double check that all holes drilled so far have been adequately deburred and deburr those that still need it.

Dimple all the rivet holes in the **leading edge skins** and along the **forward spar rivet lines of the upper and lower main skins**. Also dimple the rivet holes in the **nose rib flanges**. Finally, dimple the rivet holes where the main skins fasten to Main Rib 6; dimple both the skins and the rib flanges for both the upper and the lower skins. (Flush rivets will be used to secure the skins to Main Rib 6 to ease installation of the wing tip fairings.)

> **Note** Since the rivet holes for the spars and the ribs are different diameters, be sure to choose the correct dimple dies for each location. Use **1/8"** dimple dies for the rivet holes that secure the leading edge and main skins to the forward spar flanges and for the rivet holes that secure the leading edge skins to Nose Ribs 6 and 12; use **3/32"** dimple dies for the rivet holes that secure the leading edge skins to the rest of the nose ribs and for the rivet holes that secure the main skins to Main Rib 6.

Completed: Left [ ] Right [ ]

Step 42: Countersink the Forward Spar Flanges

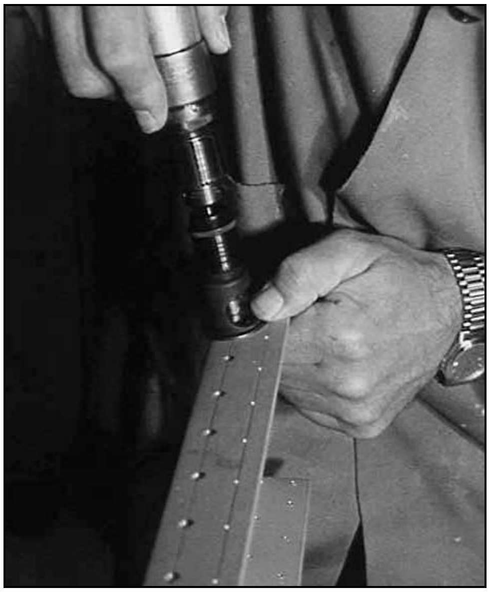

Figure 58.1: Countersinking the Spar

Use your microstop countersink with a **1/8" 100°** pilot to countersink the main spar flanges to accept the dimples in the skins. To achieve the maximum structural strength of each rivet, be careful to adjust the countersink to the proper depth of cut.

Use **scrap pieces** of aluminum to adjust your countersink, as follows:

A) Choose a piece of scrap aluminum the same thickness as the skin you're working on. Drill a #30 hole through this piece and dimple the hole.

B) Drill a #30 hole in another piece of thicker scrap (1/16" minimum), and countersink the hole. This piece simulates the spar flange.

C) Fit the dimple formed in Step A into the countersink formed in Step B, and check the fit. If, when the dimple is pressed tightly into the countersink, the two pieces are held apart so that a gap exists between them, the countersink is too shallow. Refer to Figure 59. If the pieces fit tightly together without gaps but the dimple is loose in the countersink so that the pieces can shift laterally relative to each other, the countersink is too deep. If the dimple fits snugly in the countersink and the parts fit tightly together without gaps, the countersink depth is just right.

D) Adjust the depth of the countersink, if necessary, and repeat Steps B and C until you have achieved the proper countersink depth.

Now that your countersink tool is adjusted properly, you can use it to cut the countersinks in the spar flange rivet holes.

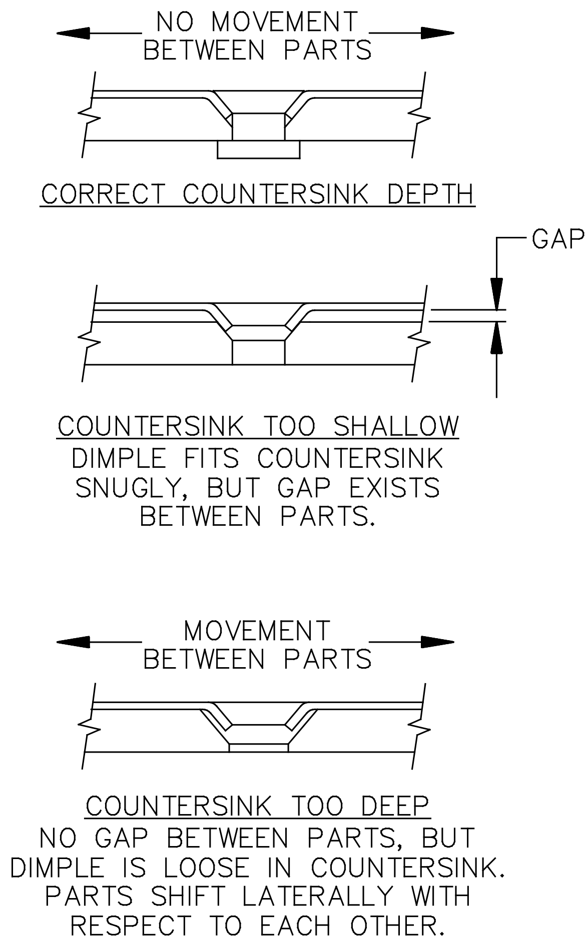

Figure 59: Countersink Adjustment

Note Since the wing skins are of various thicknesses, you must readjust your countersink tool, following the procedures described above, for each skin location on the spar. For example, you can use the same countersink adjustment for the rivet holes for the inboard leading edge skin and the inboard main skins, which are all .032" thick, but you must change the adjustment for the center leading edge skin, which is .025" thick. Refer to Table 6 for a list of skin thicknesses so you can choose the proper scrap thickness to adjust your countersink tool for each skin.

WING SKIN:	THICKNESS:
Inboard Leading Edge	.032"
Center Leading Edge	.025"
Outboard Leading Edge	.020"
Upper Inboard	.032"
Upper Center	.020"
Upper Outboard	.020"
Lower Inboard	.032"
Lower Center	.020"
Lower Outboard	.020"

Table 6: Wing Skin Thicknesses

Completed: Left [ ] Right [ ]

Step 43: Corrosion-Proof the Parts

When you have finished deburring, dimpling and countersinking all the rivet holes in the wing skins and spars, as described in Steps 41 and 42, apply corrosion protection to all of the wing components, including the insides of the wing skins, the ribs, the hat-section stiffeners, the spar cap strips and the lower skin spanwise stiffener channels. Refer to "INTERIOR CORROSION PROTECTION" in "SECTION II: TOOLS AND TECHNIQUES" for guidance in choosing a corrosion protection scheme.

Pitot/Static System Options If you are installing either of Stoddard-Hamilton's Pitot/Static System Options, be sure to corrosion-proof the pitot tube mounting doubler at this time.

Note We recommend the GlaStar Corrosion Protection Option Kit (Part number 962-01000-01), which includes a special, water-based primer and instructions. Contact our Order Desk for ordering and shipping information.

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ASSEMBLE THE AILERON HINGES

Step 44: Fit and Drill the Aileron Hinge Components

Figure 59.1: Assembling the Aileron Hinge

The **outboard** aileron hinge is made from an **aileron hinge arm** [81], a **left-flange aileron hinge rib** [83], a **right-flange aileron hinge rib** [84], a **left-flange aileron hinge attach angle** [85] and a **right-flange aileron hinge attach angle** [86], as shown in Figure 60. Lay out the rivet pattern on the hinge rib and hinge attach angle on one side, as shown, maintaining a minimum distance of 1/4" (twice the rivet diameter) from the centers of the rivet holes to the edges of all the parts. Cleco the assembly together through the two pre-drilled holes in each part.

Assemble the **inboard** aileron hinge in a similar manner, except install an **inboard aileron hinge attach angle** [87] on the **outboard side**, as shown in Figure 61.

Lay out the rivet pattern shown in Figures 60 and 61 on one aileron hinge **bearing arm doubler** [82] for each hinge assembly, and then clamp a bearing arm doubler on each side of each aileron hinge arm. Press an aileron hinge **bearing** [94] into the large hole in each hinge assembly to keep the holes concentric while drilling the rivet holes.

Centerpunch and drill **#30** rivet holes at all marked rivet locations. Install Clecos as you go.

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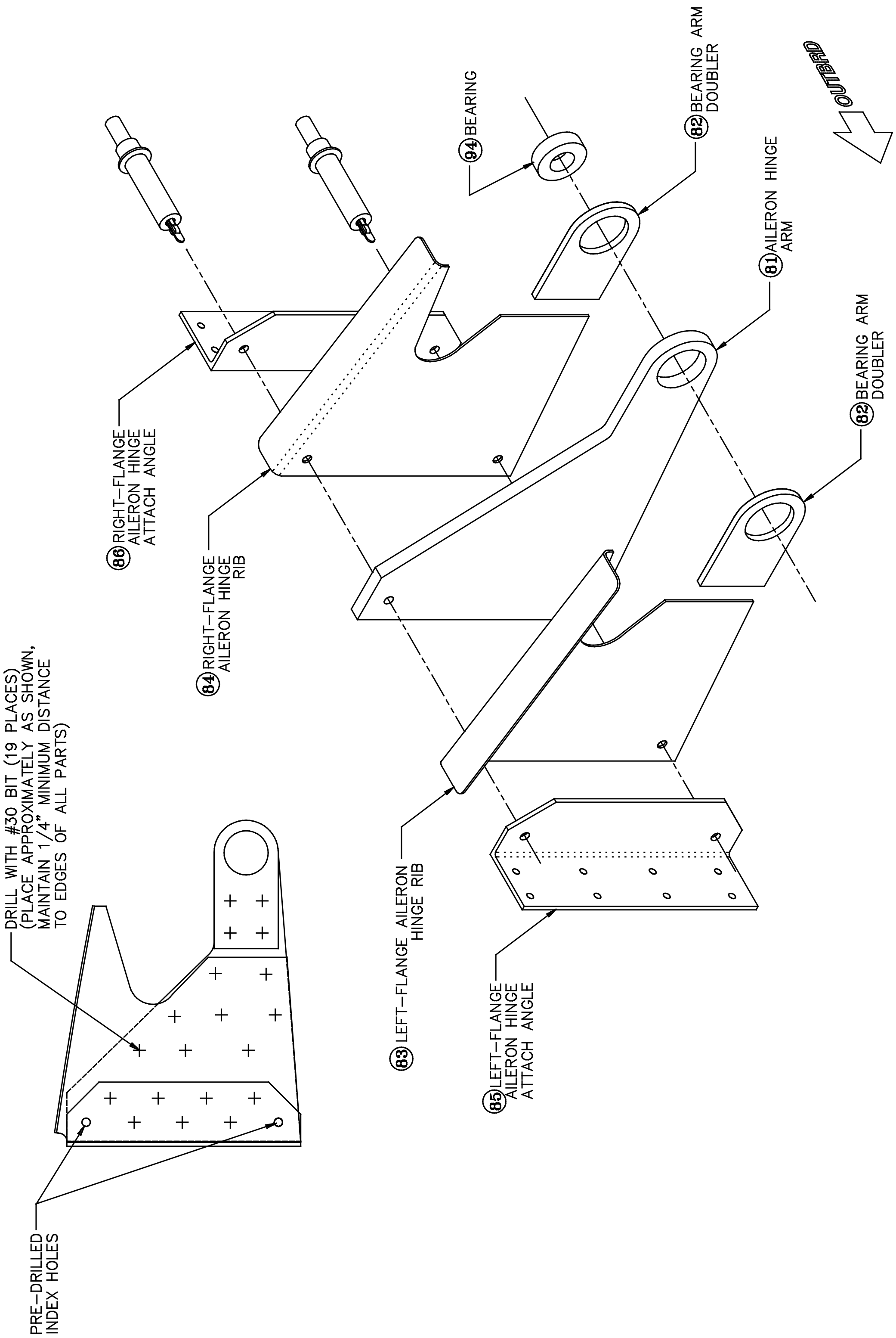

Figure 60: Outboard Aileron Hinge Assembly

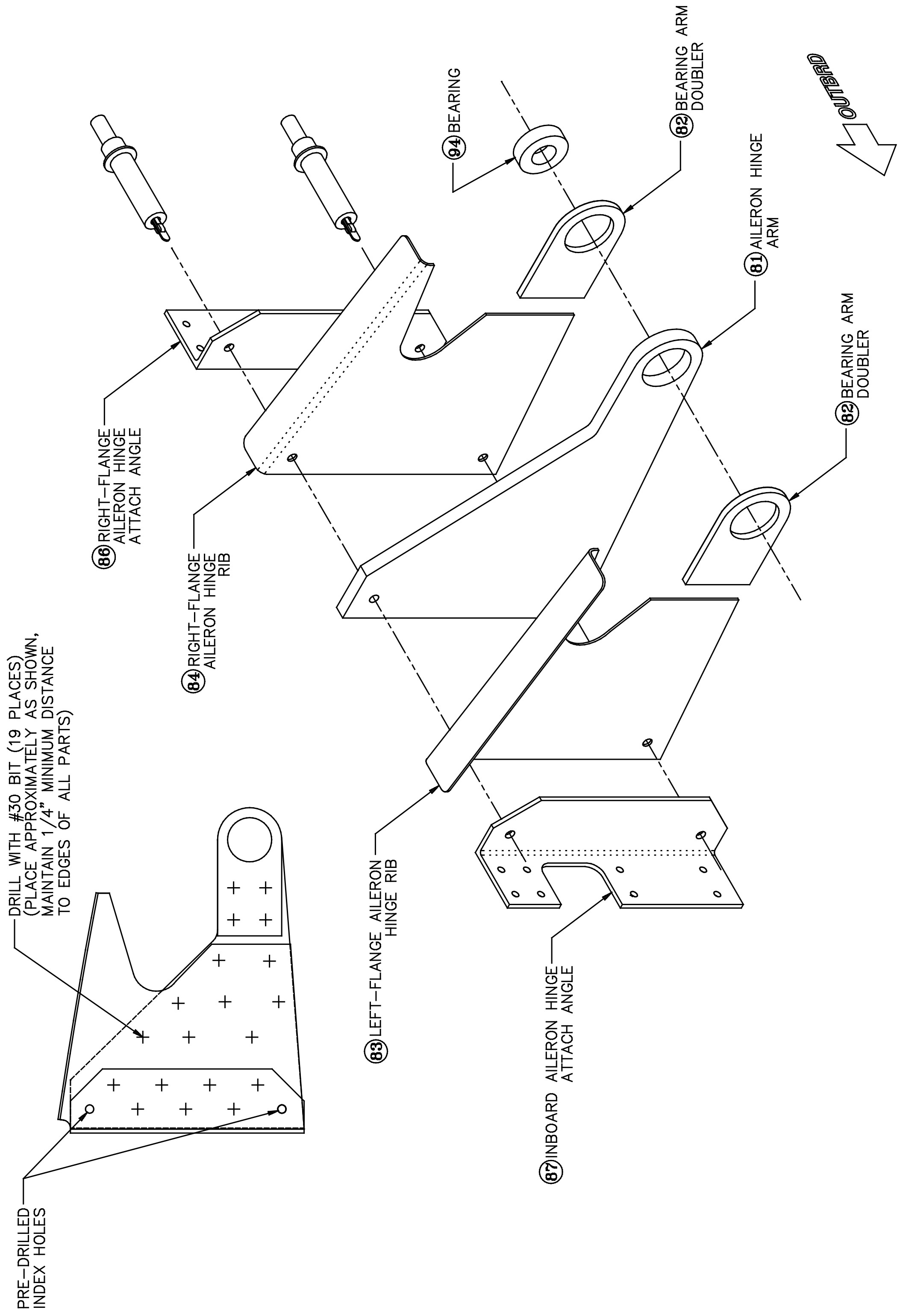

Figure 61: Inboard Aileron Hinge Assembly

Step 45: Rivet and Finish the Hinge Assemblies

Disassemble the hinges, making sure that you don't mix up the parts for each assembly. Deburr all the rivet holes and corrosion-proof the parts.

Hint Although we specify corrosion-proofing the aileron hinges at this time, you will save considerable time in the long run by assembling, drilling and deburring all the various wing control components (the aileron hinges and bellcrank, the flap tracks and bellcrank, and the flap and aileron pulley brackets) and then corrosion-proofing them all at the same time, instead of setting up to corrosion-proof each component separately.

Reassemble the hinges and clamp the hinge assemblies tightly together. Press an aileron hinge **bearing** [94] into each hinge assembly using Loctite bearing retaining compound (either low- or medium-viscosity, high-strength) to secure it. (The bearing is pressed in first to maintain alignment of the large bearing holes in the parts while riveting.)

Rivet each hinge assembly together, using 1/8" AN470AD4 universal-head rivets.

In addition, "stake" each bearing by placing the point of a centerpunch on the metal of the bearing arm doubler just outside the perimeter of the bearing and striking the centerpunch with a hammer hard enough to make about a 1/16" dimple. Repeat in four to six places around the bearing on both sides. This process slightly deforms the metal in the bearing arm doublers to crimp the bearing securely in place.

Completed: Left [ ] Right [ ]

Assemble the Aileron Bellcrank and Mount the Hinges and the Bellcrank

Step 46: Assemble the Aileron Bellcrank

Position an **upper aileron bellcrank half** [92] against a **lower aileron bellcrank half** [93] with the bent arms away from each other as shown in Figure 62. Use Clecos or 3/16" (AN3-) bolts to align the three pre-drilled holes in the arms of the bellcrank halves. Position a **bellcrank bearing** [98] on the outside of the assembly, centered in the large holes in the bellcrank halves, and clamp the assembly together with Cleco side-grips or small C-clamps. Use every other of the twelve holes in the bearing flange as guides to drill **six #30** rivet holes through the assembly. Insert Clecos in the first two or three holes and remove the clamps to finish the drilling.

Disassemble the bellcrank and deburr the holes in all the parts. Corrosion-proof the parts.

> **Note** We recommend against using standard procedures to corrosion-proof the bellcrank bearing. The chemicals and rinse water used could penetrate into the bearing, doing more harm than good. To provide some corrosion protection, brush a coat of primer onto the bearing flange where it contacts the bellcrank halves.

Reassemble and Cleco the bellcrank assembly with the bearing sandwiched **between** the two halves. Rivet the bellcrank halves to the bellcrank bearing, using six 1/8" AN470AD4 universal-head rivets.

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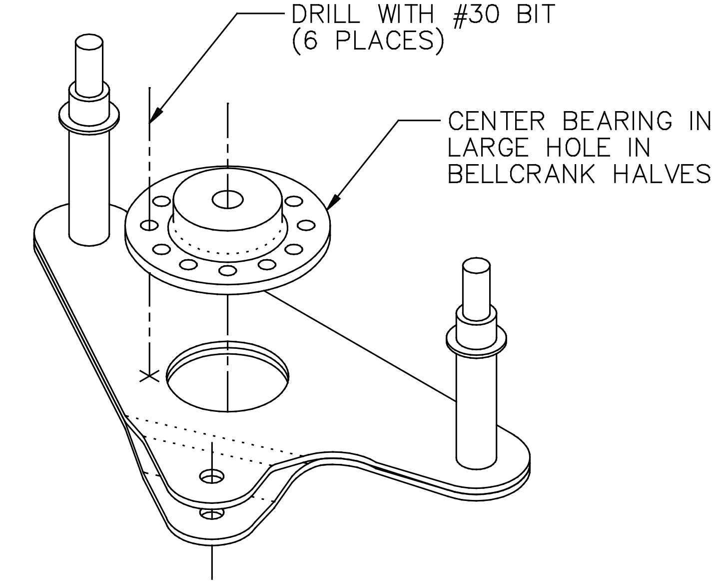
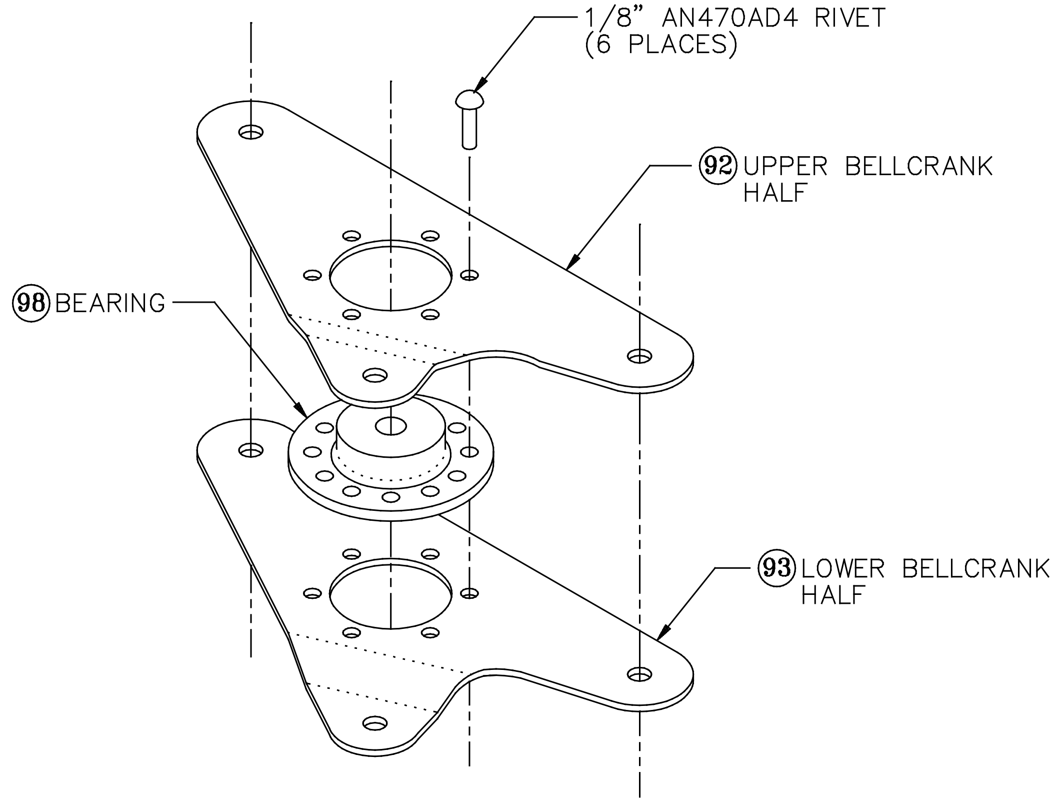


DRILLING THE BELLCRANK ASSEMBLY



RIVETING THE AILERON BELLCRANK

Figure 62: Aileron Bellcrank Assembly

Step 47: Assemble the Aileron Bellcrank Brackets

Note Both the **upper** and the **lower aileron bellcrank attach angles** [64 and 66] have two holes spaced 4" apart in one flange; these **horizontal** flanges fasten to the bellcrank brackets. The **upper** attach angle also has a single hole in the other flange of the angle (the **vertical** flange that fastens to the spar). The single hole is closer to the **inboard** end of the angle and is used to position the bellcrank assembly relative to the aileron hinge.

Note In some instances, the pre-drilled pilot holes in the bellcrank attach angles may be centered less than the minimum two rivet diameters from the edges of the parts. This is acceptable here, both because of the thickness of the material and the total number of rivets used to rivet the bellcrank assemblies.

Lay out the rivet patterns shown in Figure 63 on both the horizontal and the vertical flanges of the **upper** and **lower aileron bellcrank attach angles** [64 and 66]. Centerpunch the hole locations in preparation for drilling. Use the laid-out rivet pattern to drill four **#40** pilot holes through the **vertical** flange of each attach angle, as shown.

Cleco the upper attach angle to the **upper aileron bellcrank bracket** [62], using the two pre-drilled holes in each part, as shown in Figure 63. Similarly, Cleco the lower attach angle to the **lower aileron bellcrank bracket** [63].

Note Make sure you choose two opposite (mirror image) support brackets so that the two 3/4"-diameter access holes in each bracket are positioned opposite their counterparts in the other bracket, when the brackets are held back-to-back.

Use the laid-out rivet pattern and the two pre-drilled holes in the horizontal flanges of the attach angles as guides to drill **#30** rivet holes through the angles and the brackets. Cleco as you go.

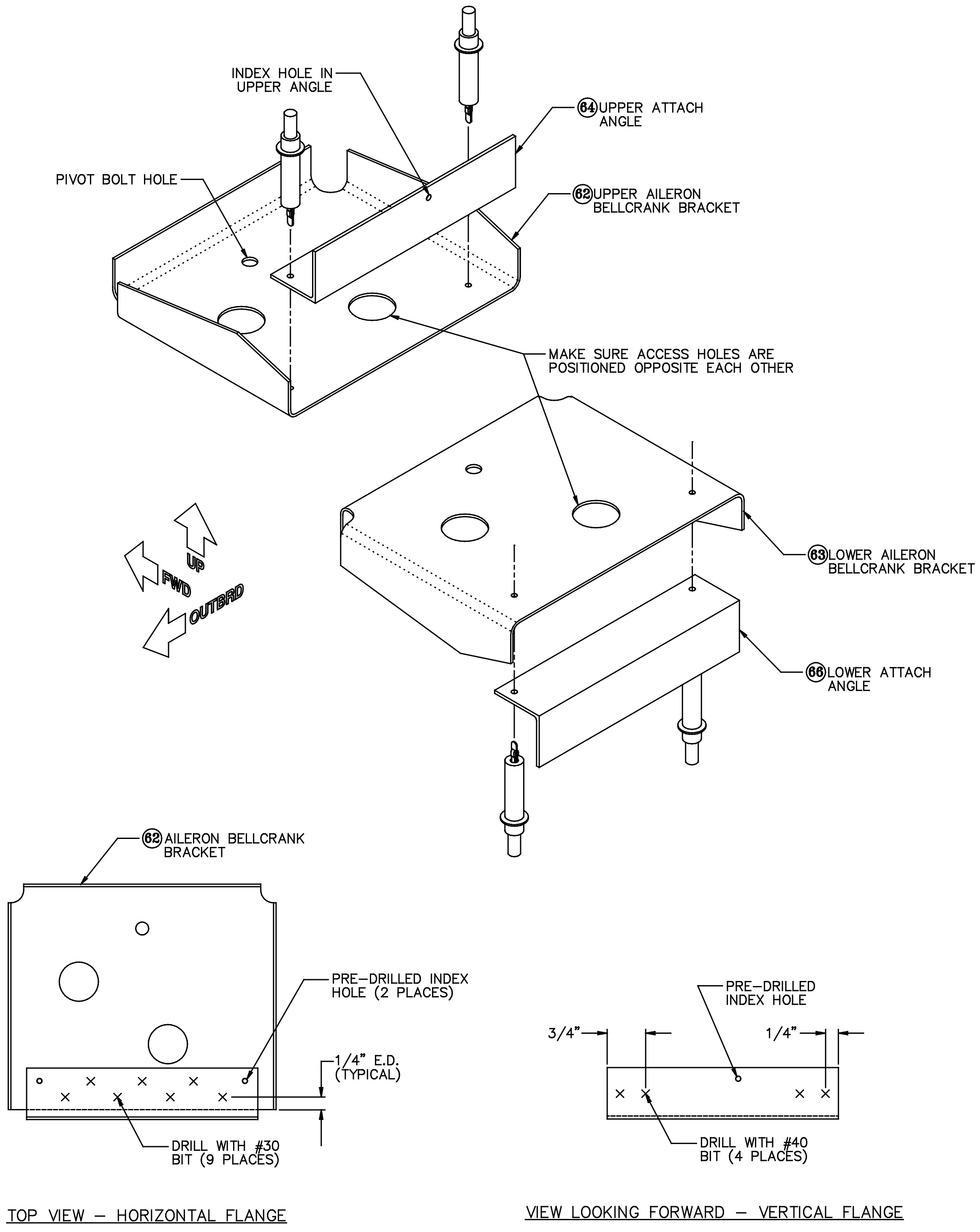


Figure 63: Aileron Bellcrank Support Bracket Assembly

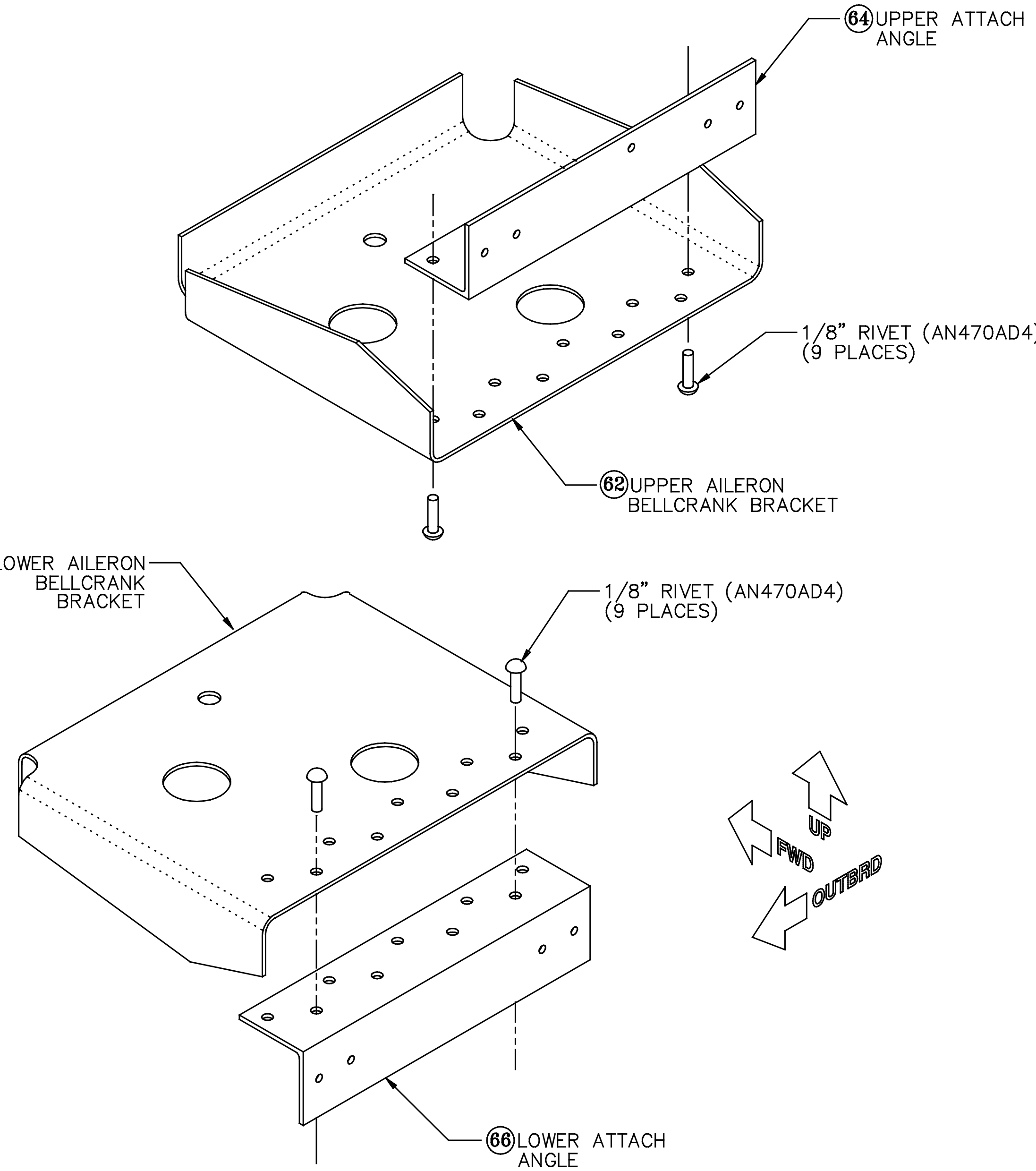


Figure 64: Riveting the Aileron Bellcrank Brackets

Disassemble the parts and deburr the rivet holes. Corrosion-proof the parts. Rivet each attach angle to its bellcrank bracket using 1/8" universal head rivets (AN470AD4) with the manufactured head on the bracket, as shown in Figure 64.

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Step 48: Assemble, Position and Drill the Aileron Bellcrank Assembly and the Inboard Aileron Hinge Assembly

Use an AN4-21 **bolt** [109], an AN310-4 **castle nut** [102], an AN960D416L **washer** [116] under the bolt head and an AN960D416 **washer** [115] under the nut to bolt the aileron bellcrank assembly to the upper and lower aileron bellcrank bracket assemblies, as shown in Figure 65. Install an NAS42DD8-20 **spacer** [118] on the upper side and an NAS42DD8-43 **spacer** [119] on the lower side of the bellcrank, as shown. (The spacers' dash numbers indicate their length in 64ths of an inch.) Secure the castle nut with an AN380-2-2 **cotter pin** [106].

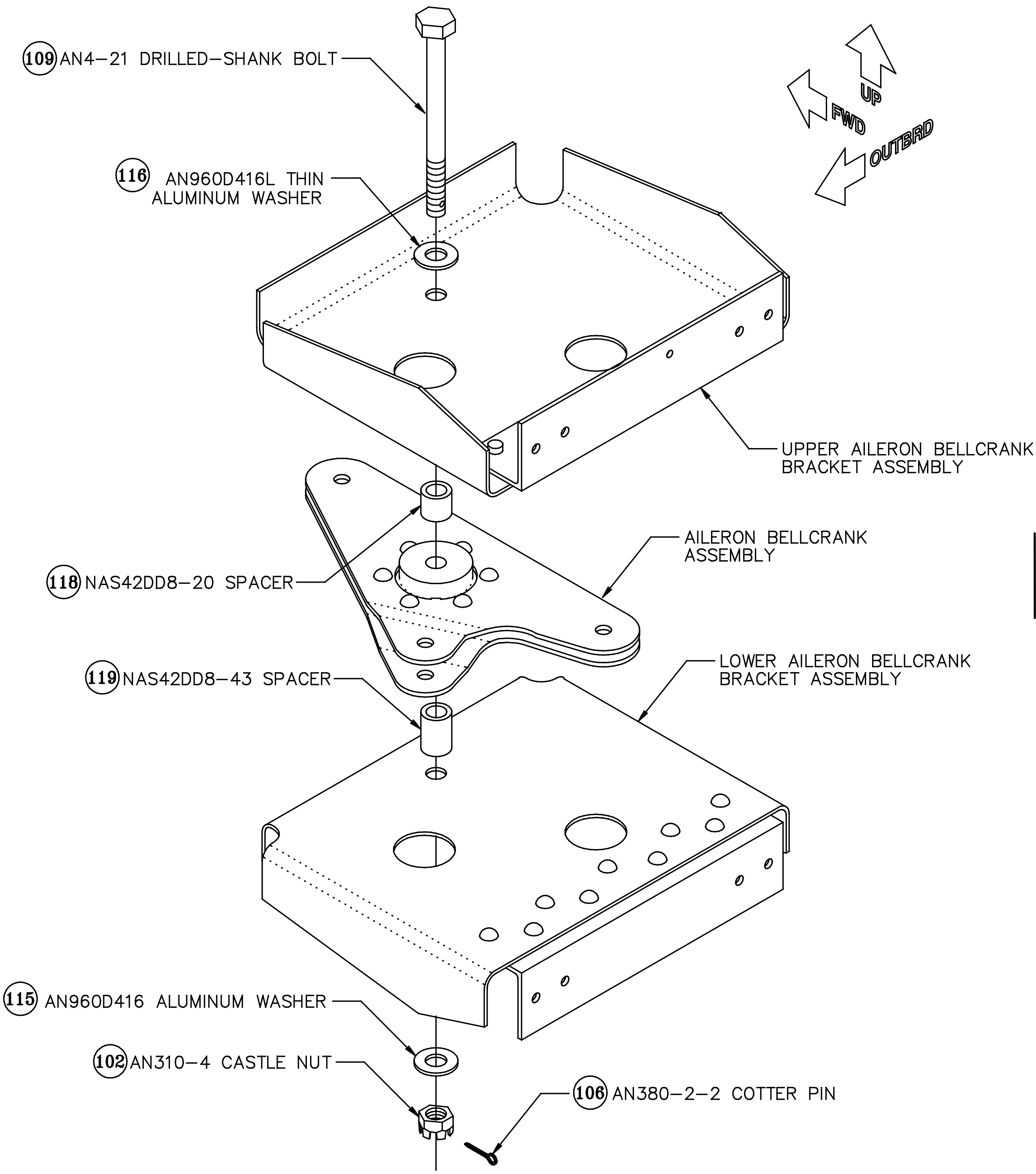

Figure 65: Mounting the Aileron Bellcrank Between the Bellcrank Brackets

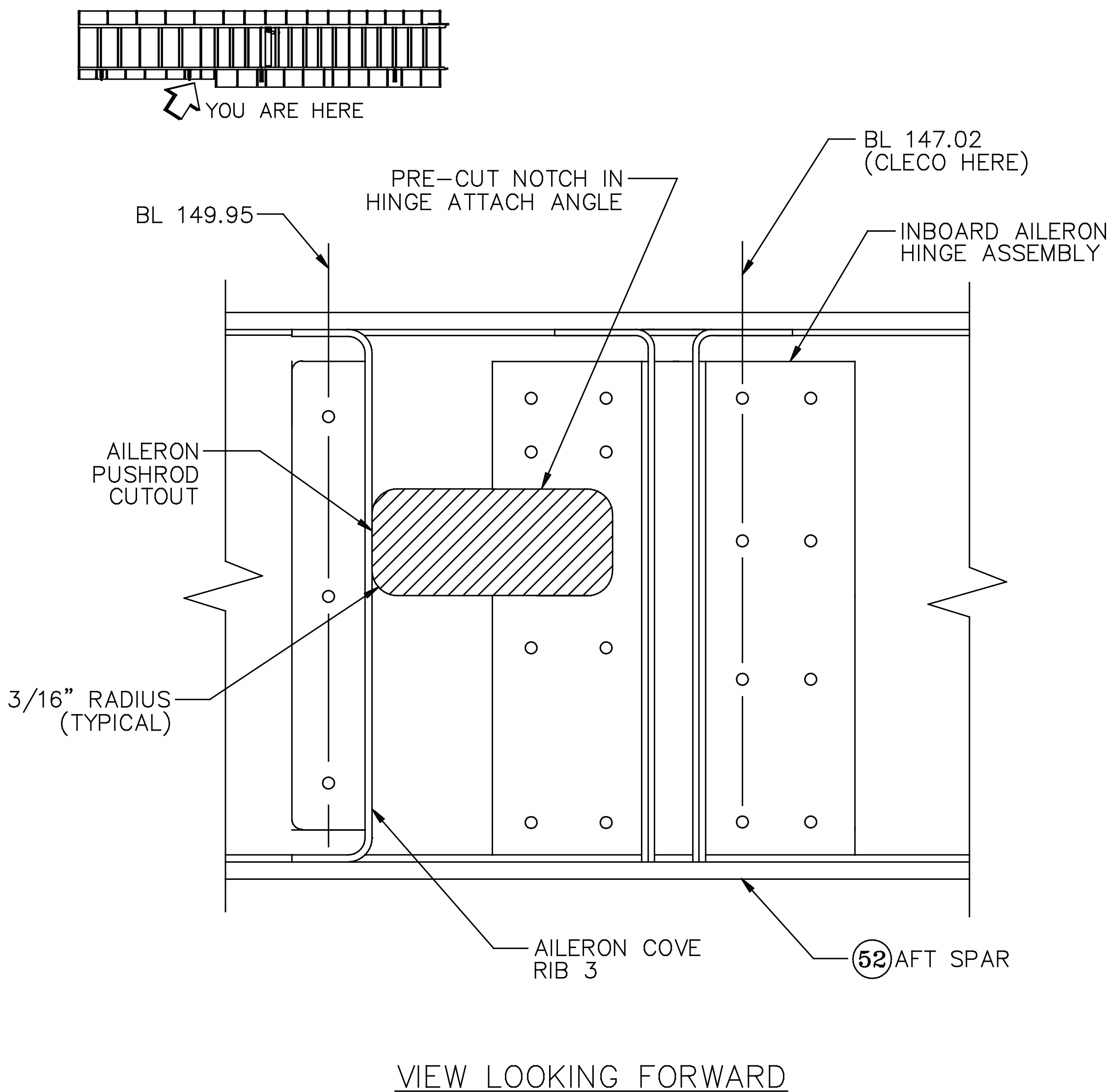

Figure 66: Aileron Pushrod Cutout

Note You will probably find it much easier to complete this and some of the subsequent procedures if you remove the aft spar from the wing jig. Use your own judgment in this regard. You will need to return the spar to the jig when you begin riveting the structure together, as described in Step 60.

Cleco the **inboard** aileron hinge assembly to the aft side of the aft spar, as shown in Figure 66, using the four pre-drilled holes located at **BL 147.02**.

Jump-Start Spar Option If you ordered the pre-assembled spar option (P/N 038-02100P01), the aileron pushrod cutout described in the following paragraph has been completed for you. **Skip to the next page**.

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Mark the aileron pushrod cutout onto the aft spar between the hinge assembly and Aileron Cove Rib 3, as shown in Figure 66, using the pre-cut notch in the attach angle as a guide. Remove the hinge assembly and the rib to prevent damage while cutting the hole. To make the cutout, first drill **3/8"-**diameter holes in the corners as well as a large central hole to provide access for starting the cut. Then use a hack saw blade, files and sandpaper to finish. Thoroughly deburr the cutout and corrosion-proof the bare metal.

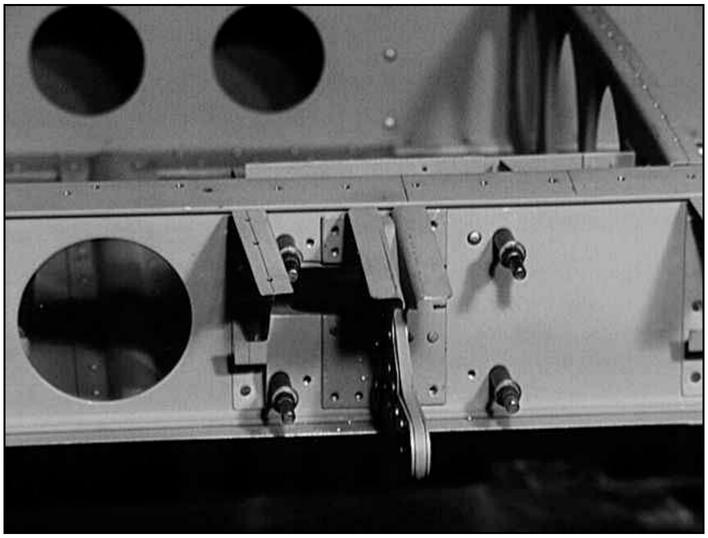

Figure 66.1: Inboard Aileron Hinge Assembly

Once the pushrod cutout is finished, Cleco the inboard aileron hinge assembly and Aileron Cove Rib 3 in place once again.

Cleco the bellcrank bracket assembly to the forward side of the aft spar, aligning the single pre-drilled hole in the **upper** bellcrank bracket attach angle with the **top outboard** hole for the **inboard** hinge attach angle, as shown in Figure 67. Level the bellcrank bracket assembly relative to the spar, and clamp it securely.

Note Make sure you choose the correct bellcrank bracket assembly for each wing. The single, pre-drilled pilot hole in the **upper** bellcrank attach angle should be closest to the **inboard** end of the angle, as shown in Figures 65 and 67.

Use the holes in the aileron hinge attach angles as guides to drill **#30** rivet holes through the spar and the bellcrank bracket attach angles. (This includes the four holes at BL 147.02.) In addition, use the two #40 pilot holes at each end of the bellcrank bracket attach angles to drill **#30** rivet holes through the angles and the spar. Install Clecos as you go.

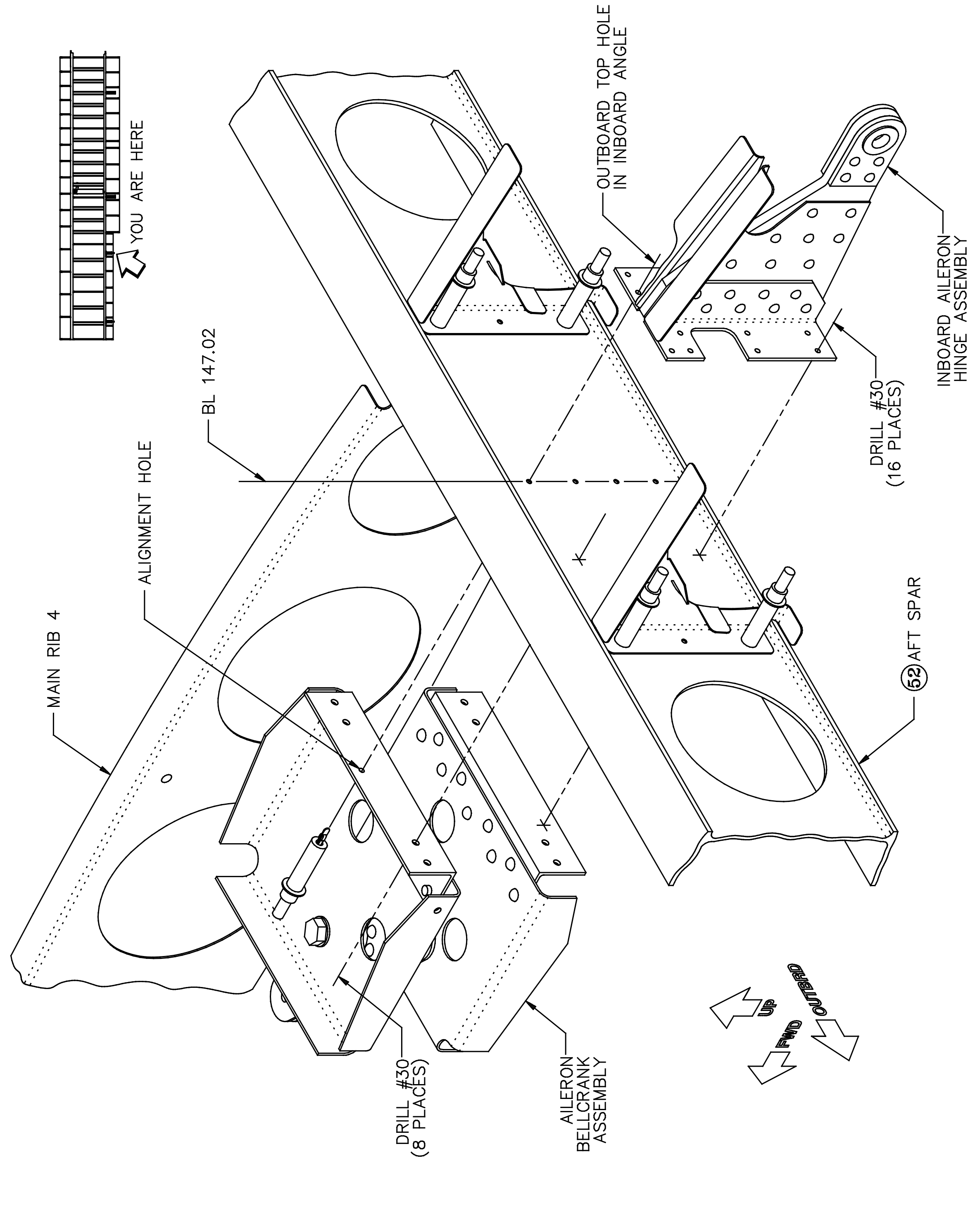

Figure 67: Aileron Bellcrank Assembly and Inboard Hinge Installation

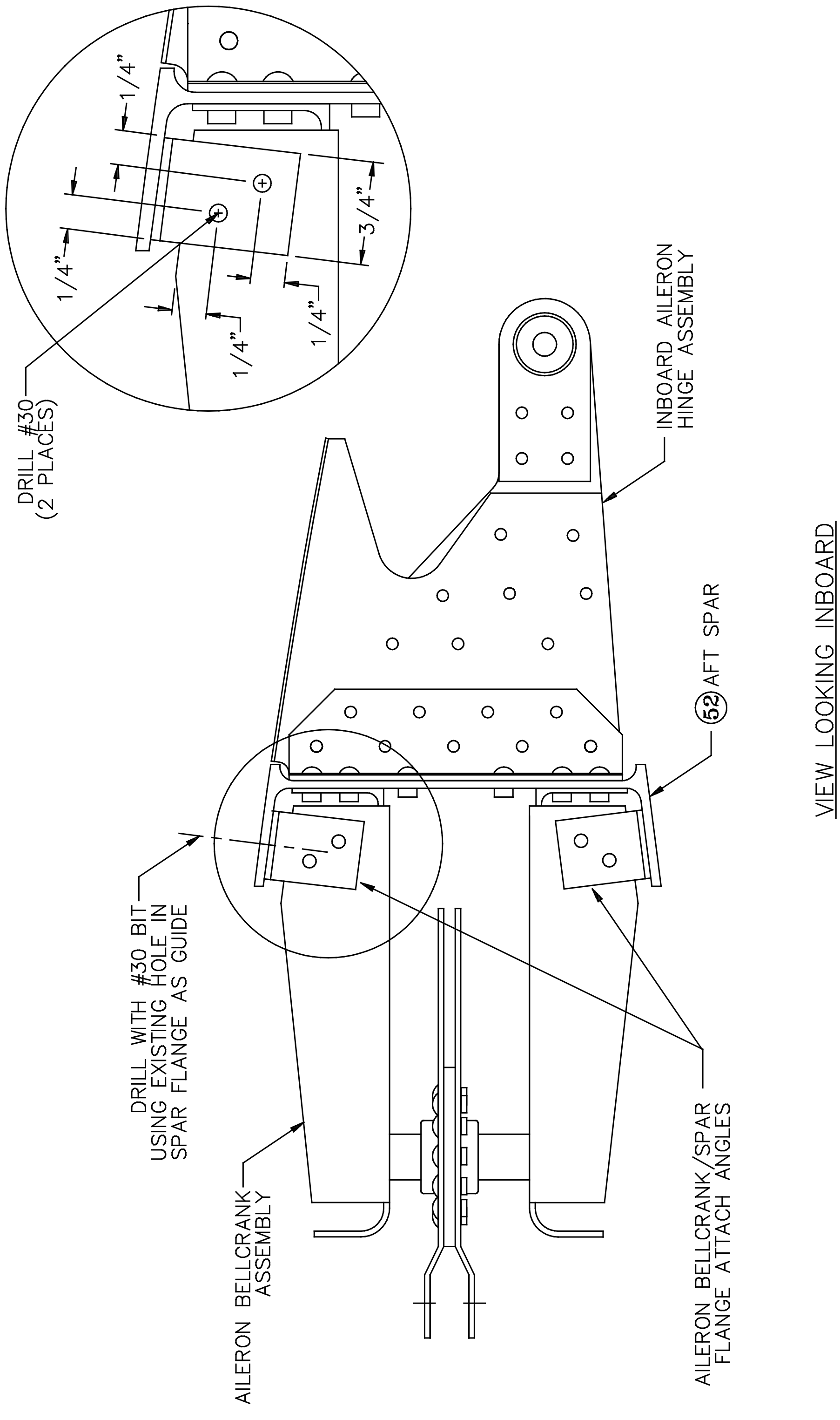

Figure 68: Bellcrank Bracket/Spar Flange Attach Angles

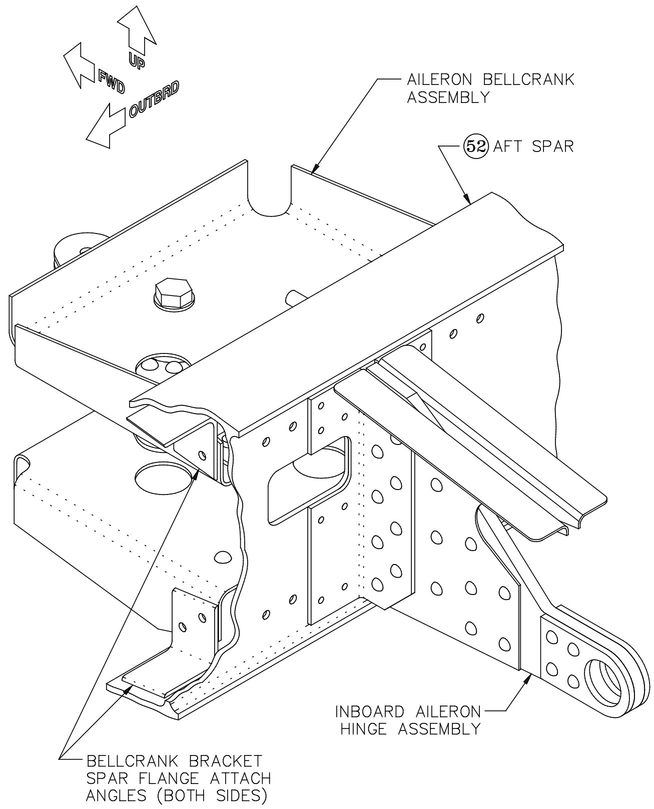

Figure 69: Bellcrank Bracket/Spar Flange Attach Angles

Fabricate four **bellcrank bracket/spar flange attach angles** from the supplied **.063" X 1" X 1" 6061-T6 aluminum angle** [96]. Cut the attach angles **3/4"** long, as shown in Figure 68, and smooth the cut edges with files and sandpaper. Mark and centerpunch the rivet pattern shown in the detail of Figure 68 onto one leg of each attach angle.

Clamp the four spar flange attach angles in place against the bellcrank brackets and the underside of the spar flanges (one on each side of each bracket) with the center-punched legs against the bellcrank brackets. Use the center-punched rivet pattern on the angles as a guide to drill **#30** holes through the attach angle/bellcrank bracket assembly.

One of the pre-drilled wing skin holes in the aft spar flange will intersect the other leg of each spar flange attach angle. Use these holes as guides to drill **#30** holes through the attach angles. Avoid elongating or enlarging the already-drilled holes in the spar.

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Step 49: Position and Drill the Outboard Aileron Hinge Assembly

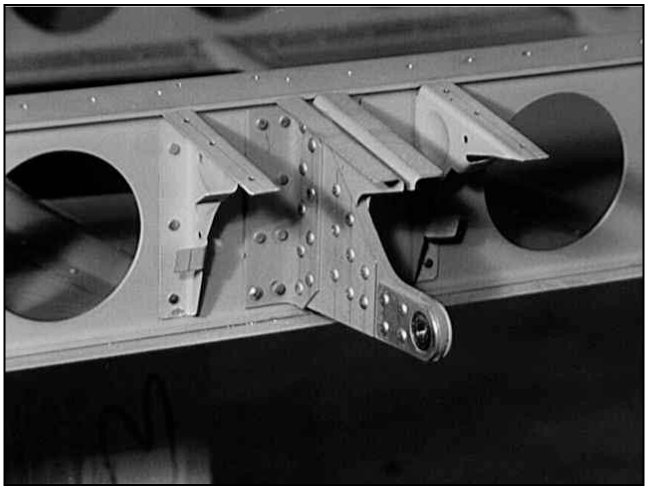

Figure 69.1: Outboard Aileron Hinge Assembly

Cleco the **outboard** aileron hinge assembly to the aft side of the aft spar using the pre-drilled holes located at **BL 190.14**, as shown in Figure 70. Use the holes in the attach angles to drill **#30** rivet holes through the spar.

Completed: Left [ ]
Right [ ]

Step 50: Mount the Aileron Bellcrank and Hinges

When all the holes have been drilled in both aileron hinge assemblies and the aileron bellcrank assembly, mark each assembly with its location and orientation. Remove the hinge assemblies and the bellcrank bracket assembly, and deburr and corrosion-proof the rivet holes.

Cleco and then rivet the hinge assemblies and the aileron bellcrank assembly to the aft spar using 1/8" AN470AD4 universal-head rivets. Rivet the bellcrank bracket/spar flange attach angles to the bellcrank brackets with 1/8" AN470AD4 universal-head rivets. **(The angles will be riveted to the spar flanges when the skins are riveted to the spar.)** Following standard procedures, position the manufactured heads of the rivets against the **thinner** material where possible.

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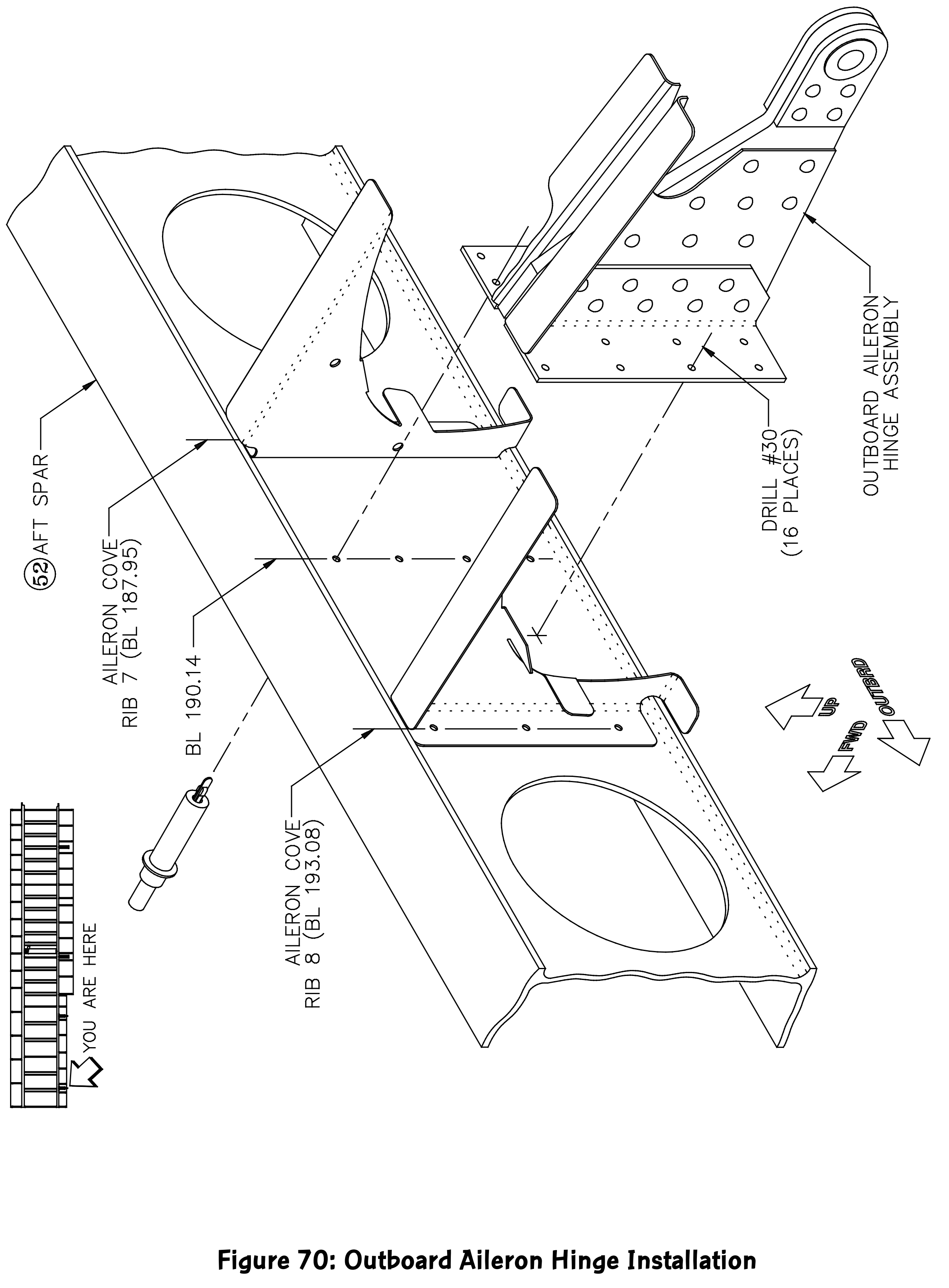

Figure 70: Outboard Aileron Hinge Installation

FABRICATE AND MOUNT THE AILERON PULLEY BRACKETS

Step 51: Fabricate and Mount the Outboard Pulley Brackets

Fabricate the two outboard aileron pulley bracket angles from the supplied **outboard aileron pulley bracket angle** stock [91], as shown in Figure 72. (The angle is .063" thick X 7/8" X 2-1/2" formed aluminum angle.) Use a hacksaw or a band saw to rough cut the angles and finish them with a belt sander or a file.

> **Note** Figure 72 shows the pulley bracket assembly for the **left** wing; the **right** wing assembly is a mirror image.

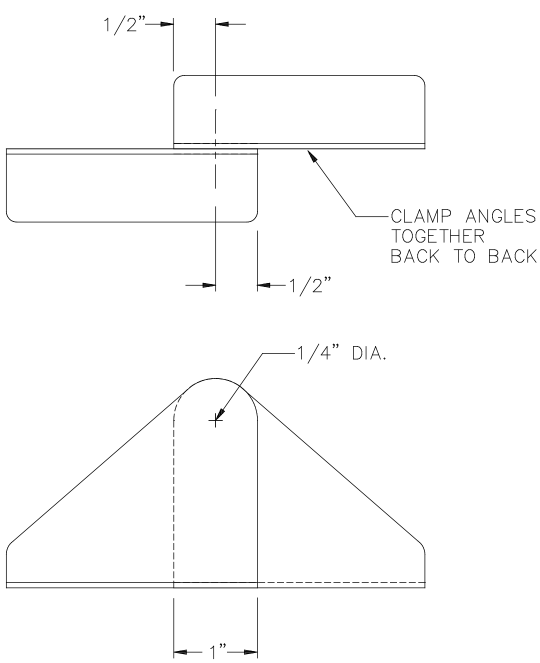

Figure 71: Drilling the Pulley Bracket Angles

To drill the 1/4" pulley pivot holes through the angles, mark and centerpunch the location of the pulley pivot hole on one of the angles. Place the two angles back-to-back, as shown in Figure 71, with the short legs of the angles resting on a flat surface and with the outboard ends of the two angles overlapping each other by 1" to align the pivot hole locations. Clamp the angles together, and use the centerpunched mark as a guide to drill the **1/4"-** diameter hole through both angles at the same time, preferably with a drill press.

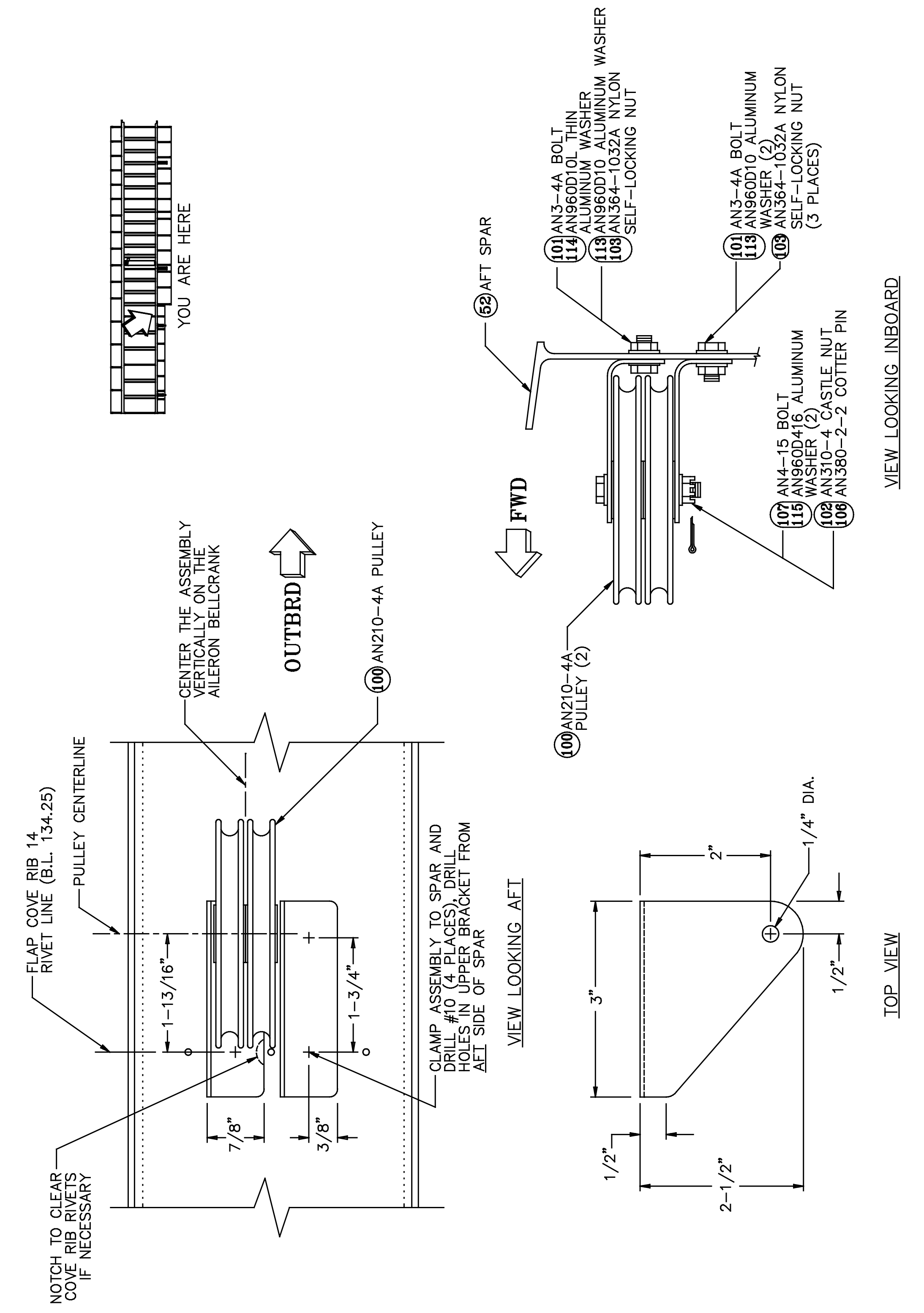

Figure 72: Outboard Aileron Pulley Brackets

Mount the two AN210-4A **pulleys** [100] between the pulley bracket angles, as shown in Figure 72, using the AN4-15 **drilled-shank bolt** [107], AN310-4 castle nut and AN960D416L thin aluminum washers under both the bolt head and the nut.

> **Note** Instead of the **AN210-4A** pulleys specified in the preceding paragraph and in Figure 72, some GlaStar kits include **MS24566-4B** pulleys. Both types of pulleys are aircraft-grade, 3-1/2" phenolic pulleys and are thus completely interchangeable. Which pulley is supplied simply depends on current pricing and availability from our vendors.

Clamp the pulley bracket assembly to the **forward side** of the aft spar, as shown in Figure 72. Position the angles parallel to the spar flange, with the pulleys' pivot axis **1-13/16" outboard** of the rivet line for Flap Cove Rib 14. Center the two pulleys vertically on the centerline of the aileron bellcrank; this will provide the best routing of the cables from the pulleys to the bellcrank.

> **Note** When the pulleys are centered relative to the bellcrank, the lower edge of the upper pulley bracket may interfere with the center rivet holes for Flap Cove Rib 14 and Aileron Cove Rib 1. Make small "U"-shaped notches in the lower edge of the upper bracket, if necessary, to accommodate the heads of the AN470AD4 rivets that will secure the cove ribs to the spar.

Drill four **#10** mounting holes through the pulley bracket angles and the aft spar, as shown in Figure 72; Cleco each hole as it is drilled. The two inboard mounting holes are in line vertically with Flap Cove Rib 14's rivet line (**BL 134.25**) and will pass through the cove rib's flange; the two outboard mounting holes are **1-3/4"** outboard of the inboard holes. Drill all mounting holes in the centers of the angle flanges vertically. The holes in the upper angle must be drilled from the aft side of the spar, so drill the holes in the lower angle first and measure from these to determine the positions of the upper holes. Use a drill stop when drilling the upper holes to prevent damage to the pulley.

When all the holes have been drilled, remove the pulley bracket assembly from the spar and disassemble it. Also remove Flap Cove Rib 14 from the aft spar. Deburr all holes and corrosion-proof the parts.

Rivet Flap Cove Rib 14 to the aft spar with 1/8" AN470AD4 universal-head rivets. Bolt the pulley bracket angles to the aft spar. Place the head of the upper, outboard AN3-4A **bolt** [101] on the **forward** side of the pulley bracket, as shown in Figure 72, to provide clearance for the pulley, and secure the bolt with an AN960D10L **thin aluminum washer** [114] under the head and an AN960D10 **aluminum washer** [113] under the AN364-1032A **nylon self-locking nut** [103]. Place the heads of the other three AN3-4A bolts on the aft side of the spar; secure them with AN960D10 washers under both the bolt heads and the AN364-1032A nuts.

Bolt the two AN210-4A pulleys between the pulley bracket angles, using the AN4-15 bolt, AN960D416 aluminum washers and AN310-4 nut. At final assembly, after the control cables and the cable retainer strap have been fabricated and installed, the castle nut will be secured with an AN380-2-2 cotter pin.

Completed: Left [ ] Right [ ]

Step 52: Fabricate and Mount the Inboard Pulley Brackets

Jump-Start Spar Option If you ordered the pre-assembled spar option (P/N 038-02100P01), the aileron pulley slot described in the following two paragraphs and illustrated on the facing page has been completed for you. **Skip to the next page.**

The inboard aileron pulleys protrude through a slot in the aft spar web. To cut the slot, you will first drill two **1-1/4"**-diameter holes in the aft spar web, as shown in Figure 73, and then remove the material between the holes. Mark and centerpunch the centers of the 1-1/4" holes on the **forward side** of the aft spar, centered vertically on the two outboard aileron pulleys, as shown. The center of the first hole is **1-1/2" inboard** of the rivet line for Flap Cove Rib 14 (BL 134.25); the center of the second hole is **4-7/8"** inboard of the line.

Clamp a scrap wood block to the aft side of the aft spar in the area of the slot. Use a **1-1/4"**-diameter hole saw to drill the two holes at the ends of the pulley slot, following the same procedures described earlier (in Step 4) for drilling the lightening holes in the spars. (Alternatively, you can use a large Unibit to drill the holes.) When the holes are finished, mark parallel lines between the two circles tangent to their upper and lower edges. Use a hack saw blade to cut inside the marked lines and then finish the cut by filing or grinding out to the lines. Smooth the cut edges of the slot with sandpaper, making sure to remove any saw marks or rough edges.

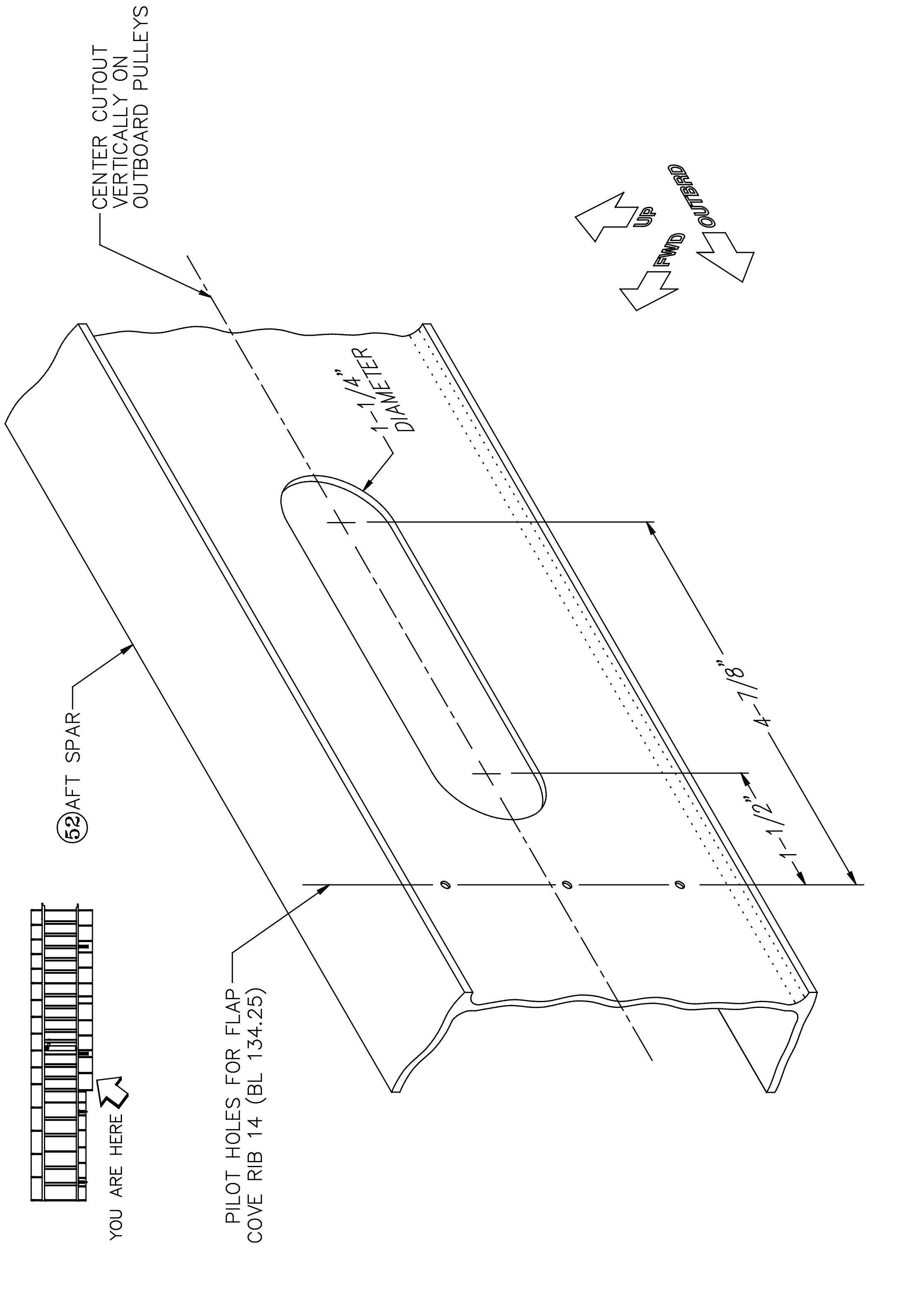

Figure 73: Inboard Aileron Pulley Slot in Aft Spar

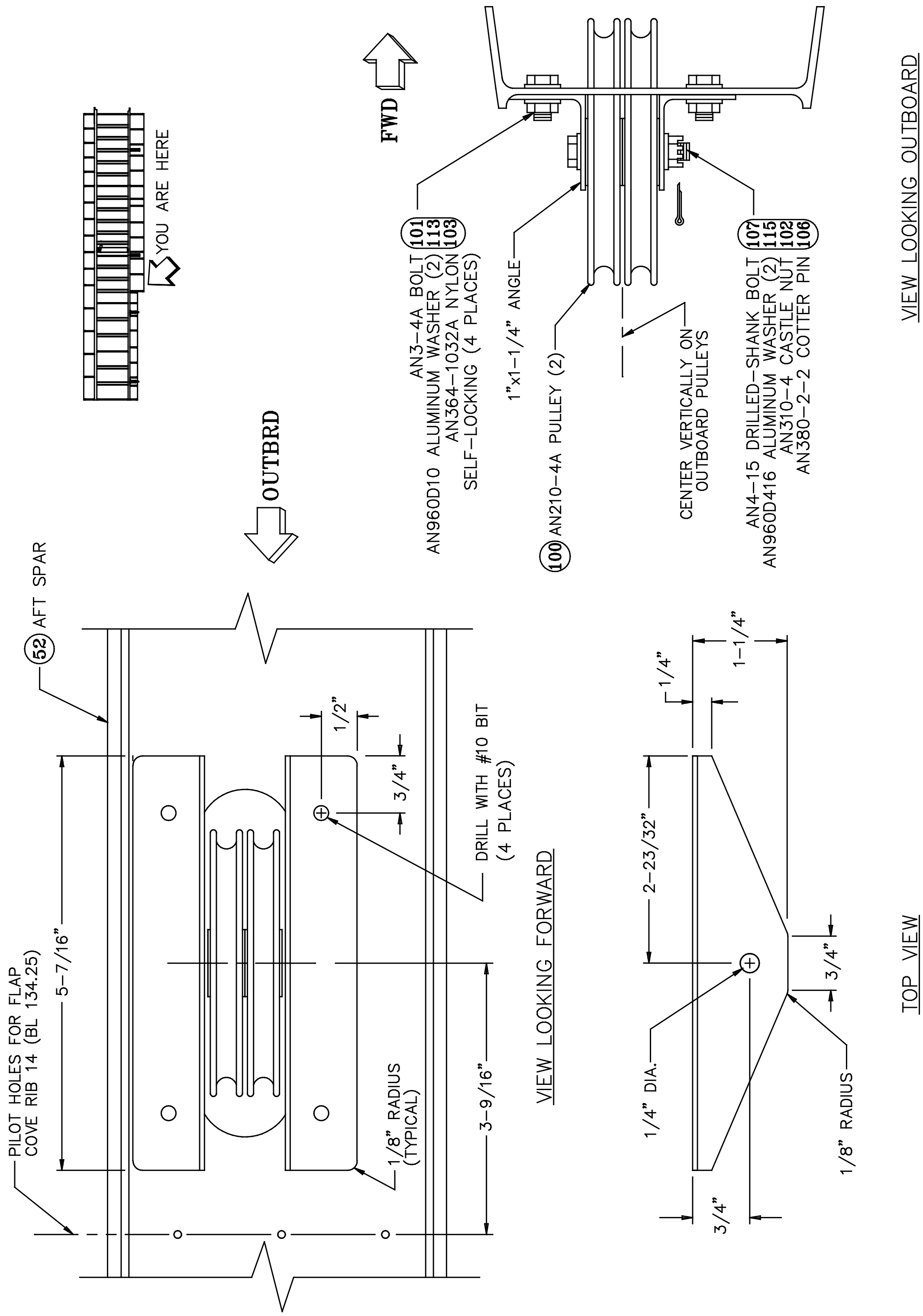

Figure 74: Inboard Aileron Pulley Brackets

Fabricate two inboard aileron pulley bracket angles from the supplied **.063" X 1" X 1-1/4" angle** [97], as shown in Figure 74. The two angles are symmetrical and identical. Cut the angles to rough shape with a hacksaw or a band saw and finish with files and sandpaper to remove saw marks. Clamp the two angles together back-to-back to drill the **1/4"**-diameter pulley mounting holes through both angles at the same time.

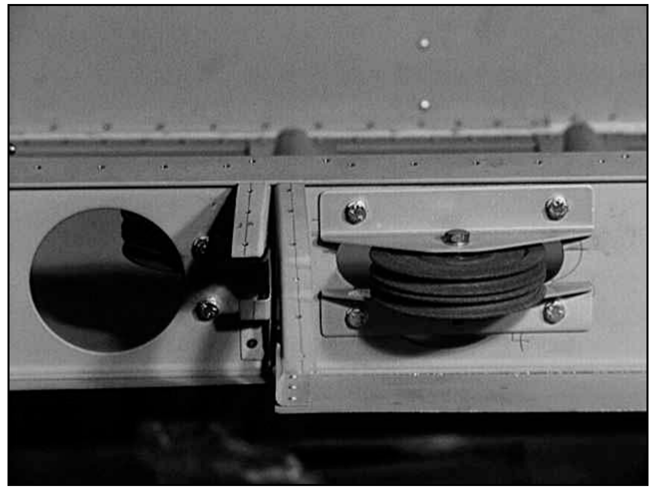

Figure 74.1: Inboard Aileron Pulley Bracket

Mount the two AN210-4A pulleys between the pulley bracket angles, as shown, using the AN4-15 drilled-shank bolt, two AN960D416 aluminum washers and an AN310-4 castle nut.

Clamp the inboard pulley bracket assembly to the **aft** side of the aft spar, as shown in Figure 74. Position the bracket angles parallel to the spar flange, with the pulleys' pivot axis **3-9/16" inboard** of the rivet line for Flap Cove Rib 14. Center the inboard pulleys vertically on the line between the two outboard pulleys.

Drill two **#10** mounting holes through each pulley bracket angle and the aft spar, as shown. When the holes have been drilled, remove the bracket assembly from the spar and disassemble it. Deburr the holes and corrosion-proof the parts.

Assemble the pulley bracket using the hardware described previously, and bolt the assembly to the aft spar using AN3-4A bolts and AN960D10 aluminum washers under both the bolt heads and the AN364-1032A nylon self-locking nuts. At final assembly, after the cables have been routed and the cable retainer installed, secure the castle nut on the pivot bolt with an AN380-2-2 cotter pin.

Completed: Left [ ] Right [ ]

Assemble and Mount the Flap Tracks

Step 53: Assemble the Flap Tracks

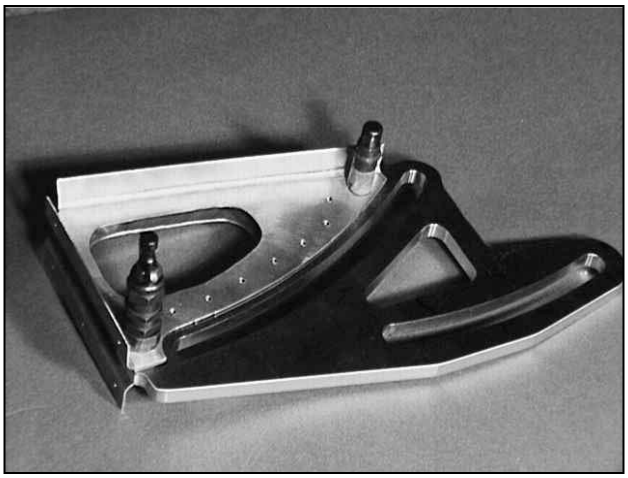

Figure 74.2: Flap Track Assembly

Lay out and center punch the rivet pattern shown in Figure 75 onto a **left-flange flap track rib** [74], being careful to maintain a minimum edge distance of 1/4" (twice the rivet diameter) from the centers of the rivet holes to the edges of the **rib**. (This may position the rivet holes less than 1/4" from the edge of the flap track, but this is acceptable, since the track is made from such thick material.)

Cleco a **left-flange** and a **right-flange flap track rib** [74 and 75] to the sides of each **flap track** [73] with the flanges of the ribs oriented away from the flap track, as shown in Figures 74.2 and 75. Use 1/8" Clecos in the two pre-drilled holes in each part.

Use the center-punched rivet pattern as a guide to drill **#30** holes through the assembly. Disassemble and deburr the rivet holes, and corrosion-proof the parts. Rivet the assembly together with 1/8" AN470AD4 universal-head rivets. Repeat for both the inboard and the outboard flap track assemblies.

Completed: Left [ ] Right [ ]

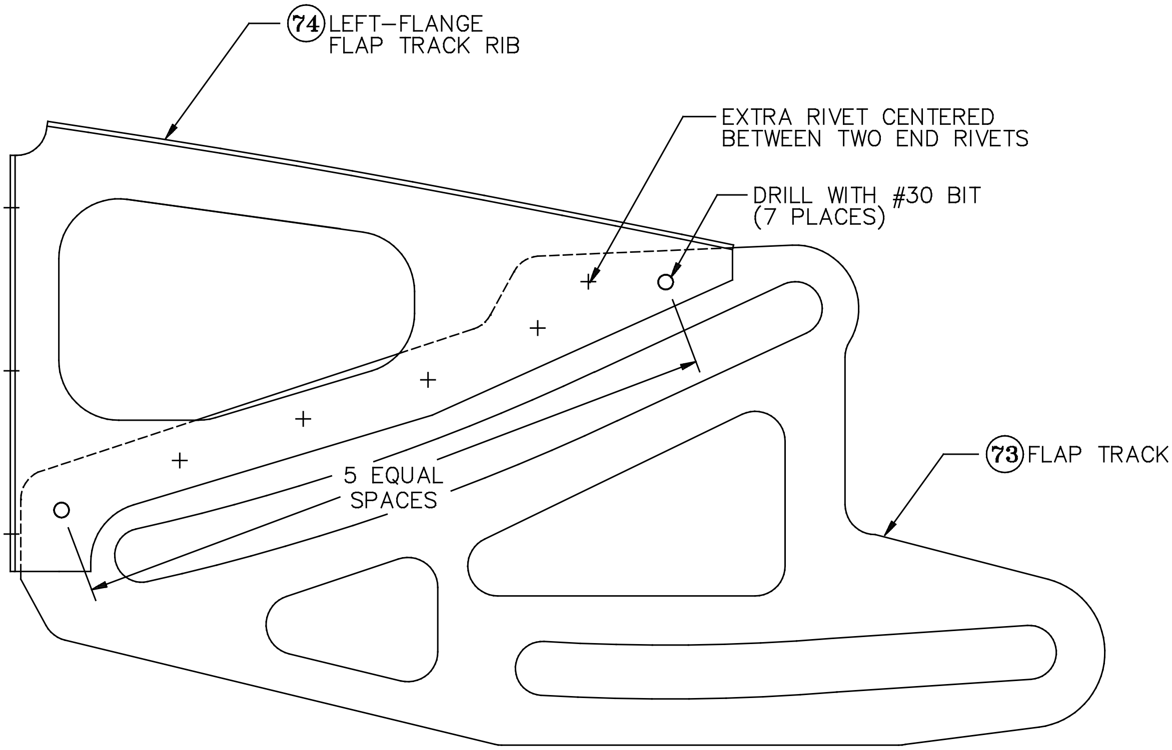

Figure 75: Flap Track Assembly

Step 54: Mount the Flap Tracks

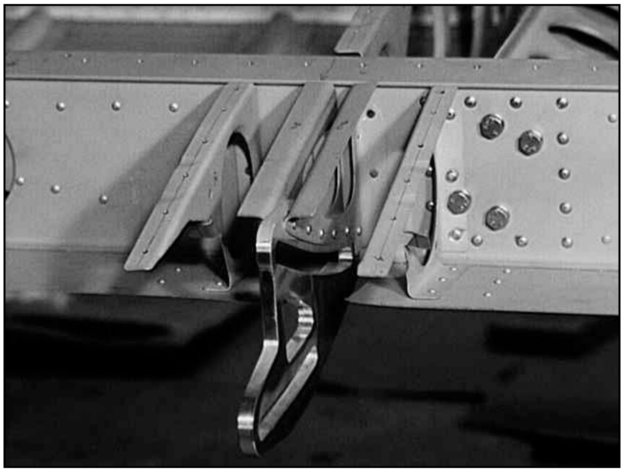

Figure 75.1: Flap Track Installation

The **outboard** rib of the **outboard** flap track assembly shares rivets with the aft end of Main Rib 3 at **BL 112.53**, as shown in Figures 75.1 and 76. The **outboard** rib of the **inboard** flap track assembly is riveted to the pre-drilled holes in the aft spar at **BL 47.03**, approximately half way between Flap Cove Ribs 3 and 4. Cleco the flap track assemblies to the aft side of the aft spar, using the appropriate pre-drilled holes in the spar. When installed correctly, the two flap tracks are **65-1/2"** apart, center-to-center.

Use the pilot holes in the flap track rib flanges as guides to drill **#30**-diameter rivet holes through the aft spar.

Note When drilling the rivet holes for the **inboard** flap track rib of each track assembly, take care to hold the inboard rib's web parallel to the web of its mate. Since the flap track separates the two ribs at the bottom only, it's easy to let the top of the inboard rib drift too close to or too far away from its mate, which will complicate later installation of the plastic cable guides.

After drilling, remove the flap track assemblies from the spar and deburr the rivet holes. Rivet the flap track assemblies to the aft spar with 1/8" AN470AD4 universal-head rivets. As always, place the manufactured heads against the thinner material.

Note Do not rivet the **outboard** rib of the **outboard** flap track at this time. The outboard side will be riveted with Main Rib 3 in Step 60, when the rest of the wing structure is riveted together.

Completed: Left [ ] Right [ ]

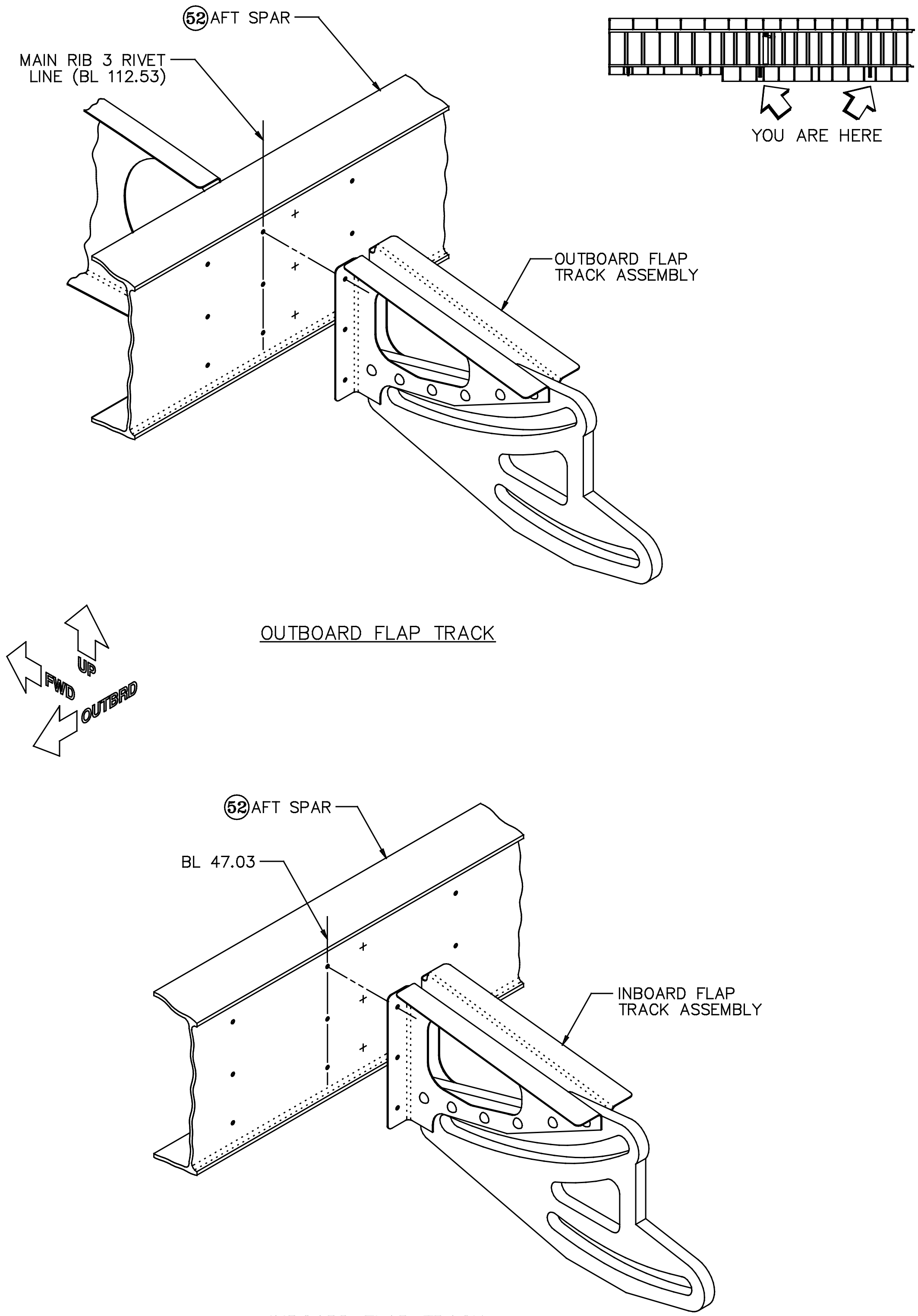

Figure 76: Flap Track Mounting

Assemble and Mount the Flap Bellcrank

Step 55: Cut the Flap Pushrod and Flap Cable Holes in the Aft Spar

Jump-Start Spar Option If you ordered the pre-assembled spar option (P/N 038-02100P01), **skip to Step 56**.

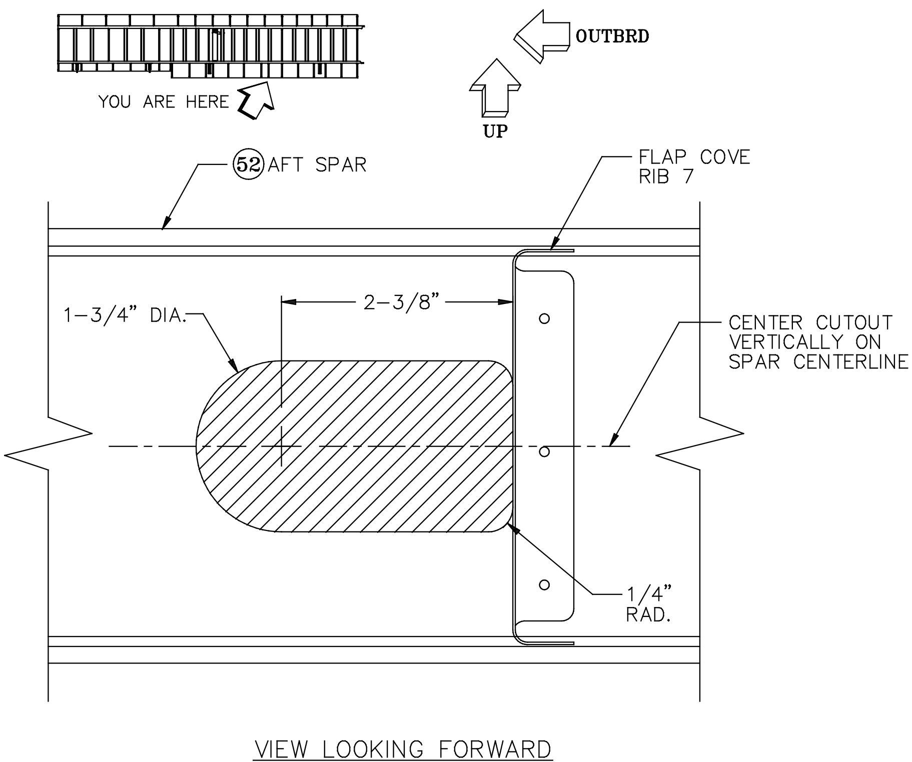

Figure 77: Flap Pushrod Pass-Through Hole in Aft Spar

Cut the hole for the flap pushrod pass-through, as shown in Figure 77. The inboard end of the cutout is flush with the outboard side of Flap Cove Rib 7. Use a 1-3/4" hole saw to cut the outboard end of the cutout (or drill a series of smaller holes just inside the perimeter) and a 1/2" drill bit for the inboard corners. Then finish the cutout with a hack saw blade, files and sandpaper. Remove the flap cove rib while cutting the hole to prevent damage.

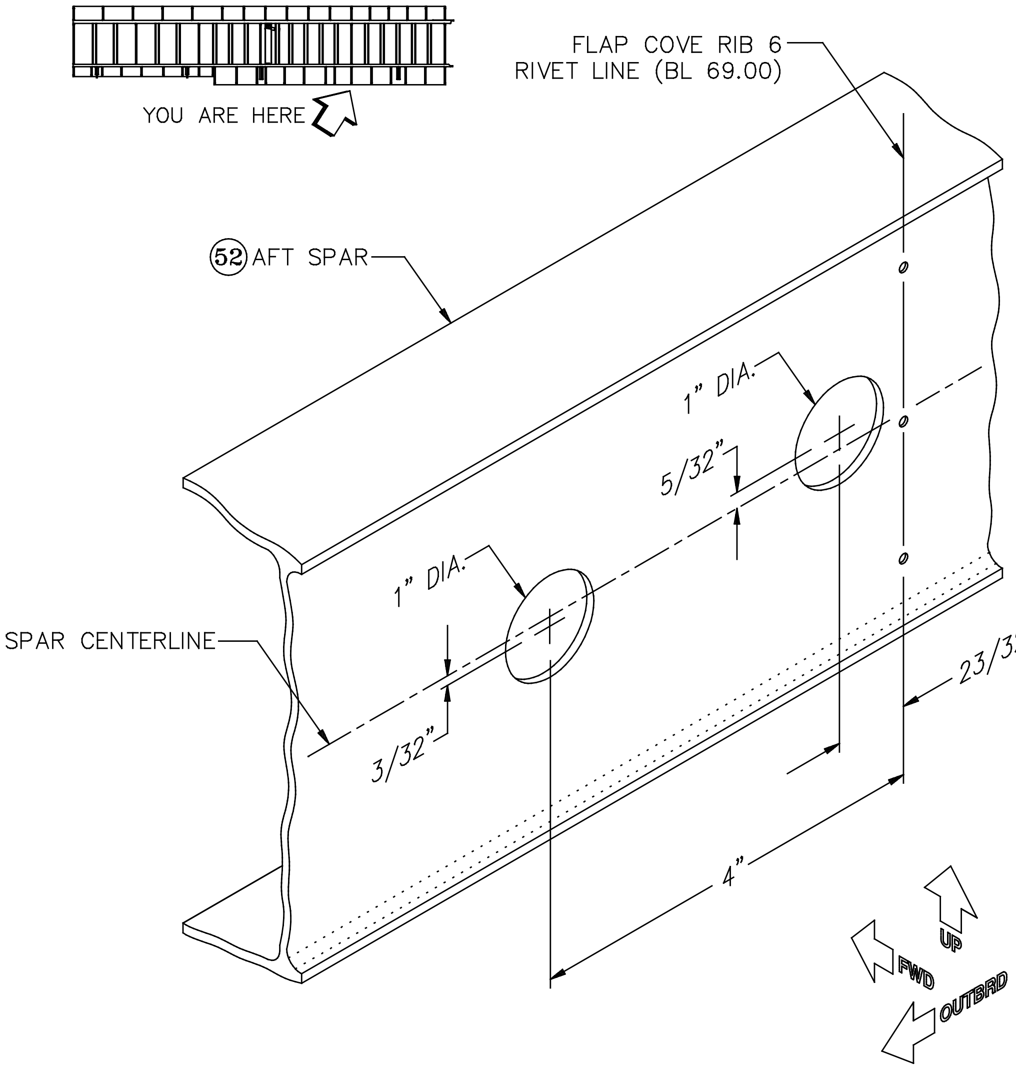

Figure 78: Flap Cable Pass-Through Holes in Aft Spar

Drill two **1"**-diameter holes in the aft spar for the flap control cables. The **inboard** hole (for the cable to the **upper** guide pulley) is located **23/32"** outboard of the Flap Cove Rib 6 rivet line (BL 69.00) and **5/32" above** the vertical centerline of the aft spar, as shown in Figure 78. The **outboard** hole (for the cable to the **lower** guide pulley) is located **4"** outboard of the Flap Cove Rib 6 rivet line and **3/32" below** the spar centerline. Use a **1"** hole saw (or a Unibit) to drill the holes, following the procedures described in Step 4 for the spar lightening holes. Part of the forward flange of Flap Cove Rib 6 overhangs the inboard hole; trim the rib flange even with the edge of the hole.

Completed: Left [ ] Right [ ]

Step 56: Assemble the Flap Bellcrank

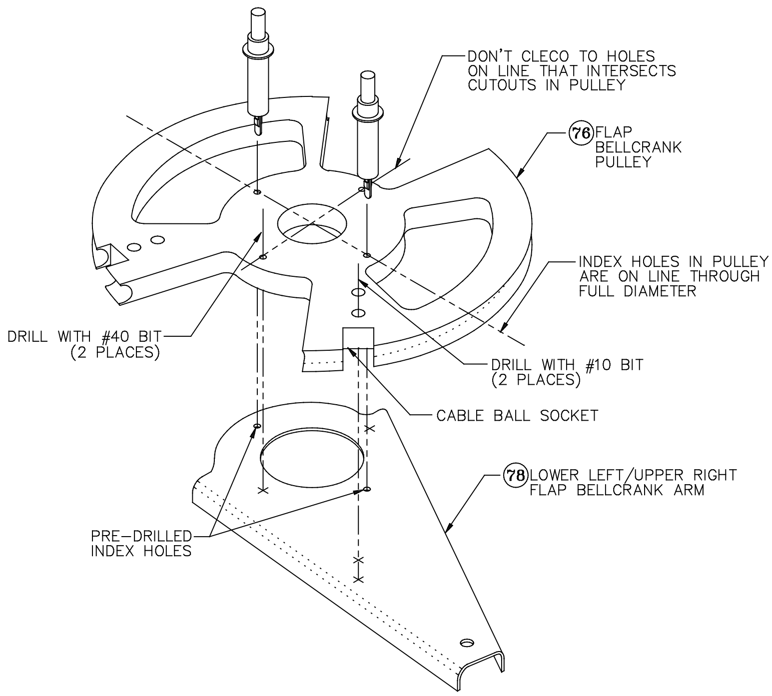

Figure 79: Drilling the Lower Flap Bellcrank Arm

Position the **flap bellcrank pulley** [76] on the upper side of the **lower left/upper right flap bellcrank arm** [78], and Cleco the arm to the pulley through the two index holes in both parts, as shown in Figure 79. Use the other two #40 holes in the pulley as guides to drill **#40** holes through the bellcrank arm. Also use the two #10-diameter holes near the cable ball socket as guides to drill **#10** holes through the bellcrank arm.

Note Assemble the bellcrank exactly as shown in the illustrations, paying careful attention to the orientation of the bellcrank arm to the pulley. In particular, notice that the two index holes in the pulley are on a line that intersects the full diameter of the pulley. The other two holes in the pulley are on a line that intersects the cutouts in the side of the pulley. If you Cleco the arm to the pulley using the correct two holes and then make sure that the arm lies under the two pre-drilled #10 holes in the pulley, you can't go wrong.

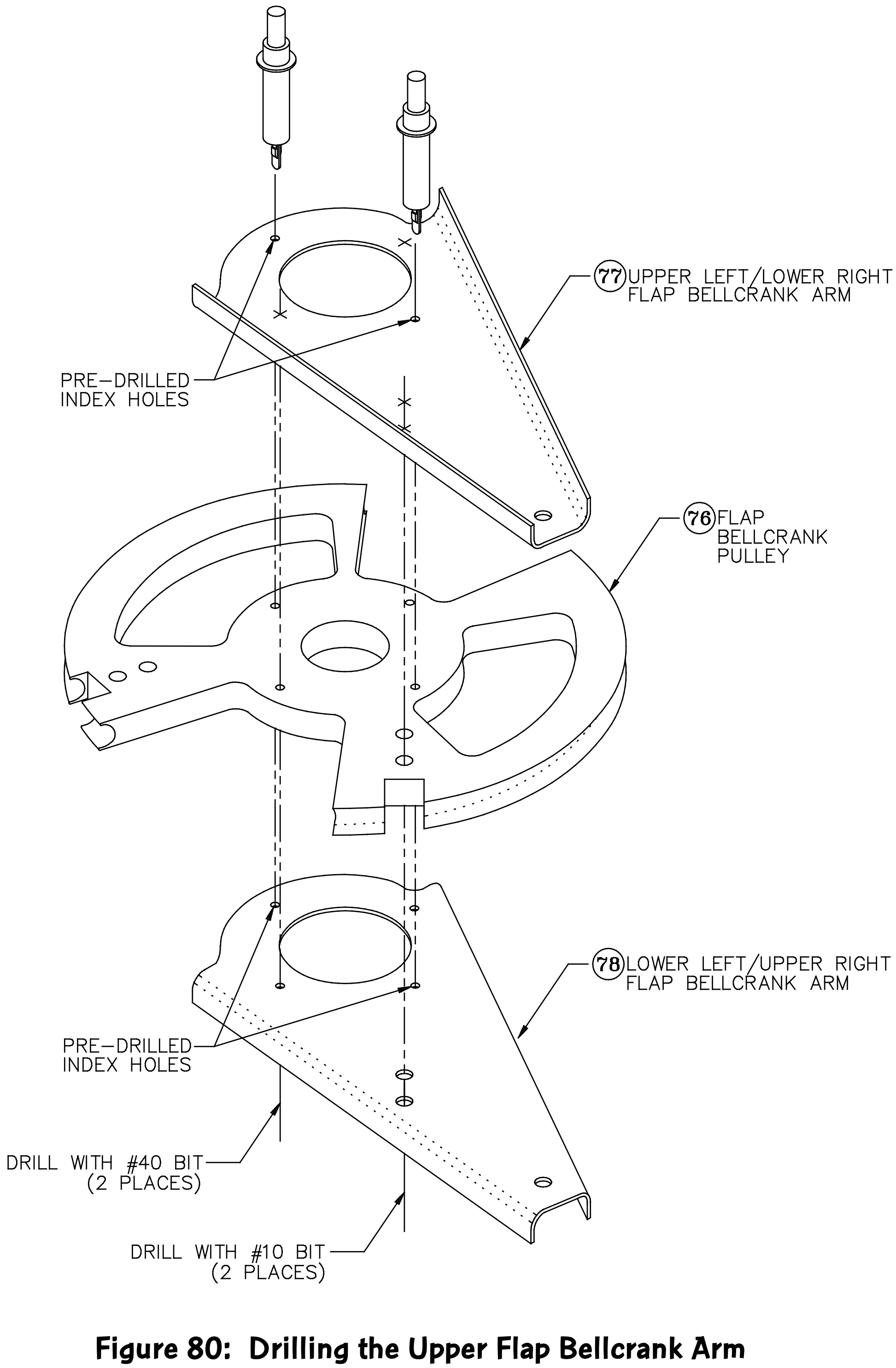

Figure 80: Drilling the Upper Flap Bellcrank Arm

Cleco the **upper left/lower right flap bellcrank arm** [77] to the other side of the bellcrank pulley, using the two pre-drilled index holes in the bellcrank arm. Drill the two **#40** holes and the two **#10** holes through the upper left/lower right flap bellcrank arm, as shown in Figure 80.

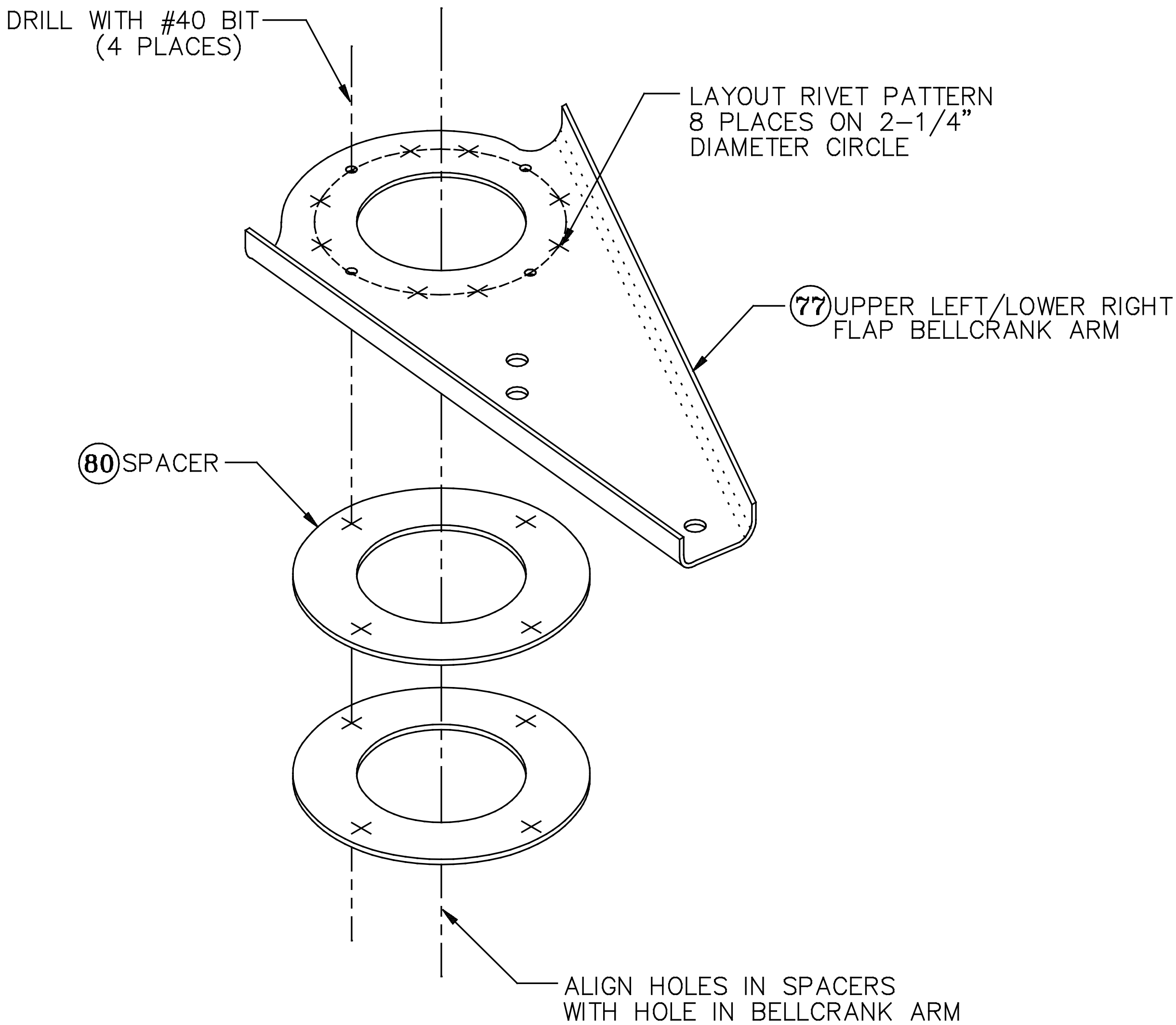

Figure 81: Drilling the Flap Bellcrank Spacers

Disassemble the bellcrank and clamp the **flap bellcrank spacers** [80] to the upper left/lower right bellcrank arm, aligning the large center holes in the spacers with the corresponding hole in the arm. Use the four #40 holes in the bellcrank arm to drill matching **#40** holes through the spacers.

Unclamp the arm from the spacers. Mark and center punch the eight additional rivet locations shown in Figure 81 onto the bellcrank arm; the rivets are equally spaced between the existing #40 holes on a 2-1/4"-diameter circle.

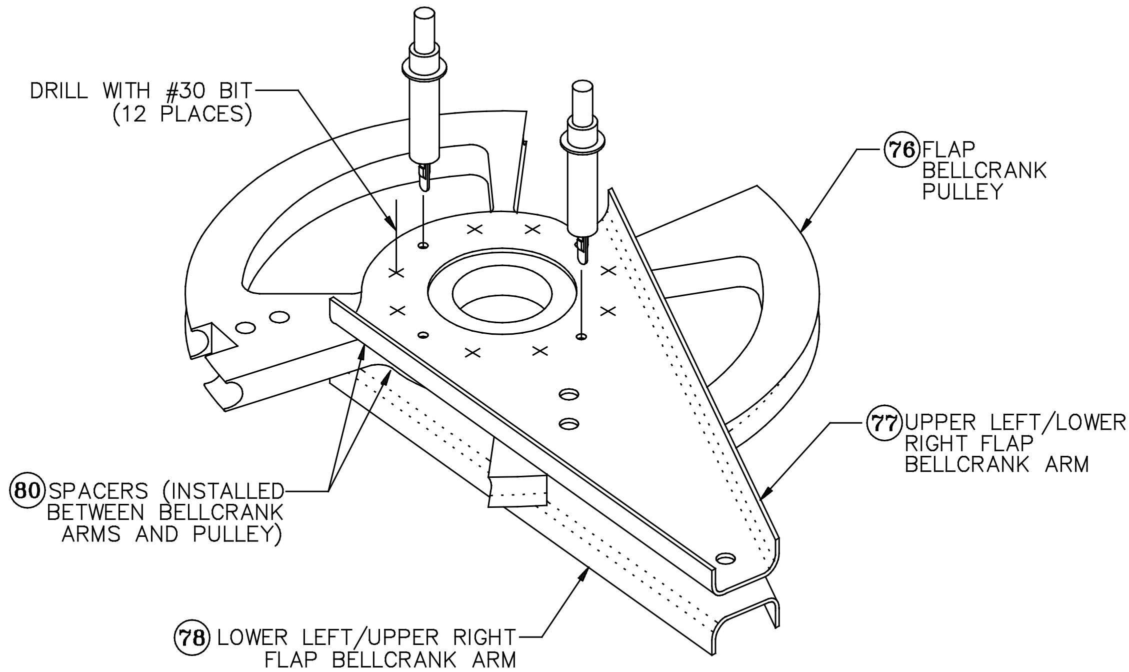

Figure 82: Drilling the Bellcrank Assembly

Cleco the two bellcrank arms, the two spacers and the pulley together in their correct positions relative to each other (the spacers fit **between** the pulley and the arms). Use the rivet pattern marked on the upper arm as a guide to drill twelve **#30** holes through the assembly. Use a drill press for this operation, if possible, to help ensure that the holes are drilled perpendicular to the surface. You will have to shift the positions of the Clecos, of course, to drill the four original #40 holes up to **#30** diameter.

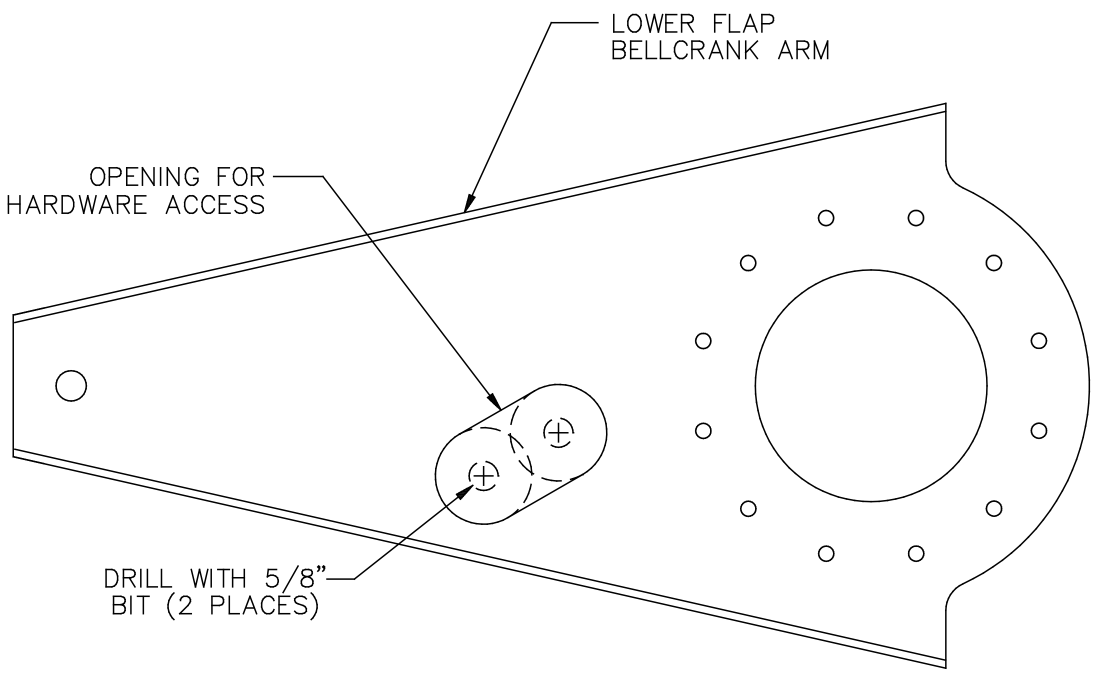

Figure 83: Cutting the Access Notch in the Lower Bellcrank Arm

Cut an opening in the **lower** bellcrank arm, as shown in Figure 83, to allow installation of the washers and nuts that secure the cable retainer clip (which will be described in "SECTION IX: SYSTEMS INSTALLATION"). To cut the opening, drill **5/8"-** diameter holes centered on the two #10 holes drilled previously. Then file to the tangent lines to make an oval shape. (The 5/8"-diameter holes should be large enough to accommodate most 1/4" drive, 3/8" socket wrenches; adjust the size of the opening to fit your own tools, if necessary.)

Note Until this point, you could have used the bellcrank assembly on either side of the airplane by simply flipping the assembly over. Now that you have defined a lower side by cutting the access notch, the bellcrank can be used on only one side. The bellcrank assembly illustrated throughout this step is for the **left** wing. Be sure you assemble a **mirror-image** part for the **right** wing.

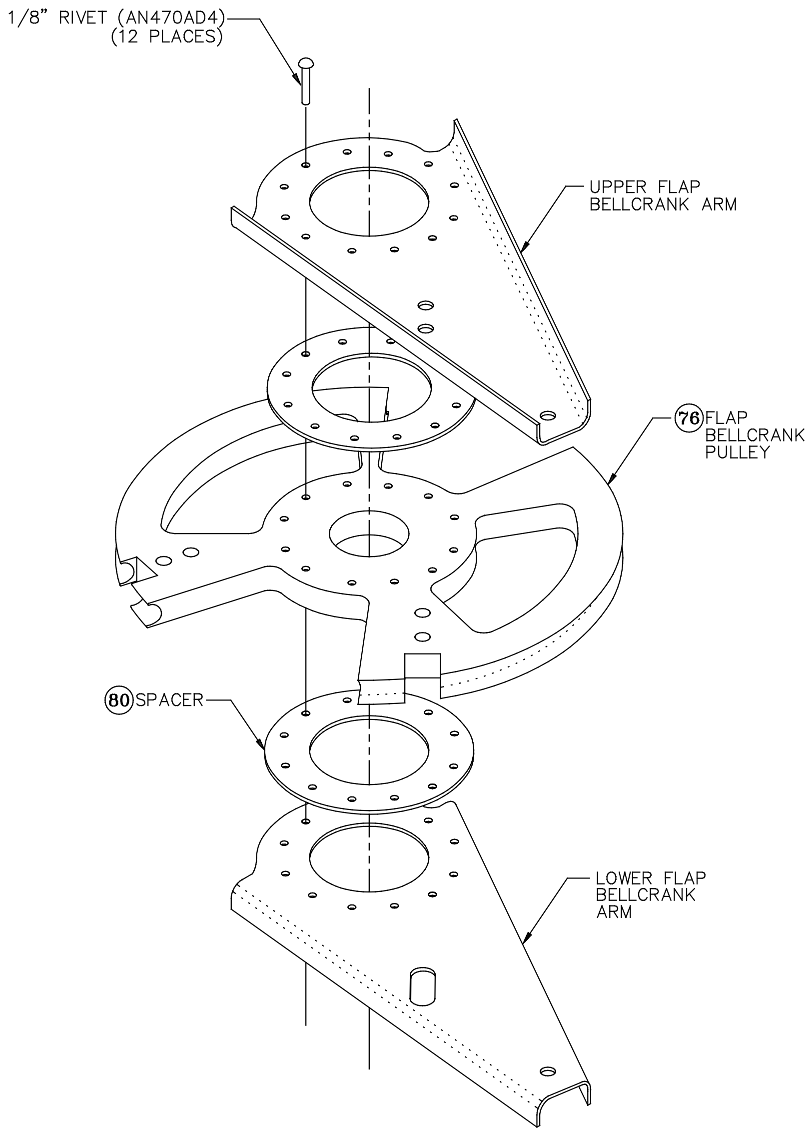

Figure 84: Riveting the Bellcrank Assembly

Disassemble the bellcrank, deburr rivet holes in all parts, and apply corrosion protection. Rivet the assembly together with 1/8" AN470AD4 universal-head rivets.

Hint Driving the long rivets used in the flap bellcrank can be difficult. We recommend **back-riveting** this assembly: clamp the universal head rivet set in a vise, place the rivet head in the set, and drive the rivet tail using either a hammer or a flush rivet set in a rivet gun. An assistant to hold things steady while you rivet will make this easier.

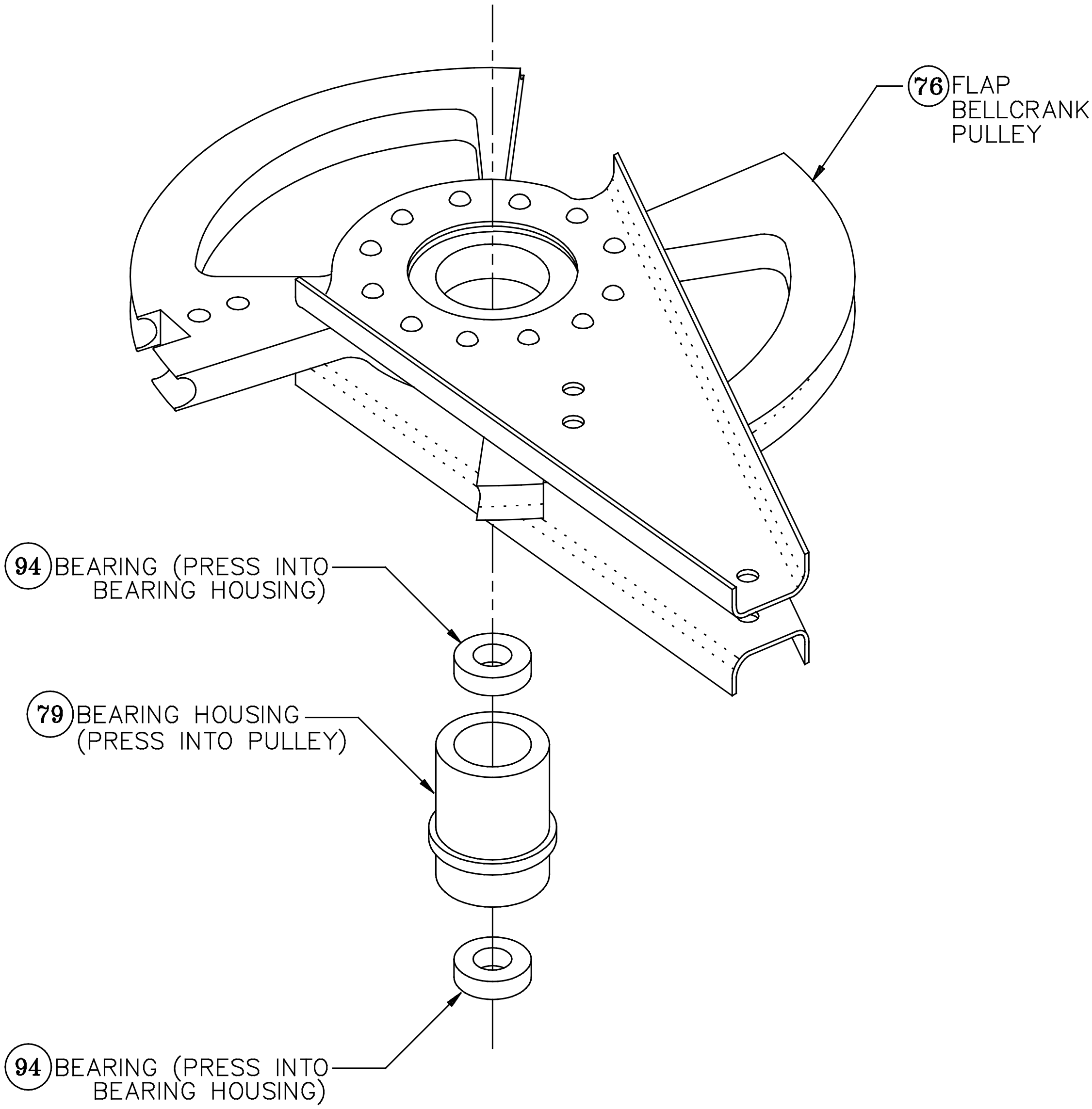

Figure 85: Install the Bellcrank Bearing Assembly

Use an arbor press or a bench vise to press the **flap bellcrank bearing housing** [79] into the flap bellcrank assembly, as shown in Figure 85. (The ridge around the bearing housing goes on the **lower** side of the pulley.) Use Loctite bearing retaining compound to secure the bearing housing (either Loctite 609 low-viscosity or 680 medium-viscosity, high-strength).

Press a **bearing** [94] into each side of the bearing housing until the outer bearing race contacts the shoulder inside the housing. Secure the outer race of each bearing with Loctite bearing retaining compound.

Completed: Left [ ] Right [ ]

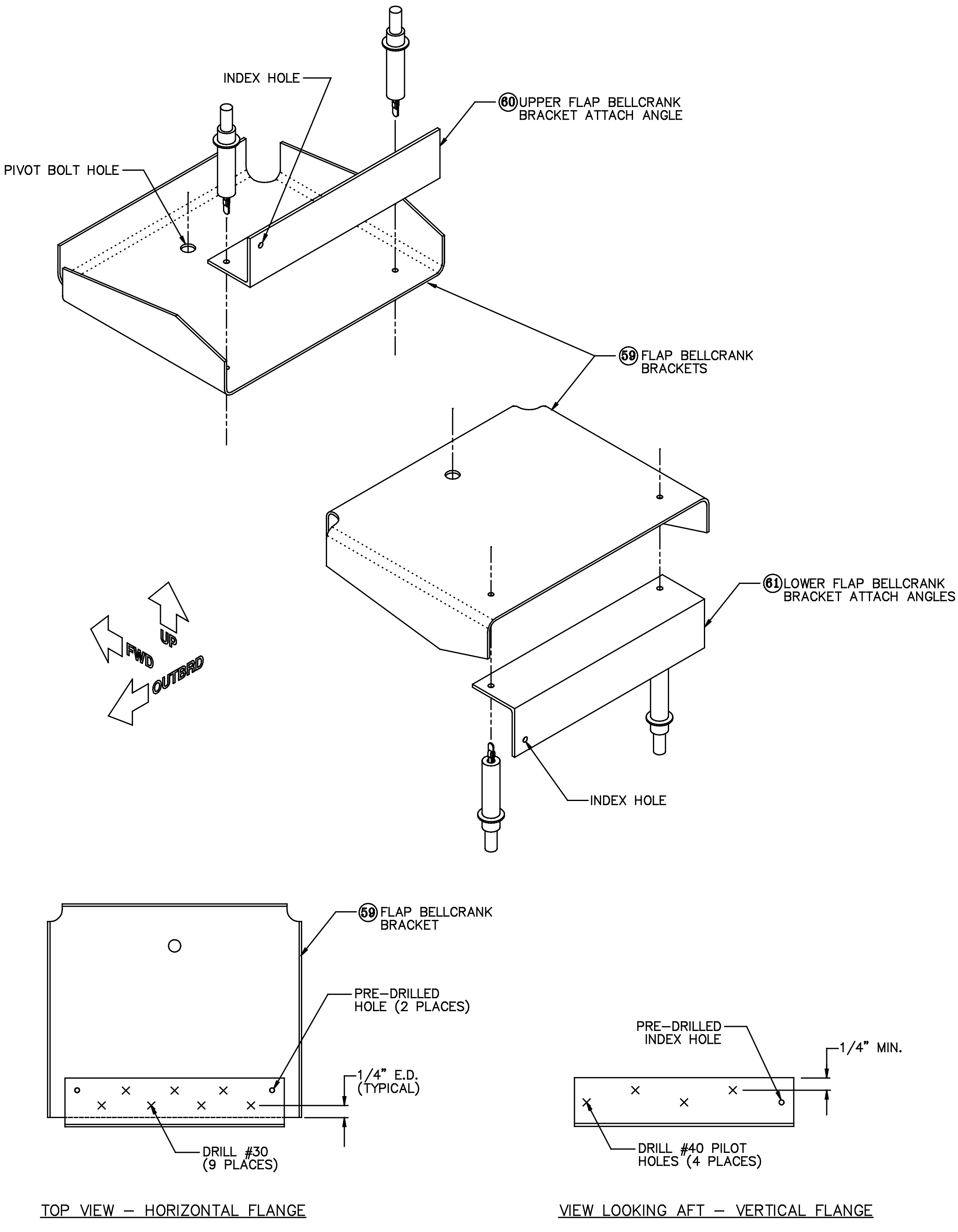

Figure 86: Flap Bellcrank Bracket Assembly

Step 57: Assemble the Flap Bellcrank Bracket

Lay out and centerpunch the rivet patterns onto both legs of the **upper** and **lower flap bellcrank attach angles** [60 and 61], as shown in the top and front views of Figure 86. Use the rivet pattern to drill **#40** pilot holes through the **vertical** legs of the angles.

> **Note** As with the aileron bellcrank attach angles, the pre-drilled pilot holes in the flap bellcrank attach angles may be centered less than the minimum two rivet diameters from the edges of the parts. This is acceptable here, both because of the thickness of the material and the total number of rivets used to rivet the bellcrank assemblies.

Cleco the **upper flap bellcrank attach angle** [60] to a **flap bellcrank bracket** [59], using the two holes in the horizontal leg of the angle to align the two parts, as shown in Figure 86. Similarly, Cleco the **lower flap bellcrank attach angle** [61] to another **flap bellcrank bracket** [59]. Make sure that the pre-drilled index holes in the vertical legs of the attach angles are positioned opposite each other, as shown. Use the center punched rivet hole locations and the two pre-drilled holes in the horizontal legs of the angles as guides to drill the nine **#30** rivet holes through each angle and bracket assembly, Clecoing as you go.

Disassemble the parts, deburr, corrosion-proof and rivet the angles to their respective brackets with 1/8" AN470AD4 universal-head rivets. Following standard procedures, place the rivet heads against the thinner material (the bracket).

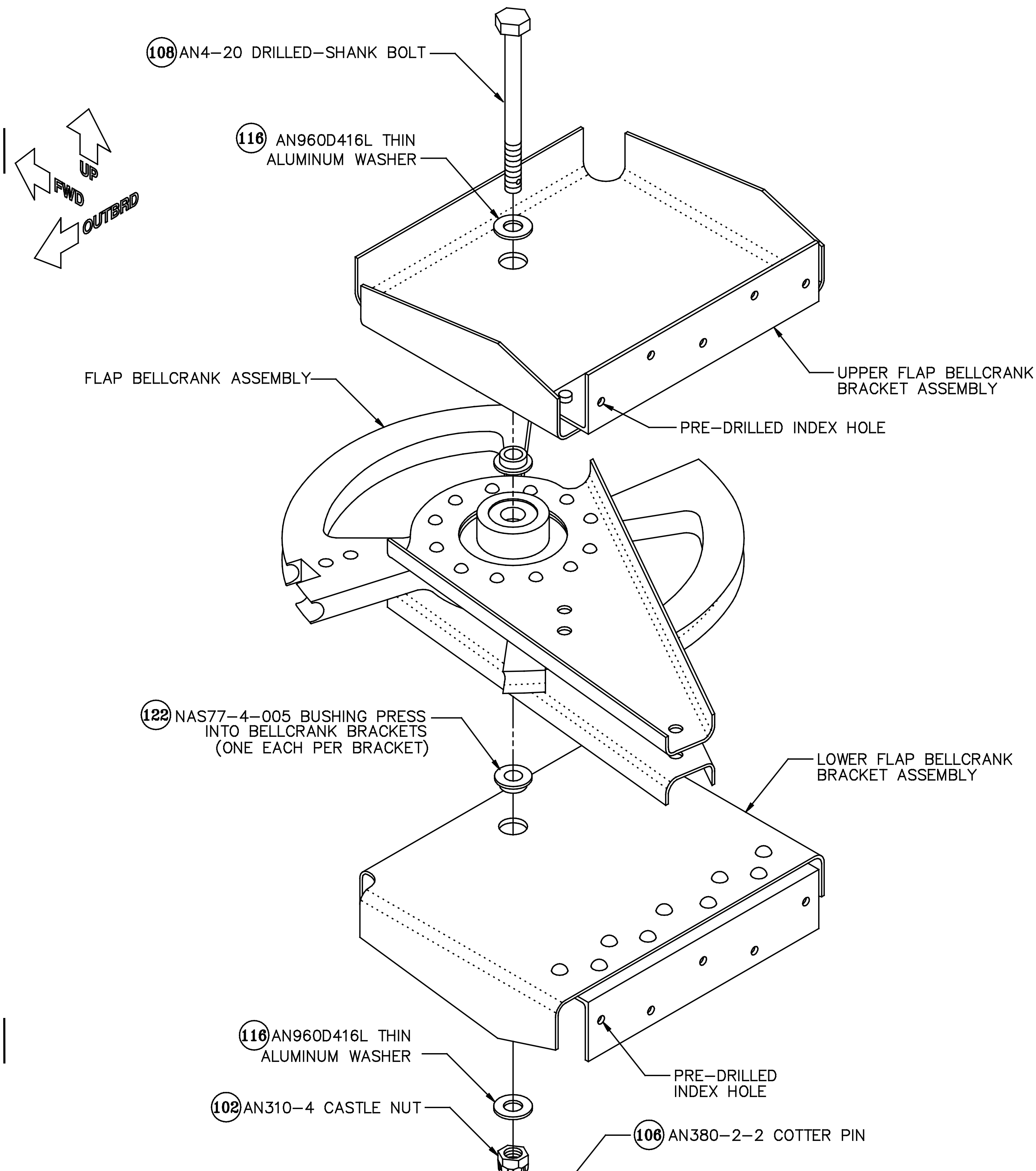

Figure 87: Mounting the Bellcrank Assembly Between the Bellcrank Brackets

Press an NAS77-4-005 **bushing** [122] into each flap bellcrank bracket, as shown in Figure 87. Position the bushing flanges toward the bellcrank, as shown. Secure the bushings with Loctite bearing retaining compound.

Use an AN4-20 **drilled-shank bolt** [108] to mount the flap bellcrank assembly between the upper and lower flap bellcrank brackets, as shown in Figure 87. Secure the bolt with an AN310-4 castle nut, an AN960D416L thin aluminum washer (under both the bolt head and the nut) and an AN380-2-2 cotter pin.

Caution Tighten the AN310-4 castle nut on the AN4-20 drilled-shank bolt only to the point at which there is no up-and-down play in the bellcrank. The bellcrank bearings are not designed to handle the loads imposed by an over-tightened bolt.

Completed: Left [ ] Right [ ]

Step 58: Mount the Flap Bellcrank Assembly

Position the flap bellcrank assembly on the forward side of the aft spar, as shown in Figure 88, and Cleco the pre-drilled index holes in the bellcrank attach angles through the upper and lower rivet holes for Flap Cove Rib 7 at **BL 76.94**.

Make sure the bellcrank assembly is square to the spar, and use the #40 pilot holes in the bracket attach angles as guides to drill **#30** holes through the angles and the spar. Cleco as you go.

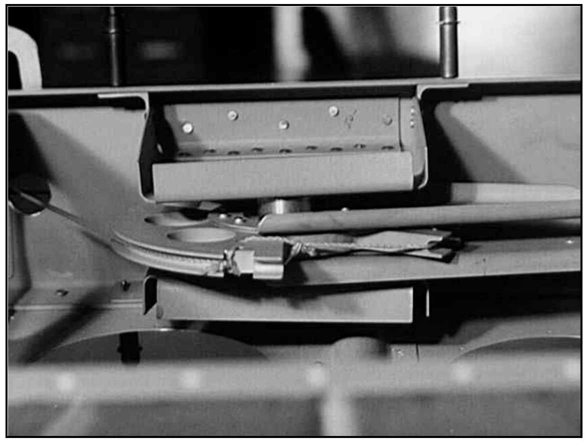

Figure 87.1: Flap Bellcrank Bracket Installation
Left Side Shown – Looking Aft

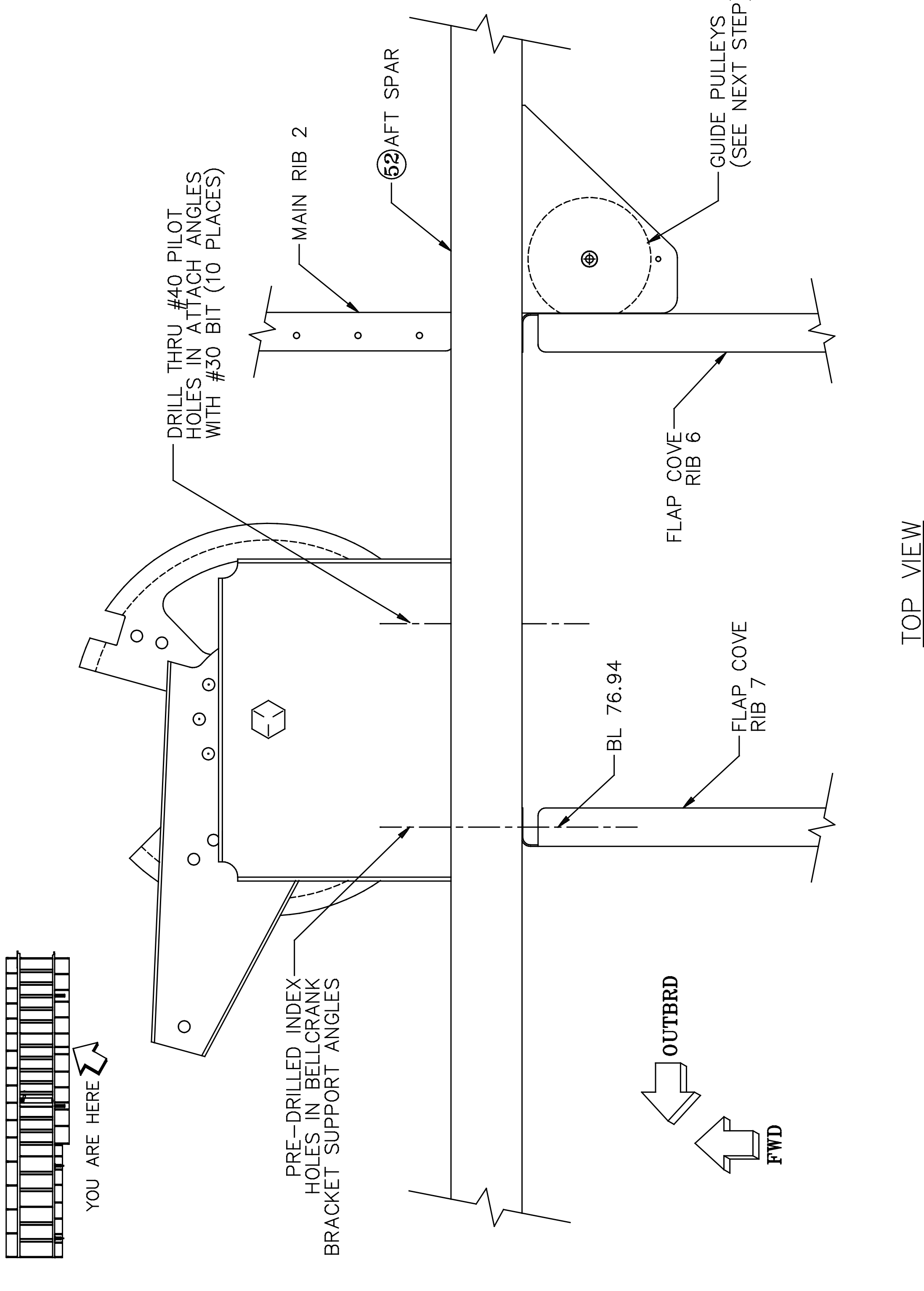

Figure 88: Mounting the Flap Bellcrank Assembly

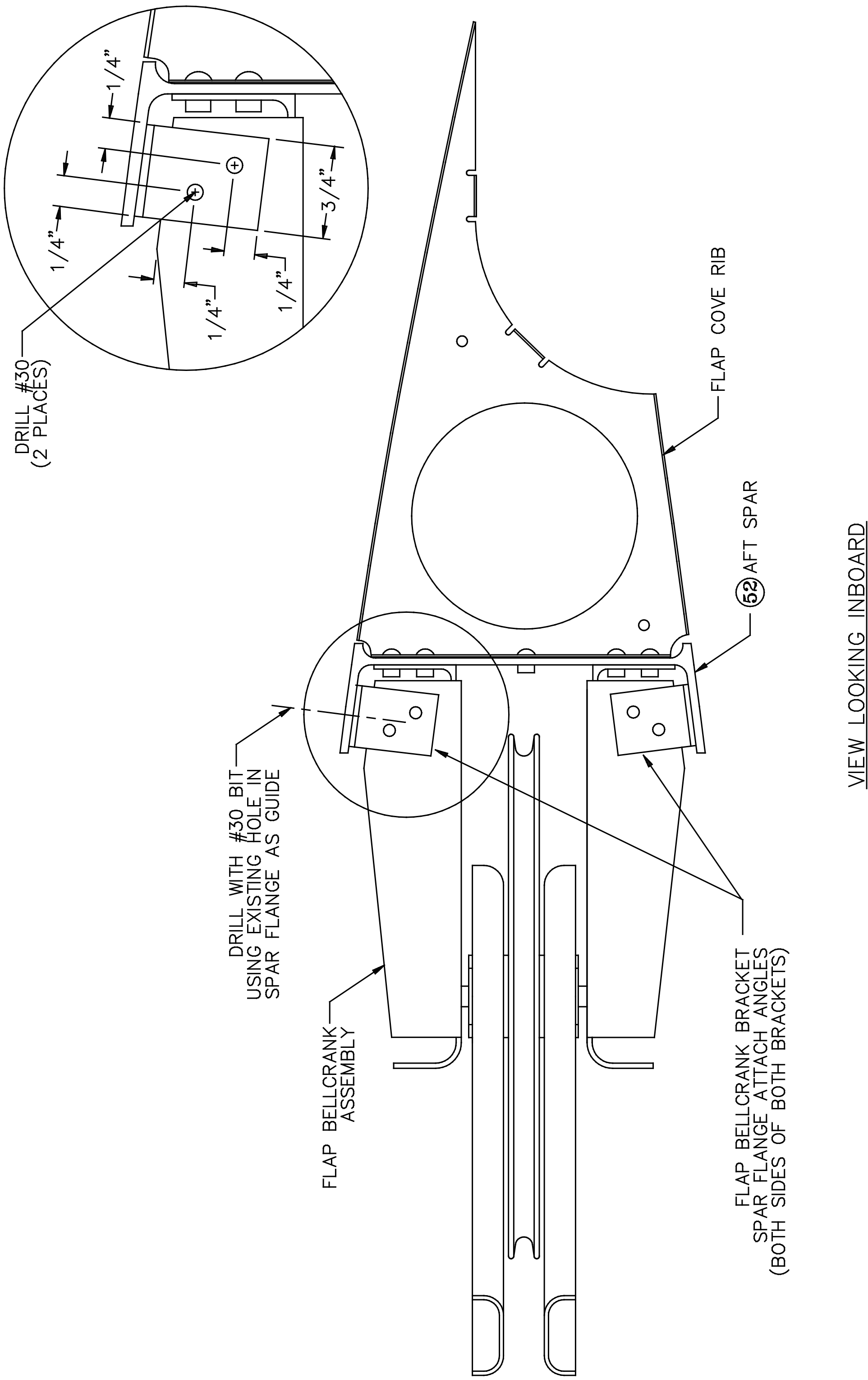

Figure 89: Flap Bellcrank Bracket/Spar Flange Attach Angles

Fabricate four **flap bellcrank bracket/spar flange attach angles** from the supplied .063" X 1" X 1" 6061-T6 aluminum angle. (These are identical to the **aileron** bellcrank bracket/spar flange attach angles described previously in Step 48.) Cut the attach angles **3/4"** long, as shown in Figure 89, and smooth the cut edges with files and sandpaper. Mark and center-punch the rivet pattern shown in Figure 89 onto one leg of each attach angle.

Clamp the four spar flange attach angles in place against the bellcrank brackets and the underside of the spar flange (one on each side of each bracket) with the center-punched legs against the bellcrank brackets. Use the center-punched rivet pattern on the angles as a guide to drill **#30** holes through the attach angle/bellcrank bracket assembly.

One of the pre-drilled wing skin holes in the aft spar flanges will intersect the other leg of each spar flange attach angle. Use these holes as guides to drill **#30** holes through the attach angles. Avoid elongating or enlarging the already-drilled holes in the spar.

When all the holes have been drilled, remove the bellcrank assemblies, deburr all holes and corrosion-proof any unprotected components.

Rivet the bellcrank assembly and Flap Cove Rib 7 to the aft spar using 1/8" AN470AD4 universal-head rivets. Rivet the bellcrank bracket/spar flange attach angles to the bellcrank brackets. **(The bellcrank bracket/spar flange attach angles will be riveted to the spar flanges when the skins are riveted in a later step.)**

Completed: Left [ ] Right [ ]

Fabricate and Install the Flap Pulley Brackets

Step 59: Fabricate and Mount the Flap Pulley Brackets

Fabricate the two flap pulley bracket angles from the supplied .063" X 1" X 2-3/4" formed aluminum **flap pulley bracket angle** stock [90], as shown in Figure 90. Use procedures similar to those used to fabricate the aileron pulley brackets.

> **Note** Figure 90 shows the pulley bracket for the **left** wing; the **right** wing pulley bracket is a mirror image.

Mount the two AN210-3A **pulleys** [99] between the pulley bracket angles, using an AN4-15 drilled-shank bolt, AN310-4 castle nut and AN960D416 aluminum washers under both the bolt head and the nut.

Butt the pulley bracket assembly against the inboard side of Flap Cove Rib 6 and center it vertically on the spar web, as shown in Figure 90. Clamp it to the aft side of the aft spar.

Drill three **#30** mounting holes through each pulley bracket angle and the aft spar, as shown. When all the holes have been drilled, remove the bracket assembly from the spar and disassemble it. Deburr all holes and corrosion-proof the parts.

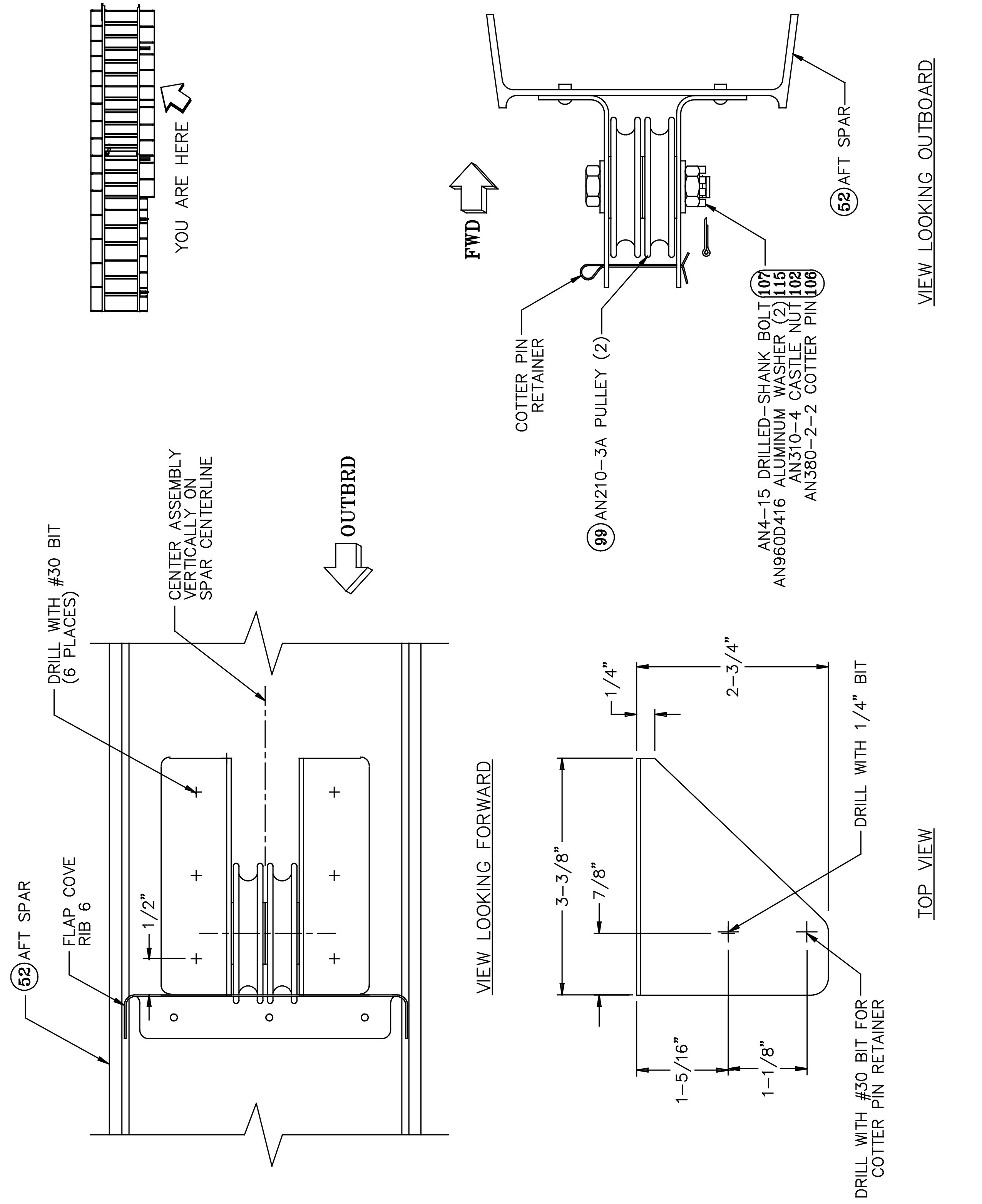

Figure 90: Flap Pulley Brackets

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Assemble the pulley bracket using the hardware shown in Figure 90, and rivet it to the aft spar with 1/8" universal head rivets (AN470AD4). At final assembly, secure the castle nut with an AN380-2-2 **cotter pin** [106].

> **Note** The large cotter pin used as a cable retainer shown in Figure 90 will be installed when the cables are routed, as described in "SECTION IX: SYSTEMS INSTALLATION."

Completed: Left [ ] Right [ ]

RIVET THE RIBS AND THE LEADING-EDGE AND LOWER SKINS

At this time, we recommend riveting the ribs to the spars, installing the strut beam assembly for the final time, and then riveting the leading edge and lower skins to the spar/rib assembly. Once this has been done, the wing will be quite rigid so it can be taken out of the jig and mated to the fuselage to fabricate and install the control cables. The wing can also be placed on a table (or supported by a pair of padded sawhorses) to facilitate installation of the fuel tank vent lines, the pitot/static system and the navigation light wiring. The lower skins are riveted on first because they have several inspection holes that provide access for riveting the upper skins later.

Note Place the wing in the jig, and make sure the jig is plumb and true for the following operations. Place the aft spar supports under the aft spar and adjust them, if necessary, to achieve a straight aft spar.

Step 60: Rivet the Main and Cove Ribs to the Spars and Install the Strut Beam Assembly

Cleco the cap strips to the insides of the forward spar flanges.

Cleco the main ribs between the spars, making sure that you place each rib in its correct location as marked in Step 20 and that the flanges are oriented in the proper direction. (All main rib flanges are oriented **outboard**, except for Main Ribs 1 and 4, the flanges of which are oriented **inboard**.)

Note Main Ribs 2, 4 and 6 share rivets with the cove ribs. Main Ribs 2 and 6 share rivets with the nose ribs. Flap Cove Rib 7 was riveted in Step 58 with the flap bellcrank. Flap Cove Rib 14 was installed in Step 51 with the outboard aileron pulley bracket.

Cleco the flap cove ribs and the aileron cove ribs to the aft spar, again making sure that each rib is placed in its correct position and that the flanges are oriented properly. (All flap cove rib flanges are oriented **outboard**, except for Flap Cove Ribs 1, 3, 7, 11 and 14 (counting from the root), the flanges of which are oriented **inboard**. Counting from the furthest inboard location, Aileron Cove Rib 7's flange is oriented **inboard**; all other aileron cove rib flanges are oriented **outboard**.)

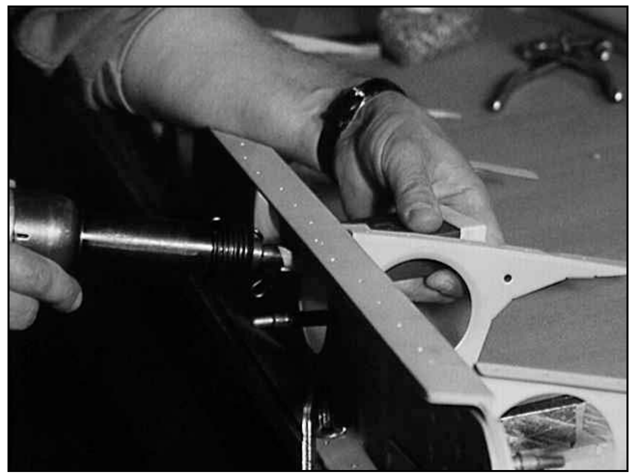


Figure 90.1: Riveting the Flap Cove Ribs

Rivet the main ribs, flap cove ribs and aileron cove ribs (**except for the root ribs and the forward ends of Main Ribs 2 and 6**) to the forward and aft spars, using 1/8" AN470AD4 universal-head rivets. Just Cleco the root ribs in place for now; they will be riveted after the fuel tanks are installed. Main Ribs 2 and 6 share rivets with the nose ribs and will be riveted with the leading edge assembly. When riveting the aft end of Main Rib 3, you will also rivet the rib for the outboard flap track assembly (refer to Step 54). Use a 1/8" AN426AD4 flush-head rivet, with the head on the forward side of the aft spar web/strut beam doubler, for the center hole of Flap Cove Rib 11 (see Figure 19). If interference exists between the upper outboard aileron pulley bracket and the center rivets of Flap Cove Rib 14 and Aileron Cove Rib 1, you may either notch the lower edge of the bracket angle for clearance, as described in Step 51 and Figure 72, or leave out these two rivets.

Bolt the strut beam assembly between the spars, using the hardware specified in Step 22.

Caution The strut beam assembly **must** be installed before the leading edge skins. Make sure that it is installed correctly and that the bolts are properly torqued; once the leading edge is riveted on, the bolts at the forward end will no longer be accessible.

Completed: Left [ ] Right [ ]

Step 61: Rivet the Leading Edges Together

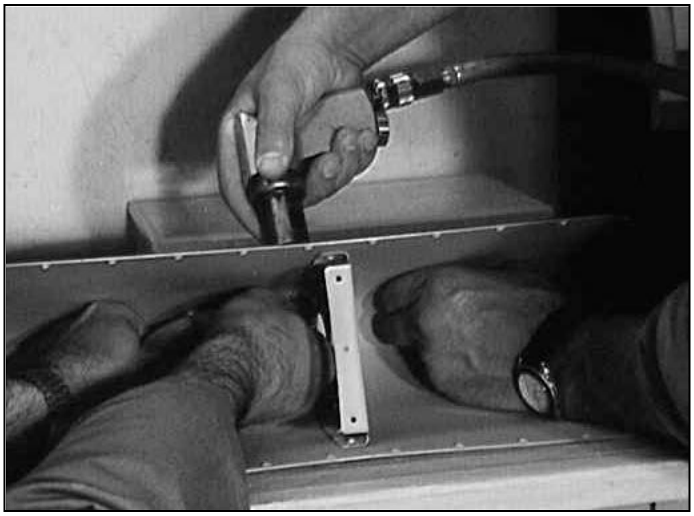


Figure 90.2: Riveting the Leading Edge

Cleco the nose ribs into the leading edge skins, **except for the ribs where the skins overlap at the joints** (Nose Ribs 6 and 12), making sure you place each rib at the correct location that was marked on the rib in Step 20. Also make sure that the rib flanges are oriented properly (all flanges outboard except for the root rib). Use 3/32" AN426AD3 flush-head rivets to rivet the leading edge ribs into the leading edge skin sections, **except for Nose Ribs 6 and 12**. After all the ribs have been riveted into the individual leading edge skins, Cleco the skins to Nose Ribs 6 and 12, making sure that the outboard end of each skin overlaps the inboard end of the adjacent skin at each joint. Use 1/8" AN426AD4 flush-head rivets to rivet the leading edge sections together to Nose Ribs 6 and 12. When finished, you will have the full-span leading edge ready to rivet onto the forward spar.

Caution Be careful handling the leading edge assembly; it could bend, if picked up incorrectly, and buckle the skins. It's best to have a helper when moving the assembly.

Completed: Left [ ] Right [ ]

Step 62: Cut Flap Track Clearance Slots in the Lower Skins

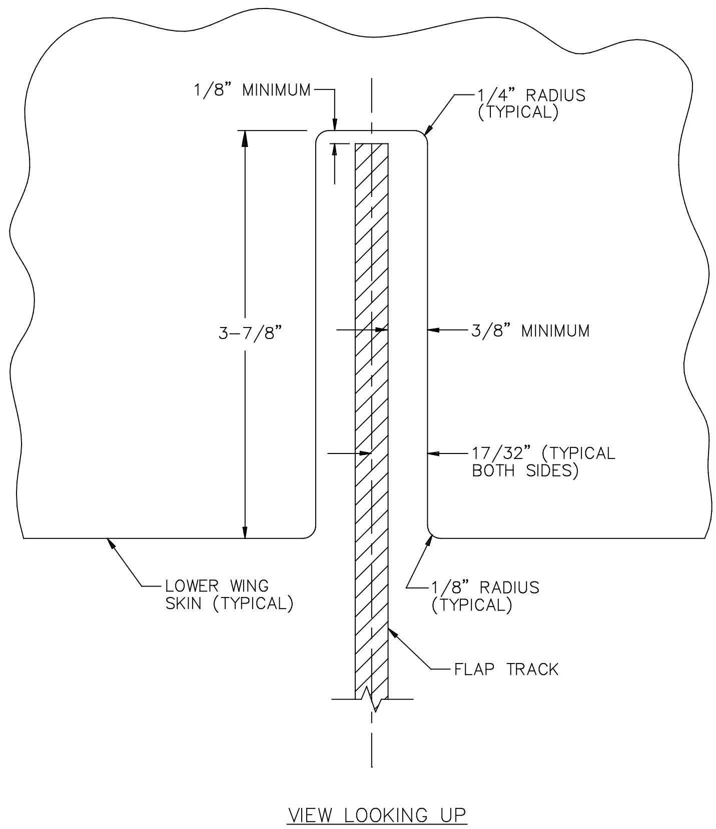


Figure 91: Flap Track Clearance Slots in Lower Skins

Slots are necessary in the **center** and **inboard lower main skins** to provide clearance for the flap tracks in the wing and the flap track guide arms on the flaps. Cleco these skins in place, allowing them to lap over the flap tracks. Use a try square to set each flap track square to the aft spar, and then mark the centerline of each track onto its respective skin. Remove the skins and mark parallel lines **17/32"** inboard and outboard of the flap track centerlines, as shown in Figure 91. Mark the leading edges of the slots **3-7/8"** forward of the skin trailing edges. Use a **1/2"** Unibit or Blair hole cutter to cut the **1/4"** radii for the inside corners of the slots and then cut along the marked lines with offset snips. Deburr the cut edges. Re-Cleco the skins to the spar/rib assembly and check for clearance around the flap tracks. There should be at least **3/8"** of clearance on each side and **1/8"** forward. Trim and file further as necessary to achieve these clearances.

Completed: Left [ ] Right [ ]

Step 63: Rivet the Leading Edge Assembly and the Cap Strips to the Forward Spar

Starting with the outboard skin, Cleco the lower skins to the wing structure. Install the lower center skin gusset (described in Step 31) with the lower center skin; install the lower inboard skin doubler (described in Step 33) with the lower inboard skin. When all of the lower skins have been installed, Cleco the hat section stiffeners in place.

Move the Clecos securing the cap strips to the **insides** of the spar flanges so that the leading edge assembly can be placed on the outside. Position the leading edge assembly on the forward spar, and then Cleco the leading edge assembly and the cap strips to the forward spar flanges from the outside. Remove the inside Clecos.

Note The lower edge of the inboard leading edge skin fits over the forward edge of the inboard lower main skin.

Cleco the nose ribs to the forward spar (and to Main Ribs 2 and 6).

Use 1/8" AN470AD4 universal-head rivets to rivet the nose ribs to the spar at the wing tip and near lightening holes where access to both sides for driving and bucking is possible. **Do not rivet the root nose rib** (Nose Rib 1) to the spar at this time; it will be riveted with the root main rib (Main Rib 1) after the fuel tank is installed. Where access is not possible for installing hard rivets (Nose Ribs 7 through 12), use 1/8" AAPQ-43 or AAPQ-44 structural blind rivets to rivet the nose ribs to the spar. (Use the longer, -44 rivets at the top and bottom edges of the spar web where the web is thicker and also for all three rivets at the strut beam doubler location.)

Use 1/8" AN426AD4 flush-head rivets to rivet the leading edge skin and the cap strips to both the upper and the lower forward spar flanges. However, do **not** rivet the holes that go through **both** the leading edge skin and the **inboard** lower main skin at this time. The inboard lower main skin must be removed in a subsequent step to drill the flap track reinforcement angles.

Note Do **not** rivet the inboard-most hole through the upper or lower spar flange. Rivets in these holes will also secure Main Rib 1 to the forward spar and will be driven in "SECTION X: FINAL ASSEMBLY" after the fuel tanks are installed.

Completed: Left [ ] Right [ ]

Step 64: Fabricate the Flap Track Reinforcement Angles

Fabricate two reinforcement angles for each flap track (eight total; four left-flange and four right-flange) from .063" X 1" X 1" 6061-T6 aluminum angle, as shown in Figure 92.

Separate the flap track reinforcement angles into four pairs, with each pair consisting of a left-flange and a right-flange angle. Associate each pair of reinforcement angles with one specific flap track and mark both angles of each pair with the location of that track (left inboard, left outboard, right inboard and right outboard).

Completed: [ ]

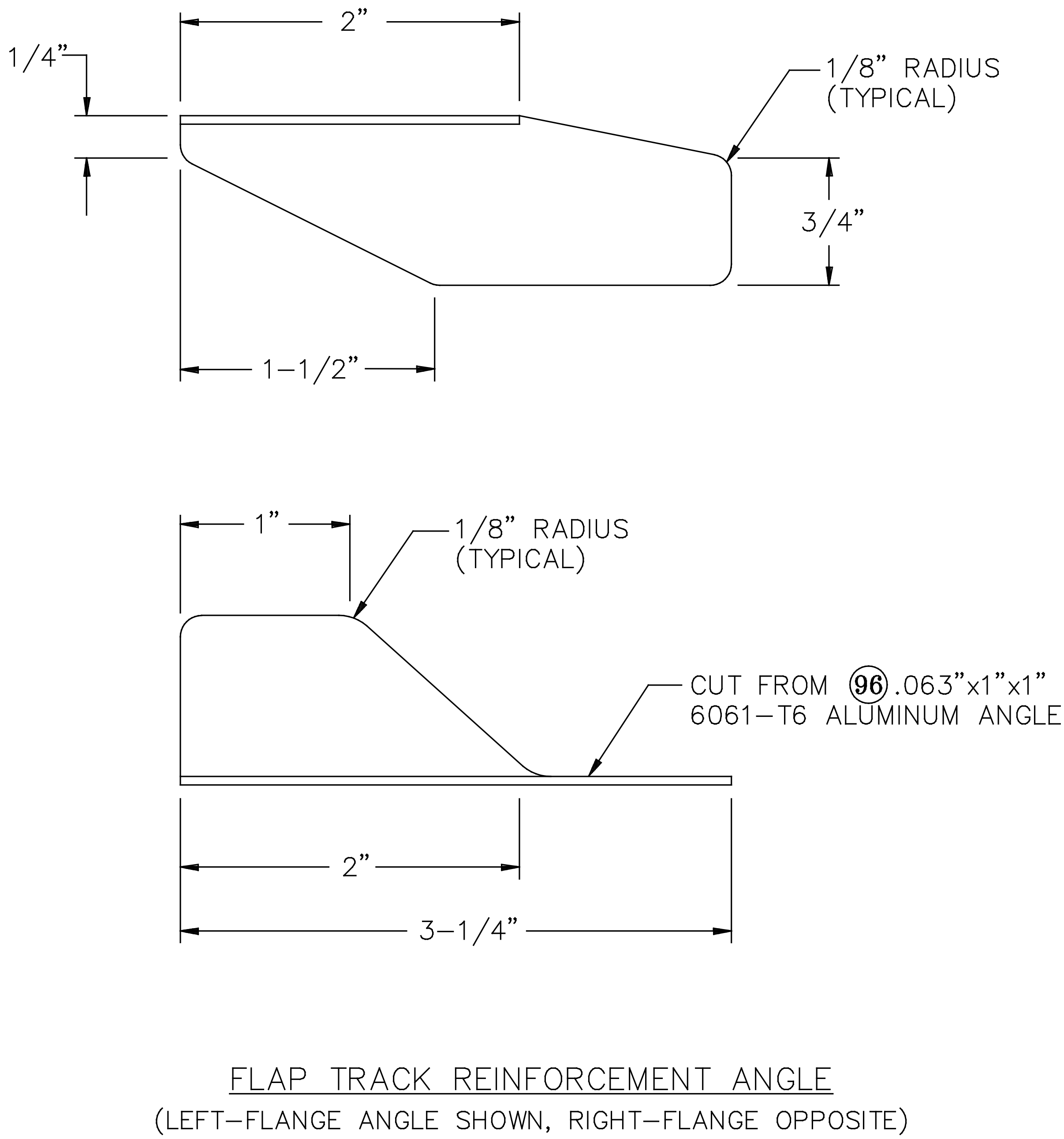


Figure 92: Flap Track Reinforcement Angles

Step 65: Drill Rivet Holes for the Flap Track Reinforcement Angles

Remove the inboard and center lower wing skins, if they are installed.

At each flap track location, make sure the flap track is square to the aft side of the spar when viewed from above.

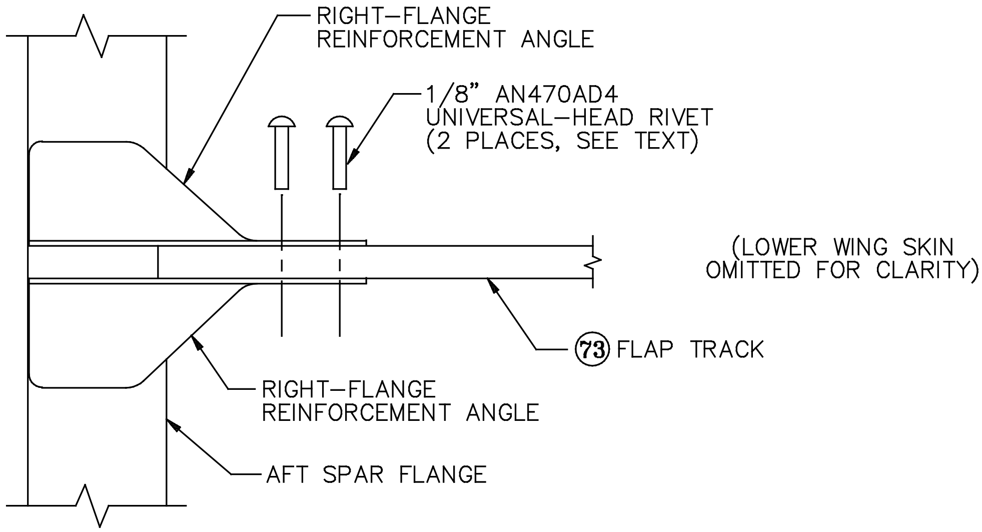
Note The flap tracks must be square to the spar after the reinforcement angles are installed. Otherwise, the flap will tend to bind in the track.

For each flap track, hold a pair of reinforcement angles in place between the flap track and the aft spar's lower flange, as shown in Figure 93a, with the forward end of the angle even with the forward edge of the spar flange. Clamp the angles to the flap track and to the spar flange.

The forward, horizontal flange of each reinforcement angle will be riveted with two 1/8" AN470AD4 universal-head rivets through the spar flange, as shown in Figure 93b. The aft, vertical flanges of each pair of reinforcement angles will be riveted to the flap track with two 1/8" AN470AD4 universal-head rivets. The locations of the reinforcement angle rivet holes are different for each angle, as described on the following pages.

Note Do not drill any rivet holes at this time.

(A)



VIEW LOOKING UP

(B)

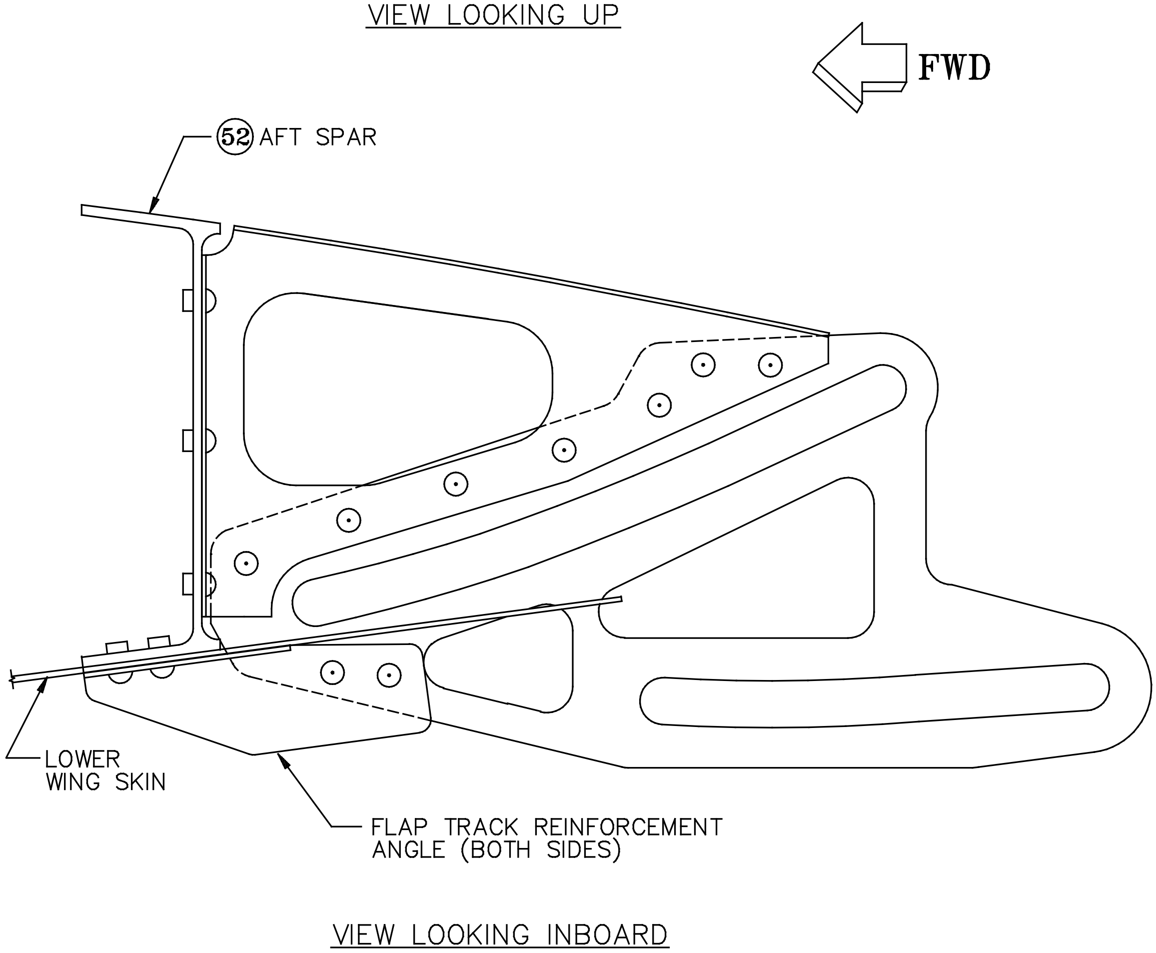


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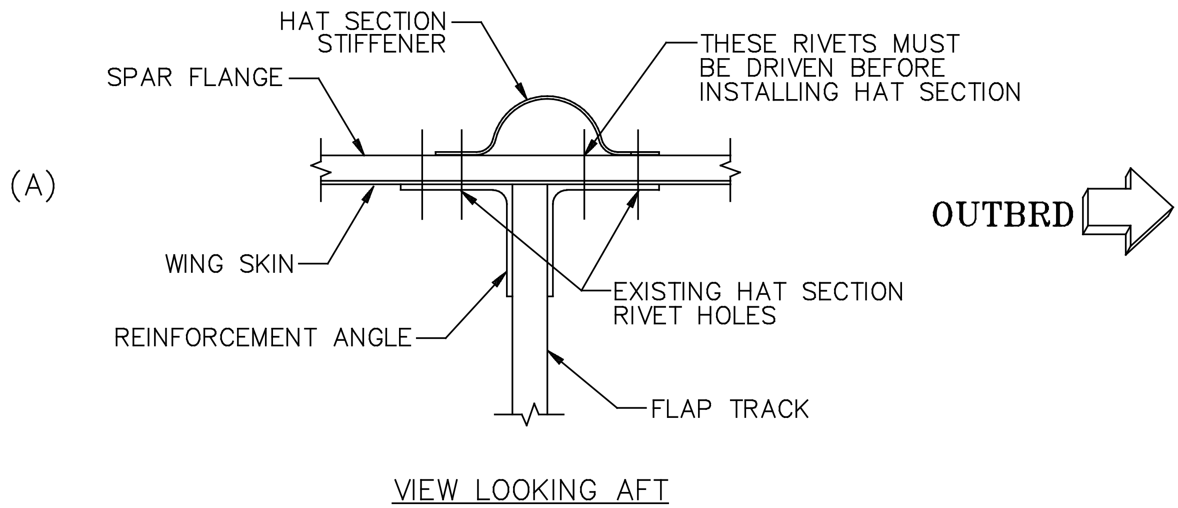
Figure 93: Flap Track Reinforcement Angle Installation



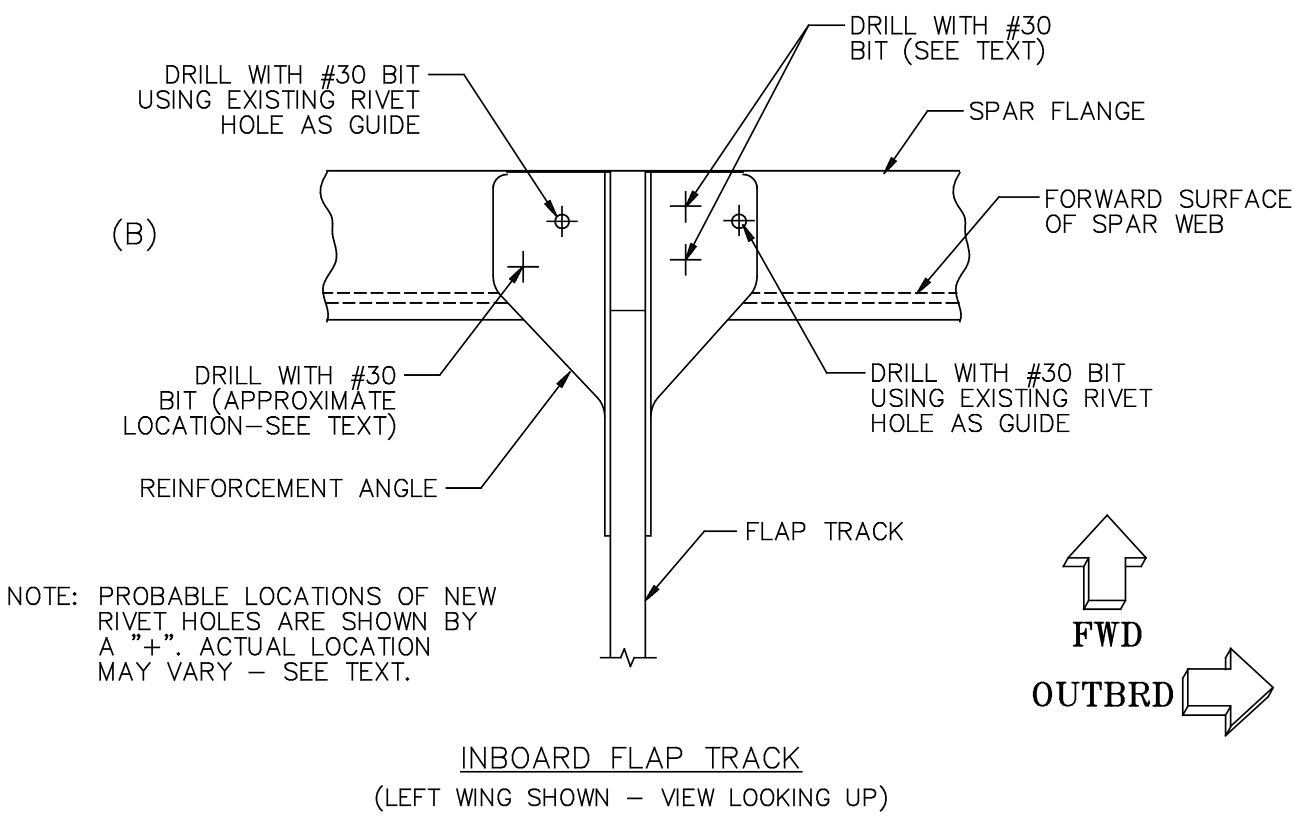


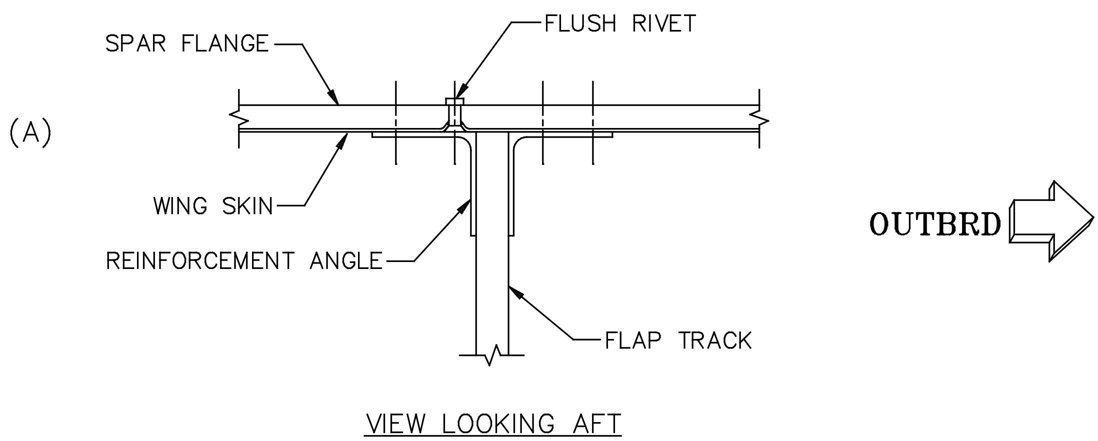
Figure 94: Inboard Reinforcement Angle Rivet Holes

The two 1/8" universal-head rivets that secure the reinforcement angles to the aft spar flange must satisfy standard spacing requirements: twice the rivet diameter (1/4") measured from the center of the rivet to the edge of all components and a minimum of three times the rivet diameter (3/8" center-to-center) between the rivets. Also, the centers of the rivets must not be located closer than about 1/4" to the spar web or to the vertical flange of the reinforcement angle; otherwise, rivet installation will be difficult. An existing spar/skin rivet location that satisfies these requirements can be used to secure the angle and will count as one of the two required rivets. You can install more than the two required rivets, if you wish; specifically, additional spar/skin rivets located by existing holes can be used, even if the extra rivets don't satisfy the edge-distance and spacing criteria.

Note Since there is no absolute index for the spanwise position of the wing skins relative to the spar, there can be slight variations among GlaStars for the spanwise position of the hat section and skins relative to the flap track. This makes it impossible for us to specify exact locations for the reinforcement angle rivet holes. You must determine the optimum locations for the rivets, using the guidelines described above.

So, for the **inboard flap track reinforcement angles**, first use the existing hat section rivet holes through the aft spar flange as a guide to drill one **#30** rivet hole through each reinforcement angle, as shown in Figure 94b. Insert a 1/8" universal-head rivet through the **outboard** hat section rivet hole from below. If the rivet head overhangs the edge of the angle, remove the angle and trim off its edge to allow installation of the rivet through just the skin and the spar next to the reinforcement angle. Then, mark, center punch and drill additional **#30** rivet holes through the reinforcement angles and spar flange, as necessary to satisfy the requirements described above. The approximate locations of the necessary rivet holes are shown in Figure 94b.

Note If positioned as shown in Figure 94b, the new rivet holes through the **outboard** reinforcement angle lie beneath the hat section stiffener inside the wing, as shown in Figure 94a. These rivets must be set before installing the hat section, as described in the next step.



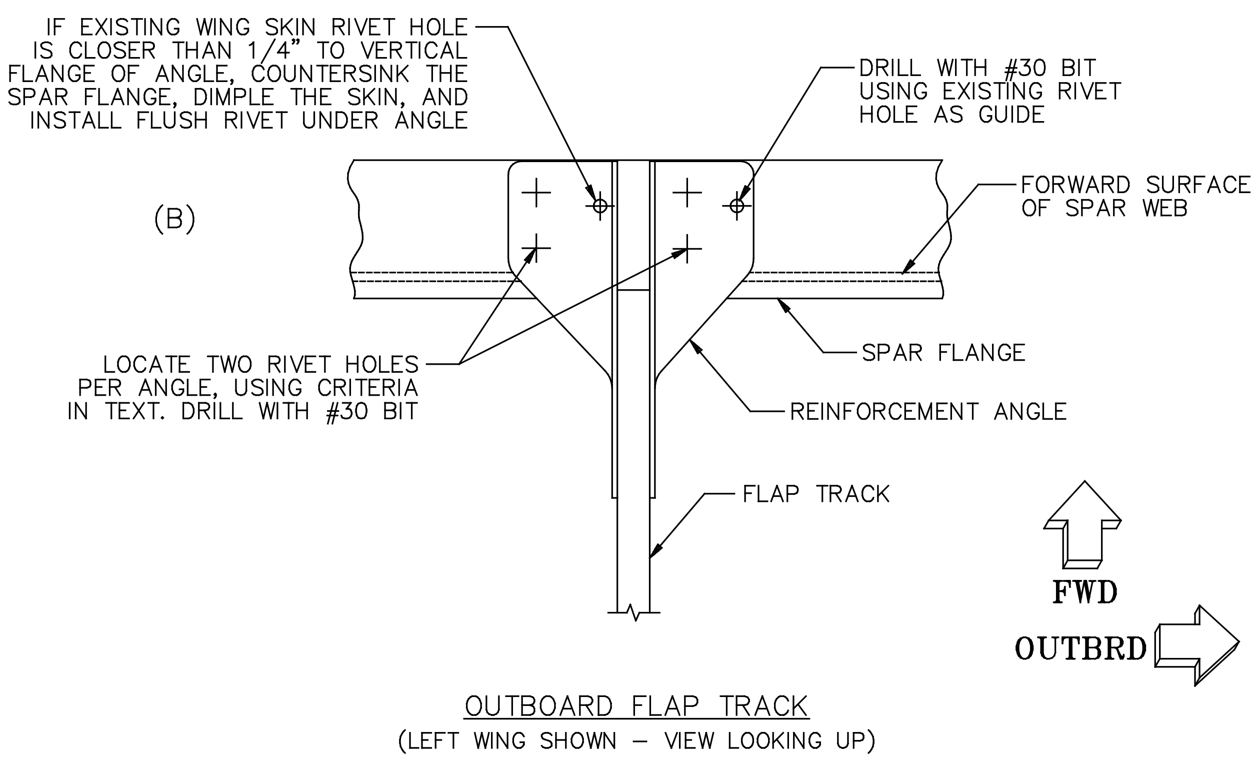


Figure 95: Outboard Reinforcement Angle Rivet Holes

For the **outboard flap track reinforcement angles**, use the existing wing skin rivet hole through the spar flange on the **outboard** side of the flap track as a guide to drill a **#30** hole through the outboard reinforcement angle, as shown in Figure 95b. Also, mark, center punch and drill two additional **#30** rivet holes through each reinforcement angle in the locations shown. Follow the standard spacing requirements described previously when laying out the locations of the rivet holes.

Note The existing wing skin rivet hole on the **inboard** side of the flap track lies almost directly under the inside corner of the reinforcement angle, as shown in Figure 94b. If this rivet hole is closer than about 1/4" to the vertical flange of the angle, the spar flange must be countersunk, the skin dimpled and the skin flush-riveted to the spar before installing the reinforcement angle. The proper sequence will be described in the next step.

When all the spar flange rivet holes through the reinforcement angles for both the inboard and outboard flap tracks have been drilled, remove all the reinforcement angles. Reinstall the lower wing skins, and use the **new** rivet holes through the spar flange as guides to drill matching **#30** rivet holes through the wing skins.

Cleco the reinforcement angles in place, and clamp them to the flap tracks. Verify once again that the flap tracks are square to the aft spar web and, when satisfied, drill two **#30** holes through the aft, vertical flanges of the angles and the flap track in the locations shown in Figure 93b, being careful to maintain the minimum edge distance (twice the rivet diameter) to the centers of the holes in both the angles and the flap tracks.

Remove the reinforcement angles and the skins and deburr all the freshly drilled holes. Apply the corrosion protection of your choice to the flap track reinforcement angles.

Completed: Left [ ] Right [ ]

Step 66: Cleco and Rivet the Lower Skins, Flap Track Reinforcement Angles, Hat Section Stiffeners and Strut Area Stiffener Channels

If the original skin rivet hole through the aft spar flange just **inboard** of the **outboard** flap track is too close to the vertical flange of the flap track reinforcement angle to permit installation of a universal-head rivet, countersink the spar flange and dimple the skin for a flush-head rivet. Refer to Figure 95 and the previous step to identify this rivet.

Use 1/8" AN426AD4 flush-head rivets to rivet the lower skins, the inboard lower skin doubler, the center lower skin gusset and the forward ends of the hat section stiffeners to the forward spar flange, **with this exception**: do not install or rivet the hat section that straddles the **inboard** flap track. Then, use 1/8" AN470AD4 universal-head rivets to rivet the skins and the aft ends of the hat section stiffeners to the aft spar flange, **except** do not set rivets in any holes shared by the flap track reinforcement angles. If necessary, use a 1/8" AN426AD4 **flush-head** rivet to rivet the skin to spar flange hole just **inboard** of the **outboard** flap track, as shown in Figure 95a.

Now, Cleco the flap track reinforcement angles to the lower skin/spar flange and to the flap tracks. Use 1/8" AN470AD4 universal-head rivets to rivet the angles to the lower skin/spar flange, **except** in the rivet holes shared by the hat section that straddles the inboard flap track. Install this last hat section and rivet it to the forward spar with AN426AD4 flush-head rivets and to the aft spar and the reinforcement angles with 1/8" AN470AD4 universal-head rivets. Use 1/8" AN470AD4 universal-head rivets to rivet the aft, vertical flanges of the flap track reinforcement angles to the flap tracks.

Next, use 1/8" AN470AD4 universal-head rivets to rivet the skins to Main Rib 2. Use 3/32" AN470AD3 universal-head rivets to rivet the skins to Main Ribs 3, 4, and 5. Use 3/32" AN426AD3 **flush-head** rivets to rivet the outboard skin to Main Rib 6. **Do NOT rivet the root rib** (Main Rib 1) at this time; it will be secured after the fuel tanks are installed.

Use 3/32" AN470AD3 universal-head rivets to rivet the skins to the hat section stiffeners. Use the same rivets to rivet the lower inboard skin doubler to the lower inboard skin through the extra spanwise lines of holes drilled between the two innermost hat sections.

Pitot/Static System Option If you are installing a Pitot/Static System Option, **turn to the option instructions now**. Return to this *Assembly Manual* when the specified option steps have been completed.
☞

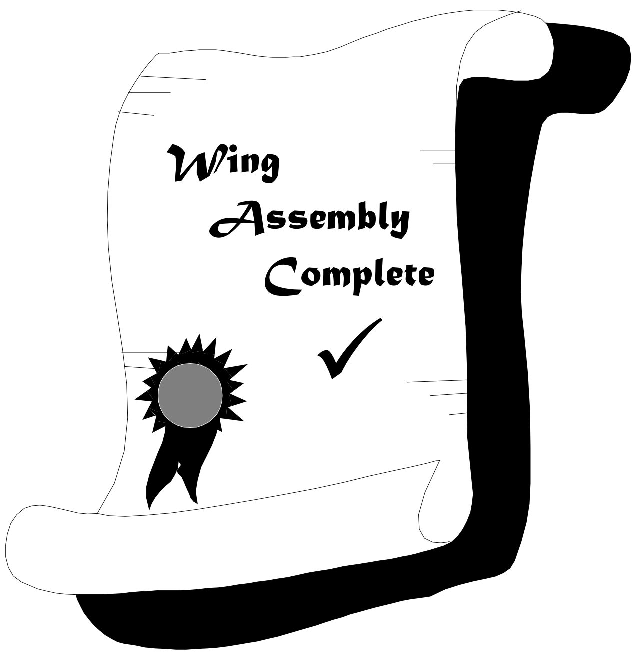
Cleco the strut area stiffener channels and lower center skin stiffeners in place and rivet them with 3/32" AN470AD3 universal-head rivets.

Rivet the lower wing skins to the flap and aileron cove ribs with 3/32" AN470AD3 universal-head rivets.

Completed: Left [ ] Right [ ]

CONGRATULATIONS!

The wings are ready for mounting to the fuselage so that the control system rigging (and other procedures) can be completed. Before you can do that, however, you need to fabricate the fuselage and the wing control surfaces. So, let's proceed to the next section—Aileron and Flap Assemblies!



SECTION VII: AILERON AND FLAP ASSEMBLIES

> **Note** The ailerons and flaps can be built in any order, and if space permits, they can all be built simultaneously. However, the following instructions treat the assemblies separately for clarity. Flap instructions begin on Page 49.

AILERON ASSEMBLY PARTS LIST

Key No.:	Part Name:	Qty:	Part No.:
1	Left skin	1	201-15001-01
2	Right skin	1	201-15001-02
3	Left spar	1	201-15002-01
4	Right spar	1	201-15002-02
5	Left-flange nose rib	8	201-15003-01
6	Right-flange nose rib	8	201-15003-02
7	Left-flange aft rib	7	201-15004-01
8	Right-flange aft rib	7	201-15004-02
9	Inboard hinge bracket	2	201-15005-01
10	Outboard hinge bracket	2	201-15006-01
11	Inspection hole doubler	4	201-15007-01
12	Inspection hole cover	4	201-15008-01
13	Left-flange counterweight nose rib	2	201-15009-01
14	Right-flange counterweight nose rib	2	201-15009-02
15	Screw	16	AN526-8R6
16	Nutplate	16	K1000-08
17	Nutplate	4	K1000-3
18	Nutplate	6	K2000-4

TOOL LIST

1. Try square
2. Duck bill pliers (with jaws taped to protect aluminum parts)
3. Assorted flat and round files
4. Edge deburring tool (optional)
5. Rule, 12", graduated in 1/32nds of an inch
6. Fine-point marking pen
7. Clecos, 3/32" and 1/8" (approximately 150 each); and 3/16" (2), with pliers
8. Electric or pneumatic drill motor, with #40, #30, #19, #10, 3/32" and 1/4" bits
9. Center punch
10. Hole deburring tool
11. Dimple dies, #40, and rivet squeezer or C-frame riveting tool
12. Assorted Cleco side-grip clamps (with pliers) or small C-clamps, 6-10
13. Long #40 bit
14. Phillips screwdriver
15. Small, rubber-padded spring clamps, 6-10 (recommended)
16. Smart Level (recommended)
17. 90° drill motor or adapter, with #40 bit
18. Rivet gun, air compressor and bucking bars
19. Flush head rivet set
20. Universal head rivet sets, 3/32" and 1/8"
21. Blind rivet puller
22. Rivet squeezer (recommended)
23. Rotary cutting tool (optional)

ADDITIONAL MATERIALS

1. Two 1/4" bolts, 2" long (hardware-store quality)
2. Masking tape
3. Two pieces of 2" X 2" metal angle, approximately 2" long
4. Sheetrock screws
5. Scrap wood blocks
6. 1/4"-thick board, at least 69" long, any width
7. Corrosion protection materials

Workspace

Like the tail surfaces, the ailerons are built on a flat table without jigs. Each aileron is approximately 69" X 15". For assembly steps in which aluminum skins are lying flat on the bench, it's a good idea to pad your bench surface with cardboard to avoid unnecessary scratching of the finish. Also, you might consider leaving the plastic protective film on the outside of the skin through the positioning and drilling stages; remove it for hole deburring and riveting.

Assembly Sequence

Construction of the ailerons is very straightforward, consisting of two phases: **positioning and drilling** and **riveting**. In the first phase, the structural components are clamped into place and rivet holes are drilled. In the second phase, the basic structure is riveted together.

Note The ailerons are not identical, but they are mirror images of one another, and construction procedures are identical left and right. For clarity, therefore, the text and illustrations that follow refer to the **left aileron only**. Note, however, that each step in the assembly process is followed by a check box for both left and right ailerons.

Figure 1 shows the configuration of the left-hand aileron.

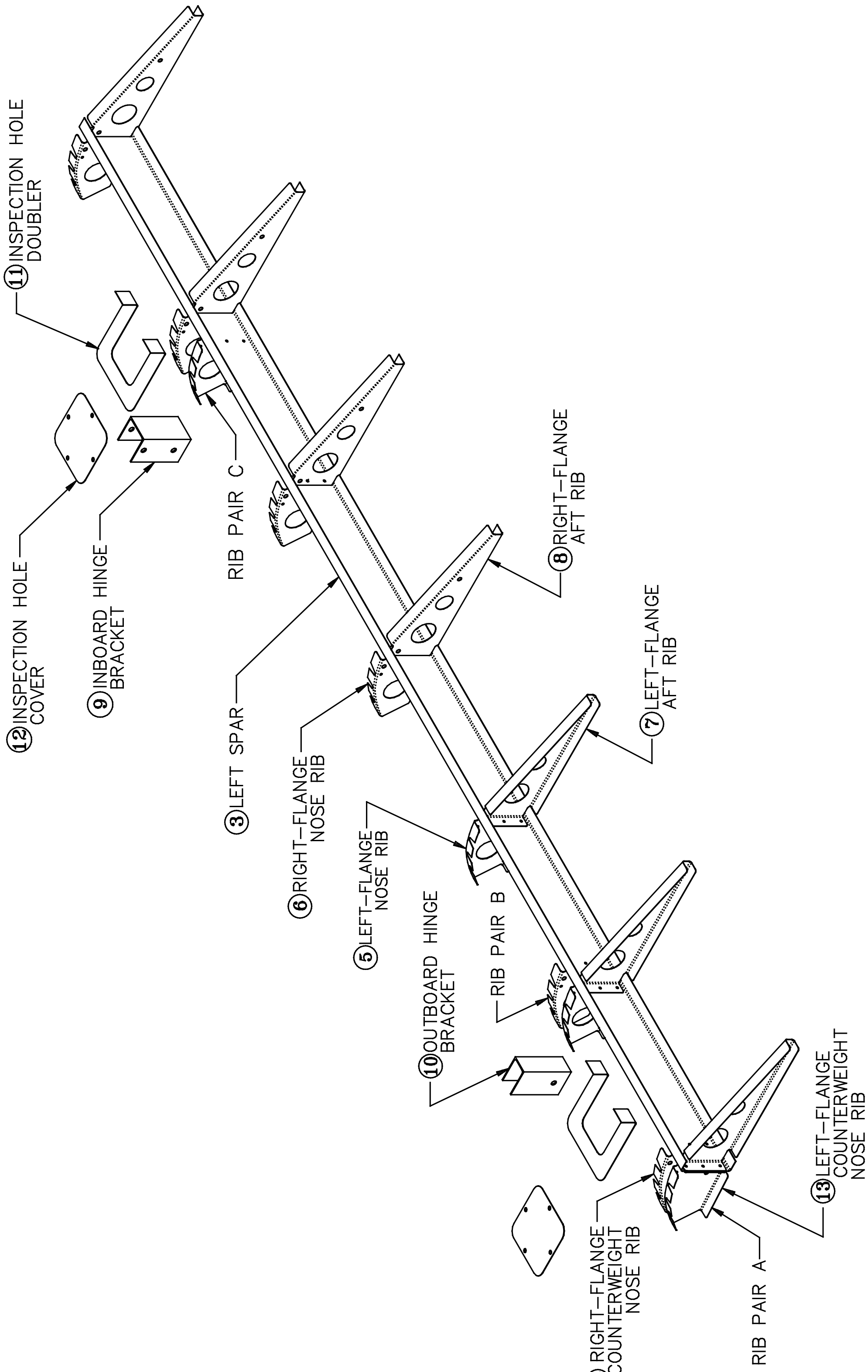


Figure 1: Aileron Assembly (Left-Hand Shown)

POSITIONING AND DRILLING

Step 1: Straighten and Deburr the Parts

Using a square, check the flanges on all the **left-flange** [5] and **right-flange nose ribs** [6], **left-flange** [7] and **right-flange aft ribs** [8], and **left-flange** [13] and **right-flange counterweight nose ribs** [14] for squareness, straightening as necessary with a pair of padded duck bill pliers.

Deburr the edges and lightening holes of all parts as necessary.

Completed: Left [ ] Right [ ]

Step 2: Mark Rivet Lines on the Flanges of the Ribs and Spar

Using a marking pen, mark a centerline on the upper and lower flanges of all the ribs. Rivet lines must also be marked on both the upper and lower flanges of the **spar** [3], but these are not strictly centerlines: as shown in Figure 2, mark these rivet lines parallel to and **11/32"** in from the edge of the **upper** flange and **9/32"** in from the edge of the **lower** flange.

> **Note** The upper flange of the spar is the one that is bent more acutely to the spar web, as shown in Figure 2. To distinguish the left spar from the right, hold a spar right-side up with the flanges pointing toward you. If the double column of rivet holes in the spar web is on the left end, then you're holding the left-hand spar. In other words, the double column of holes is at the **outboard** end of each spar.

Completed: Left [ ] Right [ ]

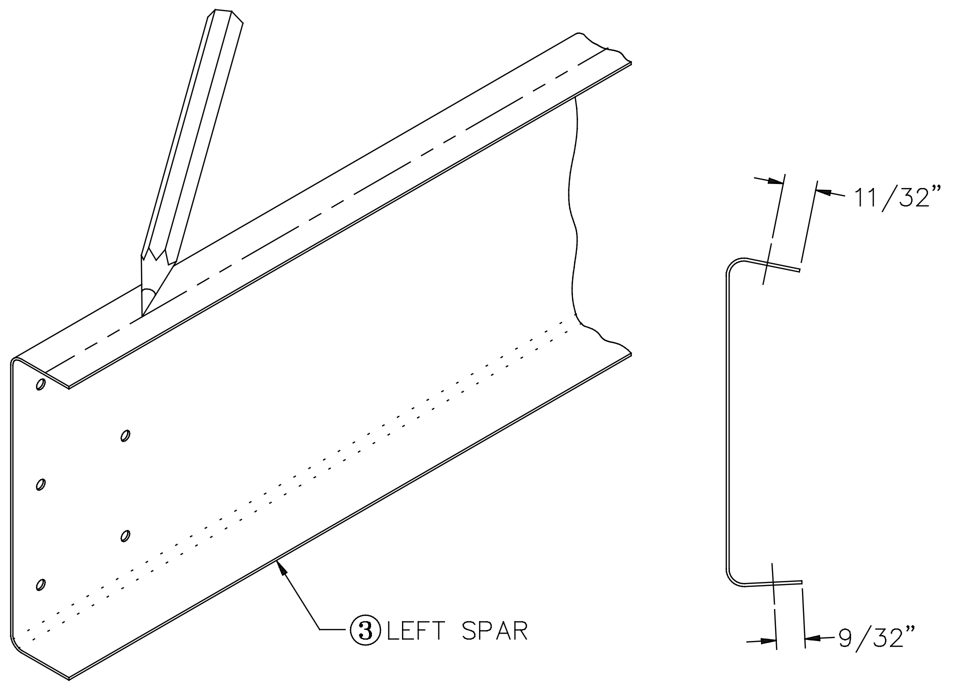
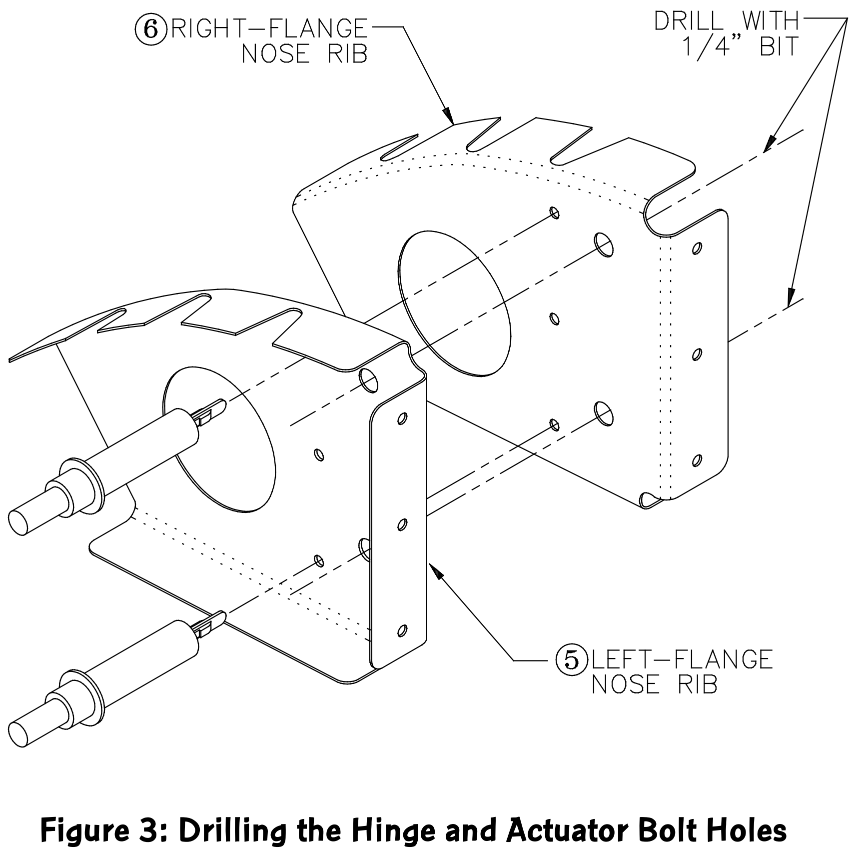


Figure 2: Marking the Spar Rivet Lines

Step 3: Drill the Hinge and Actuator Bolt Holes in Rib Pairs B and C

A pair of nose ribs with opposite flanges is located web-to-web at each hinge location on the spar. These are labeled Rib Pairs B and C in Figure 1. Quarter-inch bolts running between these ribs serve as the hinge points for the aileron, and a similar bolt running between the ribs of Pair C anchors the actuator rod end.

Pilot holes exist for all these holes, but they must be drilled up to final size. First, choose a pair of nose ribs—one left-flange and one right-flange—to be the inboard hinge pair (Pair C). Clamp these together web-to-web as shown in Figure 3 with a pair of Clecos through two of the three small, pre-punched rivet holes in the webs. Use a **1/4"** bit to drill the two 3/16" holes to final size. Take care to keep your drill perpendicular to the webs while drilling these holes. After the holes are drilled, label these ribs as Pair C.



Repeat the process for a second, outboard pair of nose ribs (Pair B). The only difference is that you only need to drill the lower pair of holes up to **1/4"** size (one hole per rib). Label these ribs as Pair B.

After drilling, remove all the Clecos and deburr the holes.

Completed:
Left [ ]
Right [ ]

Figure 3: Drilling the Hinge and Actuator Bolt Holes

Step 4: Mark and Drill the Counterweight Bolt Holes

Two 3/16" bolts are used to secure the counterweight assembly to the outermost pair of nose ribs (labeled Pair A in Figure 1). Pilot holes do not exist for these holes, so the first step is to mark their locations.

Choose a left-flange counterweight nose rib; this is one of the nose ribs **without** a lightening hole. Figure 4 shows where the centers of the two bolt holes should be located. Mark them as accurately as possible on the outboard web and lightly center punch them.

Then clamp the rib together web-to-web with one of its right-flange counterparts using two 3/16" Clecos through the large holes in each rib. Drill the marked bolt holes with a **#10** bit, and then remove the Clecos and deburr the holes.

Completed:
Left [ ]
Right [ ]

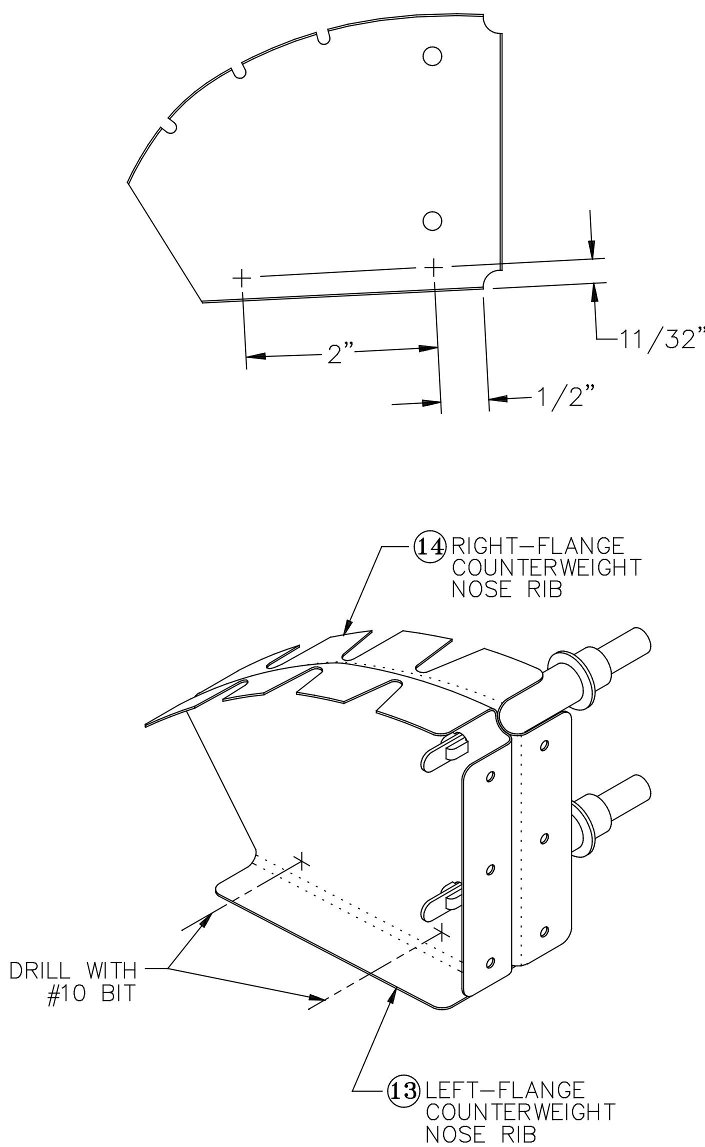


Figure 4: Marking and Drilling the Counterweight Bolt Holes

Step 5: Position and Drill the Bolt Nutplates

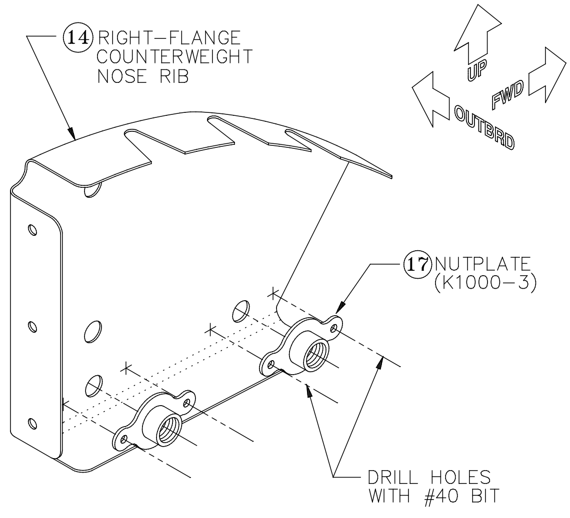


Figure 5: Positioning and Drilling the Counterweight Nutplates

Nutplates of various types are used to secure the blind ends of the hinge, actuator and counterweight bolts. Standard, two-lugged K1000-3 **nutplates** [17] are used with the counterweight bolts. Using the usual procedures outlined in "SECTION II: TOOLS AND TECHNIQUES," position and drill a nutplate at each of the two 3/16" holes **you drilled** along the lower flange of the **inboard** counterweight nose rib, as shown in Figure 5. Use a **#40** bit to drill the rivet holes.

> **Note** The counterweight nutplates should be positioned on the **right-flange** counterweight nose rib on the **left-hand** aileron and on the **left-flange** counterweight nose rib on the **right-hand** aileron.

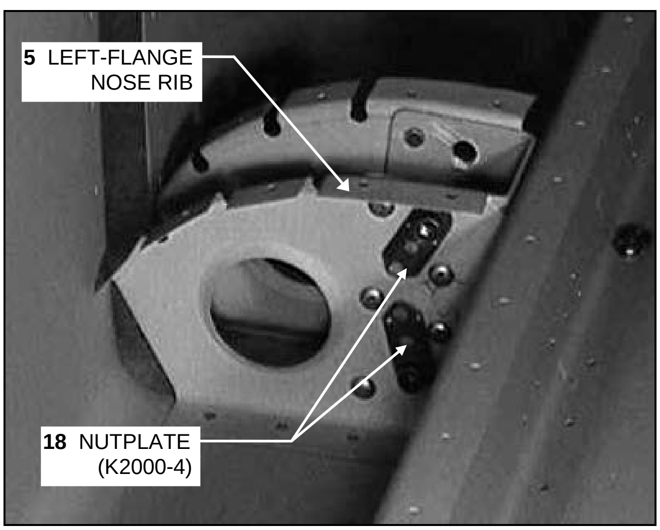


Figure 6: Positioning and Drilling the Hinge and Actuator Bolt Nutplates (Rib Pair C Shown)

Due to clearance problems, the hinge and actuator bolts are secured with single-lugged K2000-4 **nutplates** [18]. Position these at an angle, as shown in Figure 6, and drill them as usual with a **#40** bit. They should be positioned inside the flanges of the **outboard** rib of the **inboard hinge rib pair** (Pair C) and the **inboard** rib of the **outboard hinge rib pair** (Pair B). Remember that Pair B accommodates only one bolt and, therefore, one nutplate.

Note Figure 6 and many of the subsequent photos are provided to illustrate the basic relationships among parts. However, because these photos show the prototype aircraft, there are many minor differences, especially in things like rivet counts and construction sequences. In the event you note any discrepancies between the text or line illustrations and the photos, the text and illustrations should always be taken as definitive.

Note Remember that the main text of the *Assembly Manual* applies to the **left aileron**. For the **right aileron**, the nutplates should be positioned on the **right-flange** rib of the **inboard** pair and the **left-flange** rib of the **outboard** pair.

Hint To help keep straight where the nutplates go, remember that the hinge and actuator bolts are inserted through the inspection holes in the skin. The nutplates must therefore always be on the opposite side of the rib pairs from the holes. Similarly, the counterweight bolts are inserted from the open, outboard end, so their nutplates must be on the inboard side.

After drilling, deburr all the rivet holes.

Completed: Left [ ] Right [ ]

Step 6: Dimple the Ribs and Nutplates

All five of the nutplates you just positioned and drilled will be installed with 3/32" AN426AD3 flush-head rivets. Dimple the ribs and the nutplates themselves to accommodate these rivets. The male die should be on the **outboard** side of the Pair A rib, the **outboard** side of the Pair B rib and the **inboard** side of the Pair C rib.

Note As in portions of the elevator assembly, you'll need to use a ground-down female dimple die in order to clear the lower rib flange.

Completed: Left [ ] Right [ ]

Step 7: Cleco Nose Rib Pairs B and C to the Spar

Use two Clecos per rib through the pre-punched holes to clamp the four nose ribs of Pairs B and C to the spar. Refer to Figure 1 to ensure that the rib flanges are all properly oriented.

Completed: Left [ ] Right [ ]

Step 8: Mark and Drill the Hinge Brackets

The **inboard** [9] and **outboard hinge brackets** [10] are situated between the pairs of nose ribs you just Clecoed to the spar. As shown in Figures 7 (inboard) and 8 (outboard), the "bottom" of each U-shaped bracket sits tightly against the spar web, while the "sides" of the 'U' are tight against the rib webs on either side.

> **Note** Figures 7 and 8 depict the brackets already riveted to the adjacent nose ribs. This operation will not be performed until much later in the assembly sequence, and so these photographs are intended **only** to show how the hinge brackets are positioned.

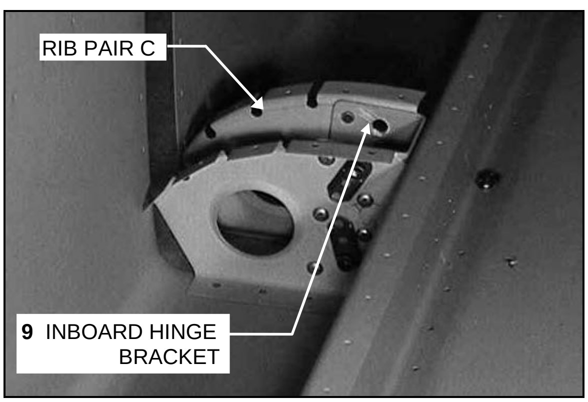


Figure 7: Inboard Hinge Bracket

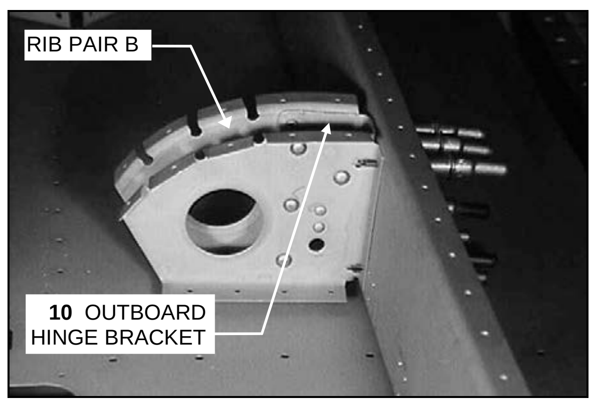


Figure 8: Outboard Hinge Bracket

Each bracket is riveted to the spar web through six holes; the locations of these holes must be marked on each bracket. Figure 9 shows the dimensions of the four corner hole locations on each bracket. Mark and center punch these holes on the outside of both brackets, and then mark and punch two additional holes midway between each corner pair. The location of these holes is not overly critical, but be sure to observe the edge margin specified in the figure between the bracket flanges and the holes. Once all the holes are marked and punched, pilot drill them with a **3/32"** bit.

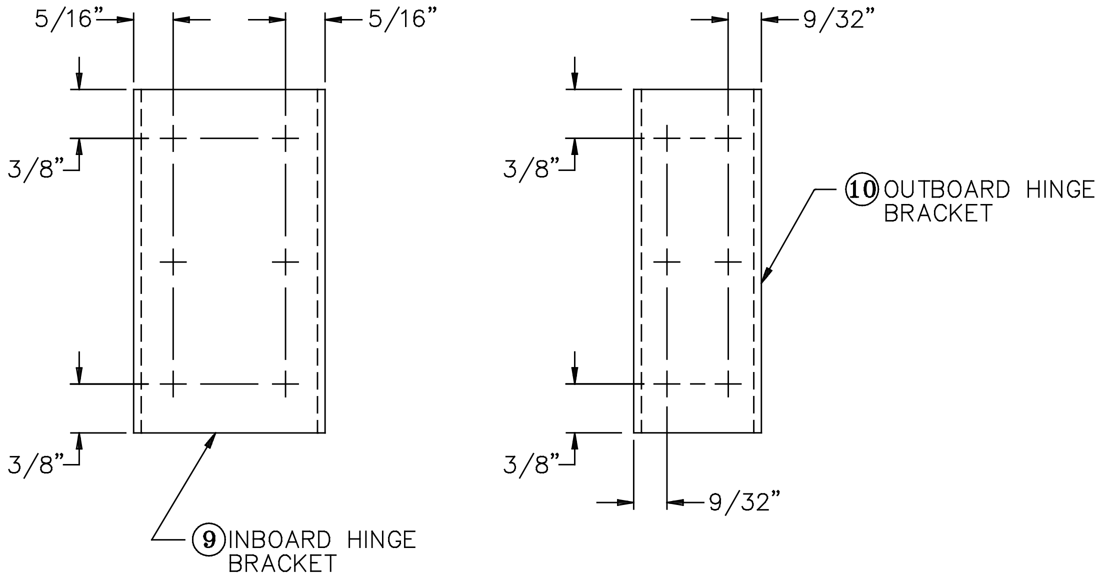


Figure 9: Hinge Bracket Rivet Hole Locations

With both brackets pilot drilled, begin with the inboard bracket, which is the wider of the two. Note that there are two 1/4" holes in each side of the bracket corresponding to the hinge and actuator bolt holes in the ribs of Pair C. Slide the bracket between these ribs and align it vertically by sliding a 1/4" bolt or drill bit through one set of these holes in the bracket and rib webs, as shown in Figure 10. Then, holding the bracket tightly in position, drill through the bracket and spar web from the forward side at the six pilot drilled locations. Use a long **#40** bit and Cleco as you go. After two Clecos are in place, you can remove the alignment bolt.

With the bracket Clecoed to the spar web, slide two 1/4" alignment bolts or drill bits through the holes in the bracket and the rib webs, as shown in Figure 11. Then use a **#30** bit to drill the three rivet holes through each rib web and the sides of the bracket. Cleco two holes on each side after drilling.

After drilling all the holes in the inboard bracket, repeat the process for the outboard bracket. The procedures are identical.

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Right [ ]

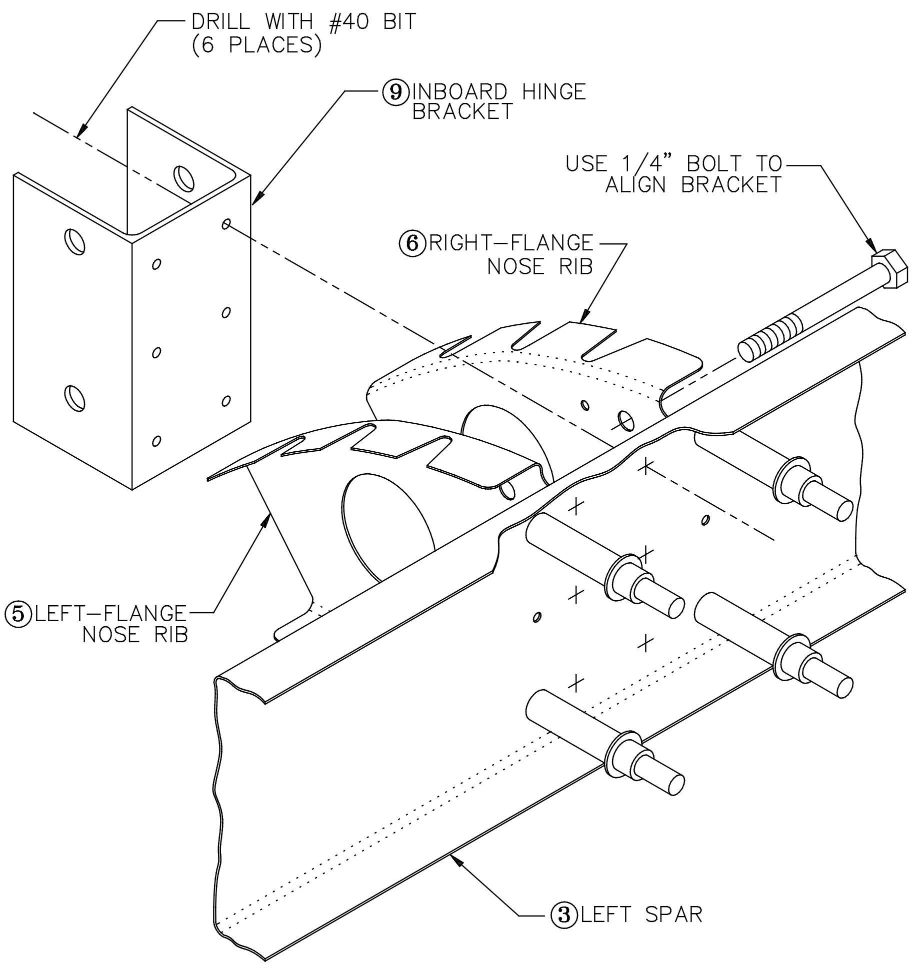

Figure 10: Drilling the Hinge Bracket/Spar Web Rivet Holes

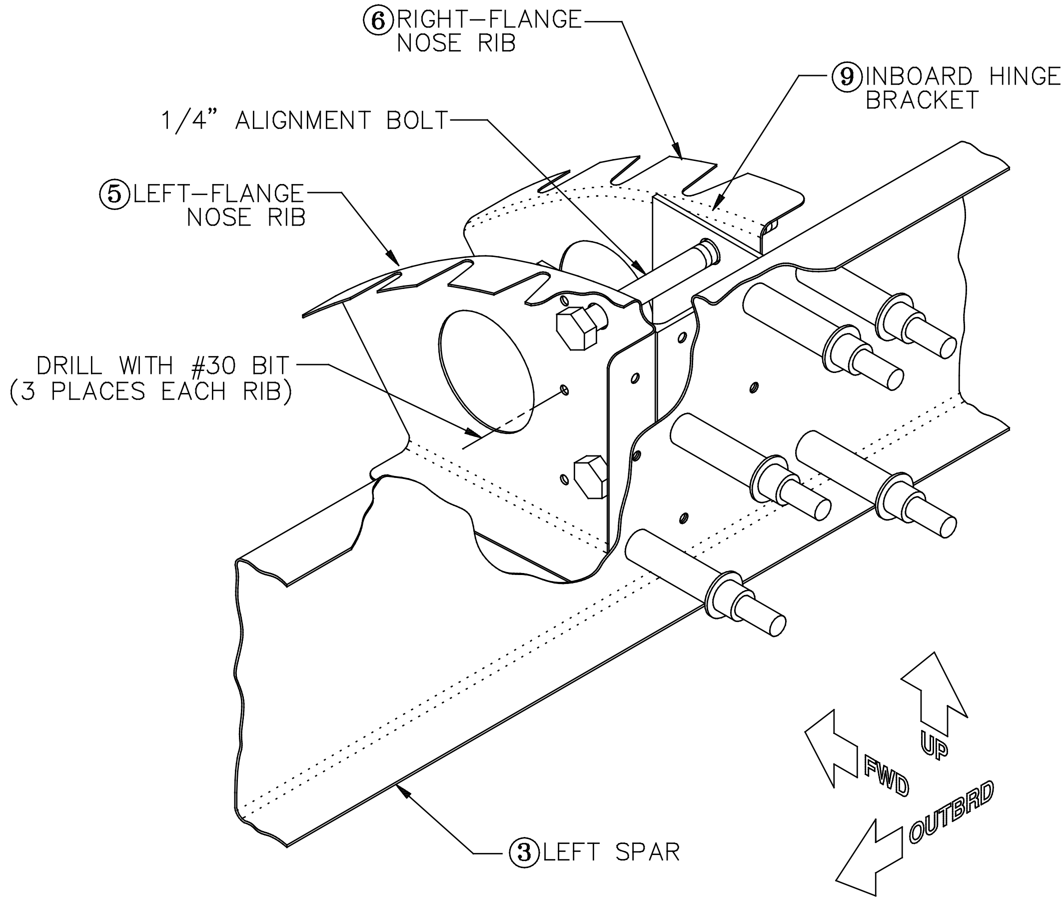

Figure 11: Drilling the Hinge Bracket/Rib Web Rivet Holes

Step 9: Cleco the Remaining Ribs to the Spar and Drill All the Rib/Spar Rivet Holes to Final Size

Cleco all the remaining nose, aft and counterweight nose ribs to the spar. Pay careful attention to the orientation of the rib flanges, as shown in Figure 1, and note that in most cases the same Clecos will secure a nose rib and an aft rib.

The two counterweight nose ribs of Pair A require some special attention. In a subsequent step, a 1/2"-square steel tube that bears the aileron counterweight will be mounted between these two ribs. For this reason, it's imperative that the facing webs of these ribs be held **at least** 1/2" apart. This spacing is too important to entrust to the marked rivet lines on the rib flanges. Instead, use a temporary spacer inserted between the Pair A ribs. A small square of 1/2" plywood attached to one rib web with a loop of masking tape will work fine. This will hold the ribs the requisite distance apart while the skin-to-rib rivet holes are drilled.

Note To be absolutely certain that the ribs are held the required distance apart, carefully measure the 1/2" plywood spacer to ensure that it's not undersize. We recommend applying a couple layers of masking tape on the 1/2" spacer to produce a gap 5–10 thousandths over 1/2".

When all the ribs are in position, number them so they can be returned to the spar in the same order after disassembly. Finally, juggling the Clecos as necessary, drill all the holes in the flanges of each nose and aft rib and the corresponding holes in the spar web up to **#40** size. Leave two Clecos in each rib pair and the temporary spacer between the ribs of Pair A when finished.

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Step 10: Clamp the Spar/Rib Assembly to the Bench

Two pieces of metal angle mounted on the edge of the bench provide a convenient way to clamp the spar/rib assembly to the bench while positioning and drilling the skin. The dimensions and material specifications of these angles are not at all critical. Two-inch-long pieces of 2" X 2" aluminum angle are ideal, but angle of smaller dimensions would also work, and steel is fine as well.

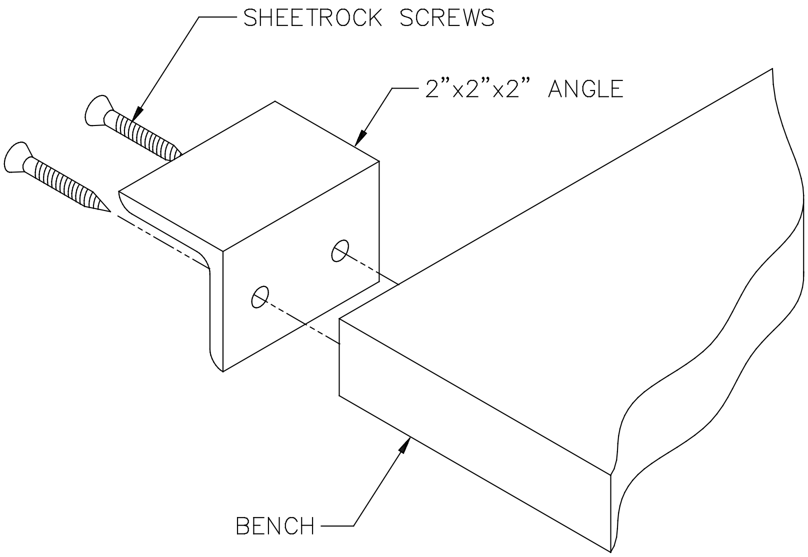

Figure 12: Mounting the Clamping Angle

As shown in Figure 12, drill two holes in one flange of each angle to accommodate mounting screws. Sheetrock screws are easiest, but any wood screw will do. Once the holes are drilled, mount one of the angles on the edge of your bench near one end with the upper flange flush with the bench surface.

Next, as shown in Figure 13, use a C-clamp to clamp the spar/rib assembly to the angle. The assembly should initially be clamped **upside down** and the nose ribs should hang over the edge of the bench.

Once the spar/rib assembly is clamped at one end, mount the second clamping angle under the opposite end of the spar and use a second clamp to secure the spar to the second angle. Finally, as shown in Figure 13, slide a 1/4"-thick strip of wood under the aft ribs to support them against the bench top

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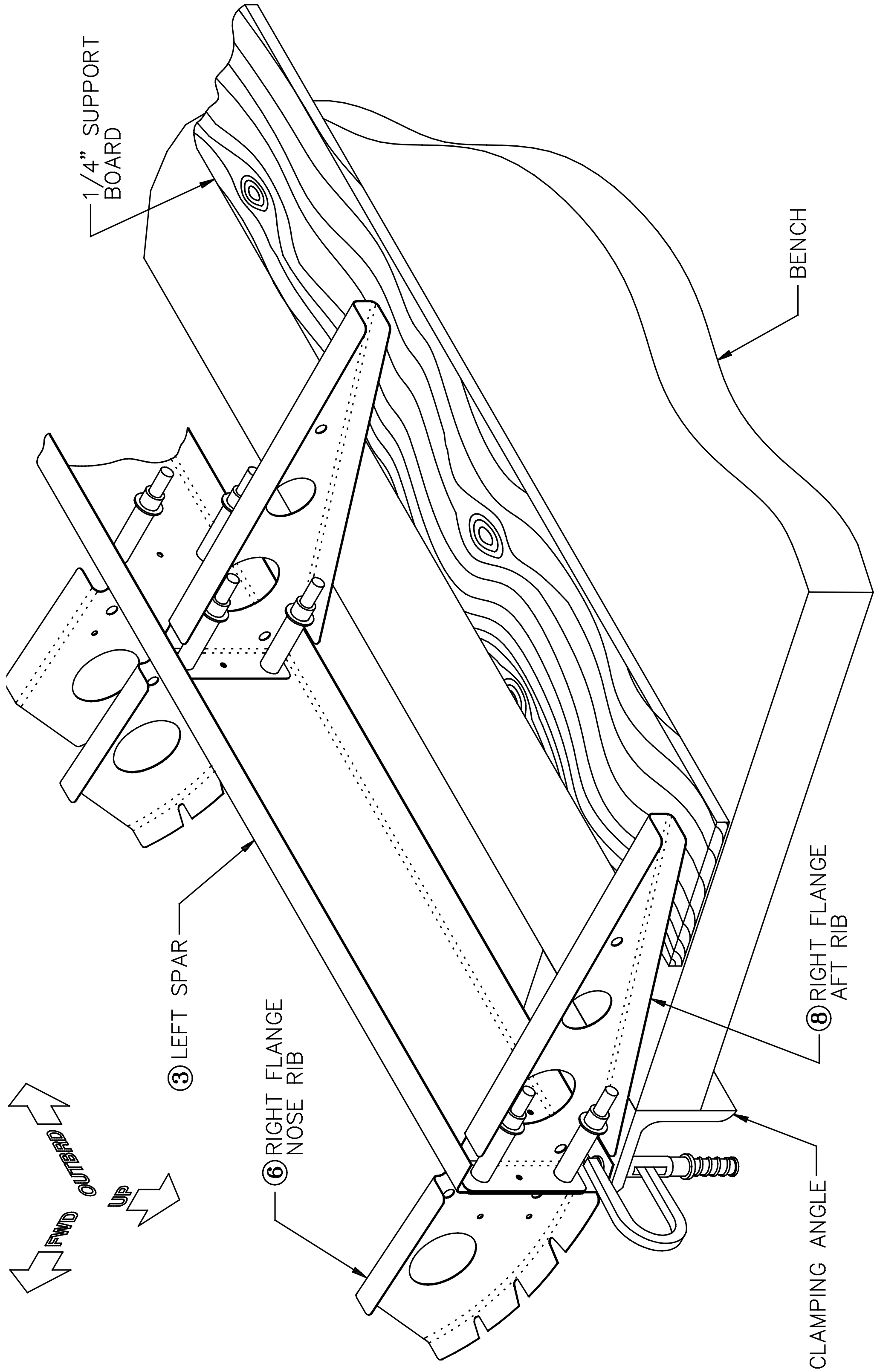

Figure 13: Clamping the Spar/Rib Assembly to the Bench

Step 11: Position the Skin and Drill the Lower-Surface Rivet Holes

With the spar/rib assembly clamped upside-down to the bench top, open the **left skin** [1] and slide it over the assembly. As shown in Figure 14, the upper surface of the skin will hang down toward the floor.

> **Hint** The left and right skins can be distinguished most easily by observing that, with the inspection holes **down**, the **double row** of pre-punched nose rib pilot holes are always on the **outboard end**—that is, on the **left end** of the **left aileron** and the **right end** of the **right aileron**. Check this carefully, because these parts may have been mislabeled in some early GlaStar kits.

Pull the skin back until the rivet line on the lower spar flange is centered under the pre-punched rivet holes in the lower surface and align the inboard and outboard edges of the skin on the ends of the spar. When it's positioned properly, clamp the skin to the spar flange at each end with a pair of side-grips, as shown in the figure.

With the skin clamped in place, adjust the spar as necessary to keep the marked rivet line centered under the holes, and then drill several **#40** holes along the spar flange. Cleco these holes, remove the side-grips and then drill (**#40**) and Cleco all the remaining holes along the lower spar flange.

> **Note** Some of the pre-punched skin holes over the spar flanges lie almost directly beneath (relative to the aircraft) the web of an aft rib. For this reason, it may be virtually impossible to properly buck a hard rivet in some of these holes. Check your spar holes as you drill; if they appear to be too close to the underlying rib web to enable bucking—say, within 1/8"—drill them up to **#30** size for later installation of blind rivets. Use a drill stop set at **3/16"** when drilling these holes to avoid the possibility of damaging the underlying rib web.

Next, bring the aft ribs into alignment by centering the lines you marked under the pre-punched skin holes. You can simply raise the trailing edge of the skin slightly to adjust these ribs. When the rivet lines are centered, drill all the rib holes, starting at the spar and moving aft. Cleco periodically as you go.

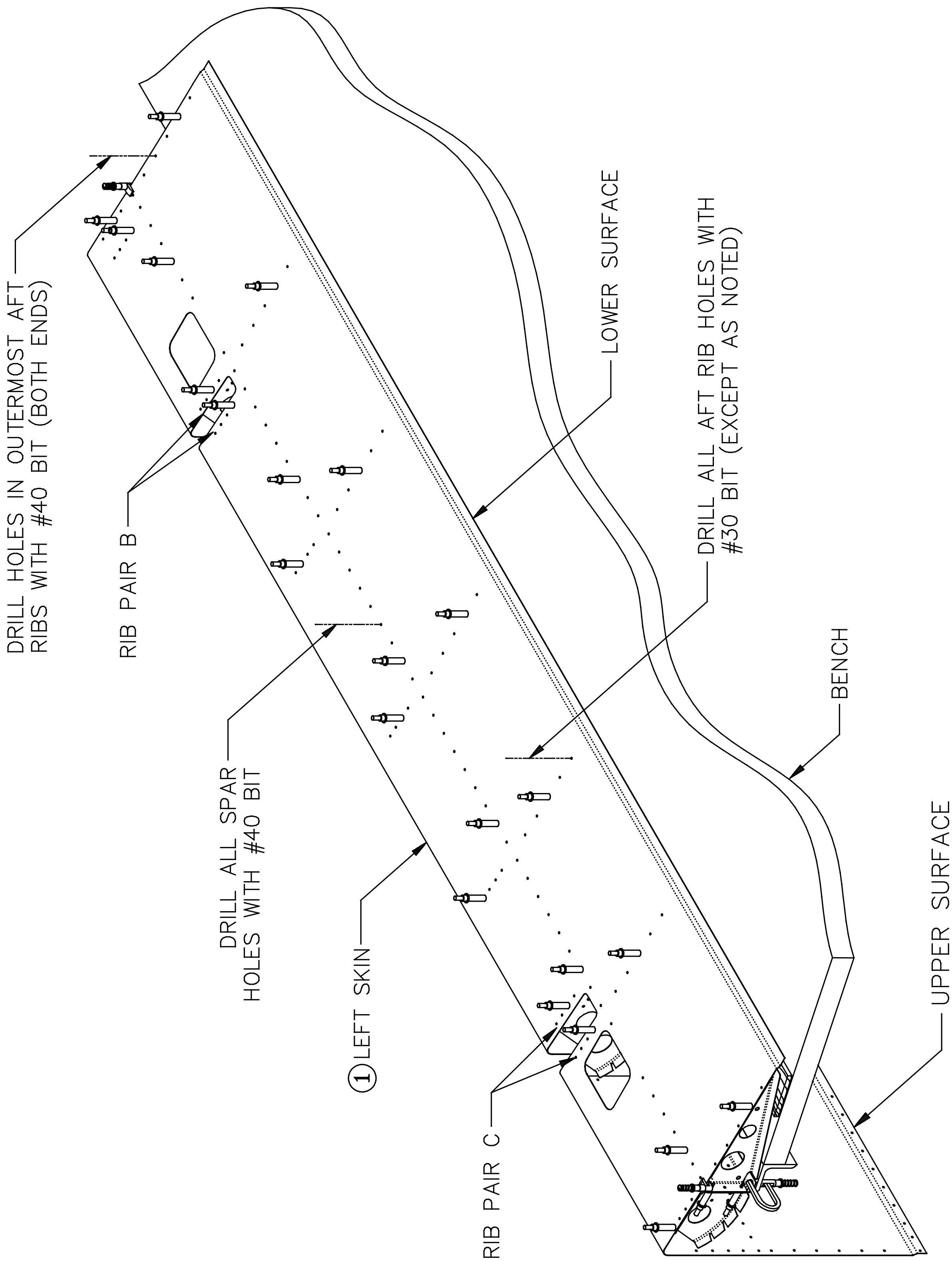

Figure 14: Positioning the Skin and Drilling the Lower-Surface Spar and Aft Rib Holes

Caution Be very careful to use the proper drill bits for the various aft ribs. As noted in Figure 14, all the aft rib holes are drilled with a **#30** bit **except** the holes in the **outermost** aft ribs at each end, which are drilled with a **#40** bit. The reason for this difference is that the latter two ribs are accessible for bucking or squeezing, whereas blind rivets must be used for the remaining aft ribs.

Finally, repeat the above procedure on all the nose ribs. You can easily adjust them left or right as necessary simply be reaching under the hanging upper skin surface. When they are properly aligned, drill them beginning at the spar and working forward; Cleco periodically as you go.

Caution Be very careful to use the proper drill bits for the various nose ribs. As noted in Figure 15, all the nose rib holes are drilled with a **#30** bit **except** the holes in the **outermost** nose ribs at both ends and the **ribs immediately to the left and right of the inspection holes in the skin**; these are drilled with a **#40** bit. As with the aft ribs, the reason for this difference is that the latter four ribs are all accessible for bucking or squeezing, whereas blind rivets must be used for the remaining nose ribs.

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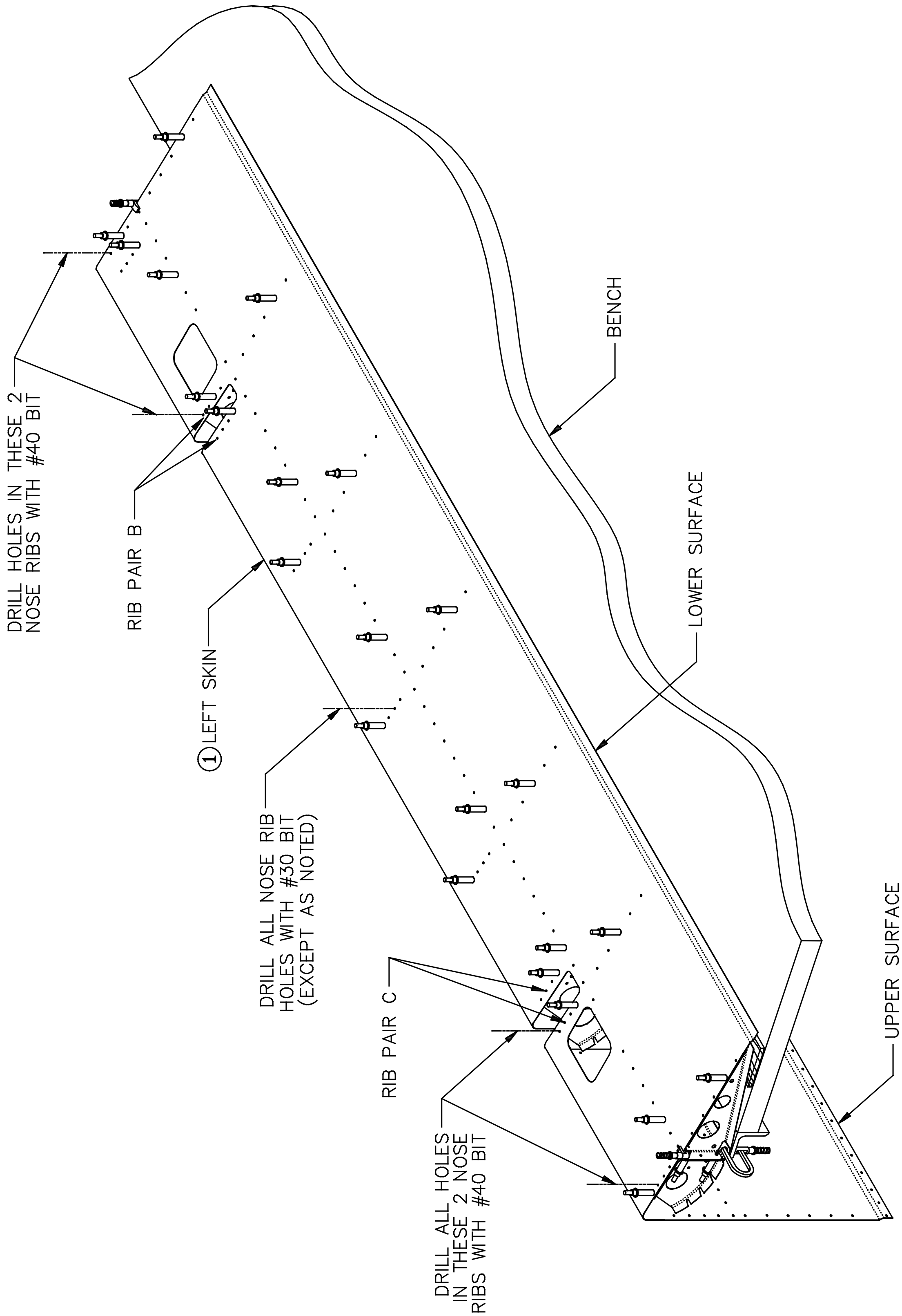

Figure 15: Drilling the Lower-Surface Nose Rib Holes

Step 12: Mark Locations for the Inspection Hole Doubler Rivet Holes

The two inspection holes in the skin allow access to the aileron hinge and actuator bolts. An **inspection hole doubler** [11] is installed inside the skin around each hole to provide anchor points for the nutplates that secure the **inspection hole covers** [12]. Before positioning the doublers under the skin for drilling, you need to mark hole locations for the rivets that will hold them in place, as there are no pre-punched pilot holes for this purpose.

As shown in Figure 16, the eleven necessary holes are arranged around the forward, inboard and outboard edges of the inspection holes. The placement of the holes is not overly critical except that you must maintain an edge margin to the hole centerpoints of **3/16"**. If you index the aftmost holes on the inboard and outboard edges to the aftmost rivet hole in the adjacent nose rib, then a spacing of **7/8"** all the way around results in a good pattern.

Mark and lightly center punch these locations.

> **Note** Figure 16 shows the **inboard** inspection hole. The **outboard** inspection hole is exactly the same size, but the hole locations are mirror image.

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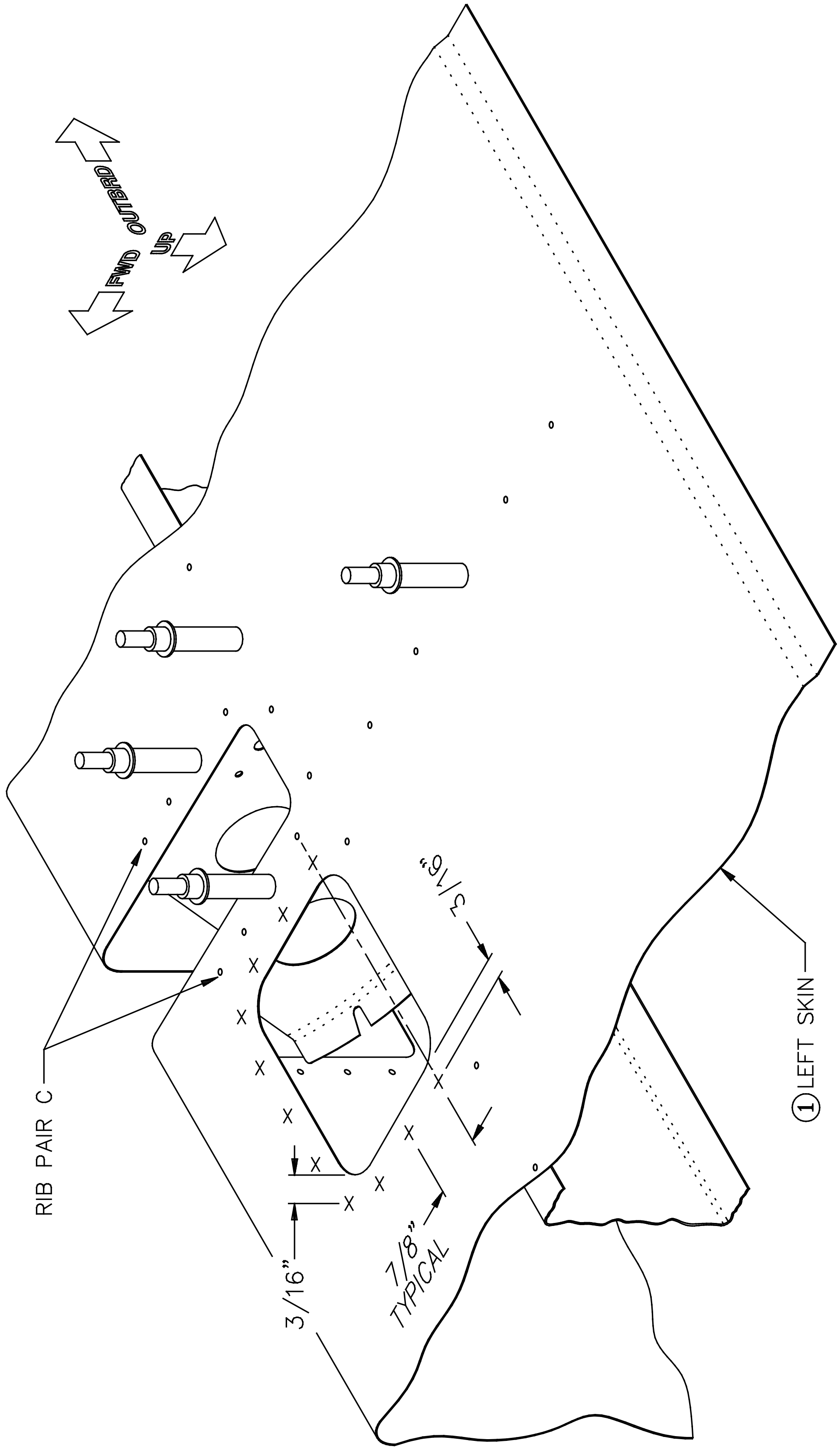

Figure 16: Marking the Inspection Hole Doubler Rivet Holes

Step 13: Position and Drill the Inspection Hole Doublers

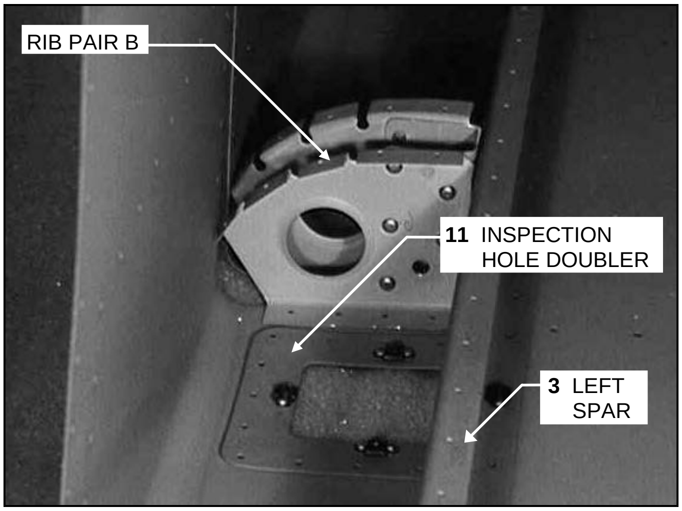

Figure 17: Inspection Hole Doubler

Figure 17 shows the basic orientation of the inspection hole doubler for the **outboard** inspection hole: the closed end of the U-shaped doubler is forward of the spar, and the bent end-tabs are tight against the spar web.

With the spar/rib assembly still clamped to the bench and the lower surface of the skin Clecoed in place, position the doublers and clamp them in place to the skin with side-grips or small C-clamps, as shown in Figure 18. The doubler should be centered on the inspection hole, which means that approximately **1/2"** of the doubler should extend inward beyond each edge of the hole, creating a recessed flange for the cover plate.

Note As with Figures 8 and 9, Figure 17 shows the inspection hole doubler at a more advanced stage of construction. Its presentation here is intended solely to indicate how the doubler is positioned relative to the skin and spar.

With the doublers clamped in position, use a **#40** bit to drill through the skin and doubler at each of the eleven marked locations. Drill your first holes near the clamps and then insert Clecos. Drill subsequent holes adjacent to the Clecos and move outward, Clecoing as you go.

Hint Because the doubler is made of very thin, flexible stock, you may find it helpful to hold it tightly against the skin from underneath with a block of scrap wood while drilling.

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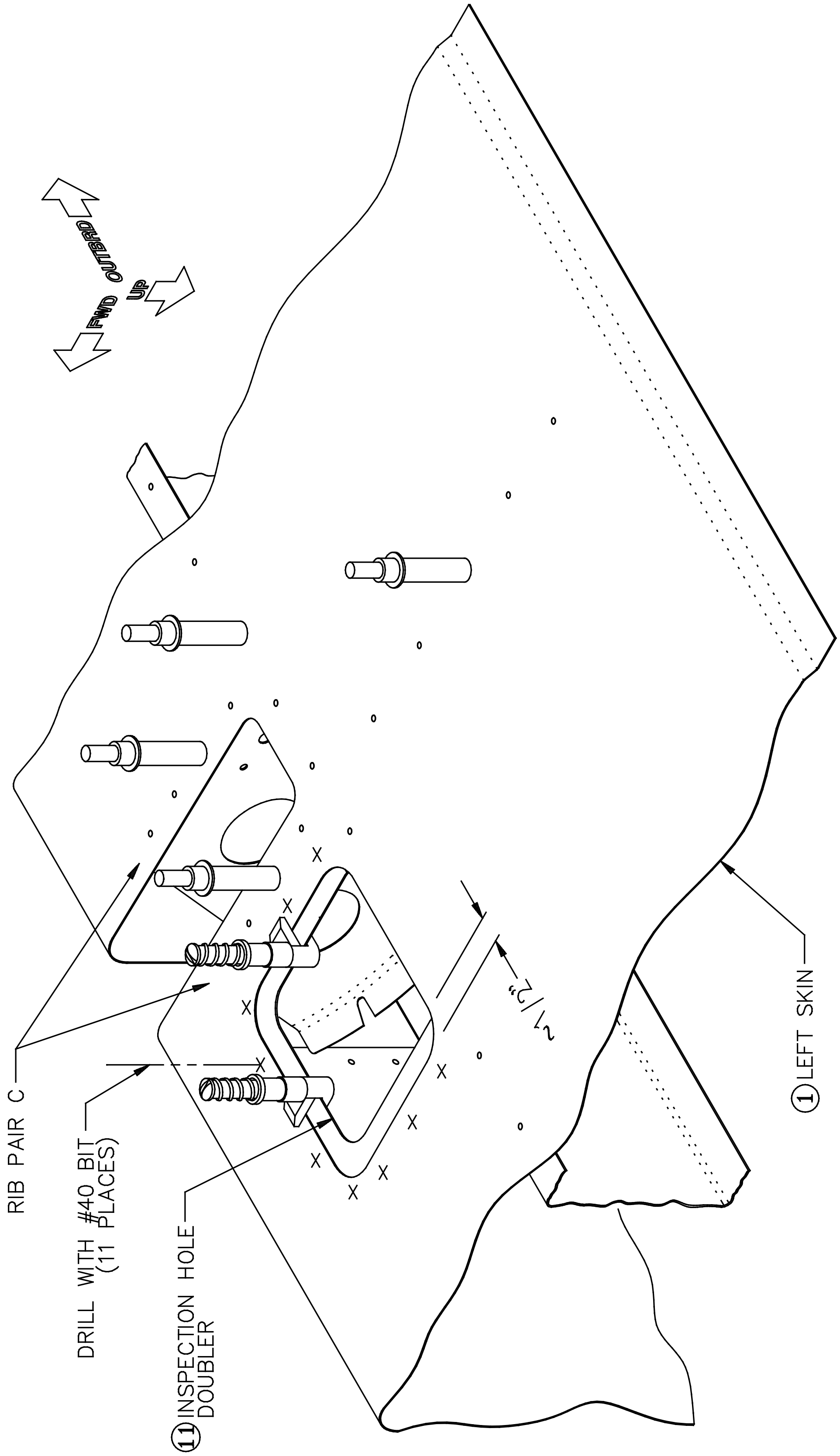

Figure 18: Drilling the Inspection Hole Doubler Rivet Holes

Step 14: Drill the Inspection Hole Cover Mounting Screw Holes

After drilling all the rivet holes around the perimeter of both doublers, leave Clecos in at least the three middle holes along each edge of the inspection hole, as shown in Figure 19.

Press the cover plate into the inset formed by the skin and one of the doublers and drill through each of the four pilot holes for the AN526-8R6 mounting **screws** [15] with a **#19** bit.

Note The cover plates are identical. As Figure 19 shows, each plate is slightly longer than the inspection hole, so when the forward edge of the plate is seated in the cutout, the aft edge will overlap the lower surface of the skin. This is perfectly proper. For this reason, the two side holes and the forward hole will be drilled through the cover plate and the doubler; the aft hole will be drilled through the cover plate, the lower surface of the skin and the lower spar flange.

Deburr the holes in the cover plate and set it aside. Repeat the process on the remaining cover plate and doubler.

Caution You may be tempted to extend the inspection holes aft of the spar so that the covers will fit flushly. We **strongly** discourage such a modification. The aileron is a stressed-skin structure in which the skin must be riveted to the spar along its entire length to provide the necessary torsional strength. Rivet holes to tie the skin to the spar aft of the inspection holes will be drilled in a subsequent step.

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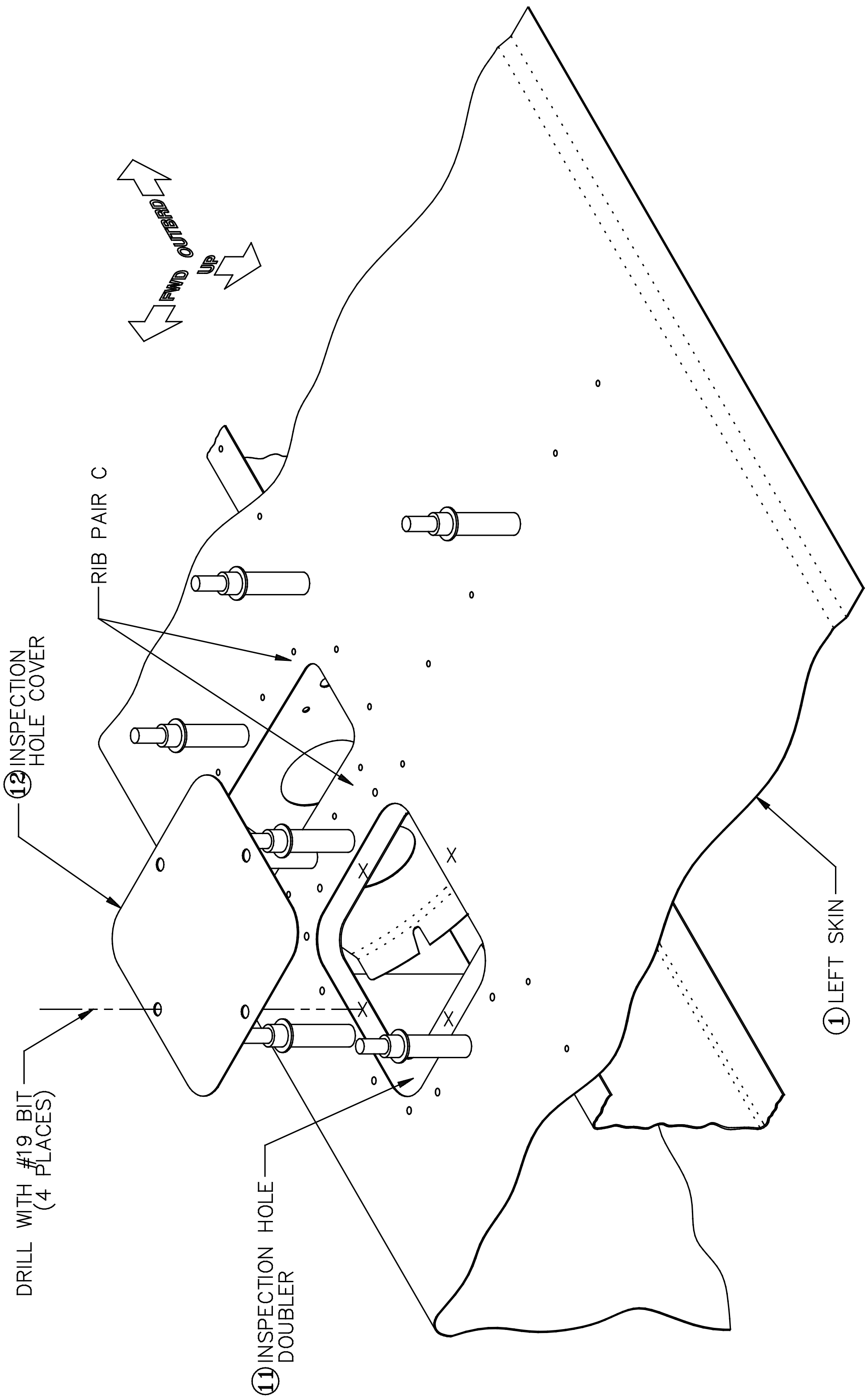

Figure 19: Drilling the Inspection Hole Cover Mounting Screw Holes

Step 15: Mark and Drill the Spar Web/Inspection Hole Doubler Rivet Holes

With the lower surface of the skin still Clecoed to the spar/rib assembly, remove the C-clamps holding the spar to the bench and turn the entire assembly over so that it's sitting right-side up on the bench, supported on the Clecos.

As shown in Figure 20, mark two hole locations on each tab of both doublers. These holes need not be too precise, but be sure to maintain at least **1/4"** edge margin between the hole locations and the edges of the tabs. Drill all marked holes with a **#40** bit.

After drilling, mark the doublers so they can be returned to their original locations after disassembly. Then remove the Clecos securing the doublers and thoroughly deburr all the holes. Set the doublers aside.

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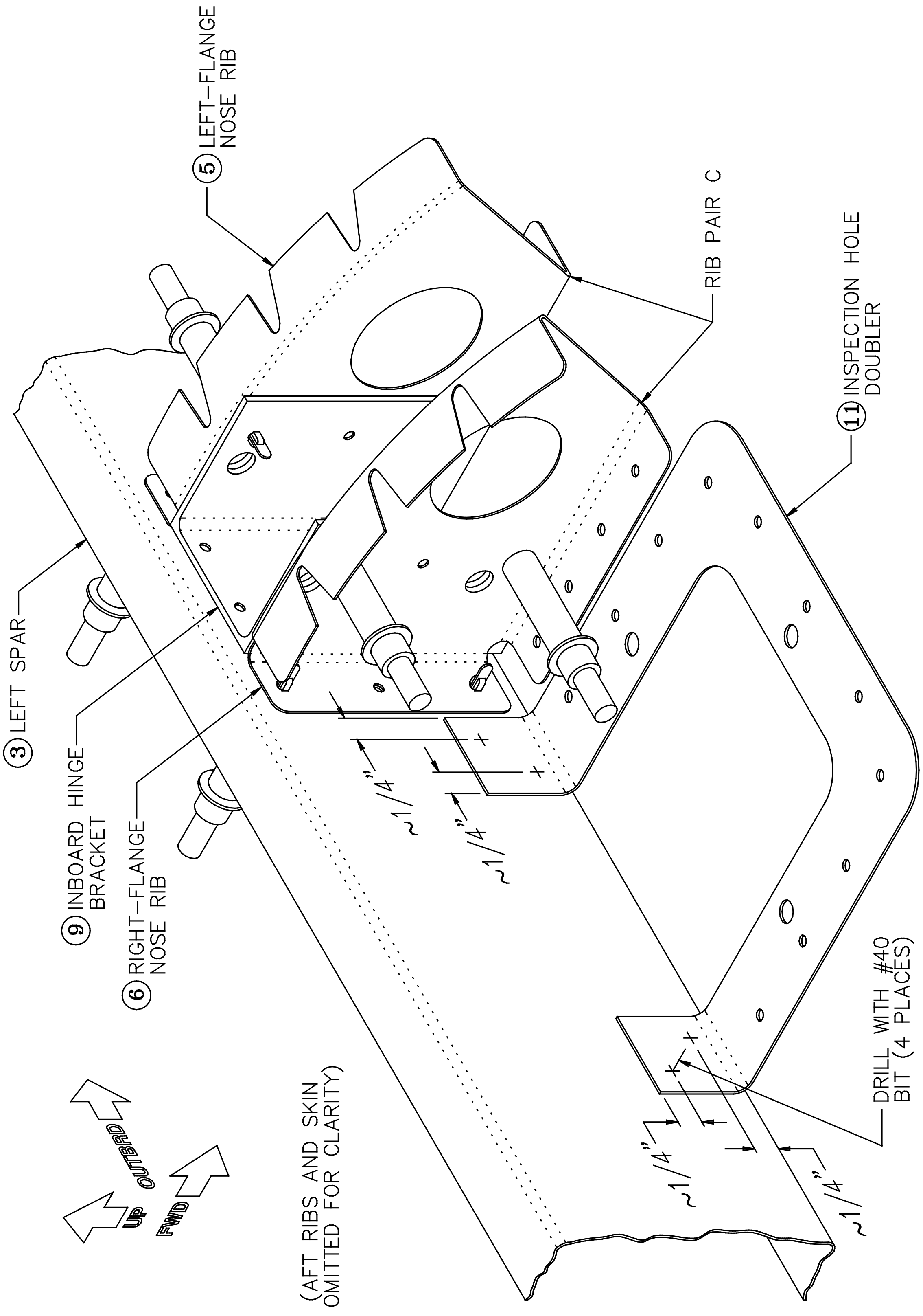

Figure 20: Drilling the Spar Web/Inspection Hole Doubler Rivet Holes

Step 16: Position and Drill the Upper Surface of the Skin

With the lower surface of the skin Clecoed to the spar/rib assembly and the entire assembly sitting right-side up on the Clecos, pull the upper surface of the skin back tightly against the ribs. Use side-grips or small, rubber-padded spring clamps along the trailing edge joggle to clamp the upper surface of the skin to the lower along the entire length of the aileron.

> **Hint** Extra clamps—either side-grips or spring clamps—used to clamp the skin to the rib flanges at each end may make the final positioning easier.

Ideally, the rivet line you marked on the upper spar flange and the centerlines you marked on the ribs will all be centered under their respective lines of pre-punched skin holes. As a practical matter, however, the more important thing is to keep the skin tight against the rib and spar flanges and to bring the trailing edge joggles of the upper and lower surfaces together as flushly as possible. Because the upper camber of the aileron airfoil is so pronounced, it may take some effort and numerous readjustments of the clamps to achieve this.

When you are satisfied with the alignment of the trailing edge joggles and the skin is lying flat against the rib and spar flanges, you may want to make a final check to ensure that no twist has been introduced into the structure. As described in "SECTION IV: HORIZONTAL STABILIZER ASSEMBLY," you can use a level supported on two blocks to check this precisely. Readjust the trailing edge clamps as necessary to true up the aileron.

Beginning with the spar and then moving aft along the aft ribs and forward along the nose ribs, drill through all the pre-punched pilot holes with a **#40** bit **with the following exception**: as shown in Figure 21, drill the **forward-most hole** in each nose rib with a **#30** bit, except for the **outermost** nose ribs at each end, which should both be drilled entirely with a **#40**. Cleco as you go.

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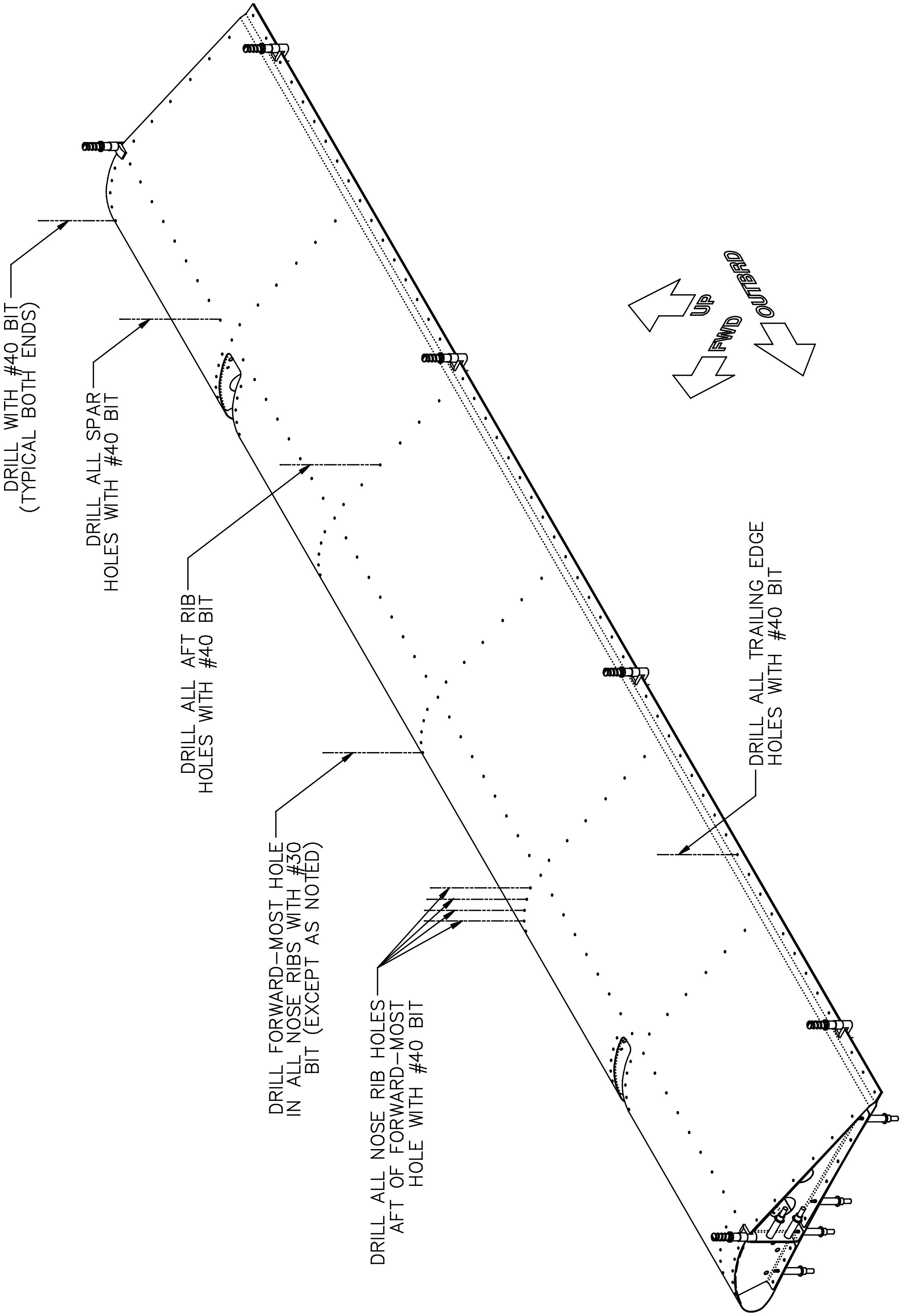

Figure 21: Positioning and Drilling the Upper Surface of the Skin

Step 17: Drill the Trailing Edge Joggles

With Clecos holding the skin to the spar/rib assembly and side-grips or spring clamps holding the upper and lower trailing edge joggles together, use a **#40** bit to drill through both skin surfaces at each pre-punched pilot hole, being careful to keep the trailing edge as straight as possible. Replace the clamps with Clecos as you go. When all the drilling is complete, un-Cleco the upper surface of the skin.

Completed: Left [ ] Right [ ]

Step 18: Position and Drill the Inspection Hole Cover Nutplates

As Figure 22 shows, the inspection hole covers are secured with four K1000-08 **nutplates** [16], one on each edge of each cover. The nutplates on the inboard, outboard and forward edges of the plate are riveted to the inspection hole doubler, while the aft nutplate is riveted **through the lower surface of the skin** to the lower flange of the spar. Using standard procedures, position these nutplates and drill the necessary **#40** rivet holes.

Additionally, you should drill **two more #40 holes** through the lower surface of the skin and the lower spar flange, one on either side of the aft nutplate. Drill these holes on the spar rivet line and halfway between each nutplate rivet hole and its adjacent pre-punched skin hole, as shown in Figure 22.

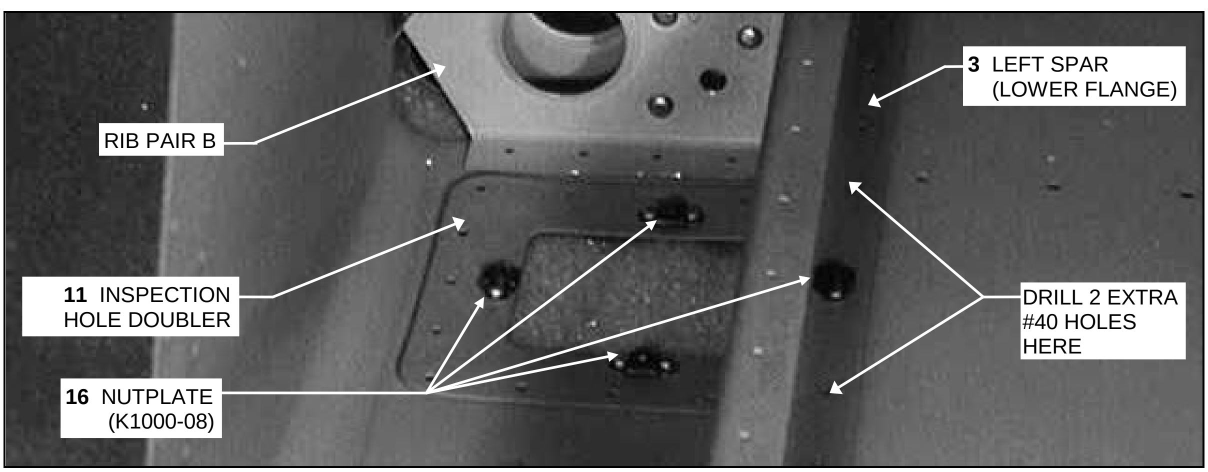

Figure 22: Positioning the Cover Plate Nutplates

After all the drilling is complete, remove all the Clecos holding the skin to the spar/rib assembly and thoroughly deburr all the holes in the skin, spar flanges and rib flanges.

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Step 19: Dimple the Inspection Hole Doublers, Spar Flange, Skin and Nutplates

All the nutplates you just positioned and drilled will be mounted with 3/32" flush head rivets (AN426AD3). These rivets will also be used in the two extra skin-to-spar holes you just drilled in the last step. Dimple all the relevant holes in the doublers, the spar flange and the skin, as well as in the nutplates themselves.

Completed: Left [ ] Right [ ]

Step 20: Smooth and Deburr the Parts

Carefully smooth and deburr all cut edges and holes. Brush away any chips or shavings that might be clinging to the parts away from drilled holes or cut edges.

Completed: Left [ ] Right [ ]

Step 21: Corrosion-Proof the Aileron Interior

Take whatever cleaning, surface preparation and priming measures you deem necessary to protect the interior parts of your aileron from corrosion. At a minimum, you should thoroughly clean and alodine-treat the skins, ribs, spar and brackets. See "SECTION II: TOOLS AND TECHNIQUES" for a more complete discussion of corrosion-proofing options.

Completed: Left [ ] Right [ ]

RIVETING

Step 22: Rivet the Hinge and Actuator Bolt Nutplates to the Nose Ribs of Pairs B and C

Using 3/32" flush head rivets (AN426AD3), rivet the K2000-4 hinge and actuator bolt nutplates to their respective ribs—one to the **inboard** rib of Pair B and two to the **outboard** rib of Pair C. In all cases, the manufactured head should be on the rib web, with the shop head formed on the nutplate.

Completed: Left [ ] Right [ ]

Step 23: Rivet the Counterweight Bolt Nutplates to the Inboard Counterweight Nose Rib

Rivet the two K1000-3 nutplates to the web of the **inboard** counterweight nose rib to accommodate the counterweight bolts. Use 3/32" flush head rivets (AN426AD3).

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Step 24: Rivet the Inspection Hole Cover Nutplates to the Doublers

Use 3/32" flush head rivets (AN426AD3) to rivet the six K1000-08 nutplates that are located on the inspection hole doublers. Rivet three nutplates to each doubler with the manufactured heads on the outside.

Completed: Left [ ] Right [ ]

Step 25: Rivet Rib Pairs B and C to Their Respective Hinge Brackets

Use 1/8" AN470AD4 universal-head rivets to rivet the left- and right-flange nose ribs of Rib Pairs B and C to the outboard and inboard hinge brackets, respectively. The manufactured heads should be on the outside (i.e., on the rib webs), as shown in Figure 23.

> **Note** Make sure that the shop heads of these rivets are no greater than 3/32" tall. This is necessary to provide sufficient clearance for the hinge spacers, which you will install in "SECTION IX: SYSTEMS INSTALLATION."

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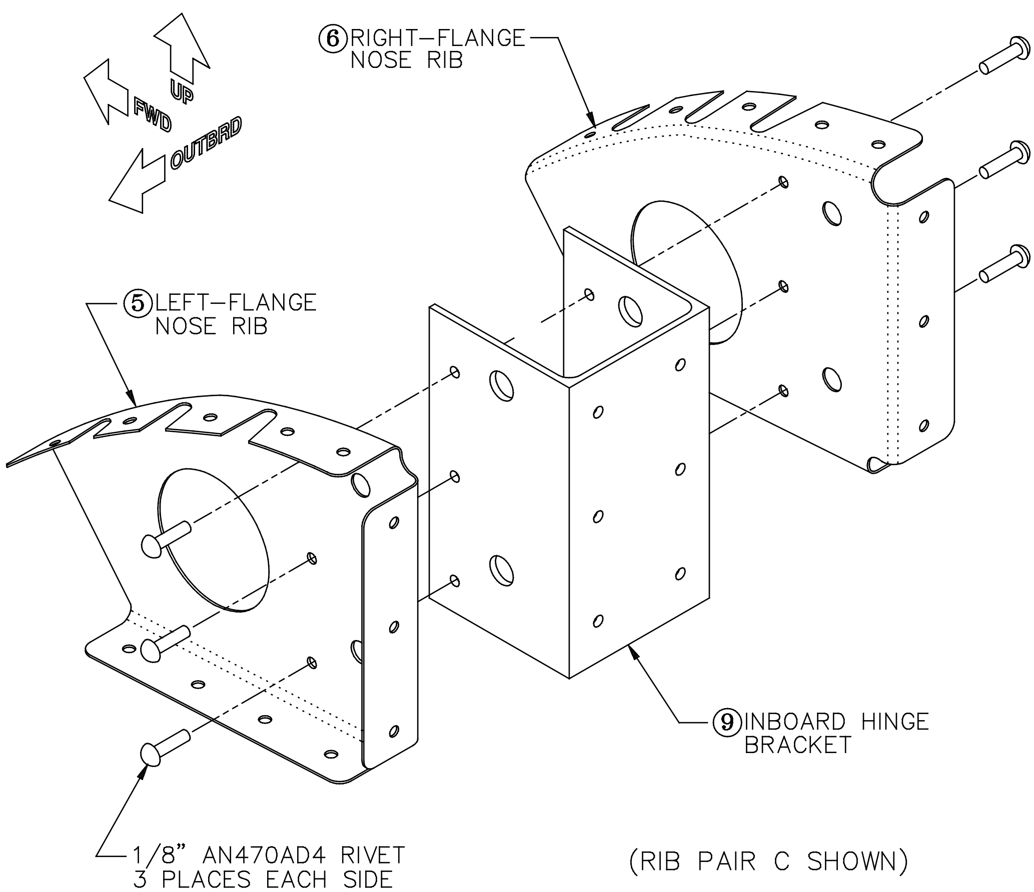

Figure 23: Riveting the Nose Ribs to the Hinge Brackets

Step 26: Rivet the Ribs and Inspection Hole Doublers to the Spar

Rivet all the nose, counterweight nose and aft ribs to the spar with 3/32" AN470AD3 universal-head rivets. The manufactured heads should be aft, as shown in Figure 24.

> **Note** Be sure to remove the temporary spacer from the counterweight nose rib if you haven't already done so.

Also, using the same rivets with the manufactured heads aft, rivet the inspection hole doublers to the spar. Refer back to Figure 20 to ensure proper orientation.

Completed: Left [ ] Right [ ]

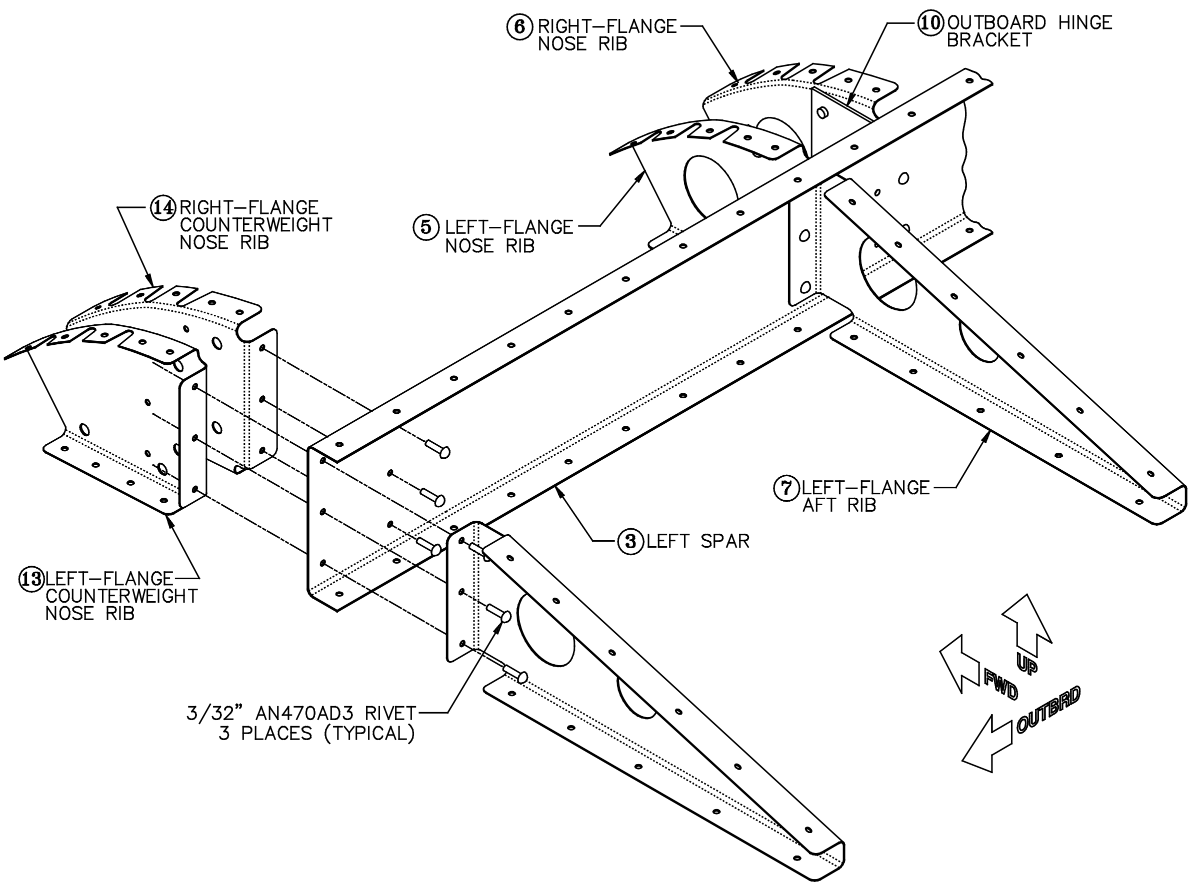

Figure 24: Riveting the Ribs to the Spar

Step 27: Rivet the Hinge Brackets to the Spar

Use 3/32" AN470AD3 universal-head rivets to rivet the hinge brackets to the spar web. As shown in Figure 25, the manufactured heads should be on the **aft** side of the spar web.

Completed: Left [ ] Right [ ]

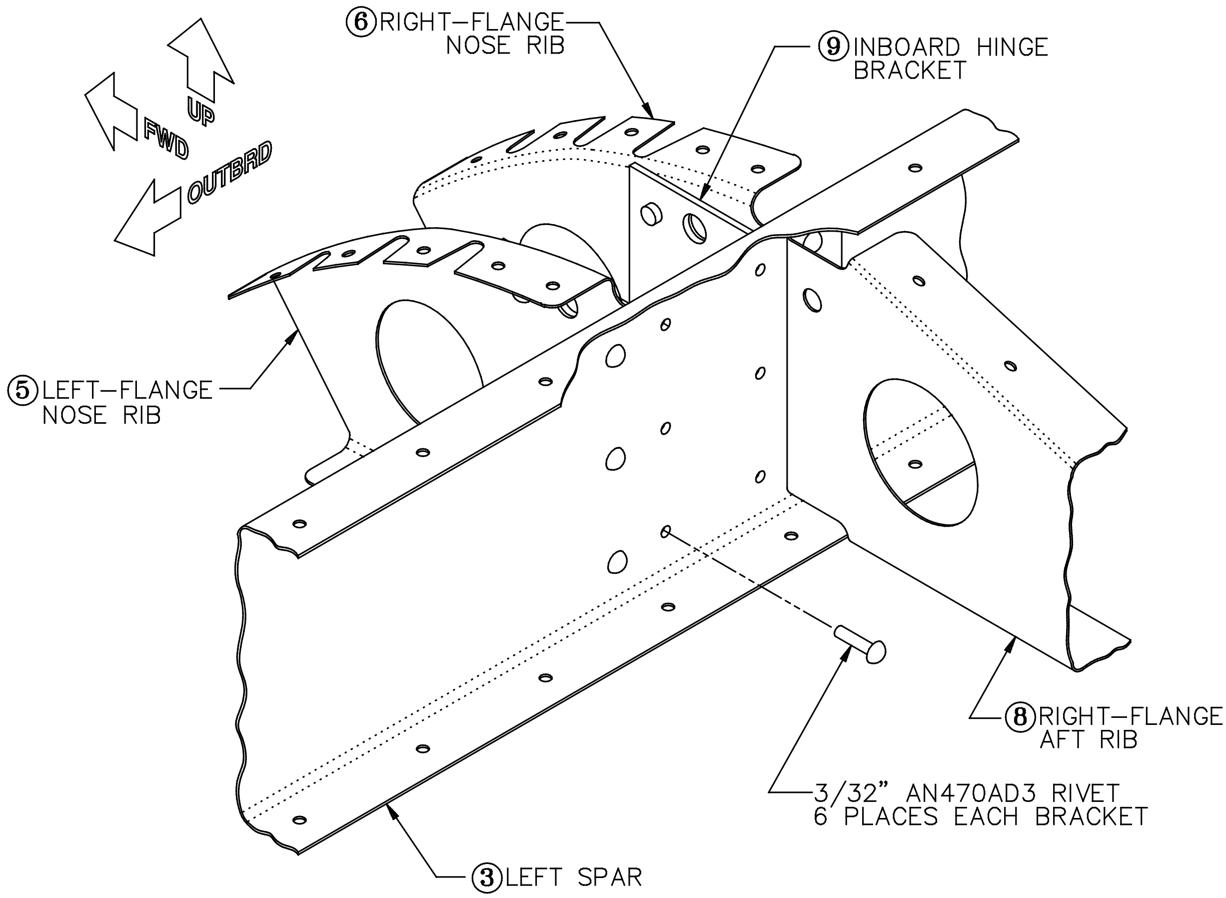

Figure 25: Riveting the Hinge Brackets to the Spar

Step 28: Rivet the Skin to the Upper Flanges of the Spar and Aft Ribs

Slide the skin over the spar/rib assembly, Cleco the upper surface in place and clamp the assembly **right-side up** to the clamping angles on the edge of your bench, as shown in Figure 26. Then use 3/32" AN470AD3 universal-head rivets to rivet the skin to the upper flange of the spar, as shown in the figure. Refer back to "SECTION II: TOOLS AND TECHNIQUES" for a discussion of the proper sequence for driving a line of rivets. Then, starting at the spar and moving aft, use the same type and size of rivets to rivet the skin to the upper flanges of the aft ribs.

Completed: Left [ ] Right [ ]

Step 29: Rivet the Skin to the Upper Flanges of the Nose Ribs

Begin at the spar and rivet forward along each nose rib's upper flange using 3/32" AN470AD3 universal-head rivets. You will find it increasingly difficult to hold the skin tightly against the rib flange as you move forward due to the curve being imposed on the skin. For this reason—as well as an awkward angle for bucking—it is impractical to drive a hard rivet into the forward-most hole in each nose rib. As shown in Figure 26, use a 1/8" AAPQ-42 blind rivet for this location on each rib, **except on the outermost ribs**. Because there is access there for a rivet squeezer, use 3/32" AN470AD3 universal-head rivets for **all** holes in these two ribs.

> **Note** The forward-most hole in each nose rib should have been drilled with a **#30** bit to accommodate the larger blind rivet. If this has not been done at this point, drive all the hard rivets aft of these holes. Then insert a Cleco in each of the forward-most holes and, removing one Cleco at a time, drill the holes up to #30 size. After drilling one hole, insert a larger Cleco before drilling the next hole. After all have been drilled, remove all the Clecos, deburr all the holes (both in the skin and the ribs) and install the blind rivets.

Completed: Left [ ] Right [ ]

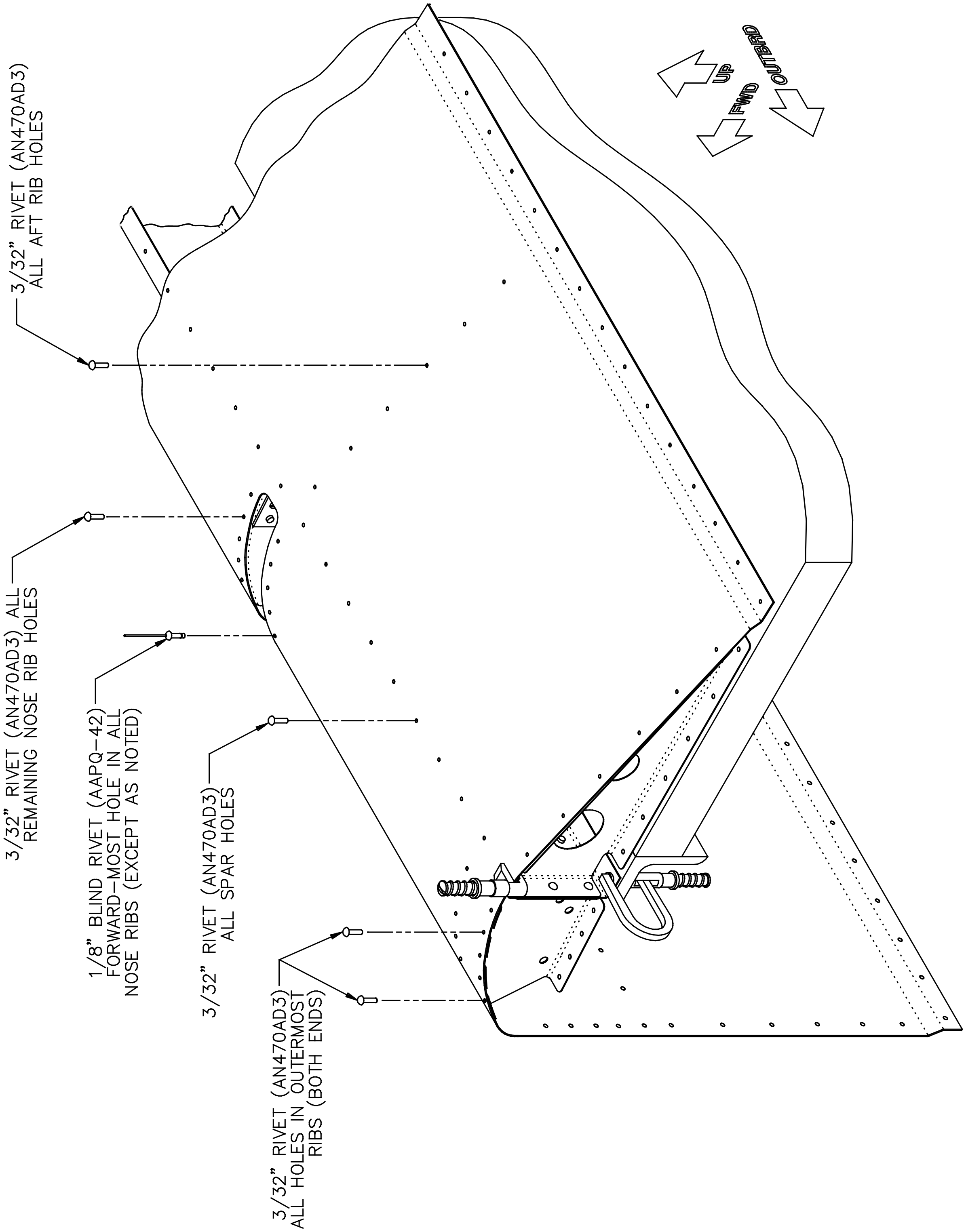

Figure 26: Riveting the Upper Surface of the Skin to the Spar/Rib Assembly

Step 30: Rivet the Skin to the Lower Flanges of the Nose Ribs

After the upper surface of the skin has been riveted to the spar/rib assembly, turn the assembly over and rivet the lower surface to the nose ribs, starting forward and moving aft to the spar. As shown in Figure 27, use 3/32" universal head rivets (AN470AD3) wherever the flange is accessible to a rivet squeezer or bucking bar—that is, all holes in both outermost ribs and all holes in the two ribs adjacent to the access holes in the skin. Rivet all the other nose ribs with 1/8" blind rivets (AAPQ-42).

Completed: Left [ ] Right [ ]

Step 31: Rivet the Inspection Hole Doublers to the Skin

Using 3/32" universal head rivets (AN470AD3), rivet the inspection hole doublers to the skin. The manufactured heads should be on the outside. Be careful not to over-drive or -squeeze these rivets, as the thin material of the skins and rings can easily buckle.

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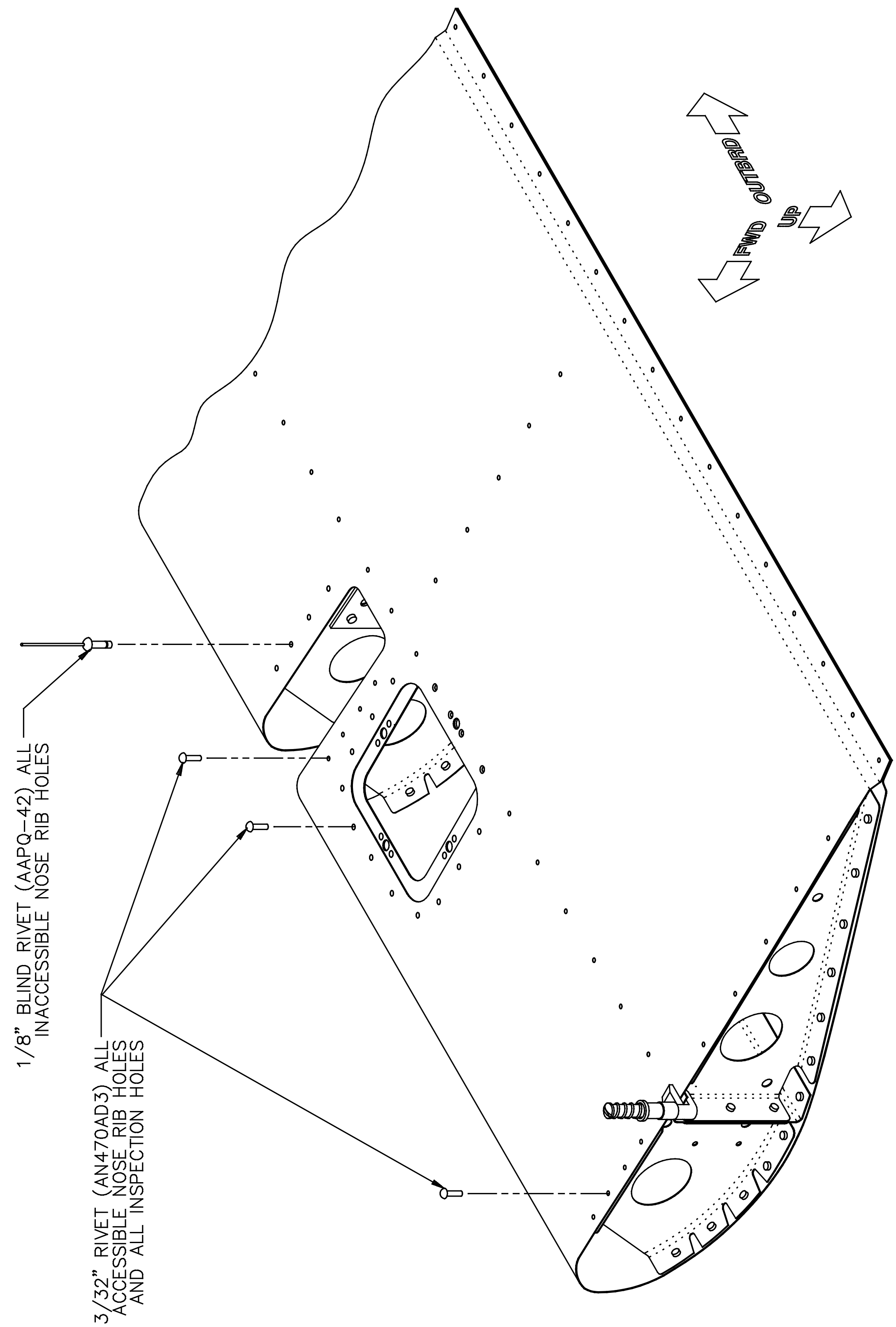

Figure 27: Riveting the Skin to the Lower Flanges of the Nose Ribs

Step 32: Rivet the Skin and the Aft Inspection Cover Nutplates to the Lower Spar Flange

Use 3/32" universal head rivets to rivet the skin to the lower flange of the spar, as shown in Figure 29. Refer back to "SECTION II: TOOLS AND TECHNIQUES" for a discussion of the proper sequence for driving a line of rivets. In order to drive these rivets, you will have to lift the trailing edge of the skin and reach inside the aileron to position the bucking bar. Figure 28 depicts this technique.

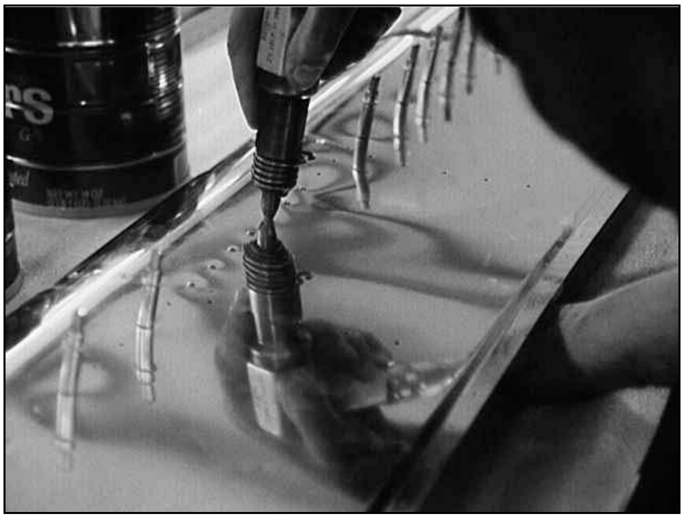

Figure 28: Riveting the Skin to the Lower Flange of the Spar

In the course of riveting the spar line, also rivet the aft nutplates for each inspection hole cover to the spar using 3/32" flush head rivets (AN426AD3). These rivets should also be used in the holes immediately to the left and right of each nutplate.

Finally, recall that a handful of holes along the lower spar flange may have been drilled up to #30 size because of their proximity to underlying rib webs. Rivet these holes with blind rivets (AAPQ-42) **after** all the other spar rivets have been driven.

Completed: Left [ ] Right [ ]

Step 33: Rivet the Skin to the Lower Flanges of the Aft Ribs

Beginning at the spar and moving aft, rivet the skin to the lower flanges of the aft ribs. As shown in Figure 29, use 1/8" blind rivets (AAPQ-42) for all the aft ribs **except the outermost pair**; because these are accessible for squeezing, use 3/32" universal head rivets (AN470AD3) on the outermost ribs.

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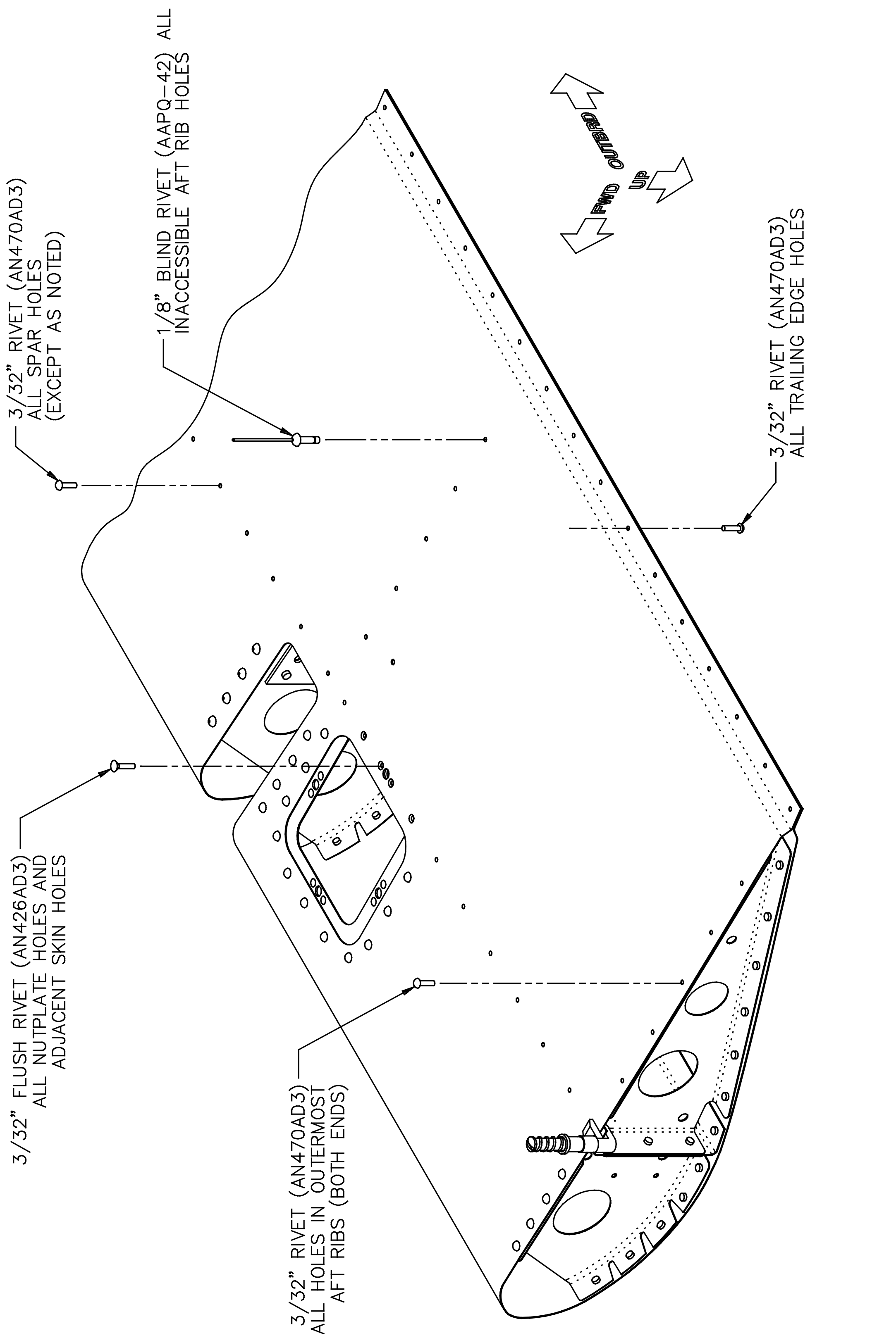

Figure 29: Riveting the Skin to the Lower Flanges of the Spar and Aft Ribs

Step 34: Rivet the Trailing Edge Joggles

Using 3/32" universal head rivets (AN470AD3), rivet the upper and lower trailing edge joggles together, as shown in Figure 29. Observe proper sequencing as discussed in "SECTION II: TOOLS AND TECHNIQUES" and avoid over-squeezing or -driving these rivets, as the thin skin material will be prone to buckling between rivets that are too tight. The manufactured heads should be on the **upper** surface.

Completed: Left [ ] Right [ ]

Step 35: Mark and Cut the Counterweight Arm Slot

As alluded to earlier, the counterweight assembly (which will be installed in "SECTION X: FINAL ASSEMBLY,") consists of a lead casting around an arm made of square steel tubing. As shown in the top panel of Figure 30, the arm slides between the two counterweight nose ribs at the outboard end of the aileron, where it is secured with two 3/16" bolts. In order to provide access to the channel between these ribs, a square slot must be cut in the skin right at the leading edge.

Make the slot by drilling a **#30** hole at each corner, then drilling a larger hole in the center, and finally cutting and filing out the remaining material. As shown in the lower left-hand panel of Figure 30, locate the hole positions by, first, drawing two chordwise lines around the leading edge. The first of these lines should be **11/16"** in from the outboard edge of the skin, and the second should be **1/2"** beyond the first.

Once these lines are established, mark the two lower hole locations **1/16"** above the flat-bottomed portion of the lower surface of the skin. The two upper hole locations should be marked **9/16"** above the flat bottom.

> **Note** The 1/2" distance from the lower holes to the upper ones must be measured **vertically**. The linear distance along the surface of the skin will be considerably greater than 1/2".

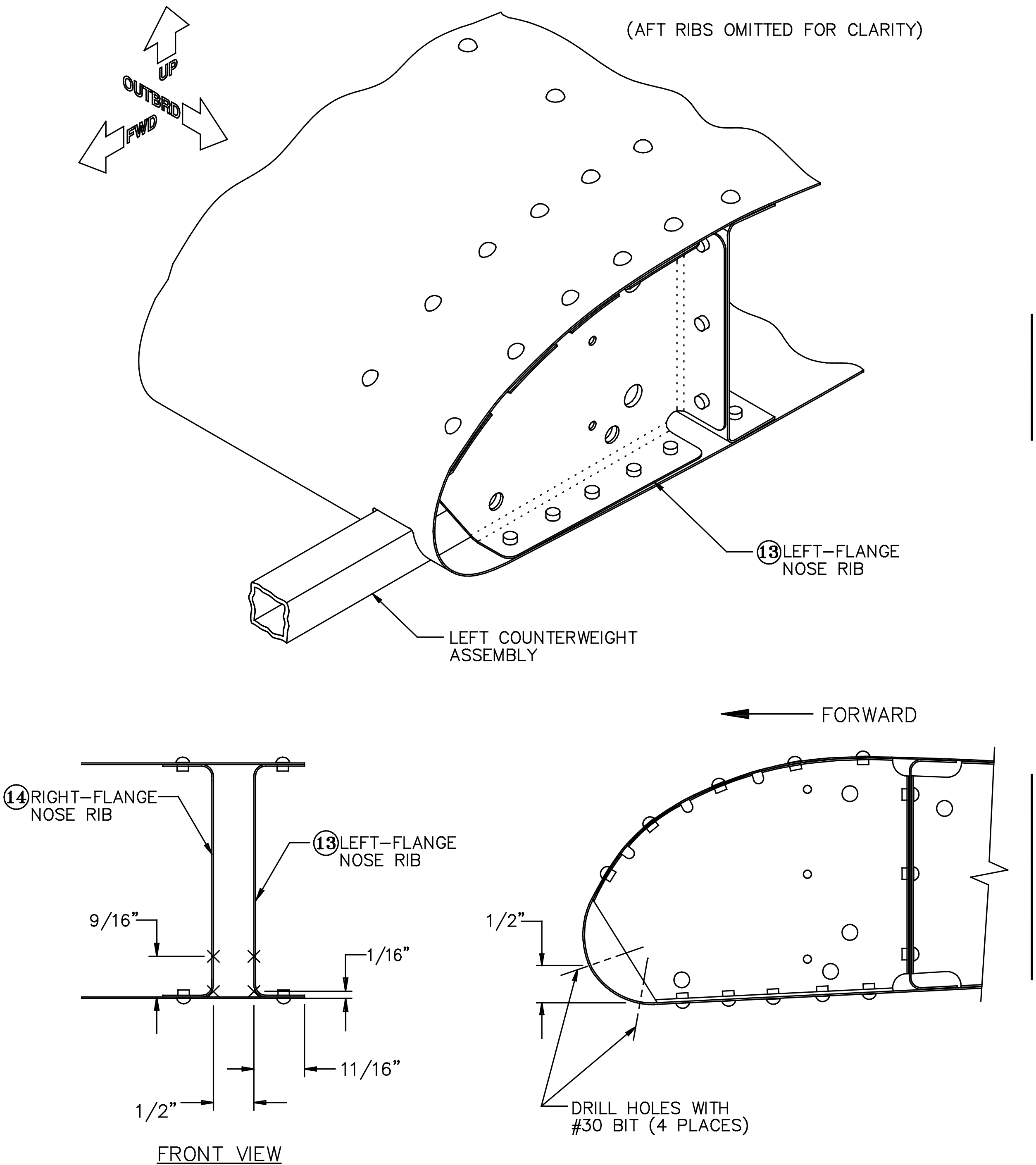

Figure 30: Marking and Cutting the Counterweight Arm Slot

Once the four corner hole locations are marked, drill each with a **#30** bit. As indicated in the cross-sectional view of Figure 30, drill the holes perpendicular to the skin surface.

Note As you may already have realized, drilling four #30 corner holes on 1/2" centers will result in a cutout that is larger than 1/2" square. This is intentional, since the aluminum aileron skins should **not** directly contact the steel counterweight arm.

Next, use a **3/8"** hole cutter or Unibit to drill out the majority of the material inside the corner holes. Use files or a rotary cutter as necessary to remove whatever is left and smooth the cut edges.

Caution Be careful **not** to square the radii left in the corners of the cutout by the #30 holes. Square corners act as stress risers, from which cracks can arise.

Completed: Left [ ] Right [ ]

Note The ailerons are now complete. They won't be needed again until Step 38 of "SECTION IX: SYSTEMS INSTALLATION" when they will be mounted to the wings to finish the control system installation. Until then, store the ailerons in a safe place to protect them from damage and corrosion.

FLAP ASSEMBLY PARTS LIST

Key No.:	Part Name:	Qty:	Part No.:
1	Skin	2	201-10001-03
2	Spar	2	201-10002-01
3	Left-flange nose rib	14	201-10003-01
4	Right-flange nose rib	14	201-10003-02
5	Left-flange aft rib	12	201-10004-01
6	Right-flange aft rib	14	201-10004-02
7	Flap-track guide arm	8	201-10005-01
8	Deployment arm	4	201-10006-01
9	Aluminum sheet, .050" X 12" X 12"	2	075-01050-01
10	Aluminum angle stock, .063" X 1" X 1"	approx. 21"	100-0640-003
11	Flush-head blind rivet, 1/8"	140	AACQ-43

Note Many early kits include first-run **skins** (P/N 201-10001-**01**), which are different in a couple ways. The -01 skins are most easily distinguished by the fact that they have a complete row of pre-punched pilot holes along the trailing edge of the upper surface. The -03 skins have only two such holes.

In addition, some early kits included 13 each of the **left-flange** and **right-flange aft ribs** [5 and 6], rather than the 12 and 14 of each, respectively, as specified in the above list.

The instructions that follow make note of procedures that are different for kits with the -01 skins and/or the original rib counts.

Tools and Additional Materials

Construction of the flaps requires most of the same tools and additional materials as the ailerons, plus the following :

1. Hacksaw (acceptable) or bandsaw or scroll saw (preferable)
2. Belt sander (recommended)
3. Small C-clamps, 2–4
4. Chip chaser
5. Sand or shot bags, 3–4
6. Microstop countersink cage with #30 piloted cutters of 100° and 120°
7. Three 10'-long 1 X 4s
8. 6"-length of steel pipe, 2–3" in diameter
9. Lead body hammer or rubber mallet

Workspace

Like the ailerons, the flaps are built on a flat table without jigs. Each flap is approximately 110" X 11". For assembly steps in which aluminum skins are lying flat on the bench, it's a good idea to pad your bench surface with cardboard to avoid unnecessary scratching of the finish. Also, you might consider leaving the plastic protective film on the outside of the skin through the positioning and drilling stages; remove it for hole deburring and riveting.

Assembly Sequence

Construction of the flaps consists of four phases: **component preparation**, **flap-track and deployment arm installation**, **skin positioning and drilling** and **main structure riveting**.

Unlike the ailerons, the left and right flaps **are identical**; construction procedures for both flaps are exactly the same. For clarity, the text and illustrations that follow refer to **one flap only**, but the instructions for each step are followed by a check box for both left and right flaps.

Figure 31 shows the configuration of the flap.

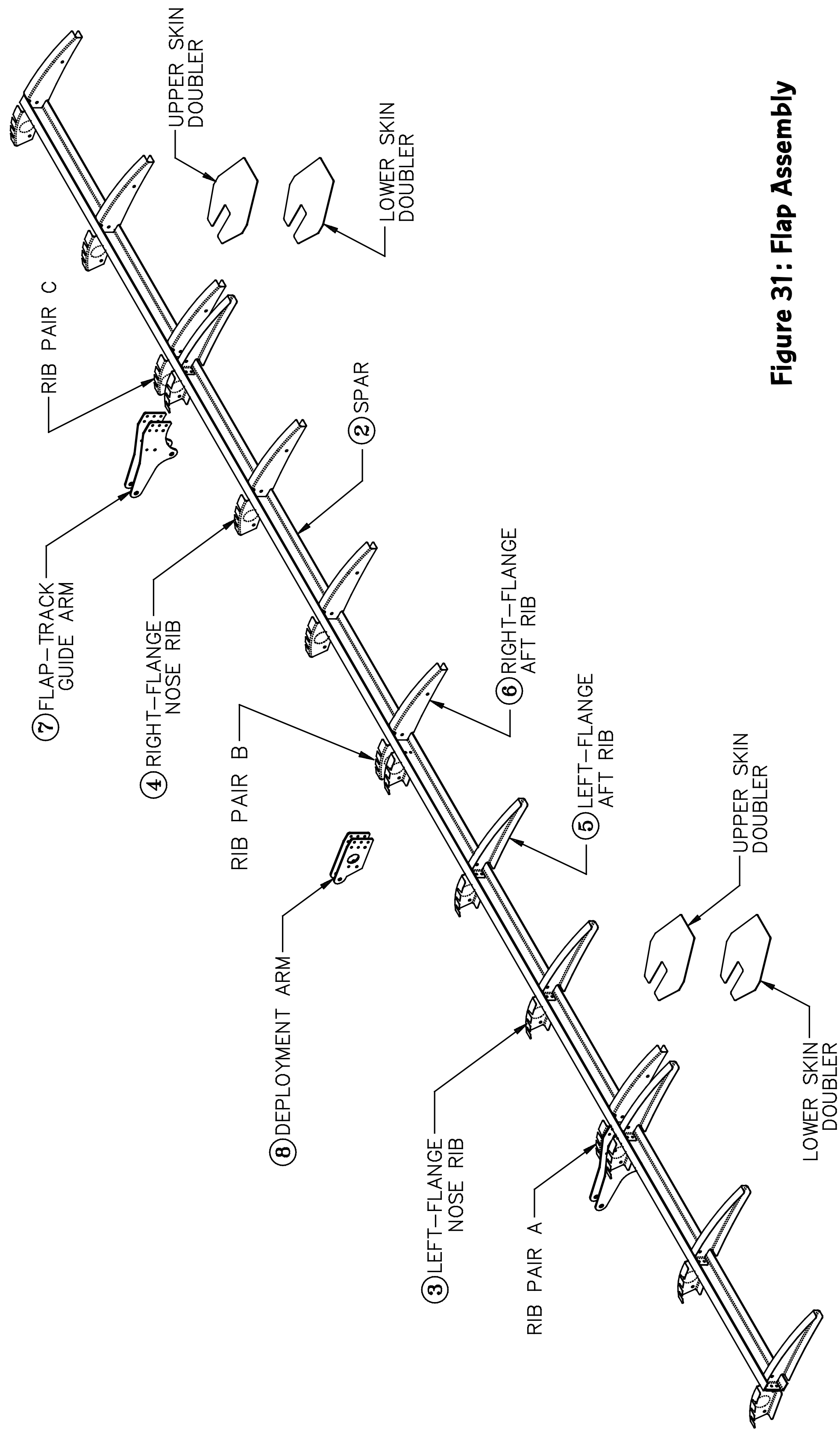

Figure 31: Flap Assembly

COMPONENT PREPARATION

Step 36: Straighten and Deburr the Parts

Using a square, check the flanges on all the ribs (**left-flange** [3] and **right-flange nose ribs** [4], and **left-flange** [5] and **right-flange aft ribs** [6]) for squareness, straightening as necessary with a pair of padded duck bill pliers.

Deburr the edges and lightening holes of all the parts as necessary.

Completed: Left [ ] Right [ ]

Step 37: Trim the Spar

The **spar** [2] is about 2" too long and must be trimmed to the proper length. The extra length may be at either end, but you can easily tell which end to trim by choosing the end on which the pre-drilled pilot holes are **farthest** from the end, as shown in Figure 32. Measure from the other end **110-1/4"** and use a hacksaw or bandsaw to cut off the excess length. This dimension should yield an edge margin of **5/16"** between the end of the spar and the first column of holes. Smooth the cut end with a fine-toothed file.

Completed: Left [ ] Right [ ]

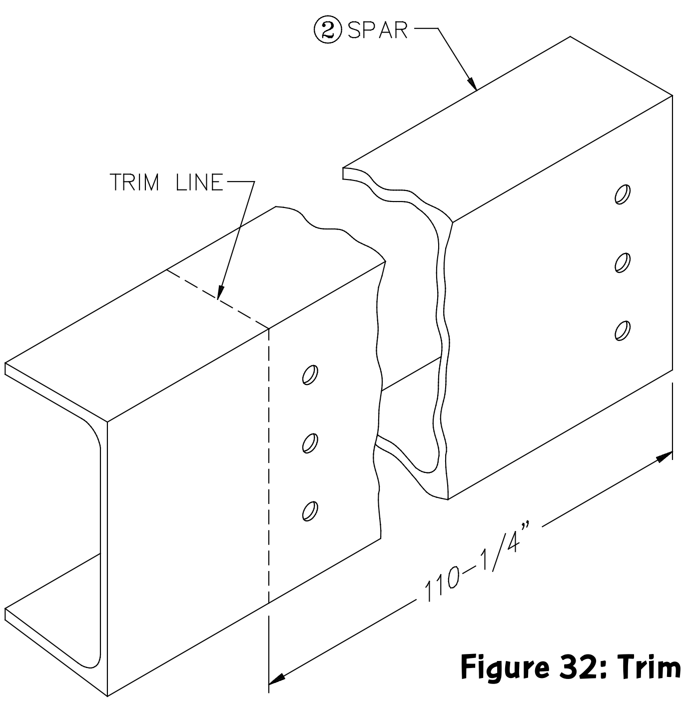

Figure 32: Trimming the Spar

Step 38: Mark Rivet Lines on the Flanges of the Ribs and Spar

Using a fine-point marking pen, mark a centerline on the flanges of all the ribs. Rivet lines must also be marked on both spar flanges, as shown in Figure 33. If you have a **first-run** (-01) skin, mark these lines parallel to and **9/32"** in from the edge of the **upper** flange and **11/32"** in from the edge of the **lower** flange; if you have a second-run (-03) skin, **reverse** these dimensions, marking the lines **11/32"** in from the edge of the **upper** flange and **9/32"** in from the edge of the **lower** flange.

Note The upper flange is the one that is more nearly perpendicular to the spar web.

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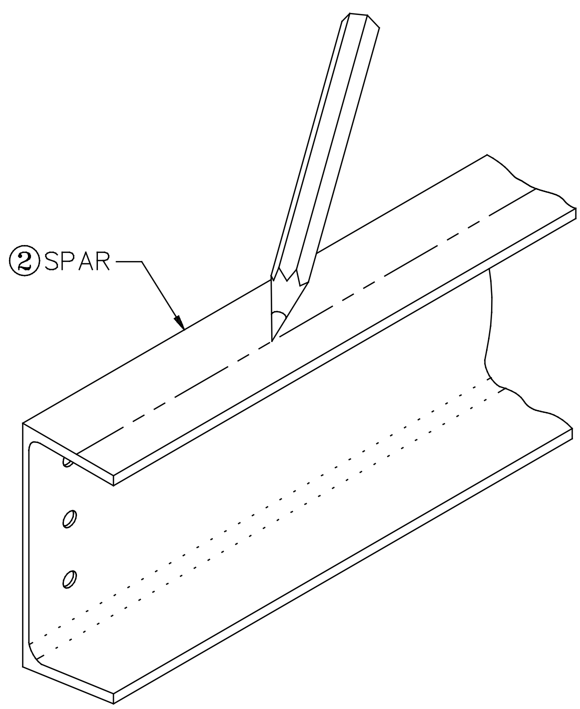

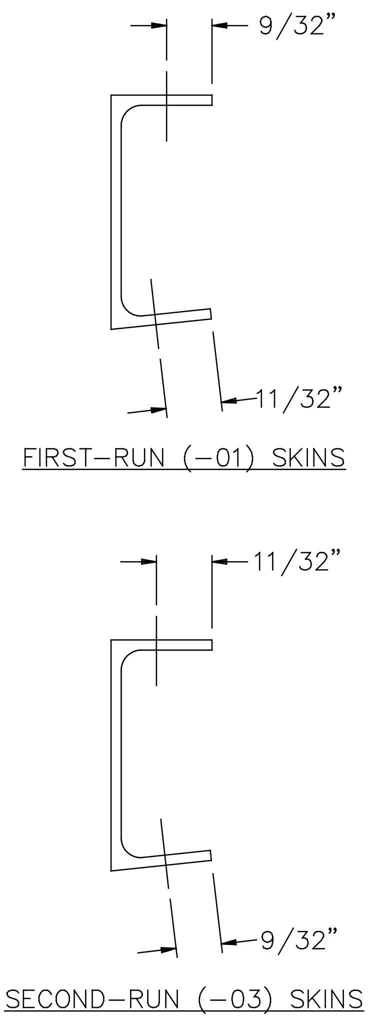

Figure 33: Marking the Spar Rivet Lines

Step 39: Cut the Nose Rib Reinforcement Angles

Each nose rib that supports either a **flap-track guide arm** [7] or a **deployment arm** [8] is reinforced with a small aluminum angle. Each angle sits inside the nose rib with one flange against the rib web and the other against the aft flange of the rib. These six angles must be cut from the supplied **.063" X 1" X 1" angle stock** [10]; there should be approximately 21" of this stock left over from the wing section, where you used pieces of it to reinforce the aileron and flap bellcrank brackets.

> **Note** Early GlaStar kits may contain two, three or even four shorter pieces of angle stock rather than one long one, and these may be stamped with the obsolete P/N 201-10007-01. The procedures for making the nose rib reinforcement angles remain identical, however.

Begin, as shown in Figure 34, by cutting the angle stock to width. As supplied, the stock is 1" X 1", but it must be cut down to 1" X **5/8"**. Mark this dimension on one of the flanges and use a hacksaw (acceptable) or a bandsaw or scroll saw (preferable) to make the cut. The stock must then be cut to length. However, because of the shape of the nose ribs into which the angles must fit, the angles can't be cut squarely. Furthermore, because left- and right-flange nose ribs are involved, the angles must be cut in mirror-imaged pairs. Figure 34a shows the dimensions for the **left-flange** nose rib reinforcement angles, and Figure 34b shows them for the **right-flange** variety. **Make three of each type for each flap**.

Finally, as shown in Figure 34c, use a belt sander or a fine-toothed file to radius the outside corner of each angle to allow it to nest tightly inside the nose ribs. Also, smooth the cut edges and slightly round the corners of each piece.

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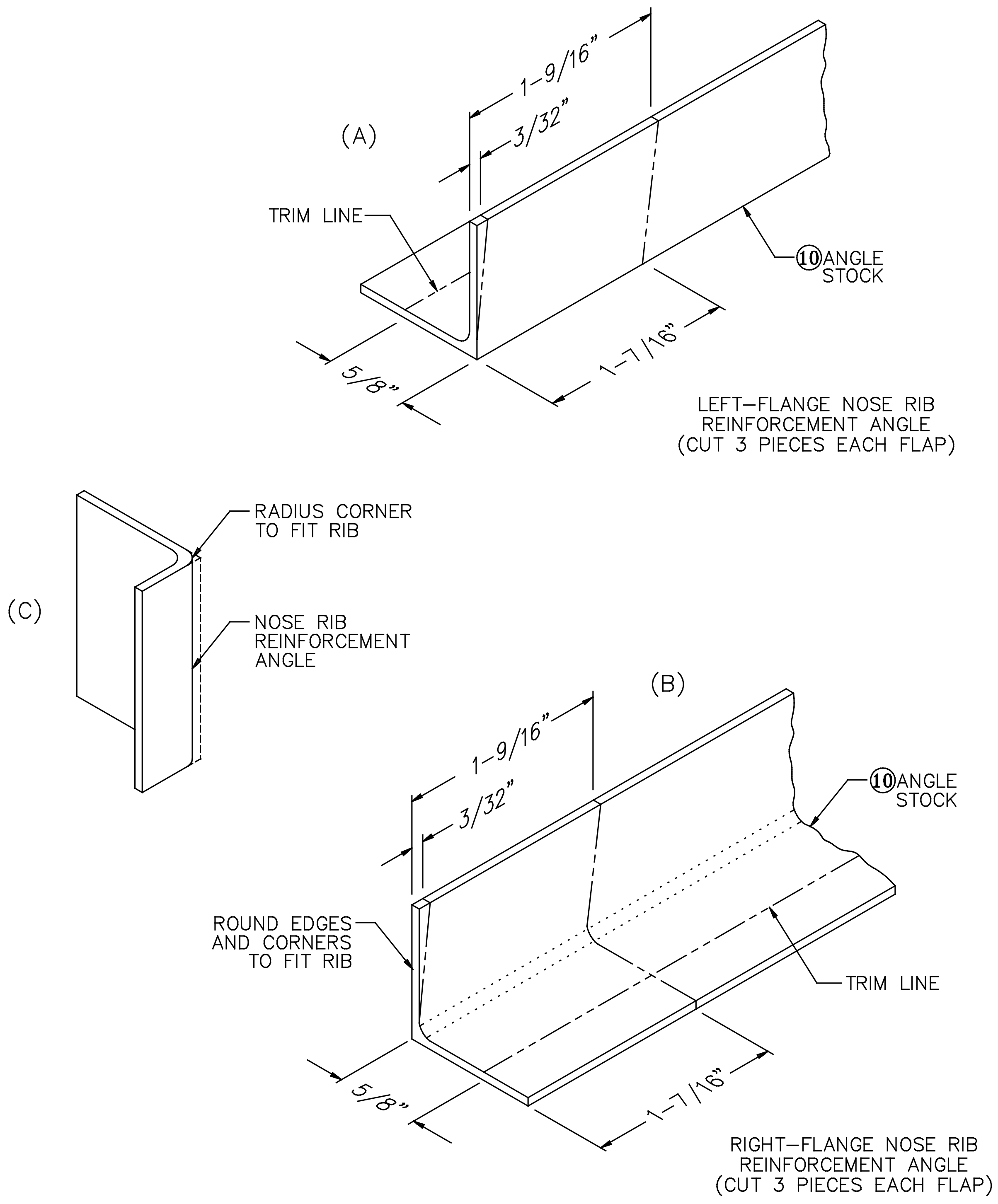

Figure 34: Cutting the Nose Rib Reinforcement Angles

Step 40: Cut the Skin Doublers

Two upper and two lower doublers are installed on the outside of the skin in the areas of Rib Pairs A and C (see Figure 31). These doublers strengthen the flap-track guide arms, which bear most of the flight loads on the flaps. These doublers must be cut to size and shape from the **.050" X 12" X 12" aluminum sheets** [9] supplied in the kit. A full-sized template for the doublers is given in Figure 35. Use a bandsaw or scroll saw to cut out **four doublers for each flap.**

> **Note** Some early kits may contain three **8" X 12"** sheets of .050" aluminum (P/N 075-01052-01) rather than two 12" X 12" sheets. All eight doublers **can** be cut from the three smaller sheets. On two of the sheets, lay out three each of the doublers by staggering their positions so that their edges nest together. The third sheet will have only two doublers cut from it.

> **Note** To do its job, each doubler must pick up **six** skin-to-nose rib rivet holes (three per nose rib), **four** skin-to-spar rivet holes and **six** skin-to-aft rib rivet holes (three per aft rib). Because the spacing of the pre-punched skin holes is slightly different at each doubler location, you may wish to custom-trim the doublers to make them fit better at each individual location. The template is big enough for all locations, but you'll find it's wider than necessary in some places and longer than necessary for all the lower-surface doublers. If you do trim the actual doublers smaller than the pattern, just be sure to leave an adequate edge margin of **3/16"** between the hole center and the doubler edge all the way around each one.

Smooth all the cut edges and radius all the inside and outside corners.

Completed: [ ]

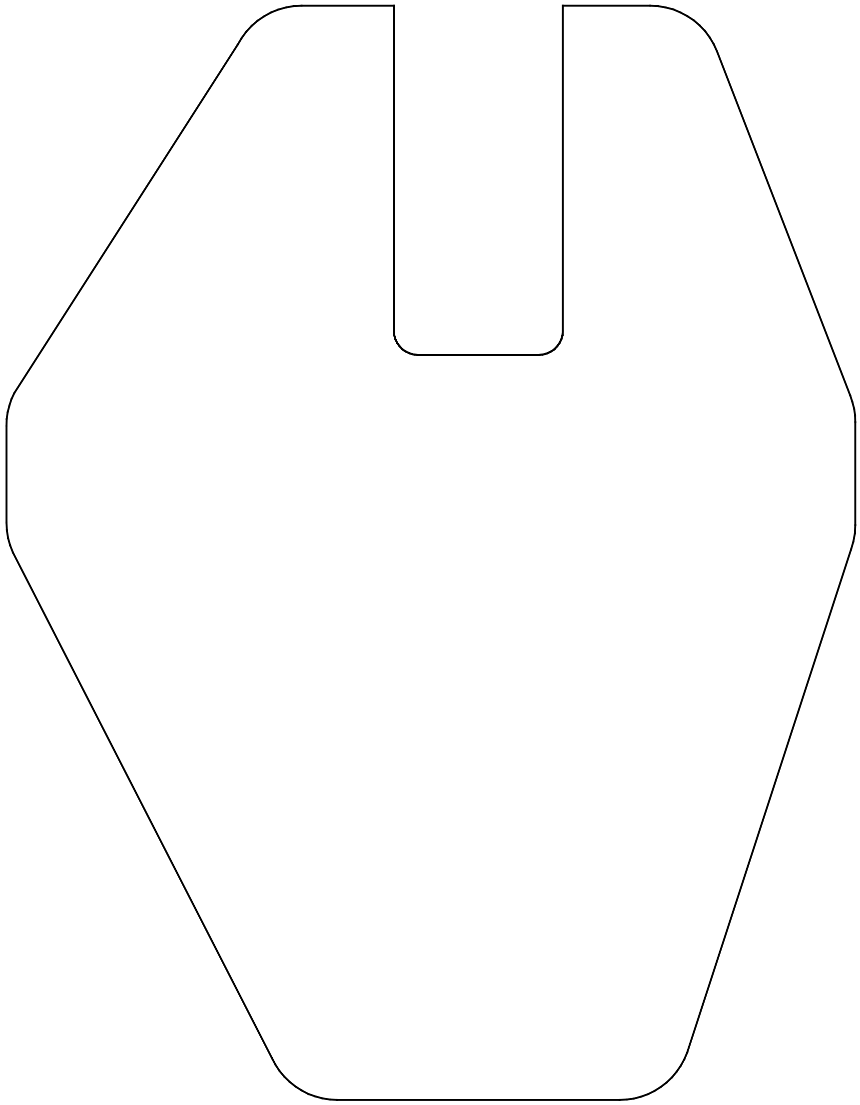

Figure 35: Template for the Flap-Track Skin Doublers (Full Size)

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FLAP-TRACK AND DEPLOYMENT ARM INSTALLATION

Step 41: Drill the Nose Rib Reinforcement Angles

The nose rib reinforcement angles must be drilled to match the hole patterns in the corresponding nose ribs so that they can be Clecoed together. Begin by choosing one left-flange and one right-flange nose rib and labeling them "Pair A." Choose a second and third pair and label them "Pair B" and "Pair C."

As shown in Figure 36, use a small C-clamp and Cleco side-grips to clamp an angle inside each of the six chosen nose ribs. Each angle should be clamped with its longer, 1"-wide flange tight against the rib web and its shorter, 5/8"-wide flange tight against the aft flange of the rib.

> **Note** Figure 36 shows an angle clamped inside a left-flange nose rib for illustration; the three right-flange ribs should be handled identically. The angles will only fit inside ribs of the same flange direction, so if you have trouble fitting one, simply switch it to an opposite-flanged rib.

With the angles clamped in place, use a **1/8"** bit to drill through each rib web and its reinforcement angle at the aft-most of the two 1/8" pre-punched rib web holes, as shown in the figure. After drilling, mark each angle so that it can be matched with its rib later.

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Left [ ]
Right [ ]

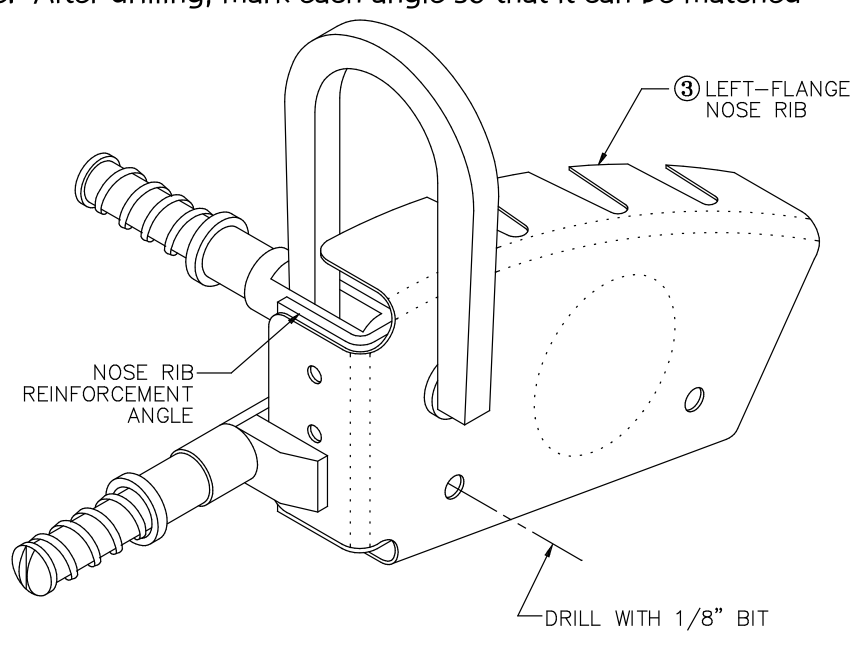

Figure 36: Drilling the Nose Rib Reinforcement Angles

Step 42: Drill the Flap-Track Nose Ribs

As shown in Figure 37, each flap-track guide arm is matched with a nose rib. At each flap track location, one arm is paired with a left-flange rib and one with a right-flange rib.

Note Figure 37 shows the flap-track nose ribs Clecoed to the spar. This will be done in a subsequent step. The figure is presented here solely to show the relationship of the flap-track guide arms to their respective nose ribs.

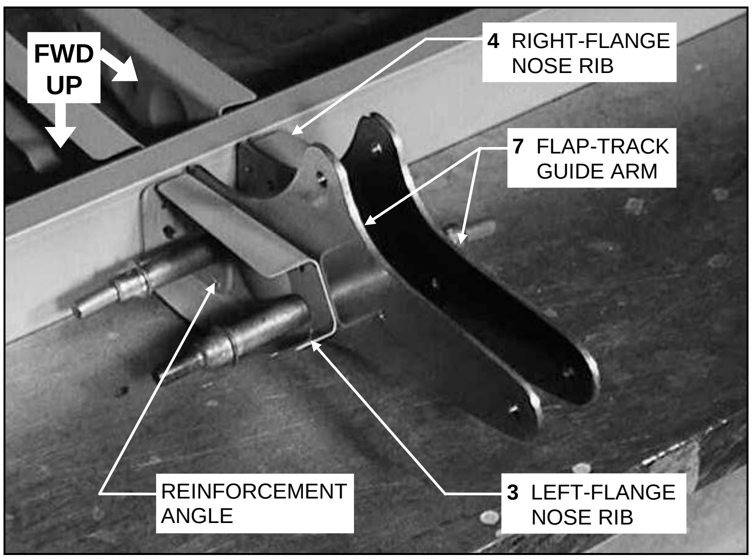

Figure 37: Flap-Track Guide Arms

Begin with Pair A. Using the two 1/8" holes near the bottom of the ribs, Cleco a flap-track guide arm and a reinforcement angle to the web of each rib. As Figures 37 and 38 show, the arms should extend forward and downward from the ribs.

Drill through the rib web, arm and angle at each of the six un-Clecoed pilot holes in the arm with a **#30** bit, as shown in Figure 38a.

After drilling, insert Clecos in two of the newly drilled holes, remove the original Clecos, and ream the two 1/8" holes up to final size with a **#30** bit. Mark each arm and its rib so they can be matched up again later.

Note Figure 38 shows the drilling of a right-flange nose rib for illustration; the two left-flange ribs are handled identically.

Repeat the process with two more guide arms and the ribs of Pair C. When all the holes have been drilled, remove the guide arms. Countersink all eight of the #30 holes in each arm on the side of the arm **opposite** the rib, as shown in Figure 38b. Set your microstop to accommodate 1/8" AN426AD4 flush-head rivets.

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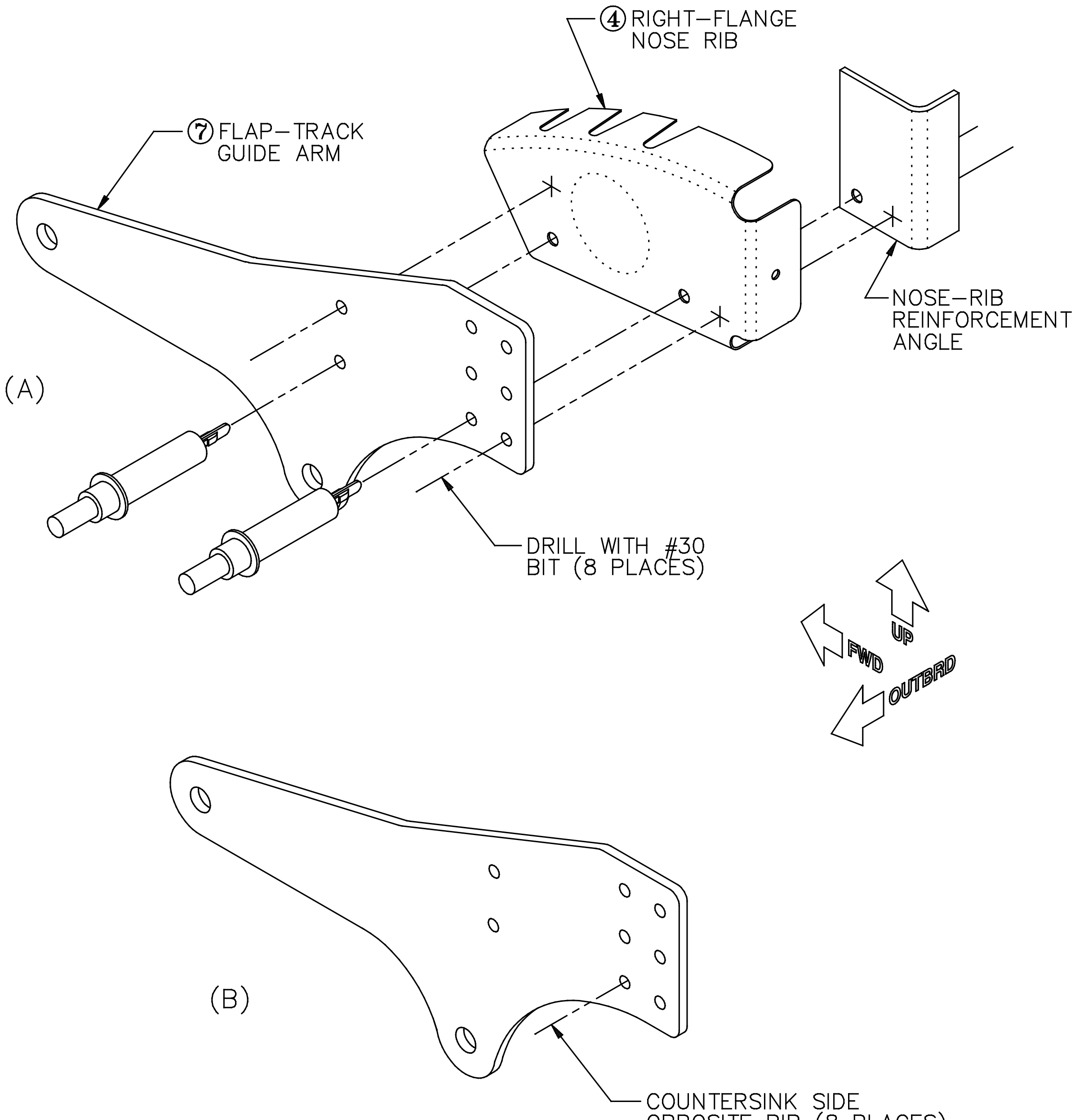

Figure 38: Drilling the Flap-Track Nose Ribs

Step 43: Drill the Deployment Arm Nose Ribs

Figure 39 shows that the deployment arms are paired with alternate-flanged nose ribs (Pair B) just like the flap-track guide arms.

> **Note** Like Figure 37, Figure 39 is presented here solely to show the relationships among the parts.

Using the two 1/8" holes near the bottom of the ribs, Cleco a deployment arm to the web of each rib and to a reinforcement angle. The arms should extend forward and upward from the ribs, as shown in the Figures 39 and 40.

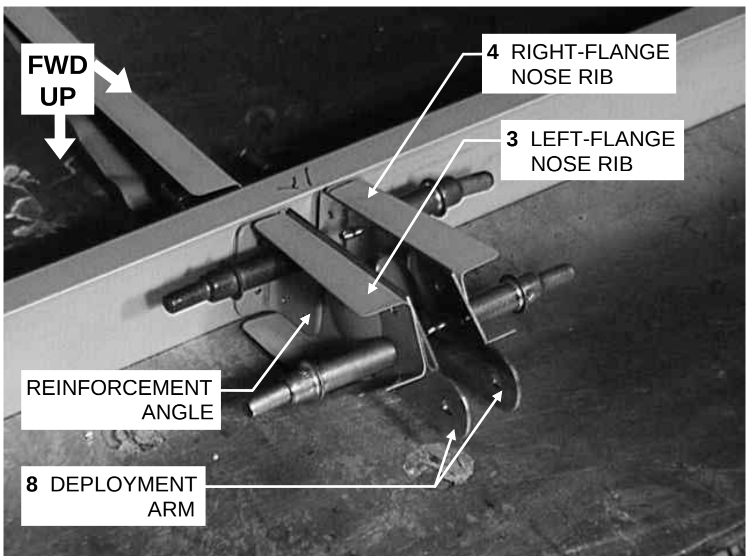

Figure 39: Deployment Arms

With the arms Clecoed to the ribs, drill through the rib web, arm and angle at each of the six un-Clecoed pilot holes in the arm with a **#30** bit, as shown in Figure 40a.

After these holes have been drilled, insert a pair of Clecos in two of the newly drilled holes, remove the original Clecos, and ream the two 1/8" holes up to final size with a **#30** bit, as shown in Figure 40b. Mark each arm and its rib so that they can be matched again later.

> **Note** Figure 40 shows the drilling of a right-flange nose rib for illustration; the two left-flange ribs are handled identically.

When all the holes have been drilled, remove the deployment arms and deburr all the holes. None of the holes in the deployment arms requires countersinking.

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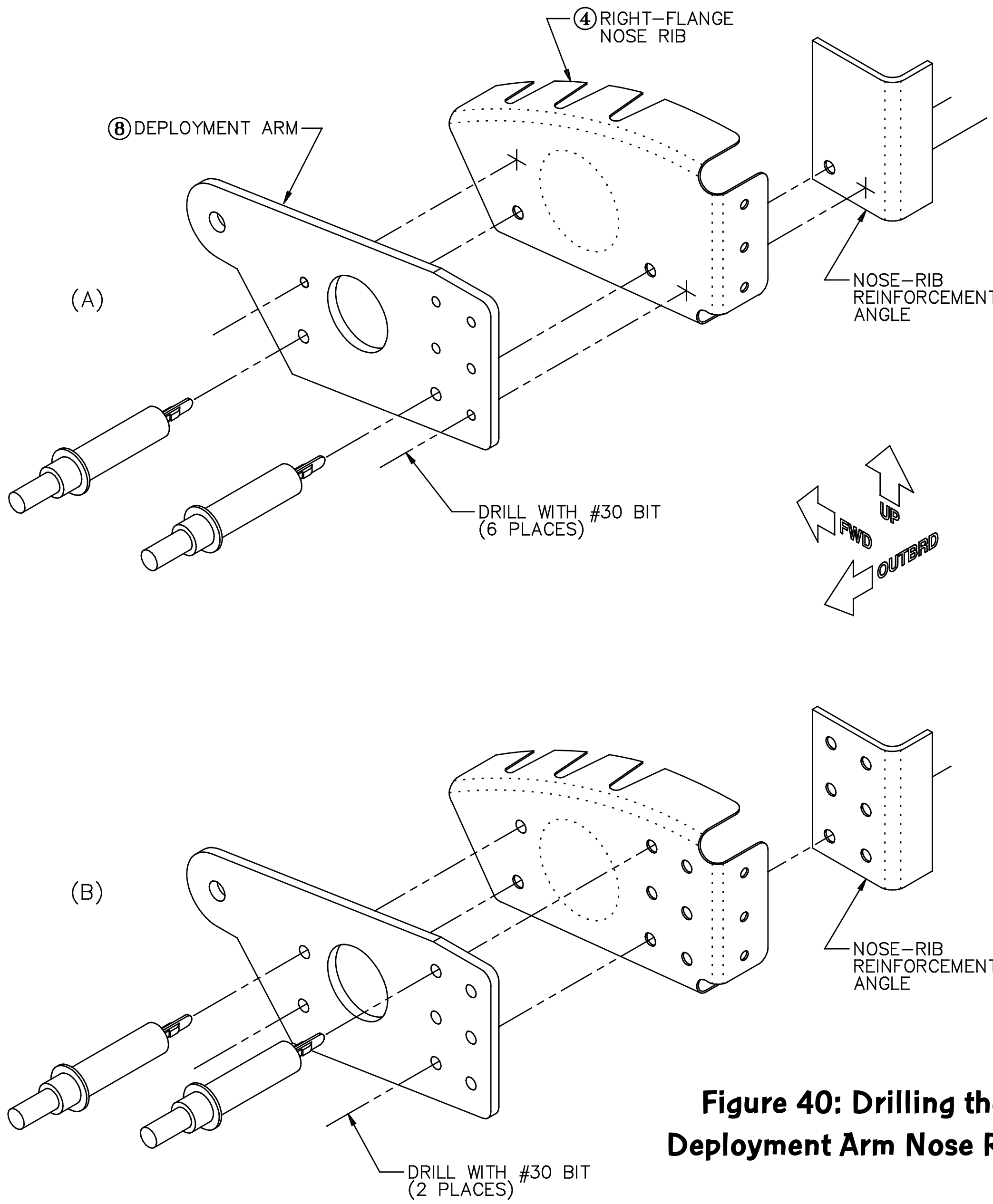

Figure 40: Drilling the Deployment Arm Nose Ribs

Step 44: Corrosion-Proof the Flap-Track and Deployment Arm Parts

Apply the anti-corrosion protection of your choice to the flap-track and deployment arms and their respective nose ribs and reinforcement angles.

Completed: Left [ ] Right [ ]

Step 45: Rivet the Reinforcement Angles and Flap-Track Guide Arms to the Ribs of Pairs A and C

Clamp the nose rib reinforcement angles and the flap-track guide arms to the ribs of Pairs A and C with three Clecos, as shown in Figure 41. Use 1/8" AN426AD4 flush-head rivets to rivet the angles and arms to the nose ribs through the five un-Clecoed holes. Then remove the Clecos and rivet the remaining three holes. Pay careful attention to the marks you made earlier to ensure that each angle and arm gets reunited with its proper rib.

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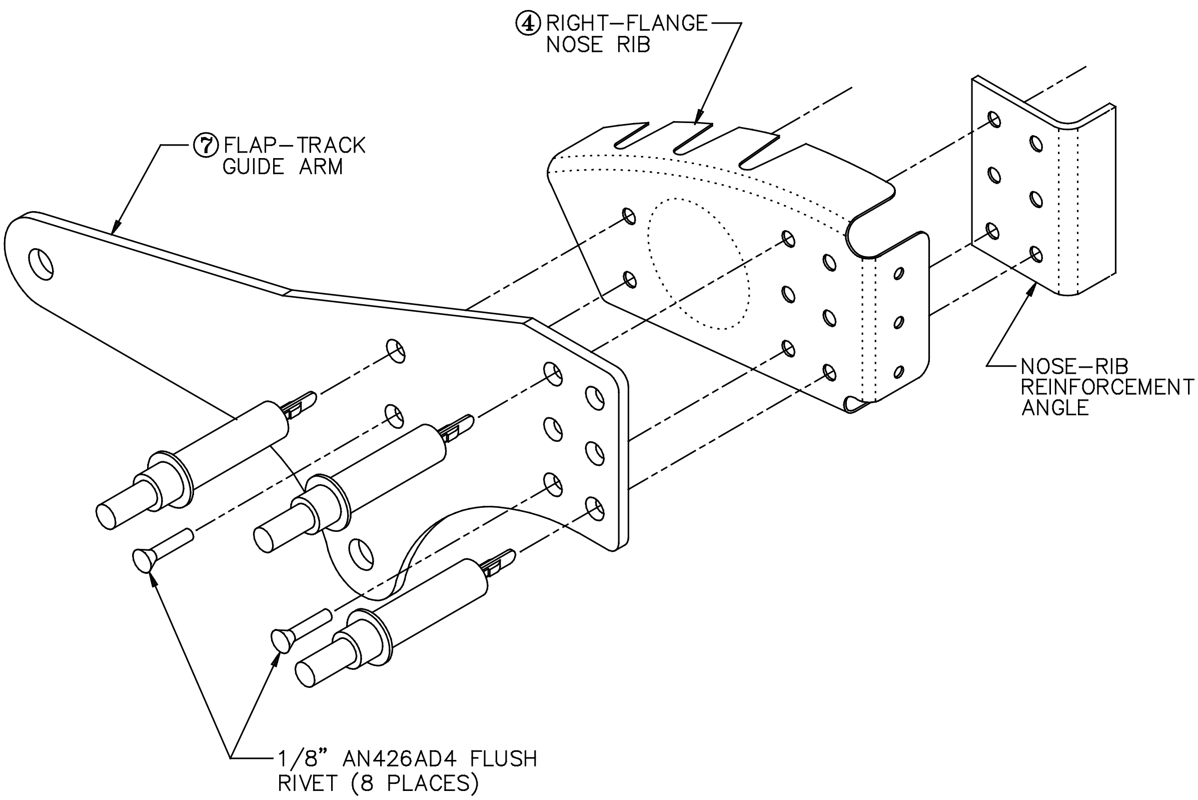

Figure 41: Riveting the Reinforcement Angles and Flap-Track Guide Arms to Rib Pairs A and C

Step 46: Rivet the Reinforcement Angles and Deployment Arms to the Ribs of Pair B

Clamp the remaining two nose rib reinforcement angles and the deployment arms to the ribs of Pair B. Then rivet the angles and arms to the nose ribs using 1/8" AN470AD4 universal-head rivets. Pay careful attention to the marks you made earlier to ensure that each angle and arm gets reunited with its proper rib. As shown in Figure 42, the manufactured heads of all rivets should be on the rib side.

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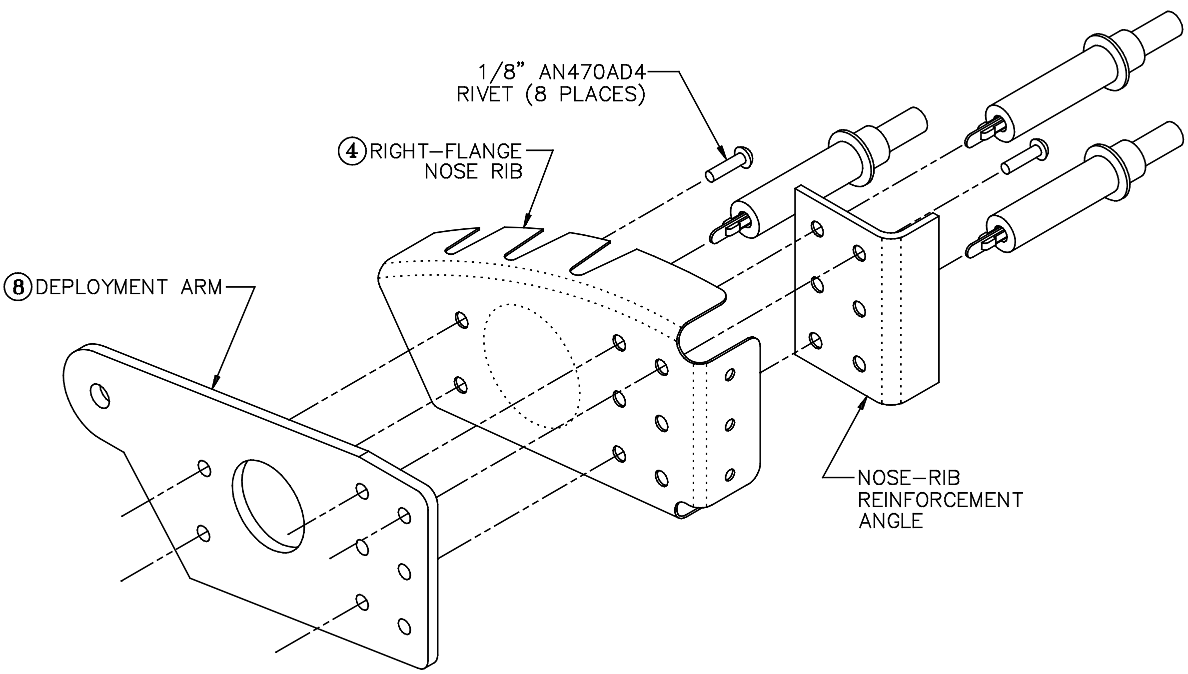
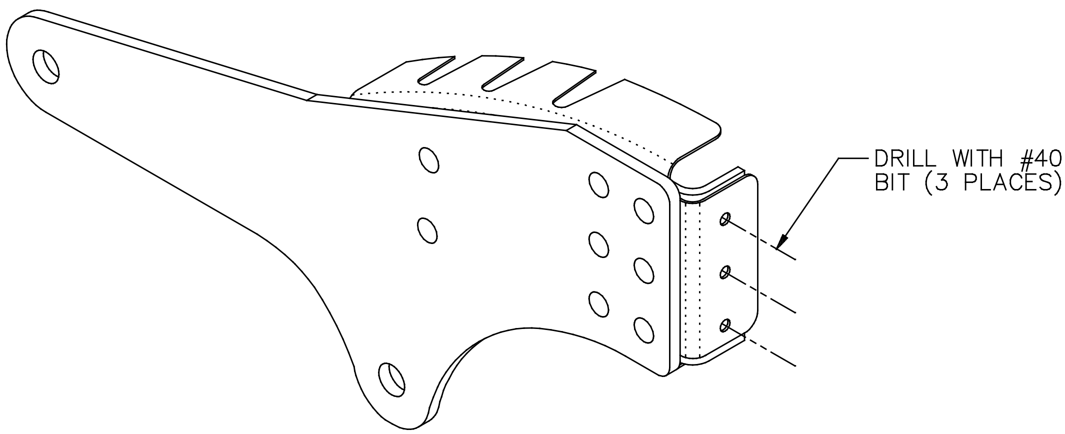


Figure 42: Riveting the Reinforcement Angles and Deployment Arms to Rib Pair B

Step 47: Drill the Rib/Spar Rivet Holes in the Reinforcement Angles

With the flap-track and deployment arms riveted to their respective nose ribs and reinforcement angles, you can now use the holes in the aft flange of each nose rib as guides to drill through the aft flanges of the reinforcement angles, as shown in Figure 43. Use a **#40** bit, and deburr all the holes after drilling. Also, use a chip chaser to ensure that no shavings are trapped between the reinforcement angles and the aft rib flanges.

Completed: Left [ ] Right [ ]



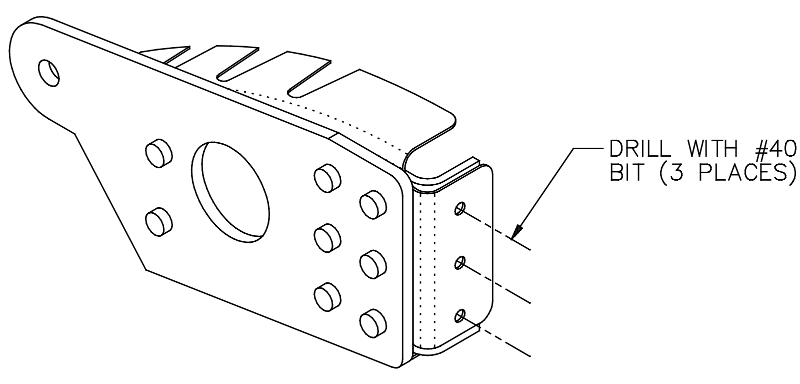


Figure 43: Drilling the Rib/Spar Rivet Holes in the Reinforcement Angles

SKIN POSITIONING AND DRILLING

Step 48: Cleco the Ribs to the Spar and Drill All the Rib/Spar Rivet Holes to Final Size

Cleco all the nose and aft ribs to the spar. Use two Clecos for each pair of ribs. In addition to referring back to Figure 31 to ensure that you orient the flanges properly, be sure also that you position the ribs of Pairs A, B and C together with their mates and at their proper stations.

Note In early GlaStar kits that contain 13 left- and 13 right-flange aft ribs, the **right-hand flap** will **not** be completely identical to the left-hand one. You must substitute a left-flange aft rib for one of the right-flange aft ribs shown in Figure 31. You may make the substitution at **either** of the two rib stations **between Rib Pairs B and C**, **or** at the rib station **immediately to the right of Rib Pair C**. Refer to Figure 31 to identify these locations.

Once all the ribs are in place, juggle the Clecos as necessary to drill all the rib/spar rivet holes up to **#40** size **with the following exceptions**: all the ribs of Pairs A, B and C (as well as their reinforcement angles) should be drilled with a **#30** bit. Label each rib so that it can be returned to its original position on the spar after disassembly. When finished, leave all the ribs attached to the spar with two Clecos each.

Completed: Left [ ] Right [ ]

Step 49: Clamp the Spar/Rib Assembly to the Bench and Position the Skin

Using the same 2" X 2" clamping angles you used in constructing the ailerons, clamp the spar/rib assembly **upside down** to the bench at one end. As shown in Figure 44, the nose ribs should hang over the edge of the bench. Move the second clamping angle to the other end of the spar, secure it to the bench and clamp that end of the assembly .

Because of the camber of the flap, the aft ribs will not be flat on the bench when the spar is clamped down. To support the ribs as the skin is being drilled, slide a spanwise 10'-long 1 X 4 behind the ribs, as shown in Figure 44.

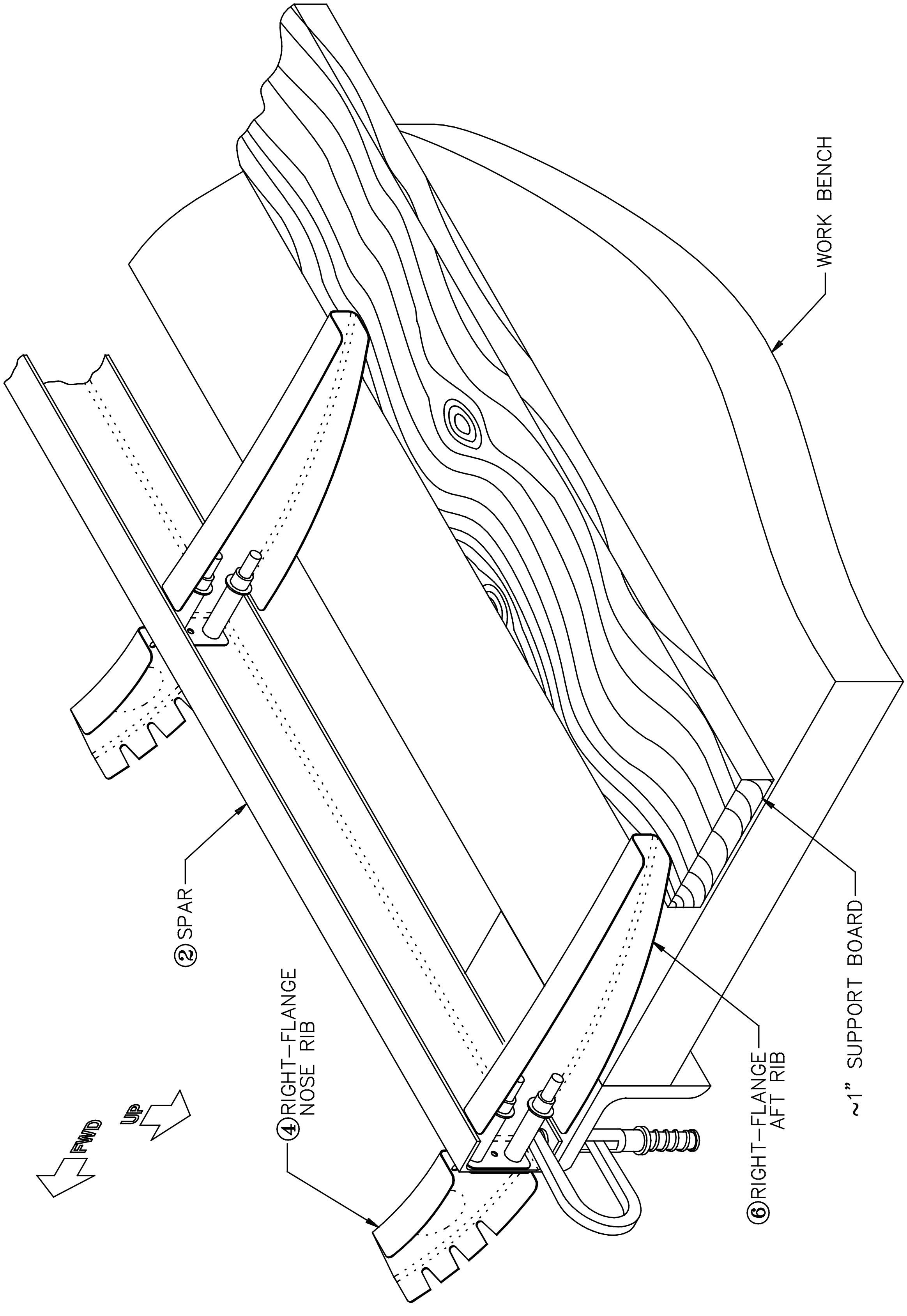


Figure 44: Clamping the Spar/Rib Assembly to the Bench

With the spar/rib assembly clamped upside-down to the bench top, open the **skin** [1] and slide it over the assembly. The flap-track and deployment arms will protrude through their respective slots in the skin. As shown in Figure 45, the upper surface of the skin will hang down toward the floor.

> **Note** You shouldn't have any trouble distinguishing the upper from the lower surface of the skin, because the skin will only fit over the deployment arms if it is right-side up relative to the spar/rib assembly.

Align the inboard and outboard edges of the skin on the ends of the spar. Then pull the skin back and push it down (up, relative to the aircraft) into the cusped underside of the flap until the rivet line on the lower spar flange is centered under the pre-punched rivet holes in the skin. When the skin is positioned properly, clamp it to the spar flange at each end with a side-grip clamp, as shown in the figure.

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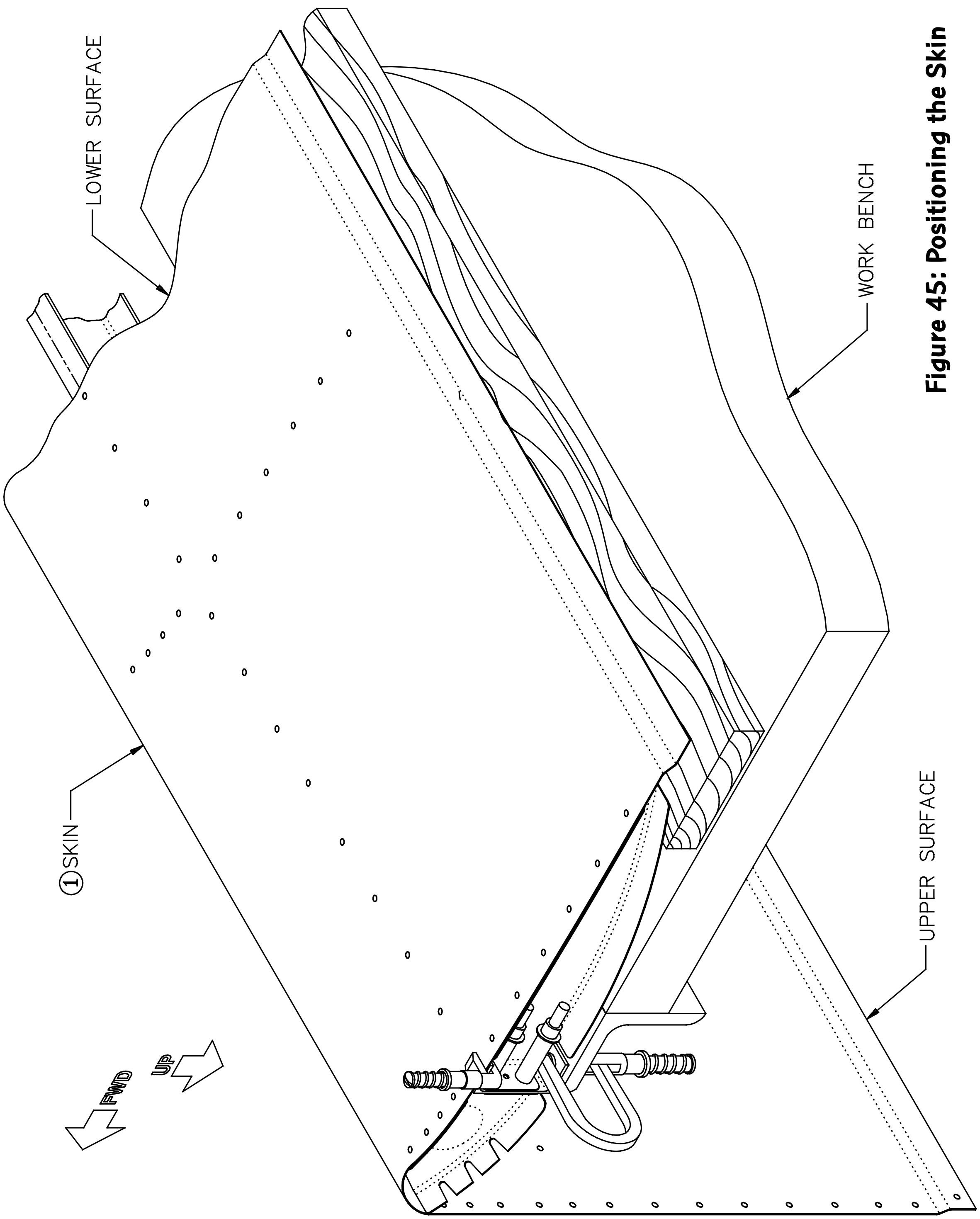

Figure 45: Positioning the Skin

Step 50: Bolt Spacers Between the Flap-Track and Deployment Arms

Because the flaps ultimately will travel in their tracks on bolts between the flap-track guide arms, it's very important to maintain the alignment of these arms while drilling and riveting the flap. The alignment of the deployment arms is slightly less critical, but it's still worthwhile to take some care in keeping them properly positioned.

The way to maintain the alignment is to bolt temporary spacers between each pair of arms, as shown in Figure 46. The spacers can be made of any metal or hard wood or plastic. Their dimensions are not critical, except for their thicknesses; to hold the arms the proper distance apart, the flap-track guide arm spacers must be **5/8"** thick, and the deployment arm spacer must be **1/2"** thick.

Drill **#10** holes through each of the spacers and bolt them in place between the arms with an AN3 or equivalent bolt of the proper length, a washer and a nut. Hardware-store quality fasteners are fine for this application.

Hint For the spacers to do their job, it's very important that the holes through them be drilled **perpendicular** to the surface. Use a drill press for this if you have one.

Note You may find that interference between the skin and the arms results when you try to insert the spacers between the arms. If so, use a fine-toothed file to enlarge the skin slots as necessary to get a clean fit. However, be sure to leave smoothly radiused corners.

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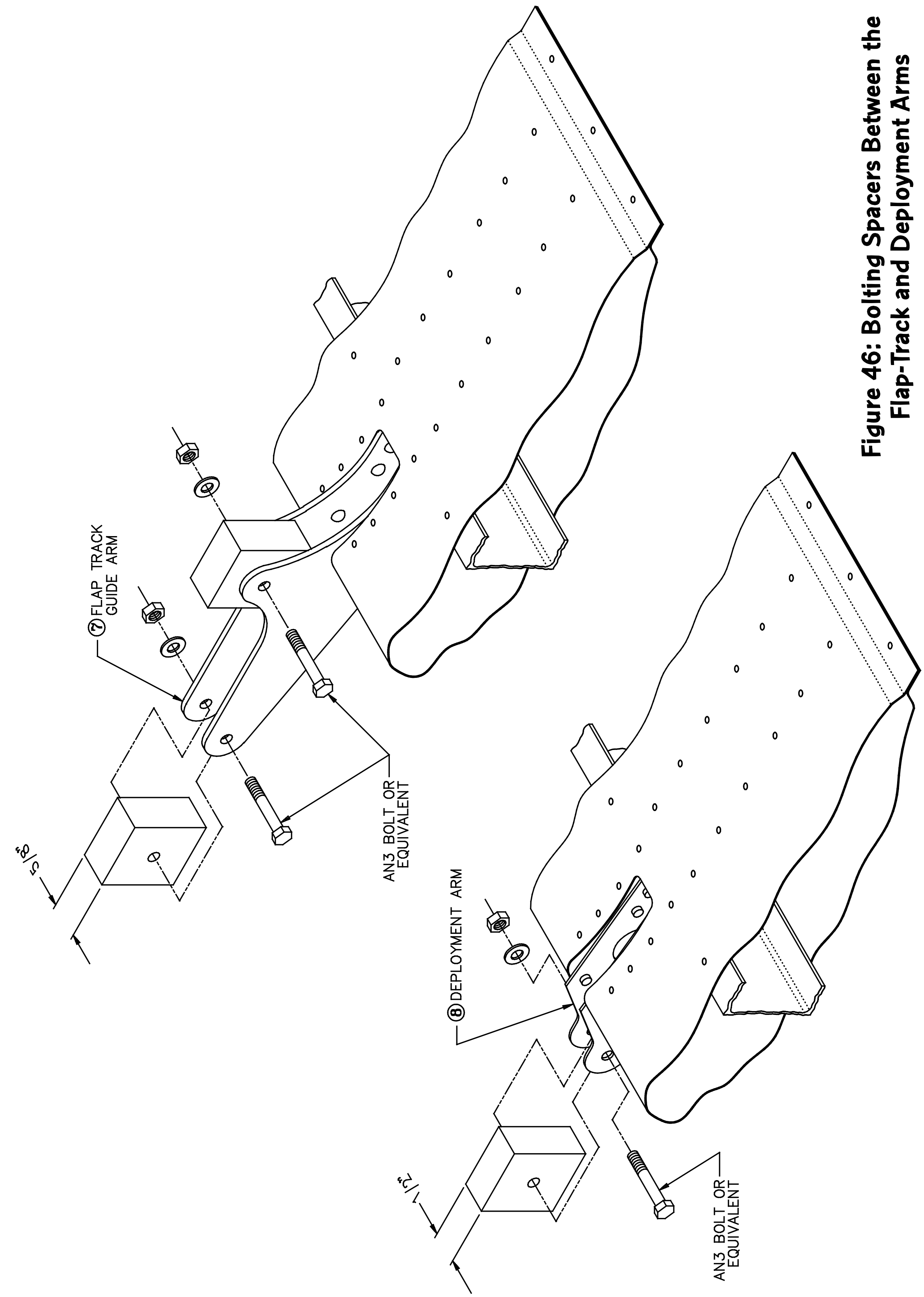

Figure 46: Bolting Spacers Between the Flap-Track and Deployment Arms

Step 51: Drill the Lower Surface of the Skin

With the skin clamped in place on the spar/rib assembly and the flap-track and deployment arms properly spaced, drill as follows:

A) Drill several **#40** holes along the spar flange, checking before drilling each time that the marked rivet line is centered under the pre-punched pilot holes. If the spar is bowed at all, you may need to reach under the assembly and adjust it manually to bring it back into alignment with the row of pre-punched skin holes. Cleco each of these holes after it is drilled. Then remove the side-grips at the ends of the spar and drill (**#40**) and Cleco all the remaining holes along the lower spar flange.

B) Bring the aft ribs into alignment by centering the lines you marked on their flanges under the pre-punched skin holes. Lift the trailing edge of the skin slightly to reach underneath to move the ribs left or right as necessary. When the rivet lines are centered, start drilling at the spar and move aft, Clecoing every hole as you go. Use a **#40** bit for all the holes, **with the exception** of the **aftmost** hole in each rib; this hole should be drilled with a **#30** bit. (These aftmost holes are drilled as #30s to take 1/8" blind rivets, which are used because the small distance between the rib flanges at that location makes it difficult to use a bucking bar there.)

C) Align the nose ribs and drill all those holes with a **#30** bit, **with the following exception**: drill all the holes in the **outermost** nose rib at each end of the flap with a **#40** bit. (These holes are accessible for a rivet squeezer or bucking bar, and thus take 3/32" hard rivets.) Again, start at the spar and work forward, Clecoing every hole.

Figure 47 illustrates these drilling instructions.

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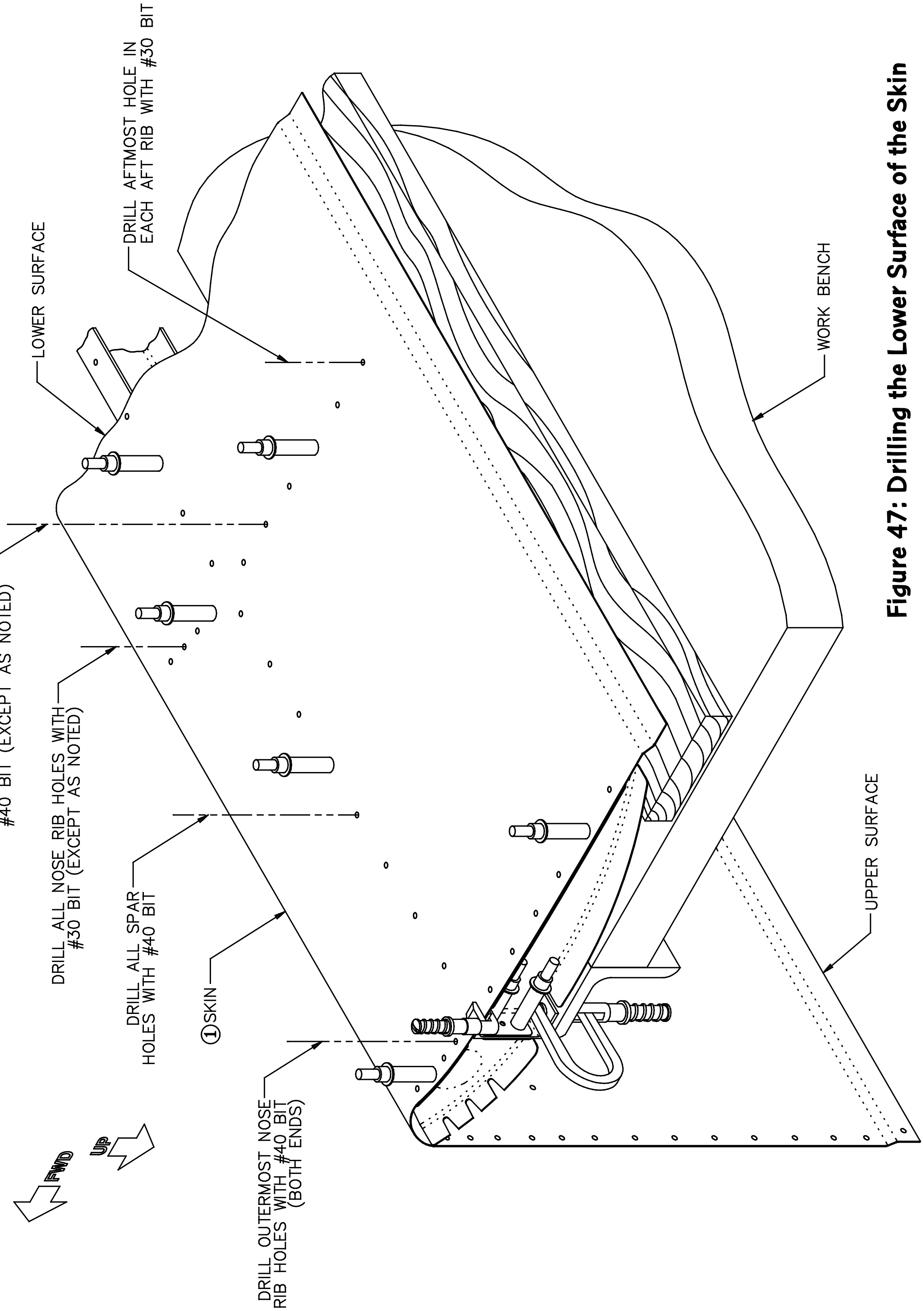

Figure 47: Drilling the Lower Surface of the Skin

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Step 52: Position and Drill the Upper Surface of the Skin

Unclamp the spar/rib assembly from the bench and set it right-side up on a pair of 10'-long 1 X 4 supports, as shown in Figure 48. These strips help prevent the introduction of twist into the flap while drilling the upper surface of the skin.

> **Hint** You may want to tack-glue or screw the support strips to your bench top so they don't tip over when you put pressure on the flap during drilling.

Pull the upper surface of the skin back against the ribs, and use side-grips or rubber-padded spring clamps along the trailing edge to clamp the upper surface to the lower along the entire length of the flap. Also, use a pair of side-grips to clamp the skin at each end of the spar. Ideally, the spar and rib rivet lines will be centered under the pre-punched skin holes, and the upper and lower trailing edge joggles will be aligned flushly with one another. **More important**, however, is **(A)** that you **retain adequate edge margin** between the spar holes and the forward and aft edges of the upper spar flange, and **(B)** that **the skin be kept tight against the ribs and spar**. This may require you to tolerate some misalignment at the trailing edge for now; if necessary, the trailing edge can be trued with a body file after riveting.

> **Hint** We strongly recommended a helper or two for folding the upper surface of the skin back against the spar/rib assembly. Because the flap is so long, it's very difficult for a single pair of hands to accomplish this task without kinking the skin. Initially, it may seem that the skin simply isn't going to fit, but be patient; once you Cleco a few spar holes, it will fall into place.

> **Note** When the skin is pulled back tightly against the spar/rib assembly, the forward ends of the nose ribs may dimple the skin slightly, interrupting the curvature of the flap airfoil. This is mostly a cosmetic problem, although it also does introduce a high-stress point into the skin. For both these reasons, you should eliminate such dimpling either by pulling the skin back less tightly (if doing so will not violate the conditions in A and B above) or by **very slightly** rounding the forward ends of the nose rib flanges where the dimple appears.

Caution If you have first-run, -01 flap skins with pre-punched holes along the entire trailing edge, you will need to pay a bit more attention to the alignment of the trailing edges. Specifically, it's imperative that the pre-punched holes fall near enough to the center of the lower-surface joggle to provide adequate edge margin for the rivets. If the **edges** of the holes fall closer than **3/32"** to the bend radius or, especially, to the trailing edge of the joggle, then the trailing edges must be realigned to move the holes closer to the center.

When you are satisfied that the skin is flat against the rib and spar flanges, weight the flap with three or four sand or shot bags placed over ribs. These will hold the flap tightly against the support strips under the flap and, assuming these are flat, will remove any twist. Readjust the trailing edge clamps if necessary to true up the flap. With the skin in final position, drill as follows (see Figure 48):

A) Drill (**#40**) and Cleco all the holes along the spar flange. Use the standard procedure of drilling and Clecoing first the two holes at each end, then several intervening holes, and finally the remaining holes.

Note As on the ailerons, some of the pre-punched skin holes along the spar may lie almost directly above a rib web, making bucking impractical. Check as you go and drill suspect holes up to **#30** size for later installation of blind rivets. Use a drill stop set at **3/16"** to avoid damaging the rib webs.

B) Begin at the spar and move aft along the aft ribs and forward along the nose ribs, drilling through all the pre-punched pilot holes with a **#40** bit. Cleco as you go. After all the drilling is complete, remove the Clecos one at a time and drill all the rib holes you just drilled up to **#30** size, **with the following exception**: the holes in the **outermost** ribs at both ends of the flap (both nose and aft) should remain #40s. Insert 1/8" Clecos in the #30 holes as you go. (The reason for drilling these holes in stages is to prevent the larger #30 bit from bending the thin rib flanges.)

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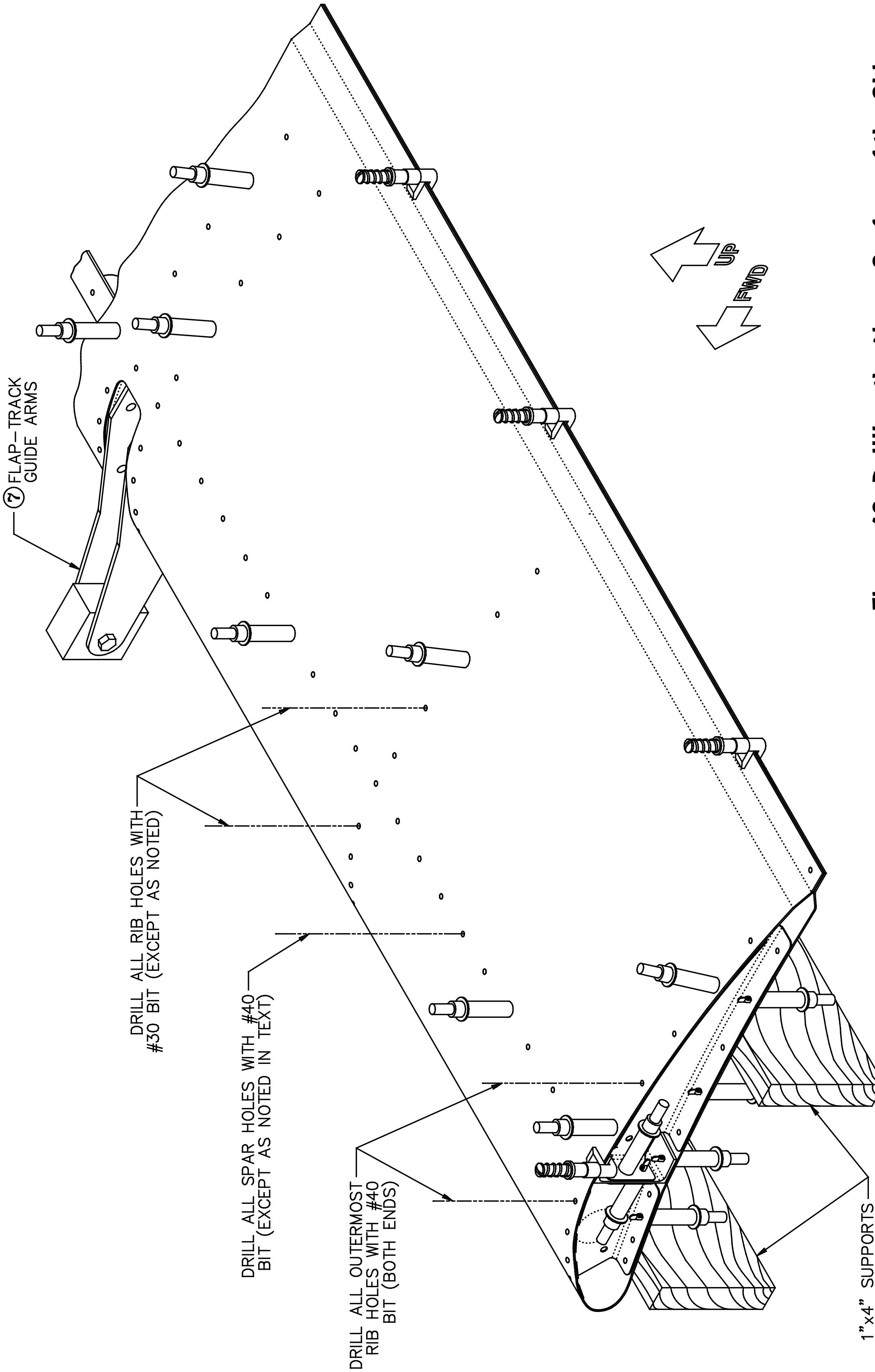

Figure 48: Drilling the Upper Surface of the Skin

Step 53: Drill the Trailing Edge Joggles

Because the aft ribs end more than an inch forward of the trailing edge joggle, the trailing edge can easily be bent up or down until it's drilled and Clecoed. It's extremely important that the flap's cusped airfoil shape be maintained all the way to the trailing edge, even when you put pressure on the trailing edge joggle while drilling. For this reason, you need to provide further support to the flap before drilling the trailing edge.

As shown in Figure 49, position a third 10'-long 1 X 4 under the trailing edge joggle. If necessary, use a hand plane or sanding block to bevel the upper edge of the board slightly to match the angle of the joggle. You may also need to place shims under the middle 1 X 4 to raise it up slightly (or, alternatively, use a table saw to rip the forward and aft 1 X 4s to a narrower width) so that the flap remains supported across its entire chord.

Note If you have first-run, -01 skins, disregard the next two paragraphs and proceed straight to drilling.

Next, lay out a line of rivet hole locations along the entire length of the joggle. Space the locations on **1-1/2"** centers, starting at one of the pre-punched end holes. Locate the holes fore-and-aft so that they fall roughly in the middle of both the upper and lower joggles, leaving adequate edge margin on both surfaces.

Caution Do **not** trust the pre-punched end holes as guides to the fore-and-aft positioning of the rivet line. Instead, carefully observe proper edge margin requirements top and bottom: the rivet line should be **clear** of the bend radius and **3/16" forward** of the trailing edge of **both** the upper- and lower-surface joggles.

With your rivet hole locations established, drill through both the upper and lower joggles (and directly into the 1 X 4 support board) at each location with a **#40** bit, as shown in Figure 49. As usual, drill the two end holes first, then several intervening holes and finally the remaining holes. Cleco every hole as you go; the board will not prevent the Clecos from clamping the joggles together.

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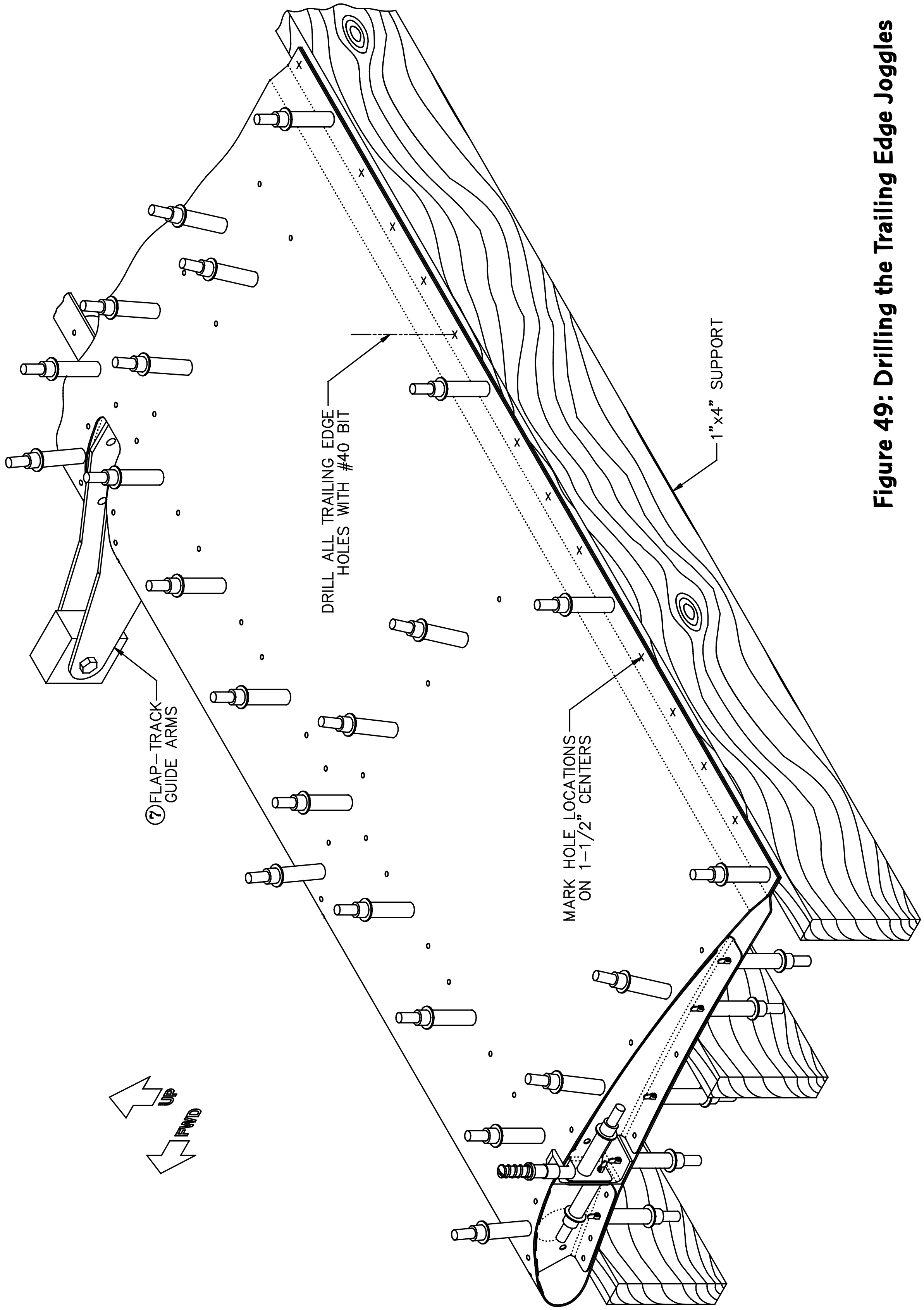

Figure 49: Drilling the Trailing Edge Joggles

Step 54: Form the Upper Skin Doublers

Figure 50 shows how the upper and lower skin doublers will be positioned on the flap around Rib Pairs A and C. Obviously, the curvature of the flap demands that these flat doublers be bent to conform with the surface. For the lower doublers, this bend is so slight that it can be imposed during the riveting process, but it's necessary to pre-bend the upper doublers to match the flap contour.

You will basically use a trial-and-error process to fit the upper doublers, with the Clecoed flap serving as a template against which to check your progress. The first step, therefore, is to remove the Clecos from the areas where the doublers will be located. As Figure 50 shows, this means the four spar holes nearest to the ribs of Pairs A and C, as well as three holes on each nose and aft rib of these pairs.

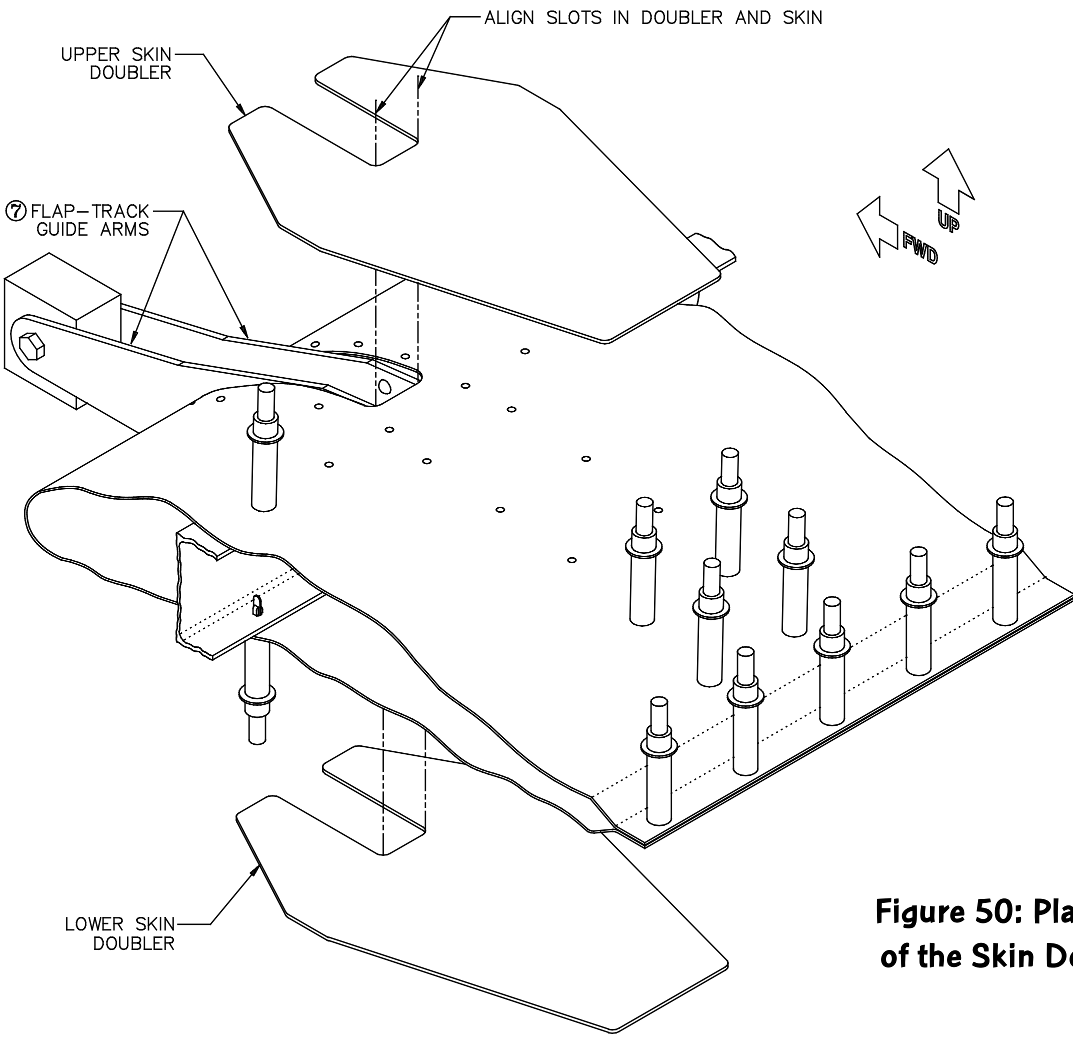

Figure 50: Placement of the Skin Doublers

The technique for forming the doubler is illustrated in Figure 51. Use a short length of steel pipe 2–3" in diameter as a form block and hammer the doubler to the desired shape using a lead body hammer or rubber mallet. Strike with the hammer just forward of the line of contact between the doubler and the pipe, and hammer back and forth across the width of the material. Move the doubler forward and back, changing the contact point between the doubler and the pipe, to get the desired bend radius. Check this frequently by positioning the doubler on the flap, aligning the slots in the two parts, as shown in Figure 50.

Note If cut according to the template in Figure 35, the doublers will **not** be laterally symmetrical. Therefore, before you begin forming a doubler, make sure you have it oriented properly to pick up the required number of spar rivets **at the particular location you intend it for**.

When you're satisfied with the fit of the doublers, mark them so you know which one goes with Rib Pair A and which with Rib Pair C.

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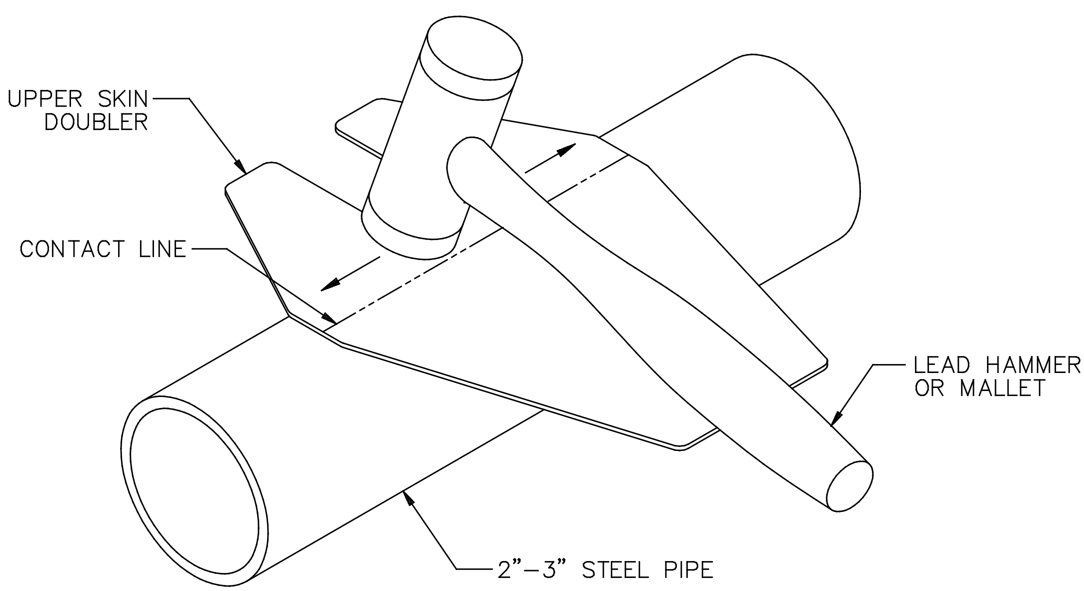

Figure 51: Forming the Upper Skin Doubler

Step 55: Drill the Skin Doublers

Figure 52 illustrates the procedure for drilling the doublers to match the rivet hole patterns in the skin. The figure shows the drilling of an upper doubler, but the procedures are identical for the lower ones, and the doublers can be drilled in any order.

Begin by removing all the Clecos from the flap, unbolting the spacers from between the flap-track and deployment arms, and removing the skin from the spar/rib assembly. Use a side-grip clamp as shown to position a skin doubler on the outside of the skin, aligning the slots in both parts. Then, with a **#30** bit, drill through the skin and doubler **from the inside**, using one of the spar rivet holes in the skin as a guide. Cleco this hole after drilling. In a similar fashion, drill and Cleco the remaining three spar holes, and then remove the side-grip clamp.

Hint The skin should open relatively easily to give you access for this drilling, but nevertheless a 90° drill motor will make the job easier.

Once all four spar holes are drilled and Clecoed, drill all the nose and aft rib holes, again using a **#30** bit. Cleco each one as you go.

Note All the rivets through the doublers are 1/8", so use a #30 bit for all the holes, regardless of whether the skin hole you're using as a pilot hole was originally drilled with a #30 or a #40. The underlying spar and rib holes will be reamed up to #30 size as necessary in the next step.

After all four doublers have been drilled, install a **120°** cutter in your microstop countersink cage and set it up for **1/8" flush-head blind rivets** [11]. Countersink all the holes on the **outside** face of the **upper** skin doublers **only**.

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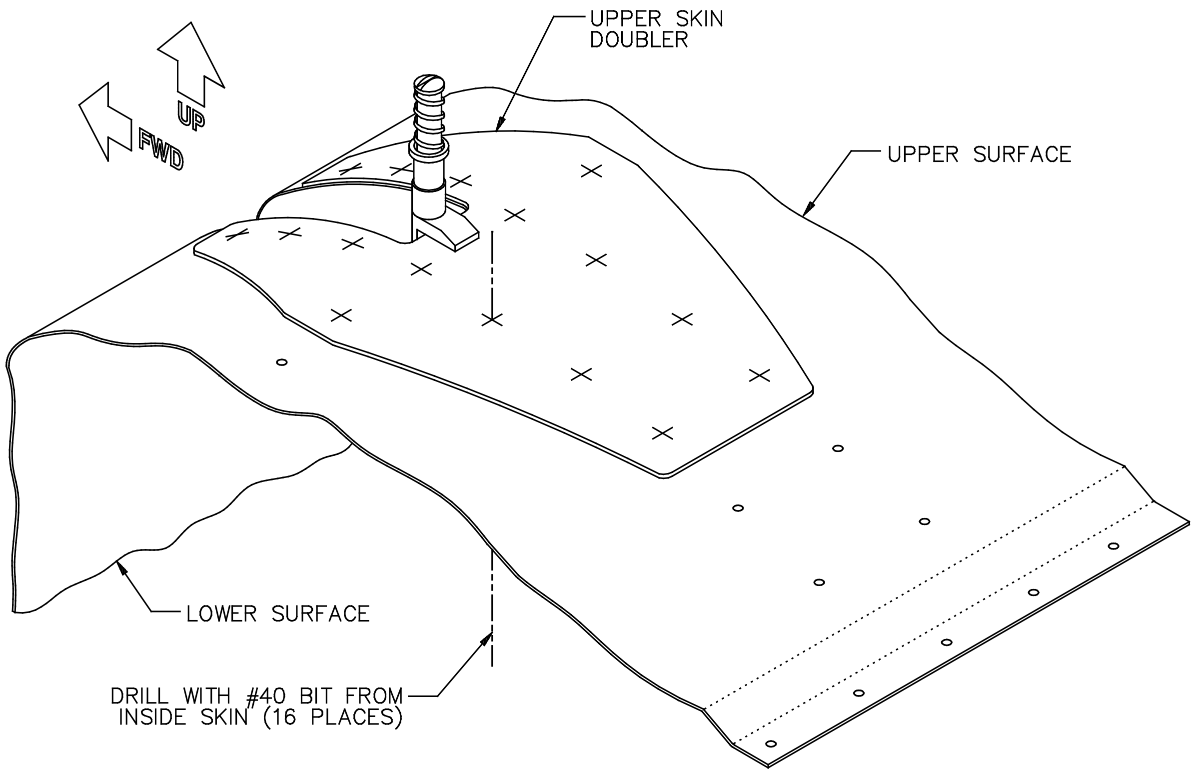

Figure 52: Drilling the Skin Doublers

Step 56: Drill the Spar/Rib Holes in the Doubler Areas Up to Final Size

Re-Cleco the skin to the spar/rib assembly and ream all the doubler holes to final size with a **#30** bit. Disassemble the flap completely when you're finished drilling.

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Step 57: Deburr and Corrosion-Proof the Flap

Thoroughly deburr, clean, prep and prime the flap components as you deem necessary, touching up the ribs of Pairs A, B and C where you drilled through the previously applied anti-corrosion protection. At a minimum, you should give the skins, ribs, spar, doublers and other parts a thorough cleaning and alodine treatment.

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MAIN STRUCTURE RIVETING

Step 58: Rivet the Ribs to the Spar

Rivet all the nose and aft ribs to the spar with universal-head rivets. Use 1/8" AN470AD4s on all the ribs of Pairs A, B and C; on all other ribs, use 3/32" AN470AD3s. As shown in Figure 53, the manufactured heads should be aft.

Note Be aware that you will need to use longer rivets on those nose ribs that have reinforcement angles riveted to them.

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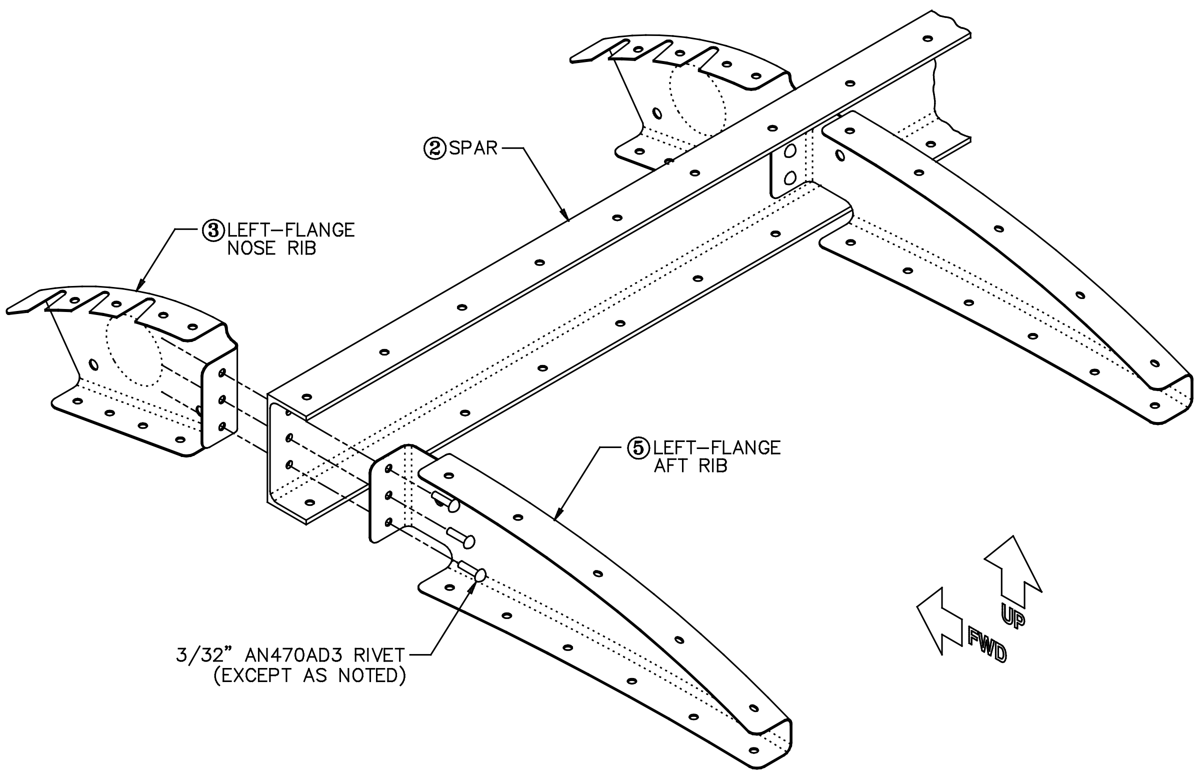

Figure 53: Riveting the Ribs to the Spar

Step 59: Rivet the Skin and the Lower Doublers to the Lower Flange of the Spar

Slide the skin over the spar/rib assembly, Cleco the lower surface in place and clamp the assembly **upside down** to the clamping angles on your bench. Cleco the lower doublers in place and re-bolt the spacers between the flap-track and deployment arms. Then use 3/32" AN470AD3 universal-head rivets to rivet the skin to the lower flange of the spar, as shown in Figure 54. For the four holes through each of the two lower skin doublers, use 1/8" AN470AD4 universal-head rivets. Refer back to "SECTION II: TOOLS AND TECHNIQUES" for a discussion of the proper sequence for driving a line of rivets.

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Step 60: Rivet the Skin and the Lower Doublers to the Lower Flanges of the Nose Ribs

Begin at the spar and rivet forward along each nose rib's lower flange to the leading edge. As shown in Figure 54, use 1/8" AAPQ-42 blind rivets for all the ribs **with the following exceptions**: first, because there is access for a rivet squeezer, use 3/32" AN470AD3 universal-head rivets for all holes in the **outermost** two ribs. Second, for the six holes in each doubler, use 1/8" AAPQ-43 blind rivets.

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Step 61: Rivet the Skin and the Lower Doublers to the Lower Flanges of the Aft Ribs

Use 3/32" AN470AD3 universal-head rivets to rivet the skin to the lower flanges of the aft ribs, **with the following exceptions**: first, use 1/8" AAPQ-42 blind rivets for the aftmost hole in each aft rib. Second, use 1/8" AN470AD4 universal-head rivets for the six holes through each of the two lower skin doublers. In all cases, first drive a rivet near the middle of the rib, then do the ends, and then fill in the remainder.

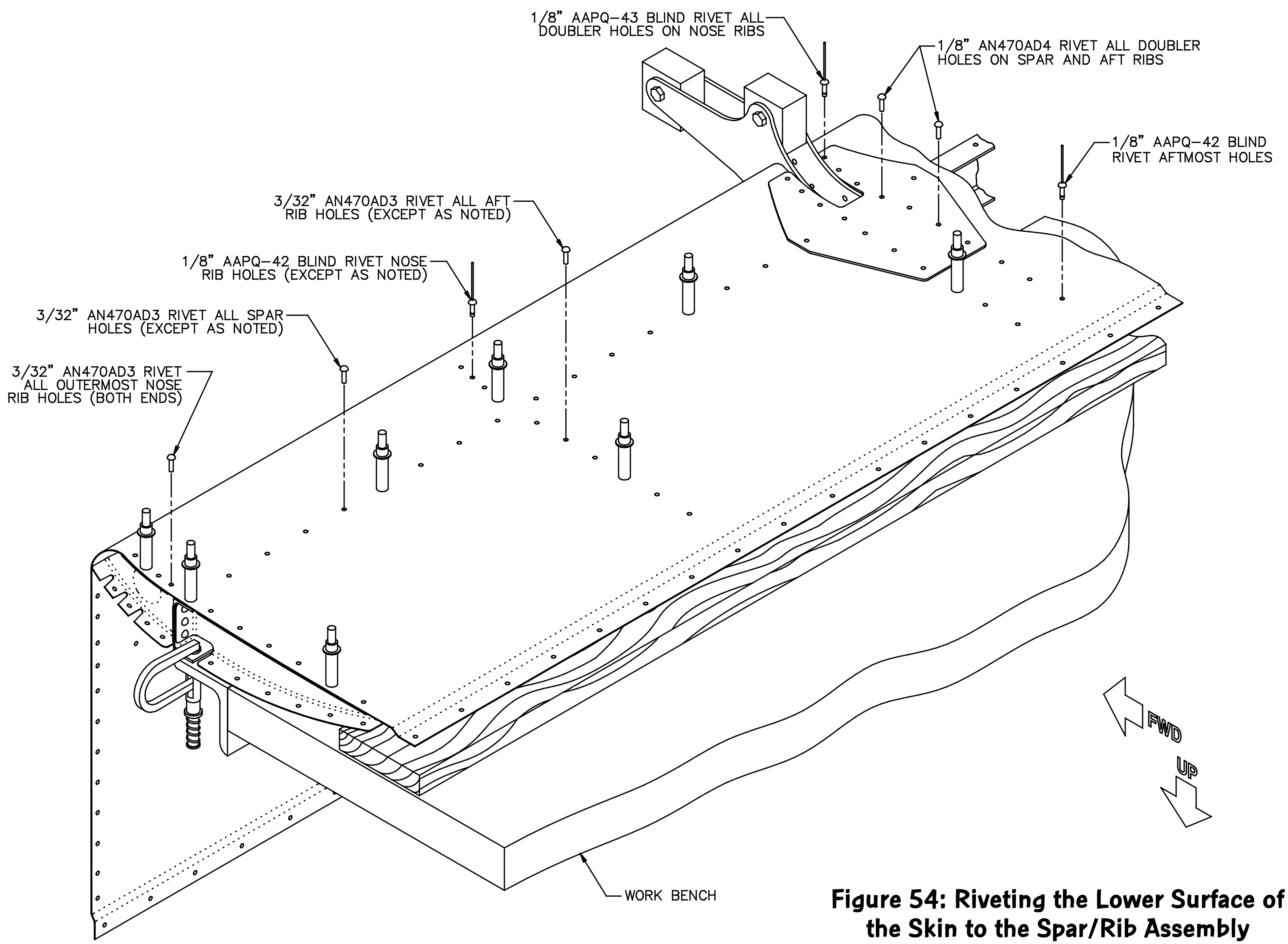

Figure 54: Riveting the Lower Surface of the Skin to the Spar/Rib Assembly

Note You'll have to move the support board out of the way to gain access to the inside of the flap for bucking, and you may in fact find it easier to unclamp the assembly from the bench to do this riveting.

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Step 62: Rivet the Skin and the Upper Doublers to the Upper Flange of the Spar

Un-clamp the flap from the bench and Cleco the upper doublers in place. Use 3/32" AN470AD3 universal-head rivets to rivet the skin to the upper flange of the spar, as shown in Figure 55. In order to drive these rivets, you will have to lift the trailing edge of the skin and reach inside the flap to position the bucking bar just as you did for the ailerons. For the four holes in each doubler, use 1/8" AACQ-43 flush-head blind rivets. Refer back to "SECTION II: TOOLS AND TECHNIQUES" for a discussion of the proper sequence for driving a line of rivets.

Note Recall that a handful of holes along the upper spar flange may have been drilled up to #30 size because of their proximity to underlying rib webs. Rivet these holes with 1/8" AAPQ-42 blind rivets.

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Step 63: Rivet the Skin and the Upper Doublers to the Upper Flanges of the Nose Ribs

Beginning at the spar and moving forward, use 1/8" AAPQ-42 blind rivets to rivet the skin to the upper flanges of all the nose ribs, **with the following exceptions**: first, since the outermost nose ribs at both ends are accessible for bucking or squeezing, use 3/32" AN470AD3 universal-head rivets in these locations. Second, for the six holes in each doubler, use 1/8" AACQ-43 flush-head blind rivets.

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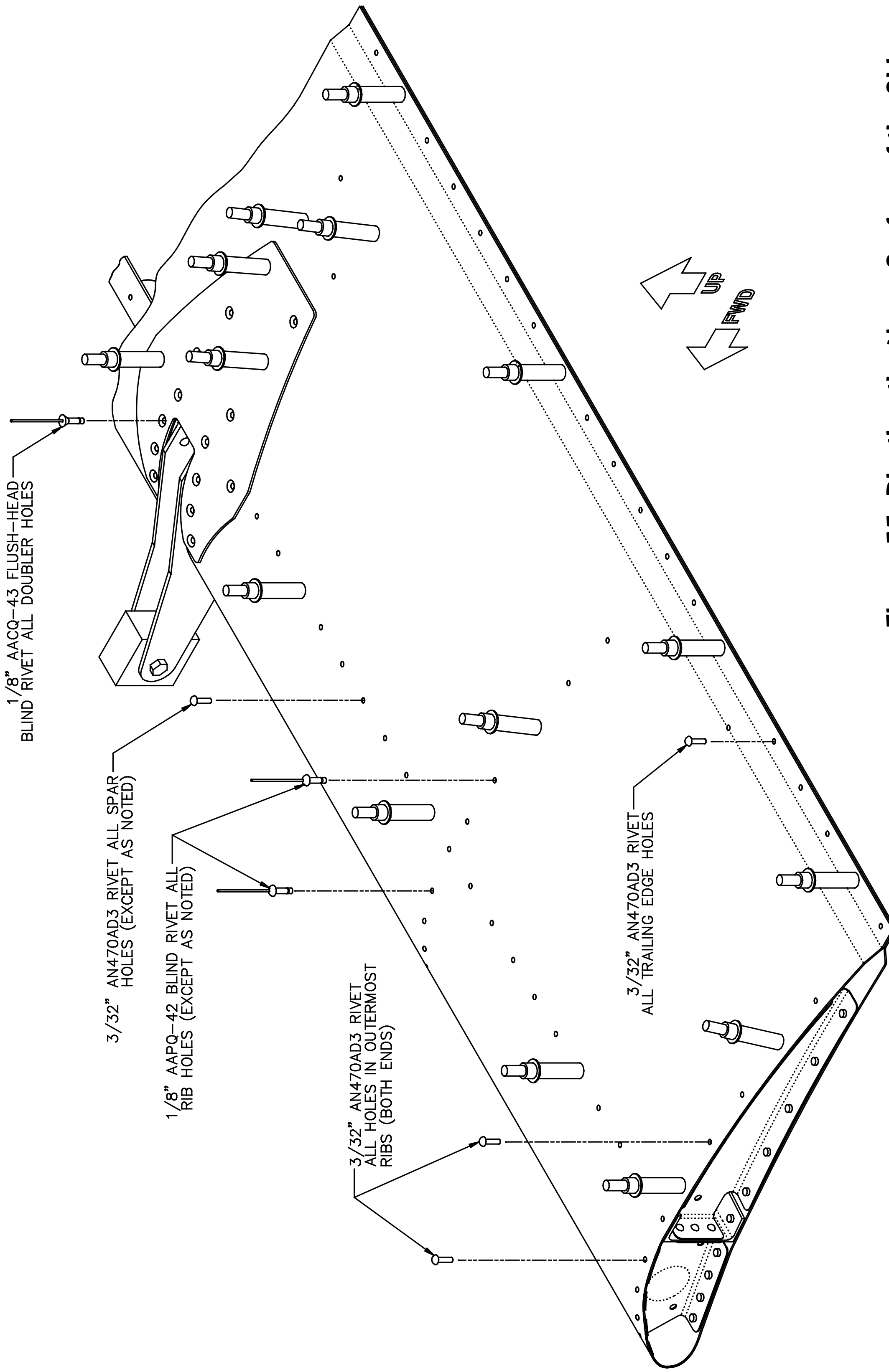

Figure 55: Riveting the Upper Surface of the Skin to the Spar/Rib Assembly

Step 64: Rivet the Skin and the Upper Doublers to the Upper Flanges of the Aft Ribs

Rivet the skin to the upper flanges of the aft ribs. As shown in Figure 55, use 1/8" AAPQ-42 blind rivets for all the aft ribs **with the following exceptions**: first, because they are accessible for bucking or squeezing, use 3/32" AN470AD3 universal-head rivets on the outermost ribs. Second, for the six holes in each doubler, use 1/8" AACQ-43 flush-head blind rivets. As usual, start in the middle of each rib, then do the ends, and finally rivet the intervening holes.

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Step 65: Rivet the Trailing Edge Joggles

Using 3/32" AN470AD3 universal-head rivets, rivet the upper and lower trailing edge joggles together. Observe proper sequencing as discussed in "SECTION II: TOOLS AND TECHNIQUES" and avoid over-squeezing or -driving these rivets, as the thin skin material will be prone to buckling between rivets that are too tight. The manufactured heads should be on the upper surface.

> **Hint** In order to produce a straight trailing edge, try clamping a pair of light, hardware-store quality aluminum angles along the trailing edge top and bottom. Position these angle aft of the rivet holes to allow room for the squeezer or rivet gun.

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CONGRATULATIONS!

You've completed the aileron and flap assemblies. On to the fuselage, where your project will very quickly begin to look like an airplane!!

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SECTION VIII: FUSELAGE ASSEMBLY

PARTS LIST

Key No.:	Part Name:	Qty:	Part No.:
1	Lower rudder hinge	1	101-00010-01
2	Vertical fin spar	1	101-00011-01
3	Upper rudder hinge	1	101-00013-01
4	Lower elevator bellcrank bracket	1	101-00014-01
5	Upper elevator bellcrank bracket	1	101-00014-02
6	Left fuselage shell	1	101-01001-01
7	Right fuselage shell	1	101-01001-02
8	Tailcone	1	101-01005-03
9	Wing pivot	2	101-02000-01
9.1	Forward spar attach pin	2	101-03000-01
10	Cage	1	101-05000-01
11	Left fuselage strut	1	101-07000-01
12	Right fuselage strut	1	101-07000-02
13	Horizontal stabilizer forward attach bracket [from Sec. IV]	1	300-01000-01
14	Lower elevator bellcrank half	1	602-05001-01
15	Upper elevator bellcrank half	1	602-05001-02
15.1	UHMW Polyethylene, 1/8" X 2" X 2"	1	620-0420-001
16	DBM cloth, 3" width	90 ft.	027-00002-01
17	Foam sheet, 20-lb., 3/16" X 24" X 24"	1	027-20316-01
18	Bulkhead A template	1	040-00101-01
19	Bulkheads B & C template sheet	1	040-00102-01
20	Bulkheads D & E template sheet	1	040-00103-01
22	Inter-bulkhead shearweb template	1	040-00105-01
23	(Reserved)		
24	(Part deleted by Revision C)		
25	Aluminum sheet, .050" X 12" X 12"	1	075-01050-01
25.1	Aluminum sheet, .125" X 3" X 10"	1	075-01253-01
26	Nylon washer, .032"	85	085-00003-01

27	Nylon washer, .064"	120	085-00004-01
28	Aluminum angle, .125" X 1" X 1-1/2"	84 in.	100-0640-009
30	Aluminum angle, .063" X 1" X 1"	1.5 ft.	100-0640-003
31	Bellcrank bearing	1	170-0134-001
32	MEKP catalyst	8 oz.	270-0105-001
33	Bi-directional cloth, 50" width	18 ft.	270-0110-002
34	Foam sheet, 5-lb., 1/4" X 24" X 30"	1	270-0123-108
35	Mill fiber	250g	270-0130-001
36	Cobalt promoter	4 oz.	270-0135-001
37	DMA accelerator	4 oz.	270-0135-002
38	Q-cell	100g	270-0140-001
39	Vinyl ester resin	2 gal.	270-0155-001
40	Aluminum sheet, .063" X 12" X 12"	2	075-01011-01
40.1	Aluminum blind rivet, 1/8"	4	700-0045-001
41	Bolt	4	AN3-4A
41.1	Bolt	8	AN3-6A
42	Bolt	8	AN3-7A
43	Castle nut	3	AN310-4
44	Castle nut	2	AN310-7
45	Jam nut	2	AN316-4R
46	Nylon self-locking nut	120	AN364-1032A
47	Nylon self-locking nut	11	AN364-428A
48	Nylon self-locking nut	3	AN364-524A
49	Nylon self-locking nut	4	AN365-1032A
51	Cotter pin	3	AN380-2-2
52	Cotter pin	2	AN380-3-3
54	Drilled-shank bolt	2	AN4-10
55	Bolt	8	AN4-11A
56	Drilled-shank bolt	1	AN4-25
57	Bolt	2	AN4-5A
58	Bolt	3	AN4-6A
61	Bolt	4	AN5-6A
62	Flush-head machine screw	40	AN507-10R16
63	Flush-head machine screw	10	AN507-10R20
64	Flush-head machine screw	10	AN509-10R10

65	Flush-head machine screw	30	AN509-10R11
66	Flush-head machine screw	5	AN509-10R12
67	Flush-head machine screw	5	AN509-10R13
68	Flush-head machine screw	40	AN509-10R14
68.1	Drilled-shank bolt	2	AN7-12
69	Drilled-shank bolt	2	AN7-44
70	Washer	60	AN960-10
71	Thin washer	70	AN960-10L
72	(Reserved)		
73	(Reserved)		
74	Washer	2	AN960-516
75	Washer	4	AN960-716
76	Aluminum washer	66	AN960D10
78	Aluminum washer	15	AN960D416
79	Thin aluminum washer	9	AN960D416L
80	Aluminum washer	4	AN960D516
81	Large washer	16	AN970-3
82	Large washer	8	AN970-4
83	Floating nutplate	4	F5000-4
84	Nutplate	2	K1000-4
84.1	Nutplate	15	MF5000-3
85	Aluminum spacer	2	NAS43DD4-39
87	Flanged steel bushing	2	NAS77-7-019
88	Flanged steel bushing	2	NAS77-7-025
89	Flanged bronze bushing	1	NAS77A4-025
90	Flanged bronze bushing	2	NAS77A5-062

Parts List for Taildragger Landing Gear

Note The following item is unique to the taildragger landing gear installation.

Key No.:	Part Name:	Qty:	Part No.:
91	Flanged steel bushing	2	NAS77-3-014

Hint Your cage and all your fiberglass parts are stamped with Serial Numbers as well as Part Numbers. These numbers are also recorded on your shipping invoice. The Serial Number identifies your part uniquely based on its place in our production run. We recommend that you either save your shipping invoice or record these Serial Numbers elsewhere, such as in your permanent airframe log. If, in the future, we ever issue an advisory publication that applies only to the parts of a particular run, this information will help you determine whether your GlaStar is affected.

TOOL LIST

1. Fine-point marking pen
2. Sanding block (at least 12" long)
3. Respirator or dust mask (highly recommended for use while sanding or grinding fiberglass)
4. Electric or pneumatic drill motor, with #40, #30, #10, letter “F”, 3/16", 1/4", 5/16", 3/8", 13/32" and 1/2" bits
5. Assorted flat and round files
6. Single-ended hacksaw
7. Die grinder with rotary files and/or sanding drums (recommended)
8. Heavy-duty scissors and/or rotary cloth cutter
9. Safety goggles (highly recommended for use while catalyzing resin and grinding fiberglass laminates)
10. Bench grinder with non-metallic abrasive wheel (recommended)
11. Rule, 12", graduated in 1/32nds of an inch
12. Bandsaw (highly recommended) or hacksaw (acceptable)
13. Belt sander (recommended)
14. Center punch
15. Hammer
16. Large C-clamp
17. Hacksaw or saber saw
18. Assorted Cleco side-grip clamps (with pliers), rubber-padded spring clamps and/or small C-clamps, approximately 5
19. Bench vise
20. Shop vacuum
21. Large-gauge syringe (without needle), at least 5cc
22. Digital level (highly recommended) or spirit level (acceptable)
23. Microstop countersink cage with #40, #30 and #10 piloted cutters (carbide-tipped #30 cutter recommended for fiberglass work)
24. Socket wrench with assorted sockets, 3/8"—3/4"
25. Plumb bob
26. 90° drill motor or adapter
27. .4375" straight reamer
28. Hole deburring tool
29. Assorted box or open-end wrenches, 3/8"—3/4"
30. Carpenter's level (6'-long recommended)

31. Utility knife
32. Saber saw with carbide grit blade for cutting fiberglass (recommended)
33. Hot-melt glue gun (recommended)
34. Small electric fan (6-8") with clamp mount (recommended)
35. Decimal rule, graduated in tenths of an inch
36. Clecos, 3/32" (4) and 1/8" (approximately 40), with pliers
37. Rivet squeezer (recommended) or rivet gun, air compressor and bucking bars (acceptable) with flush-head rivet sets
38. Small needle-nose pliers, forceps or pick-up tool
39. Protractor
40. Bevel gauge (recommended)
41. Hole saw, 3-5/8" diameter
42. Try square or combination square
43. Small inspection mirror (recommended)
44. Scroll saw (recommended)

Additional Materials

1. One 8-foot 2 X 6
2. Four 8-foot 2 X 4s
3. Two 1 X 4s, approximately 4-1/2' long
4. Two 1 X 4s, approximately 2-1/2' long
5. Scrap plywood, approximately 2 square feet
6. Sheetrock screws, approximately 75
7. Two rubber-padded bicycle hanging hooks
8. Sandpaper, various grits 80—400
9. Several sand or shot bags
10. Unwaxed resin mixing cups
11. Resin mixing sticks
12. Latex surgical gloves
13. 2" varnish-type paint brushes (one attached to the end of a 2'—3' dowel or length of tubing)
14. Acetone
15. Coarse Scotch Brite pads
16. Prep Sol or lacquer thinner
17. Corrosion-proofing materials

18. Loctite Low Viscosity or Medium Viscosity Bearing Retaining Compound or equivalent
19. Duct tape or wide masking tape
20. Padded sawhorse or stool, approximately 36" tall (depending on the height of your hanging framework; see below)
21. 1-3/4" length of piano wire or equivalent, at least .050" diameter
22. Assorted foam or cloth padding material
23. Non-styrene based plastic sheeting (Visqueen, polyethylene or equivalent)
24. Roll of sturdy packing string
25. Step ladder
26. Hardware-store quality 1" X 1" aluminum angle stock, 6–8' long, (used in various clamping and laminating procedures but **not** to be mistaken for the aircraft-grade angle stock supplied with the kit **nor** to be used in any structural application. We recommend marking this stock with a red marker to distinguish it from the good stuff!)
27. Thumbtacks or push pins
28. Spray adhesive or rubber cement
29. Hot-melt glue sticks
30. Mold-release wax (Stoddard-Hamilton P/N 270-0205-001) or equivalent
31. Two wooden shims, approximately 1/8" X 1" X 4", or equivalent (Four tongue depressors or popsicle sticks stacked in pairs will work fine.)
32. Four yardsticks or equivalent wooden slats
33. Assorted scrap wood blocks
34. Piece of stiff cardboard, 12" X 12"
35. Piece of sheet metal, Formica, Masonite or other hard, smooth material, 30" X 30"
36. Piece of 3/16"—1/2" plywood (any grade), chipboard, particle board or paneling, etc., 30" X 30"
37. Large gauge needle and syringe (from veterinary supply store)

WORKSPACE

The fuselage from the firewall to the tailcone is approximately 19' long and 4' wide.

For the work on the fuselage, it's useful to suspend the steel-tube **cage** [10] from an overhead framework such as the one illustrated in Figure 1. The hooks shown in the figure are the rubber-padded, screw-in type used to hang bicycles. They are widely available at hardware stores and cycling shops.

All the dimensions shown can be altered to suit the individual builder with the exception of the distance between the two hooks—this should remain approximately **32"** as shown. The other dimensions given in the figure keep the bottom of the fuselage about 3' off the ground. This working height is a compromise: it keeps much of the work in the fuselage (both in this section of the assembly process and in "SECTION IX: SYSTEMS INSTALLATION") at a comfortable working height, and it allows relatively easy access to the bottom of the fuselage, where you will have to drill and countersink a number of holes. However, it also raises the top of the vertical fin to slightly higher than 9' above the floor (almost 10' when the rudder is hung). This not only exceeds some builders' available ceiling height, but also means that a lot of the work in the aft fuselage must be done at about shoulder height, which some may find quite inconvenient. The bottom line is that you must make your own best compromise, taking account of your workspace and your work habits.

A final workspace consideration has to do with ventilation. Although the fuselage is entirely pre-molded, you will still be doing a considerable amount of fiberglass work on this assembly. No extraordinary measures need to be taken on account of this work, but use simple common sense: open doors or windows when working with resin, don't ventilate your shop into your living space, and use a fan if natural cross-ventilation is inadequate.

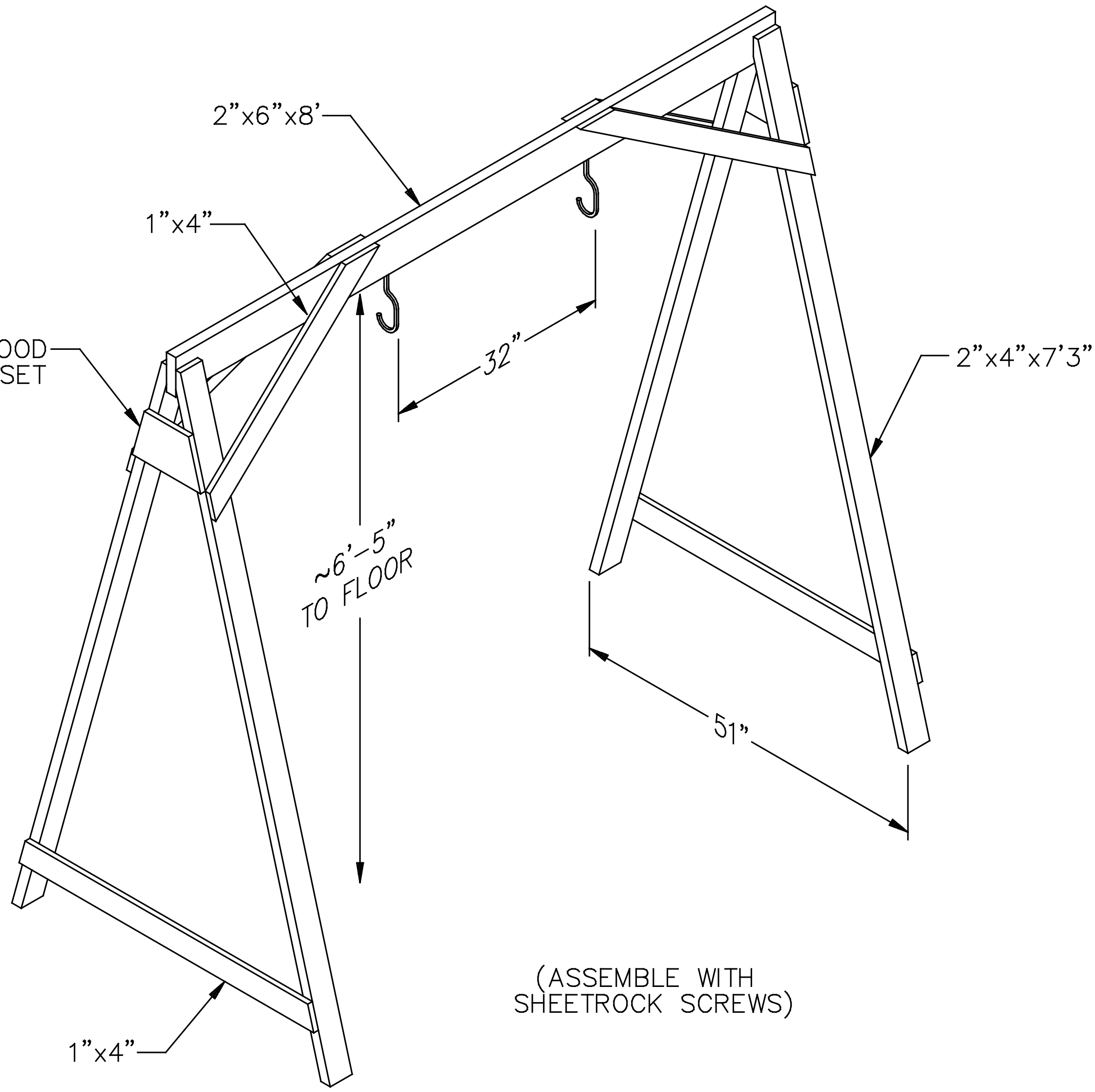

Figure 1: Suggested Design for the Fuselage Hanging Framework

Assembly Sequence

The fuselage assembly process consists of the following four main phases:

1) **Component Preparation**: surface finishing the fuselage shells, cage and other steel parts.
2) **Fitting Fabrication**: cutting and finishing the attach brackets that secure the shells to the cage.
3) **External Structure**: mounting the shells on the cage and joining them together.
4) **Internal Structure**: installing the aft fuselage bulkheads, vertical fin spar and rib, inter-bulkhead shearweb, tail surface attach points, baggage compartment bulkhead and fuselage struts.

Component Preparation

Note An inherent quality of the resins used in composite construction is their tendency to shrink during the curing process. There is no way to prevent this shrinkage. This fact may become evident to you in a couple different places when you closely examine your **left** and **right fuselage shells** [6 and 7]. First, you may be able to see or feel the weave of the fiberglass cloth through the exterior gel coat. This may be particularly apparent at seams where one layer of cloth overlaps another. Second, you may notice that the surface seems slightly sunken around the door and window cutouts.

Neither of these conditions is of any structural significance whatsoever, and most observers of your GlaStar will be hard-pressed even to notice them. However, if you find them aesthetically objectionable, they can be corrected with a little extra work. See the discussion of surface finishing in "SECTION II: TOOLS AND TECHNIQUES."

Step 1: Remove the Mold Lip from the Fuselage Shells

When fiberglass parts are trimmed at the factory before being removed from the molds, a small lip of excess resin often remains around the edges. This "mold lip" can be easily sanded off. As shown in Figure 2, use a long sanding block (12" minimum) to remove the lip from the upper and lower mating edges of the left and right fuselage shells. Hold the block **perpendicular** to the edge and sand just enough to remove the lip.

Note Do **not** sand the aft or the top edges of the vertical fin halves at this time. These will be sanded after the fuselage shells are joined.

Hint You can often **feel** the remaining mold lip more easily than you can see it, so check for adequate sanding with your fingers. To avoid oversanding, use a pen to mark the lip and then sand just until the ink line disappears. Use as long a sanding block as possible. Try using contact cement or spray adhesive to glue strips of sandpaper to a long straightedge, such as a very straight 4'-long 2 X 4. While sanding, rest the shells on blankets or foam pads to protect the gel coat. Weight the shells with sand or shot bags to hold them steady.

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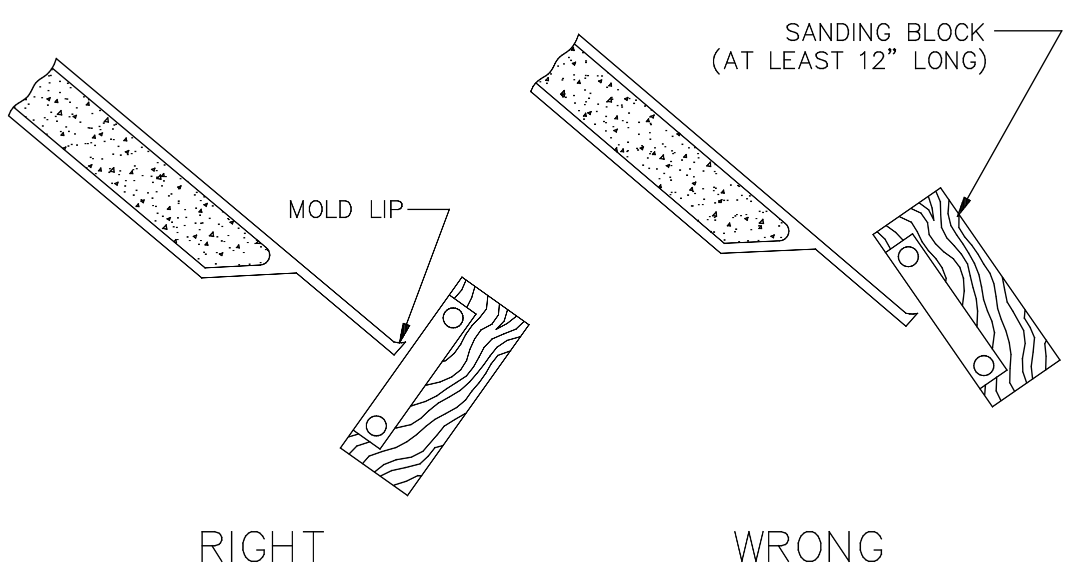

Figure 2: Removing the Mold Lip from the Fuselage Shells

Step 2: Sand the Window and Door Cutouts

Use sandpaper on a sanding block to smooth the trimmed edges of the window and door openings in the fuselage shells. Sand just enough to remove any roughness resulting from factory trimming without decreasing the width of the flanges any more than necessary. Sand until the edges are all smooth to the touch; this will make the parts more comfortable and safer to handle.

Completed: [ ]

Step 3: Make the Cutouts for the Landing Gear Legs

As shown in Figure 3, the fuselage shells come from the factory with pre-molded scribe lines for the cutouts for both tricycle and taildragger main landing gear legs. Cut away the shells to the inside of these scribe lines for the type of gear you'll be installing. Drill holes to start the cutouts and then enlarge them using a rotary file or sanding drum in your drill motor or a single-ended hacksaw and files.

> **Note** If you are installing tricycle landing gear or floats, use the aft pair of gear leg cutouts; if you are installing conventional gear, use the forward pair. Taildragger builders may ultimately have to remove at least a portion of the tricycle gear cutouts as well, but this is best done in a subsequent step.

Completed: [ ]

Step 3.1: Lay Up the Shell Attach Fitting Hardpoint Reinforcements

At six locations in the GlaStar fuselage—two on each side between the door and quarter window cutouts and one on each side on the shell ceiling aft of the quarter windows—dense foam hardpoints have been installed to accommodate structural shell attach fittings. In this step you will further strengthen these locations with additional two-layer laminates of **bi-directional cloth** [33].

Begin by cutting twelve **2-5/8" X 7"** rectangular pieces of bi-directional cloth on the 45° bias. Next, catalyze a small batch of **vinyl ester resin** [39] and saturate all twelve pieces of cloth. Apply two of the pieces to each of the four hardpoints in the door posts and two to each of the ceiling hardpoints. Take care to keep the pieces centered over their respective foam cores while working out air bubbles and excess resin.

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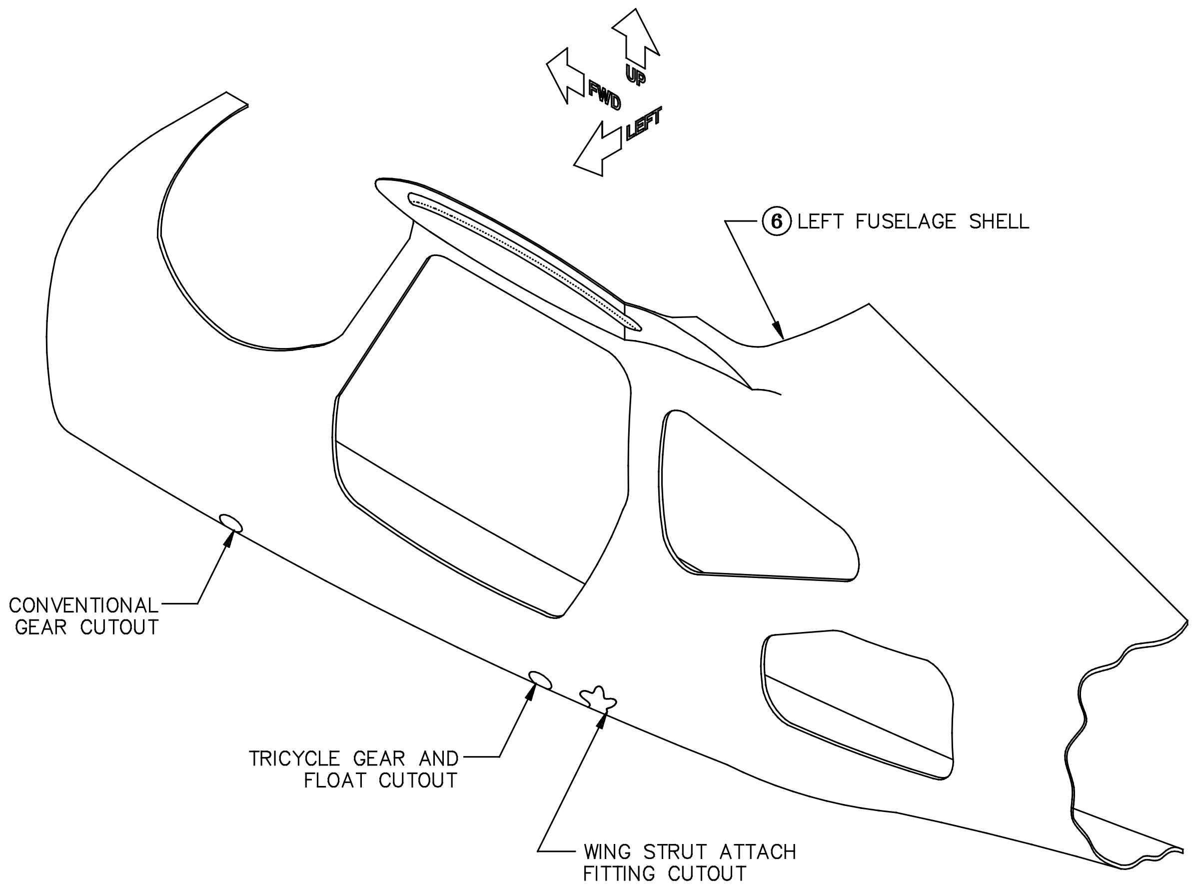

Figure 3: Landing Gear Leg Cutouts

Step 4: Install the COM Antenna in the Vertical Fin (Optional)

Since fiberglass doesn't interfere with radio reception or transmission, the communications (COM) antenna can be mounted internally. This offers the advantages of reduced drag and easy installation. The leading edge of the vertical fin is an excellent location for this antenna. If you wish to install your COM antenna there, it's best to do it now before you bond the fuselage shells together.

The optional COM antenna available from Stoddard-Hamilton (P/N 211-0112-101) consists of two 20-1/4" lengths of 1/2"-wide, adhesive-backed copper foil, a length of triaxial cable, several small ferrite toroids and a triaxial cable connector plug. Contact our Order Desk for pricing and availability.

Note Before affixing your antenna to the shell, wipe the area thoroughly with acetone to remove any dirt, oil or other contaminants.

Begin with the copper-foil element that is soldered to the **central** conductor of the triaxial cable. Position the upper end of this element about 6" below the top of the fin and, peeling off the backing paper as you go, run the element down the fin parallel to and about 2-1/2" aft of the leading edge.

Caution Be certain that the element attached to the **central** conductor of the triax is positioned on **top**. Also, be sure that the element is fastened to the full-thickness, foam-core portion of the fin so it won't interfere with the seam laminates you'll apply later. Figure 4 shows the antenna installed on the right fuselage shell, but either shell is fine.

Continue down the fin leading edge with the second copper-foil element. However, make sure to leave a gap of approximately 1/4" between the soldered ends of the two elements, as shown in Figure 4.

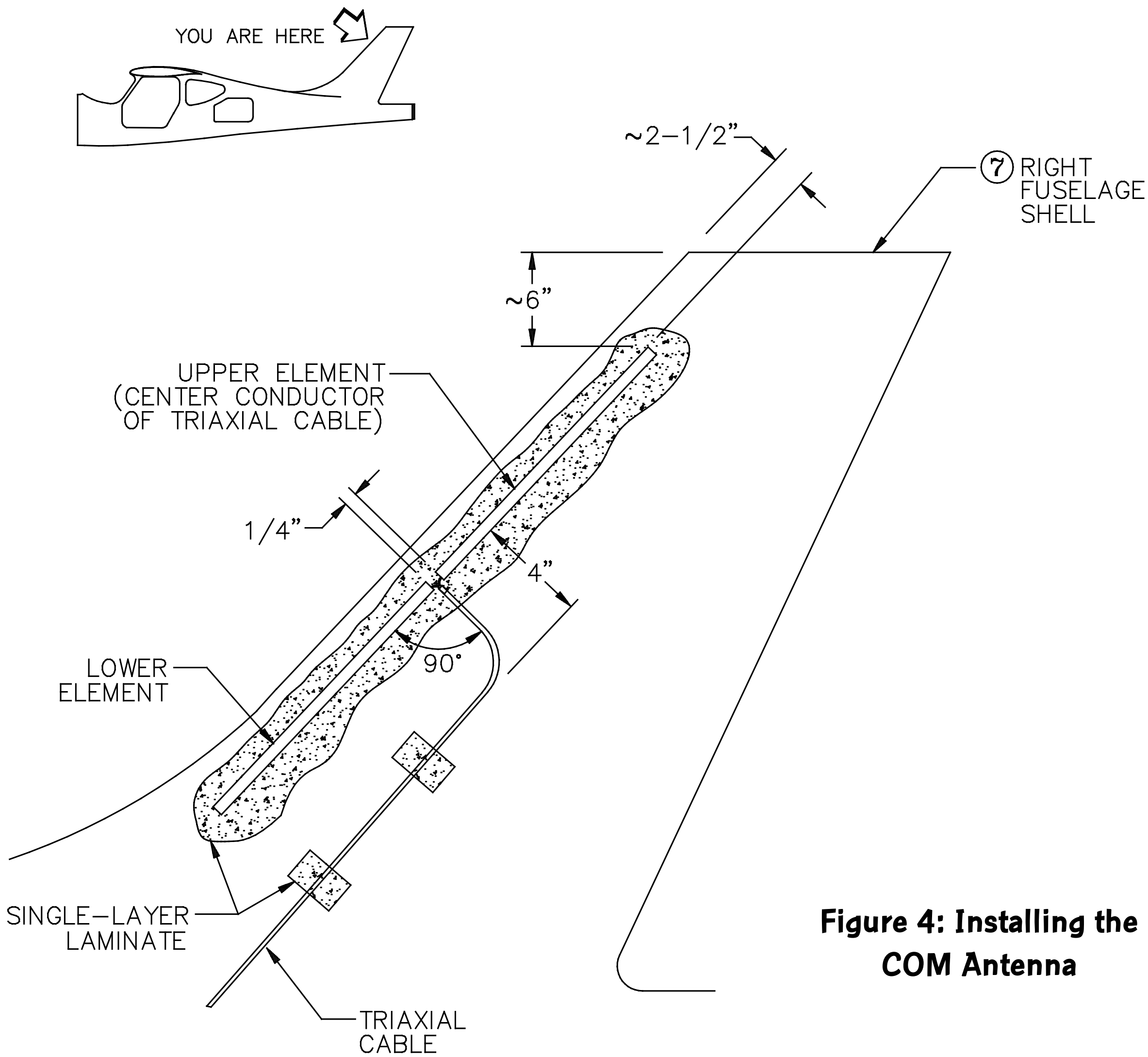

Figure 4: Installing the COM Antenna

Secure the antenna, including the central connection, to the inside of the vertical fin with a one-layer laminate of bi-directional cloth, as shown in the figure. The cable is secured away from the antenna elements with small, single-laminate tack strips of bi-directional cloth—one every six or eight inches. These can be applied immediately after the main laminate that secures the antenna elements; there's no need to wait for it to cure.

As shown in Figure 4, route the cable aft from the central connection at a **90°** angle for at least **4"** before making the turn downward and forward. Coil the extra cable at the bottom of the fin; it will be routed forward later.

Completed: [ ]

Step 5: Install the VOR Antenna Cable in the Vertical Fin *(Optional)*

Unfortunately, because of the required antenna geometry, it is impractical to install an internal VOR antenna in the GlaStar. We recommend the use of a "cat whisker" dipole antenna mounted on top of the vertical fin or on the belly of the aircraft. The actual installation of a vertical fin-mounted antenna must await the joining of the fuselage shells and installation of the vertical fin rib, but it's more convenient to install the antenna cable at this time. (See article in the Fourth Quarter 1996 issue of the *Stoddard-Hamilton News*, No. 63, for more information on GlaStar antennas. Antenna cable and BNC connectors are available from Stoddard-Hamilton.)

The VOR cable is tacked to the inside of the vertical fin with small, one-layer laminates just as the COM antenna cable was. However, to minimize possible interference, you should mount the VOR cable as far from the COM antenna and cable as possible. This means routing it along the trailing edge of the vertical fin on the **opposite** shell from the COM antenna, as shown in Figure 5. Position the cable so that the upper end—usually the female end—extends about **6"** above the top of the fin shell, but don't put a tack strip any closer than about **4"** below the top of the fin. This will ensure that there is enough slack in the cable to make the connection to the antenna but not so much excess length as to be awkward.

Completed: [ ]

Step 6: Prep Sand the Fuselage Seam Joggles as Necessary

As detailed in "SECTION II: TOOLS AND TECHNIQUES," the age of your fuselage shells determines whether it's necessary to prep sand the seam joggles along the mating edges of the shells in order to achieve a good bond. Test sand the joggles with 80-grit sandpaper. If the paper quickly fills or gums up, then the shells are still relatively "fresh" and further surface preparation is **unnecessary**. Otherwise, continue sanding with 80-grit paper until the entire joggle on both the upper and lower seams is **completely dull**—i.e., has no shininess at all.

Completed: [ ]

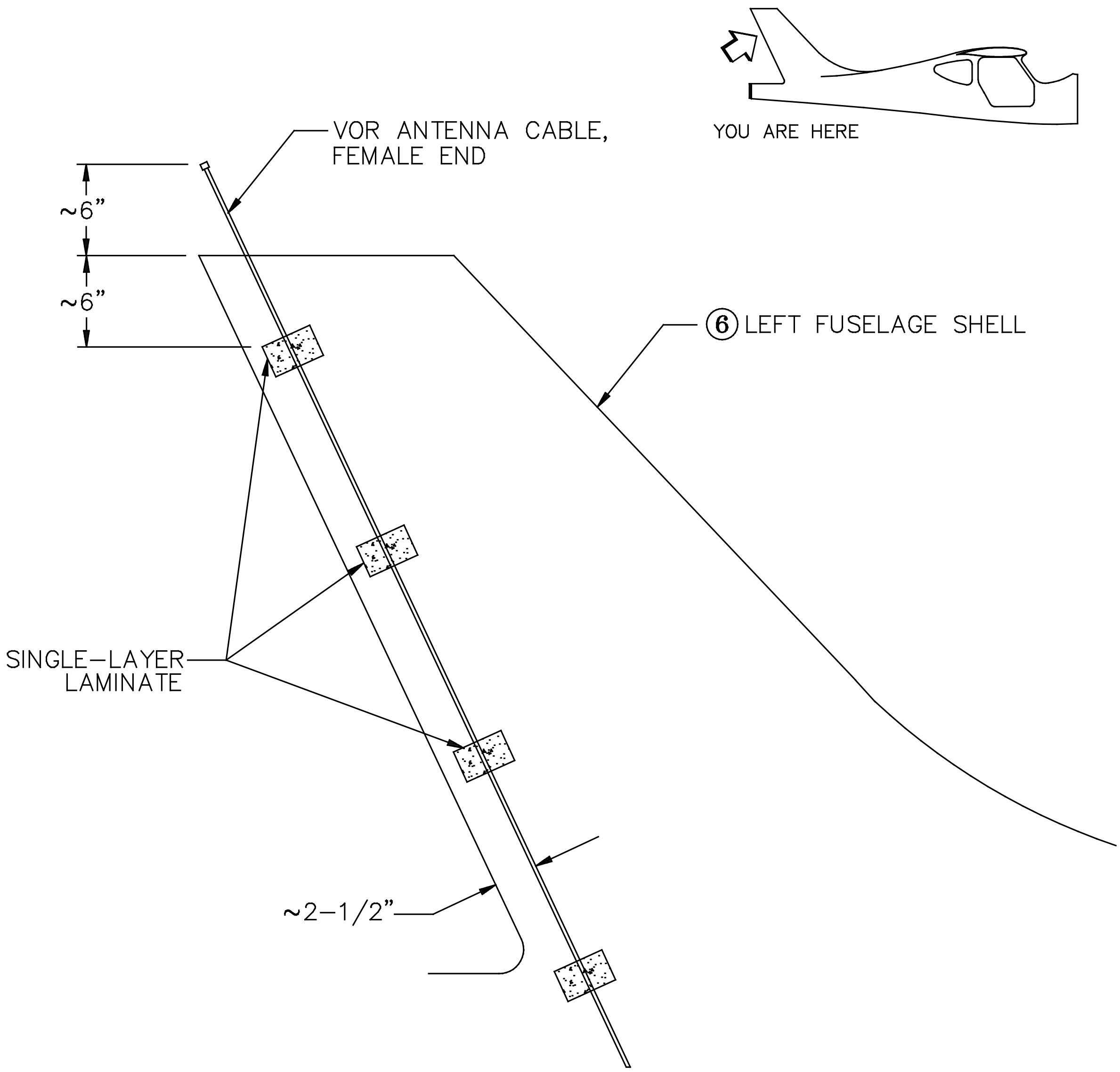

Figure 5: Installing the VOR Antenna Cable

Step 7: Prep and Prime the Steel Parts

The following steel fuselage parts come untreated in the standard GlaStar kit, and thus require corrosion protection:

cage [10]
left fuselage strut [11]
right fuselage strut [12]
wing pivots [9]

Hint The following untreated steel parts appear in the subsequent sections of the manual. You may wish to corrosion-proof them all at once. Parts marked with an asterisk (as well as all four of the parts listed on the previous page) are included in the Pre-Finished Parts Package. Other pre-treated part options may be available in the future. Call the Order Desk for details.

Part Name:	**Part Number:**	**Qty.:**
Main gear leg*	401-00001-01	2
Main gear brake mounting flange (tricycle and standard taildragger only)	401-01000-03	2
Main gear brake mounting flange (6.00 or 8.00 X 6 taildragger only)	401-01550-01	2
Nose gear leg (tricycle only)	401-05001-01	1
Lower nose gear trunnion (tricycle only)	401-05100-01	1
Upper nose gear trunnion (tricycle only)	401-05200-01	1
Nose gear fork stop plate (tricycle only)	401-06000-01	1
Nose gear fork (tricycle only)	401-07100-01	1
Lower tailwheel spring (taildragger only)	401-09001-07	1
Middle tailwheel spring (taildragger only)	401-09001-09	1
Upper tailwheel spring (taildragger only)	401-09001-11	1
Left rudder pedal control weldment*	601-01200-01	1
Right rudder pedal control weldment*	601-01200-02	1
Elevator/aileron control yoke*	601-01300-05	1
Control stick pivot bracket*	601-01400-01	1
Control stick*	601-01500-01	2
Control stick interconnect rod	601-01600-01	1
Flap deployment ratchet plate*	602-02001-01	1
Flap handle*	602-02010-03	1
Flap pushrod	602-03000-01	2
Cable attach tab	602-06002-01	6
Aileron pushrod	602-07000-01	2
Seat back*	802-02000-03	2
Seat base*	802-03000-03	2
Inboard seat track*	802-04000-01	2
Left outboard seat track*	802-05000-01	1
Right outboard seat track*	802-05000-02	1

Each steel part must be completely free of both surface rust and contaminants such as oil, dirt or dust before priming and painting. If your parts are free of surface rust, you can get by with a thorough scouring with coarse Scotch Brite and application of a degreaser such as Prep-Sol or lacquer thinner. A Scotch Brite wheel on a bench grinder is especially effective for cleaning the smaller steel parts.

Note Acetone is **not** an appropriate solvent for removing grease from metal parts.

Surface rust requires stronger measures. Sandpaper, buffing wheels and compounds and wire brushing are all acceptable methods of attacking rust, but it is extremely difficult with any of these methods to prevent the accumulation of residual corrosion and steel particles in the tiny surface pits that will inevitably remain in the parts. For this reason, we recommend sand or bead blasting as the best method of removing surface corrosion. Blasting will remove all surface corrosion much more surely than hand methods, and it minimizes the amount of residue remaining on the part.

Whichever cleaning method you use, prime and paint the cleaned part as soon as possible after the cleaning, and in any event, keep the part dry before painting. We recommend the use of an epoxy primer for maximum protection and durability.

Hint Traditionally, most steel aircraft structure has been painted black. We have found, however, that a lighter color is more desirable because it makes inspection of the structure for cracks much easier. From this point of view, white is the color of choice. The only exception to this concerns the V-brace in the windshield area. To minimize glare, this should be painted a darker color with a matte finish.

Hint FAA Advisory Circular 43-4A, *Corrosion Control for Aircraft*, is a good source for further information on this subject. See also the article "Rust Protection" by Tony Bingelis in the October 1995 issue of *Sport Aviation*, pp. 86-91.

Warning **Under no circumstances** should you drill holes anywhere in the fuselage cage tubing. Besides possibly weakening the structure directly, such holes could provide an avenue for moisture to enter, which could cause corrosion inside the tubing. If you need to attach anything to the tubing, use nylon cable ties or loop clamps.

Completed: [ ]

FITTING FABRICATION

Step 8: Cut the Angle Stock to Length for the Shell Attach Fittings

The fuselage shells are attached to the cage in part with sixteen aluminum fittings. These fittings must be fabricated from the **.125" X 1" X 1-1/2" aluminum angle stock** [28] provided.

Begin with the **27"** length of stock. Use a bandsaw or hacksaw to cut this length into two **6-1/8"** pieces and two **6"** pieces. Then, from the **57"** length of stock, cut twelve **4-1/2"** pieces.

Note The instructions in the previous paragraph assume that your aluminum angle stock [28] was shipped as one 27" length and one 57" length, the most common way for this stock to be shipped. If you were shipped different lengths of the stock, lay out all of the fittings onto it before making any cuts to make sure you don't end up short.

Completed: [ ]

Step 9: Fabricate the Upper Shell Attach Fittings

Two upper shell attach fittings must be fabricated from the **6-1/8"** pieces of stock. Figure 6 shows the dimensions of these fittings. Cut the basic shape with a bandsaw or hacksaw, and use fine-toothed files and/or a belt sander to smooth the cut edges and radius the corners.

> **Note** The two fittings are **not** identical, but rather are **mirror images**. Figure 6 shows the **left-hand** fitting; be sure to transpose the dimensions in cutting and drilling the **right-hand** fitting.

After the basic shapes have been cut and finished, lay out the hole locations shown in Figure 6 and center punch each firmly.

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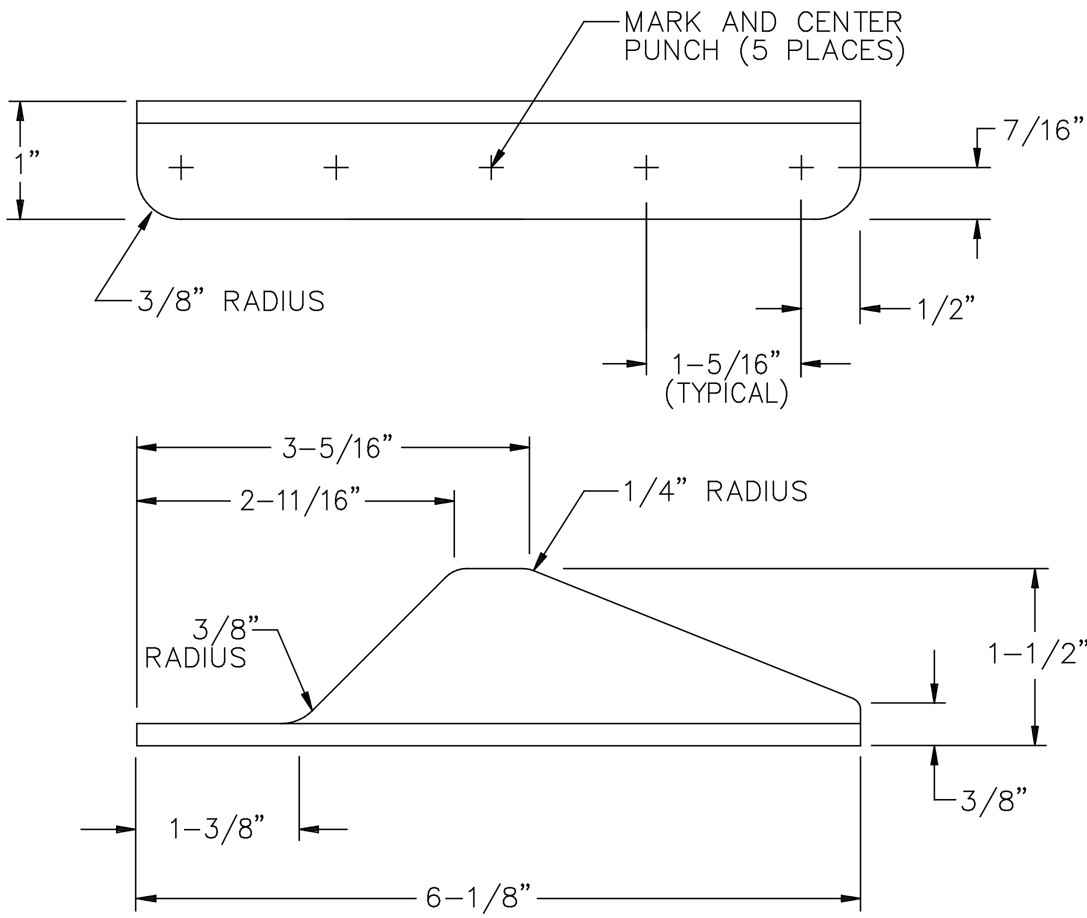

Figure 6: Upper Shell Attach Fittings

Step 10: Fabricate the Lower Shell Attach Fittings

Two lower shell attach fittings must be fabricated from the **6"** pieces of stock. Figure 7 shows the dimensions of these fittings. Cut the basic shape with a bandsaw or hacksaw, and use fine-toothed files and/or a belt sander to smooth the cut edges and radius the corners.

Note Unlike the upper fittings, the two lower fittings **are identical**.

After shaping and finishing, mark and center punch the five hole locations.

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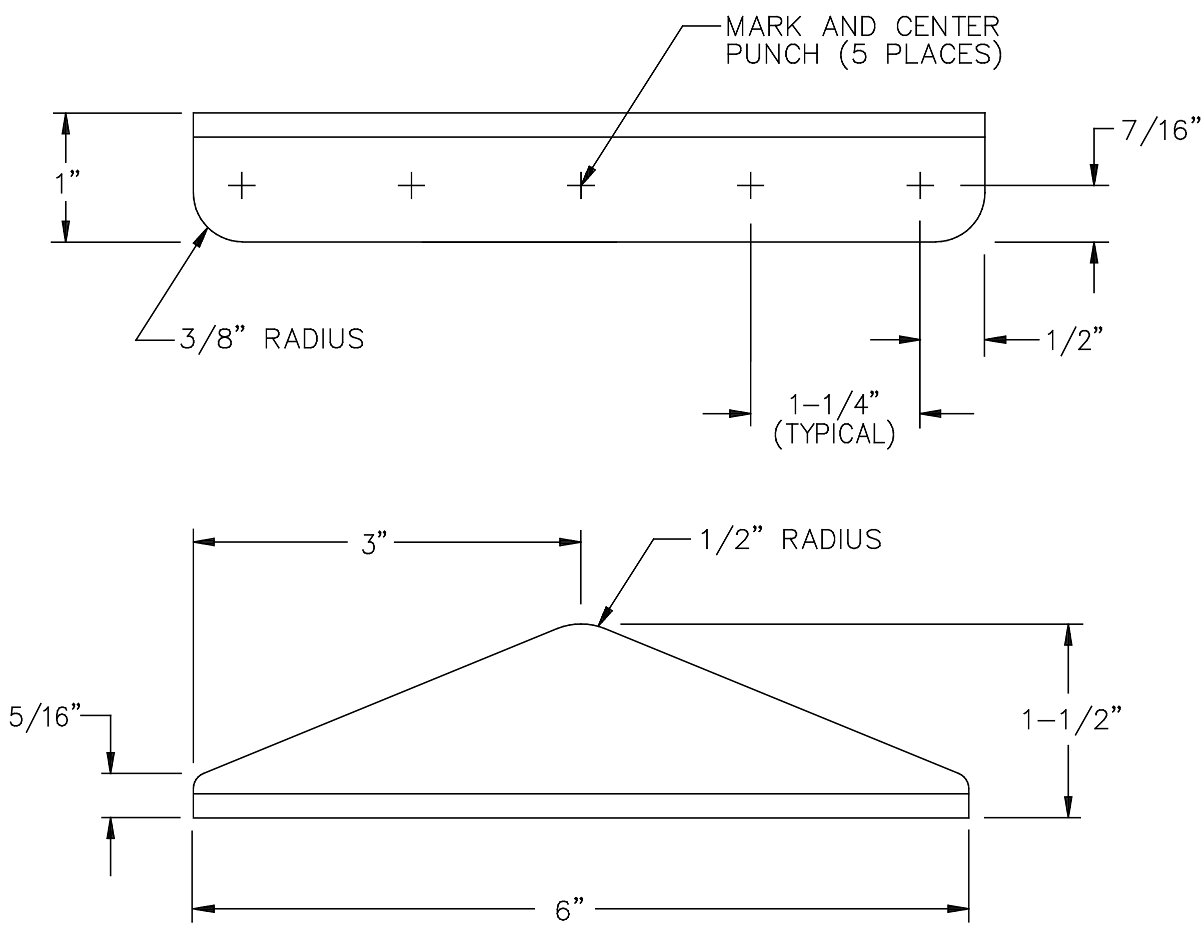

Figure 7: Lower Shell Attach Fittings

Step 11: Fabricate the Aft Shell Attach Fittings

Twelve aft shell attach fittings must be fabricated from the **4-1/2"** pieces of stock. Figure 8 shows the dimensions of these fittings. Cut the basic shape with a bandsaw or hacksaw, and use fine-toothed files and/or a belt sander to smooth the cut edges and radius the corners.

> **Note** These fittings come in left- and right-hand varieties. Be sure to make **six left-hand** and **six right-hand** fittings.

After all twelve fittings have been cut to shape, mark the locations of the four holes and center punch each of them firmly.

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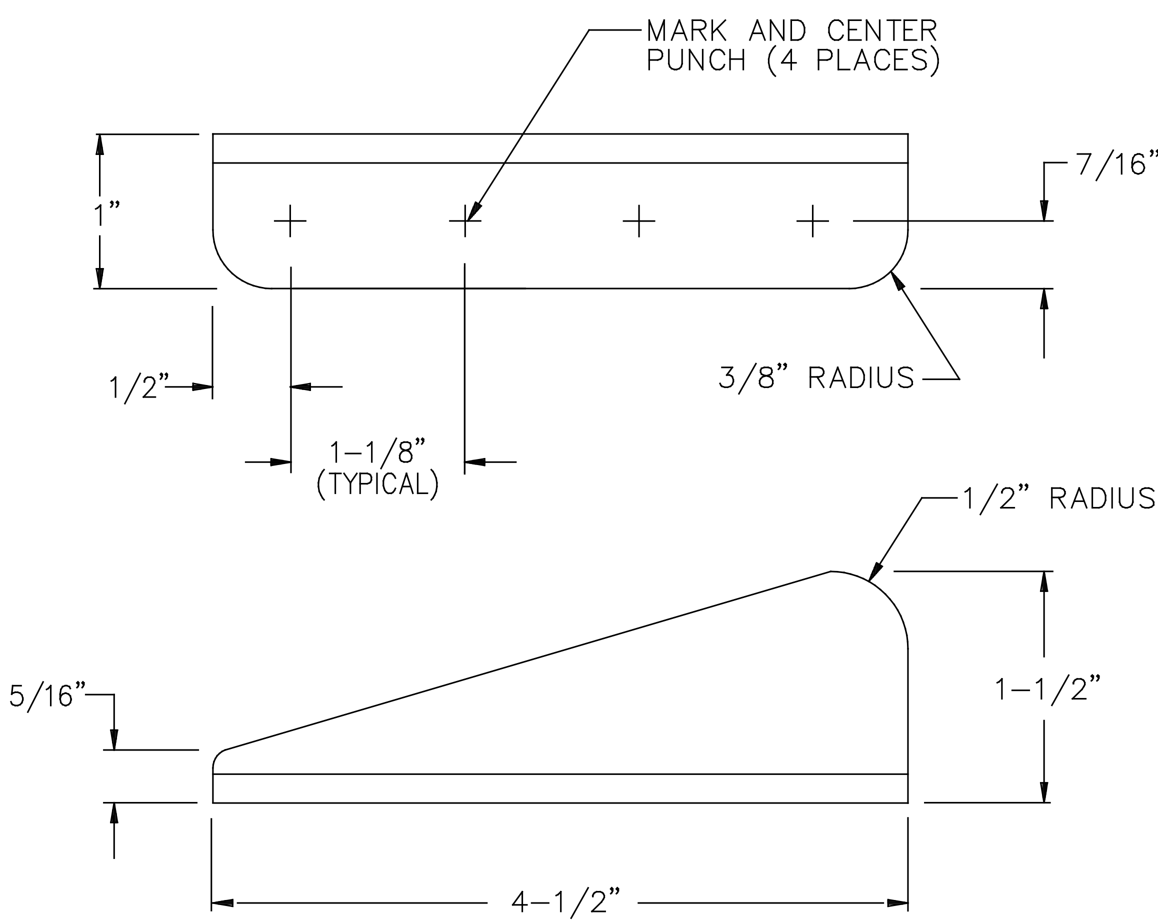

Figure 8: Aft Shell Attach Fittings

Step 12: Fabricate the Forward Shell Attach Fittings

Four fittings that serve as attach points between the forward end of the cage and the fuselage shells must be cut from the **.063" X 12" X 12" aluminum sheet** [40]. There are two types of these fittings—inboard and outboard. Figure 9 gives the dimensions for each. Cut the fittings out with a bandsaw, and file or belt sand the edges smooth. Drill the holes as indicated with a **#10** bit and deburr.

Note Use as little material as possible to make these fittings. You will use the remaining 6" X 12" piece to fabricate the rudder pedals in "SECTION IX: SYSTEMS INSTALLATION."

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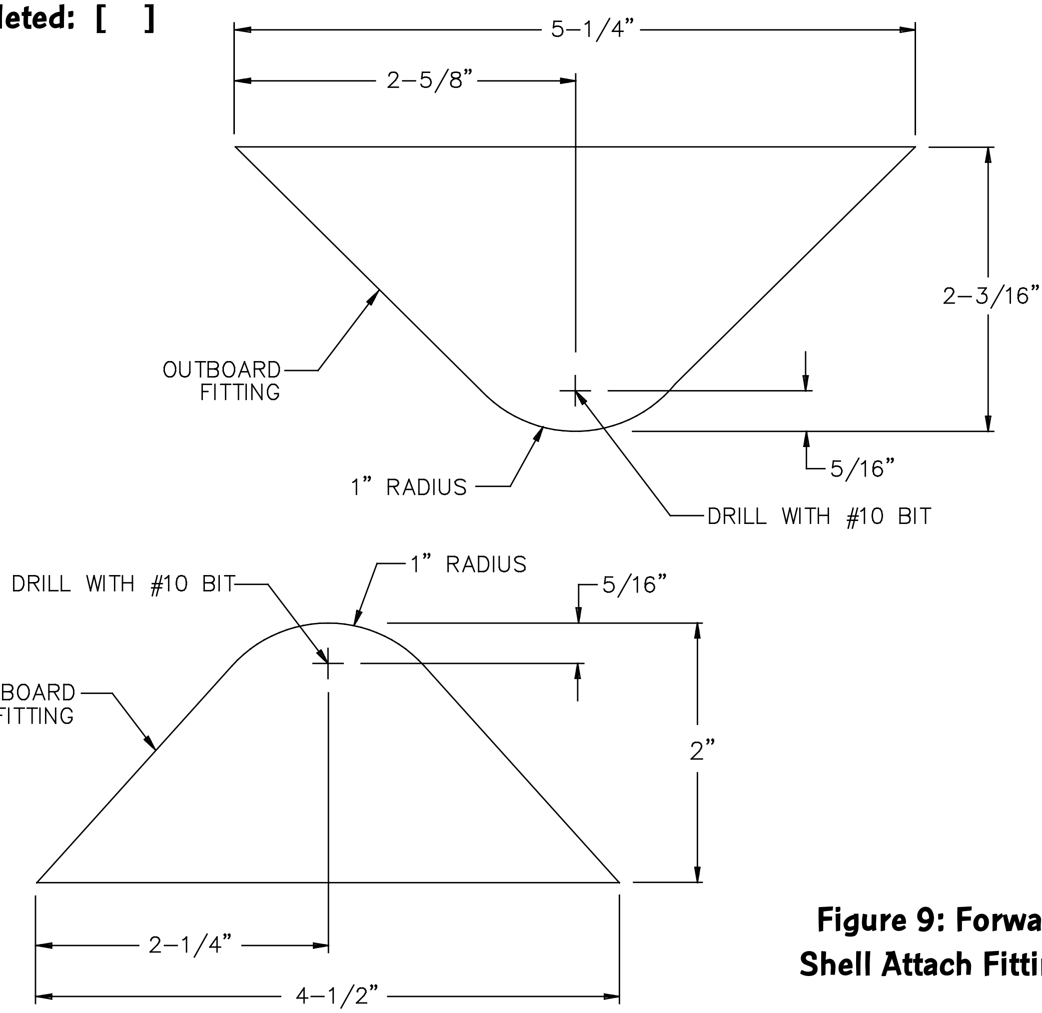

Figure 9: Forward Shell Attach Fittings

EXTERNAL STRUCTURE

Step 13: Press Bushings into the Wing Pivot Lugs on the Cage

Flanged steel bushings must be installed in the wing pivot lugs on the cage. Press an NAS77-7-025 bushing [88] into the upper lug with the flange on top, as shown in Figure 10. The lower lug takes an NAS77-7-019 bushing [87] with the flange on the bottom. Because of the close quarters between the upper and lower lugs, you'll be unable to use a bench vise here; a large C-clamp is probably the best option. As in "SECTION VI: WING ASSEMBLY," the use of Loctite or a similar bushing compound is recommended, both for a tighter press fit and for corrosion protection.

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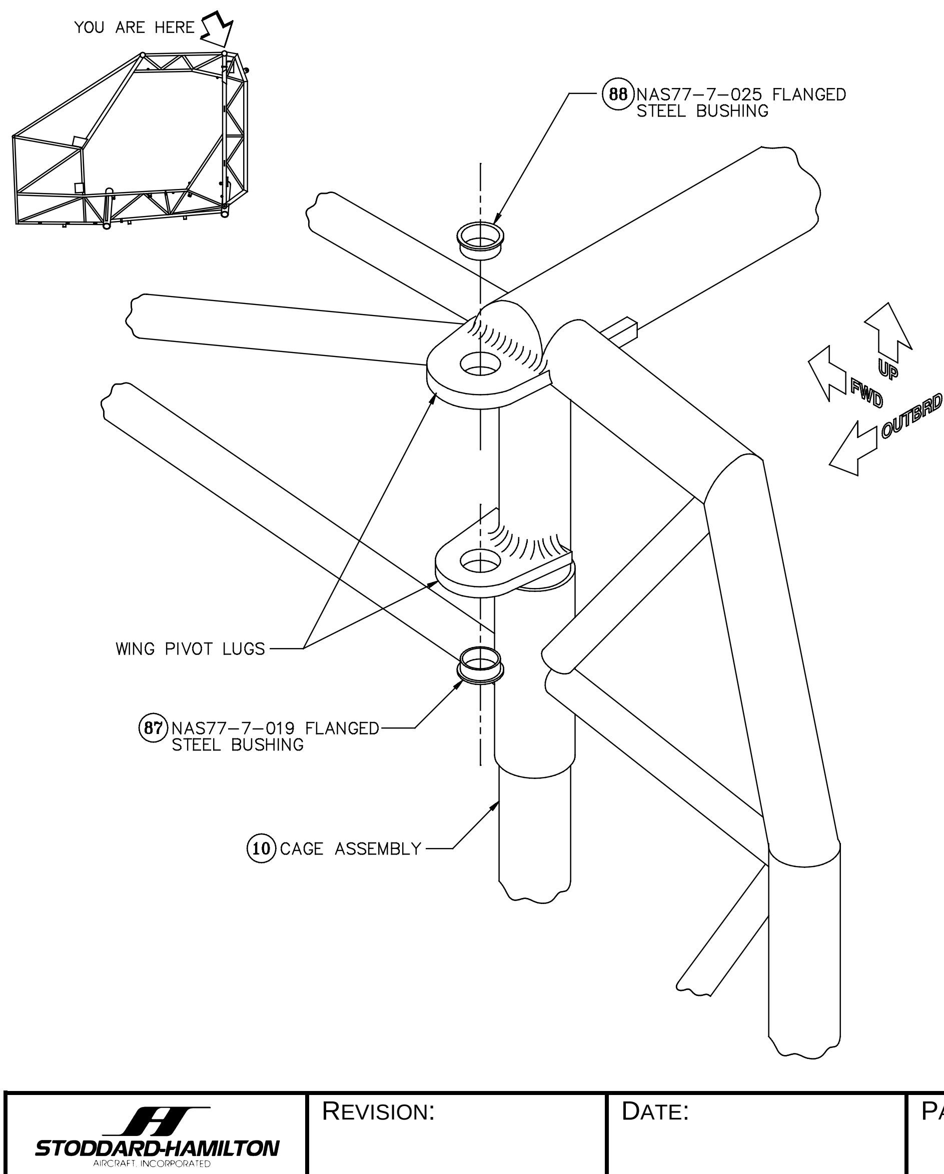

Figure 10: Pressing Bushings into the Wing Pivot Lugs

Step 14: Install the Wing Pivots

As shown in Figure 11, use an AN7-44 **drilled-shank bolt** [69], two AN960-716 **washers** [75], an AN310-7 **castle nut** [44] and an AN380-3-3 **cotter pin** [52] to bolt each wing pivot between the wing pivot lugs on the cage.

> **Note** Remember that the purpose of the wing pivots is to pivot! Grease the assembly prior to securing the bolt and don't overtighten the nut.

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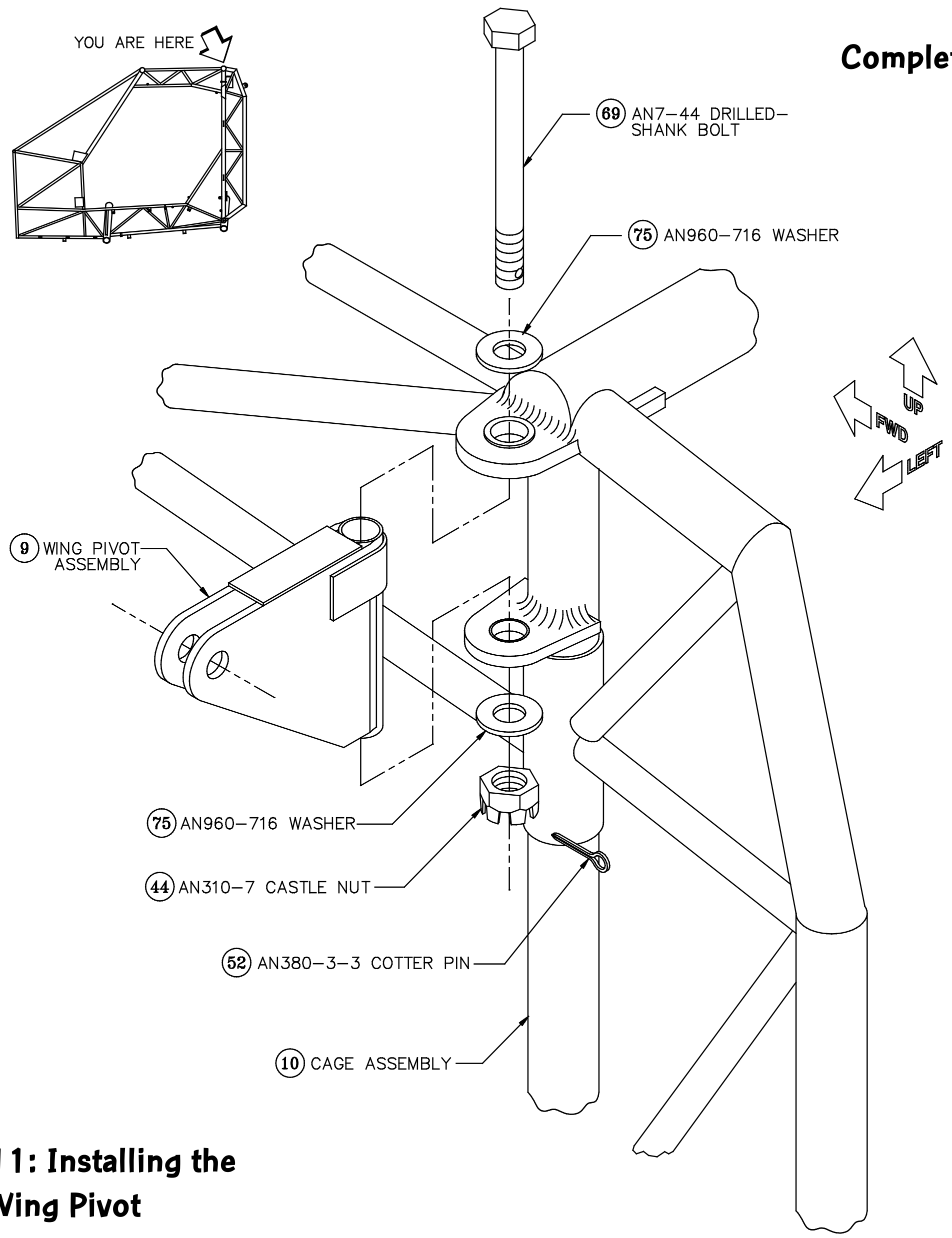
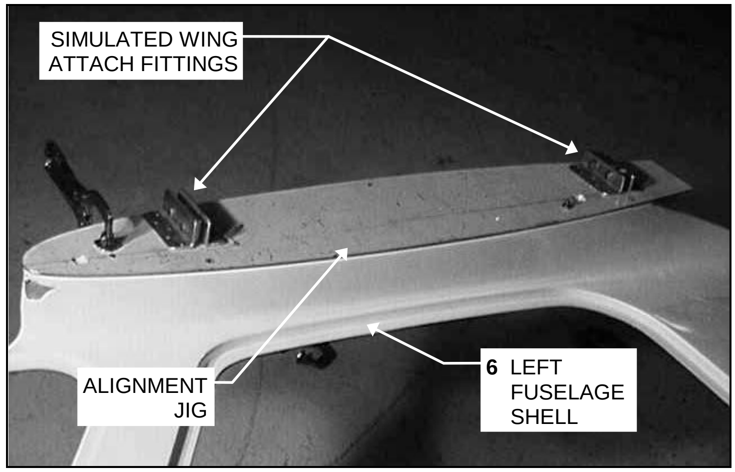


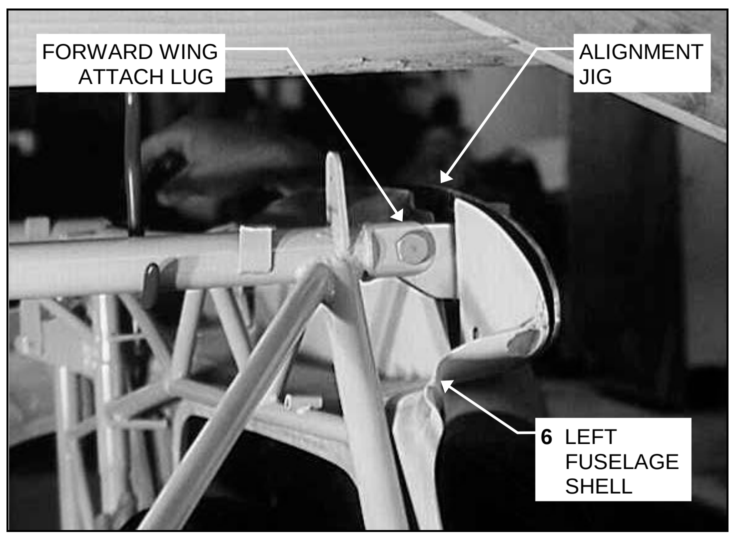
Figure 11: Installing the Wing Pivot

Step 15: Fasten the Alignment Jigs to the Fuselage Shells

In order to hold the fuselage shells in proper alignment with the cage while these components are bolted together, a pair of temporary alignment jigs will be used. These jigs consist of airfoil-shaped metal plates with fittings that duplicate the size and spacing of the attach fittings on the inboard ends of the wing spars. These plates are bolted temporarily to the wing-root portion of the fuselage shells, and then the simulated wing attach fittings on the jigs are bolted to the wing attach lugs on the fuselage cage. The shells are thus held in the proper horizontal and vertical position relative to the cage. The jigs also allow you to set the wing-root portion of the fuselage shells at the proper dihedral angle to match the root rib of the wing.



(a)



(b)

Figure 12: Fuselage Shell Alignment Jig

Figure 12a shows the left-hand jig being bolted to the left-hand shell; in Figure 12b, the left-hand jig, with the shell attached, is bolted to the cage.

> **Note** The shell alignment jigs are available on a rental basis from Stoddard-Hamilton (P/N 981-01000-01). Contact our Order Desk for pricing and availability.

Before the jigs can be mounted on the shells, you must cut away enough of the fiberglass shell to accommodate the simulated wing attach fittings. Vertical scribe lines have been provided on the shells to guide this cutting. To determine how far down to trim, measure the distances on the alignment jig from the lower edge of the airfoil-shaped portion to the simulated wing attach fittings. Transfer these measurements to the wing root area of the fuselage shell and mark horizontal lines between the vertical scribe lines. Use a hacksaw or a saber saw to cut out the material between the vertical lines and above the marked simulated wing fitting lines. These cuts will be enlarged and finished later, so don't worry too much about neatness for now. However, take care not to cut away material where you will drill holes to install the bolts that attach the jigs to the shells. The material to be cut away is represented by the shaded areas in Figure 13.

> **Note** On most of the shell alignment jigs, the guide bushings for drilling the attach holes are located just below the simulated wing attach fittings, as shown in Figure13. For these jigs, you must be careful not to cut the slots too deep; otherwise you will remove material where the attach holes will be drilled. The guide bushings on a few of the jigs are located elsewhere; for these few jigs, you don't have to worry about cutting the slots too deep.

Next, position each jig against the wing root area of the shell with the attach fittings protruding through the slots you just made. Align the jigs fore and aft with the airfoil shape of the shells and vertically by aligning the **lower** edges of the jigs with the lower edges of the shell wing-root area Clamp the jigs in place with C-clamps. Then use the two guide holes just below the jigs' attach fittings to drill **1/4"** holes through the underlying fuselage shells. Figure 13 illustrates these procedures.

Once the holes are drilled, bolt the alignment jigs to the fuselage shells, using 1/4" nuts and bolts—either from the local hardware store or from among the AN4 bolts and AN316 jam nuts supplied with the kit. Remove the clamps.

> **Note** There will likely be some excess fiberglass extending beyond the upper edge of the jigs. Don't sand this off now; it will be trimmed as necessary after the wings are mounted and the top deck is installed in "SECTION X: FINAL ASSEMBLY."

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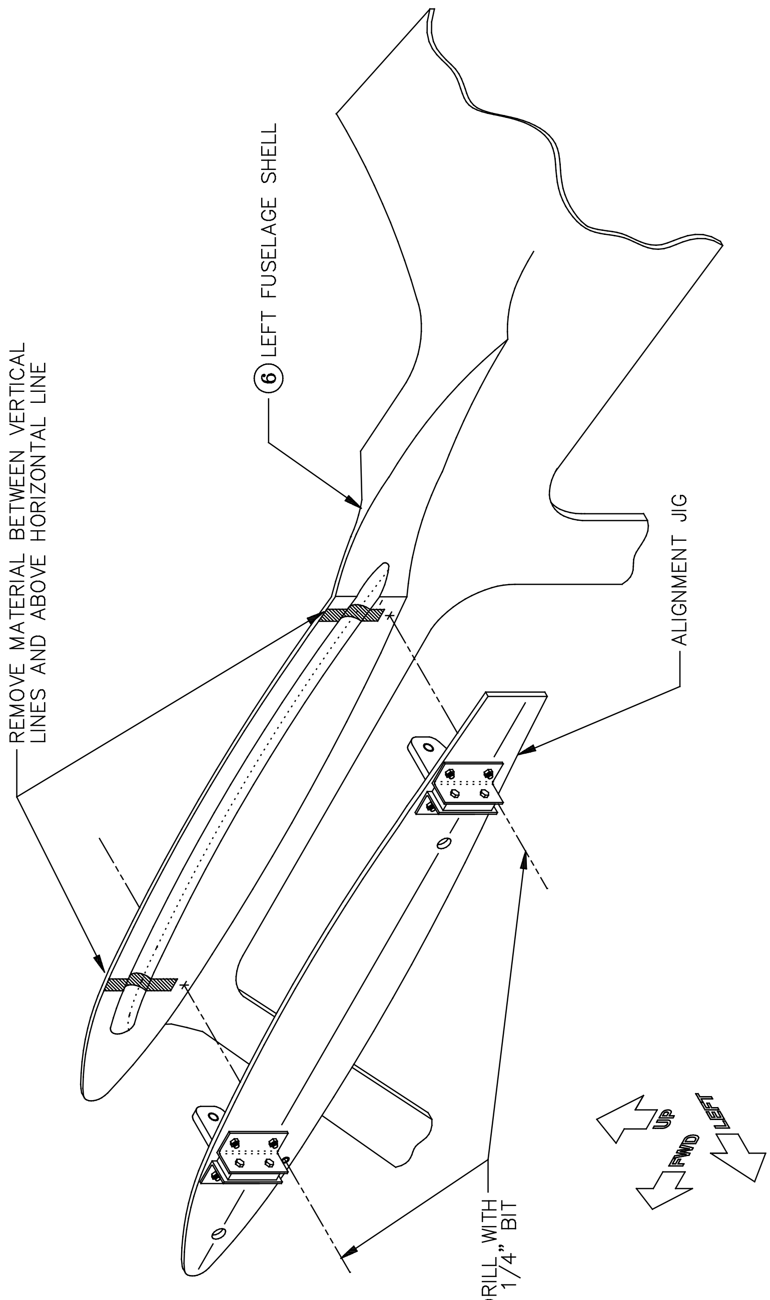

Figure 13: Mounting the Fuselage Shell Alignment Jig on the Shell

Step 16: Mount and Rough-Fit the Shells on the Cage

Hang the fuselage cage on the hanging framework you constructed earlier, with the bicycle hooks on the main cross-tube between the forward wing attach lugs. With the alignment jigs bolted to the shells, mount the jigs on the cage as shown in Figure 12b, using an **forward spar attach pin** [9.1] through the forward spar attach lugs and an AN7-12 **drilled-shank bolt** [68.1] through the aft lugs. There's no need to put a nut on the bolt or safety the pin at this time.

> **Hint** You'll find that the aft ends of the fuselage shells are quite flexible, and this flexibility will make mounting the jigs on the cage difficult without a helper to support the shells. Once you have the jigs mounted on each side, throw a loop of duct tape or a bungee cord around the tail ends of the shells to hold them together temporarily and rest the joined tails on a padded stool or sawhorse to relieve the strain on the jigs.

Once the shells are hung, further relieve the landing gear and wing strut cutouts in the shells as necessary to allow the shells to fit flush against each other along their bottom edges. You will also need to provide some additional clearance for the **unused** gear sockets in the cage—that is the **aft** gear sockets if you are building a **taildragger** and the **forward** ones if you are building a **tricycle**-geared airplane. It's all right for these sockets to contact the shells, but they shouldn't cause the shells to protrude. There are a couple options for providing this relief:

1) If you intend to convert to the alternate gear configuration sometime in the future or, especially, if you intend to switch back and forth, simply make the cutouts for the alternate sockets just as you did for the main ones. These holes and the protruding part of the sockets can easily be concealed with vinyl tape or a small fairing when not in use.

2) If it's unlikely that you'll ever want to convert your GlaStar to the alternate gear configuration, then another option for providing clearance between the unused gear sockets and the shells is to grind or cut a small amount off the bottoms of the sockets themselves. After removing the minimum amount of material necessary to provide the required clearance, use a fine-toothed file to smooth all the cut edges, both inside and outside the socket, and then touch up your corrosion protection.

Warning Removing any more than **1/4"** of material from a socket will render the socket unusable. This will reduce the resale value of your GlaStar, even if you never intend to use the alternate sockets yourself. **Under no circumstances** should you cut off so much of a socket that the cutting contacts the welds between the socket and the adjacent cage tubes. **This effectively makes the option of grinding the sockets useful only for tricycle-geared GlaStars**, because **at least 1/2"** must be removed from the tricycle gear sockets in order for them to clear the shells. We do not encourage this procedure

In addition to the gear sockets, the shell attach tabs may interfere with proper fitting of the shells. There are **fifty-four** of these tabs located at various points around the cage. The tabs in different locations may have slightly different shapes, but a typical one is illustrated in Figure 14.

We have taken stringent measures to assure that the tabs are positioned to meet the fuselage shells properly. Nevertheless, it's possible that some tabs will either stick out too far—and thus interfere with the shells—or be too short—and thus not contact the shell at all. It's the first problem that concerns us here.

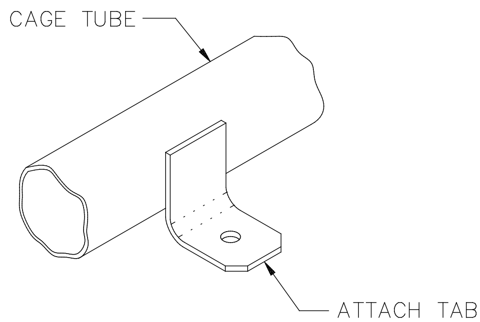

Figure 14: A Typical Attach Tab

If attach tabs that stick out too far (or any other cage interference) prevent you from fitting the shells, rout out some of the foam core to provide clearance. As shown in Figure 15, cut through the inner shell laminate and remove as much foam as necessary to allow the shell to clear the tab. Bevel the edges of the cutout. In Step 19, below, you will apply small, single-layer laminates over these cutouts to strengthen and seal them, so leave enough room for the laminates under the tabs.

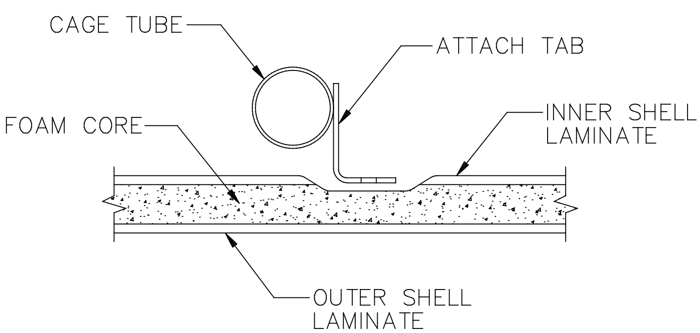

Figure 15: Relieving Interference Between the Shell and the Attach Tabs

Note Any gaps between the shells and the attach tabs on the cage will later be shimmed with nylon washers. To easily set the proper wing-root dihedral angle (as described in the next step) and to provide the best match-up between the wing-root areas of the fuselage shells and the wings, we have found that the shell attach tabs along the bottom front of the cage (at the base of the firewall opening) must be spaced within a single shim thickness from the fuselage shells. In other words, the cage must be as low as possible relative to the shells at the forward end.

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Step 17: Tape the Shells Together and Set the Wing-Root Dihedral Angle

With the shells fitted cleanly around the cage, tape them together along the upper and lower seams with wide masking tape or duct tape. Make sure the shells fit together tightly along their entire lengths without overlaps and with minimal gaps. **Use plenty of tape!** Begin at the forward end of a seam and work aft, laying short pieces of tape **across** the seam and lapping each piece over the preceding one.

Note In order to pull the shells together cleanly, you may have to provide additional relief around landing gears sockets and/or attach tabs that interfere. Repeat the processes described in the previous step as necessary .

Next, check to see whether the fuselage is level laterally by placing a level on the main cross-tube between the forward wing attach lugs. Place shims between the top tube of the cage and the hanging hooks or under the legs of the hanging framework as necessary to bring the whole assembly level.

The next step is to set the angle of the wing-root areas of the shells to match the dihedral angle of the wings. This requires raising the shells slightly, because their own weight hanging from the framework tends to reduce this angle.

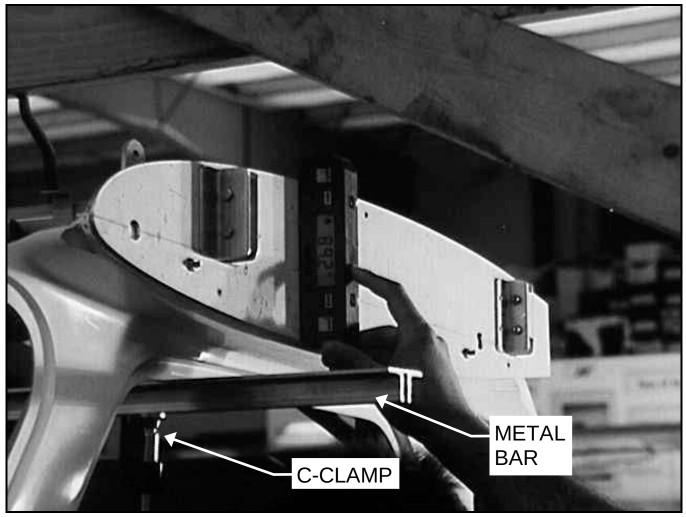

Figure 16: Setting the Dihedral Angle of the Shell

Figure 16 shows the method for raising the shells (and thus setting the angle), as well as the method for checking your results. In the former, a rigid metal bar or board is inserted through the door openings and drawn upward against the shells with a pair of C-clamps attached to the top cross-tube of the cage assembly. When some of the tension on the alignment jigs has been taken up by the clamps, you can check the resulting dihedral angle with a digital level. The target value is **1.5° off the vertical**, with the tops of the jigs angled **inboard**.

Note Once again, you may have to rout out more material around any overly long shell attach tabs in order to obtain the proper angle. It's also acceptable to relieve the insides of the shells anywhere else that interference with the cage occurs. Relieve the shells enough to leave space for a one-layer patch laminate that will be applied in Step 19.

Note Be sure to check the angle on **both** sides! Try to bring both angles to the correct figure (within the limits of your level's accuracy), but don't lose too much sleep if you are unable to make it perfect; this procedure does **not** affect the actual dihedral of the wing, but rather only the match-up of the wing-root area of the shells with the root rib of the wing. Therefore, any inaccuracies have only aesthetic effects, not aerodynamic ones.

Hint If you don't have a digital level, you can check the angle with a spirit level and a little trigonometry—and we've even done the trig for you! This method requires two small scraps of sheet aluminum from your sheet metal practice kit, one piece of **.040"** and one piece of **.032"**. The pieces can be any size or shape as long as they each have at least one straight edge about 2" long.

As shown in Figure 17, tape the two sheet scraps to the alignment jig, one on top of the other, with their straight edges aligned and exactly **2-3/4" above** the chordwise line on the jig. Then, place one end of your spirit level **on** the chordwise line and rest the body of the level on the scrap metal shims. When the jig is at 1.5°, the thickness of these shims and their distance from the end of the level will cause the bubble to be centered.

Once the proper dihedral angle has been achieved, unfasten the bolts holding the alignment jigs to the shells. (Keep the jigs bolted to the cage, however.) If you have supported the shells adequately from the bottom and through the door cutouts, releasing these bolts should have no effect on the angle of the wing-root areas of the shells. If, on the other hand, the removal of these bolts causes the angle to relax and the lower edges of the wing-root areas to sag below the lower edges of the alignment jigs, then you haven't provided enough support to the shells. Replace the bolts and repeat the process described above until the specified angle can be maintained with the bolts removed.

Note If only the lower **leading edges** of the wing-root areas of the shells sag below the jig when the specified dihedral angle remains with the bolts removed, you've done all you can for now. After the wing spar slots in the shells are enlarged to accept the ends of the spars, as described in the SYSTEMS INSTALLATION section, the wing leading edge portions of the shells become quite flexible and can be easily pulled up when the top deck is installed in FINAL ASSEMBLY. Also, as mentioned previously, matching the wing-root areas of the shells to the wings will be further simplified if the cage is kept as low as possible relative to the shells at the forward end.

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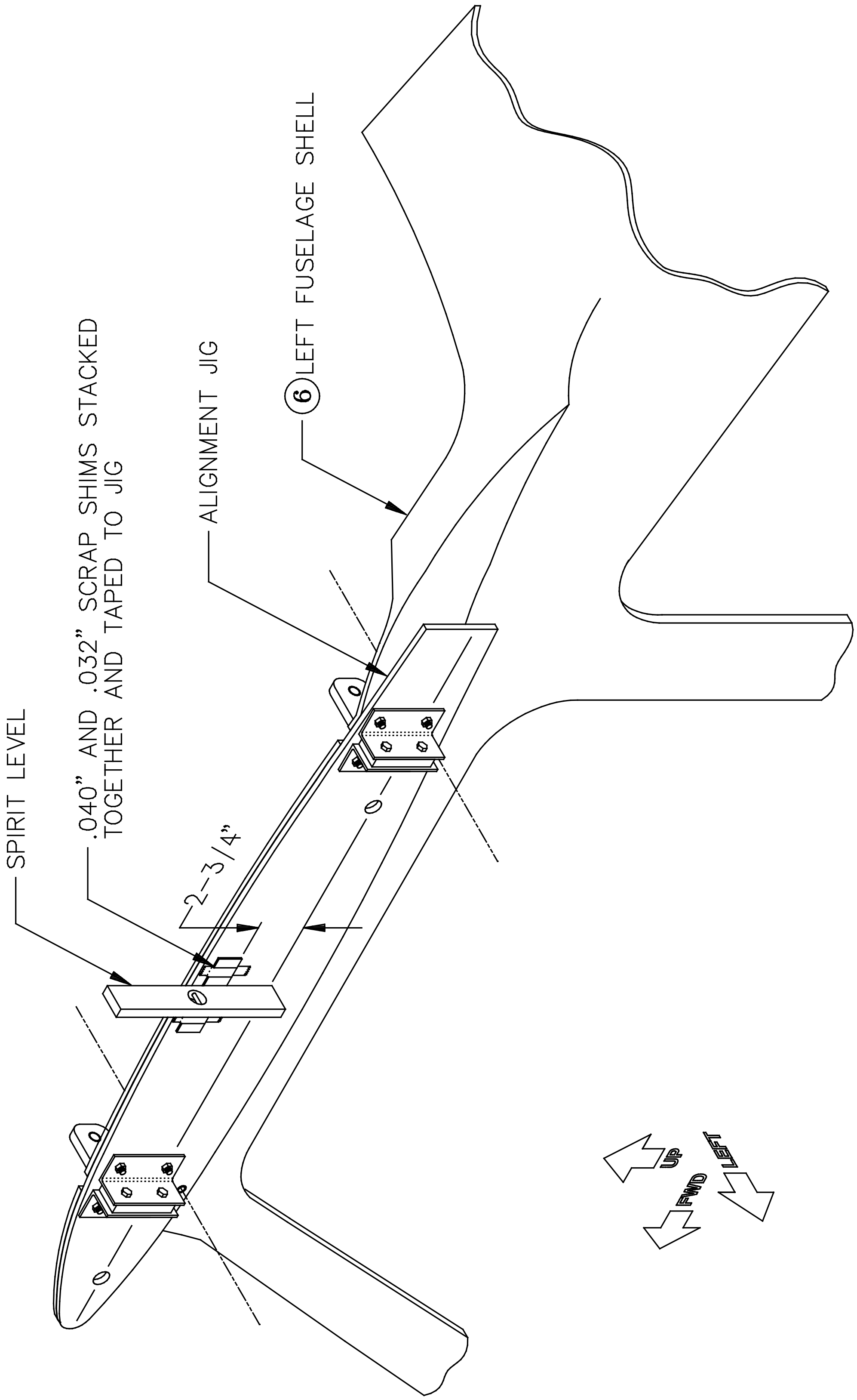

Figure 17: Alternate Method of Checking the Dihedral Angle of the Wing-Root Areas

Step 18: Drill the Holes for the Cage Floor Hardpoints

The shells are secured to the cage assembly with machine screws through the attach tabs. There are a total of **forty-six** tabs that contact the fuselage shells; their locations are shown in Figures 19 and 22. (Eight more tabs contact the top deck, which will be installed in "SECTION X: FINAL ASSEMBLY.") All of these tabs except Tabs 21 and 25 lie over areas of the shells that consist of a foam core sandwiched between inner and outer fiberglass laminates. Before installing screws through these forty-four tabs, it's necessary to provide hardpoints within the foam core to take the crush loads associated with the screws. (Tabs 21 and 25 lie over the belly seam between the two shells where there is no foam core and therefore no need for hardpoints.) These hardpoints are produced by routing out a small cylinder of foam between the inner and outer laminates of the shell and then injecting a moderately thick mixture of vinyl ester resin and **Q-cell** [38] into the void.

Note The attach tabs on the **bottom** of the cage (shown in Figure 19) will be secured to the shell first; the position of the shell can then be fine-tuned vertically by adjusting the thickness of the shims between the cage tabs and the shell. Once you are satisfied with the vertical position of the shell relative to the cage, the holes for the **side** attach tabs (shown in Figure 22) will be drilled and the side fasteners installed.

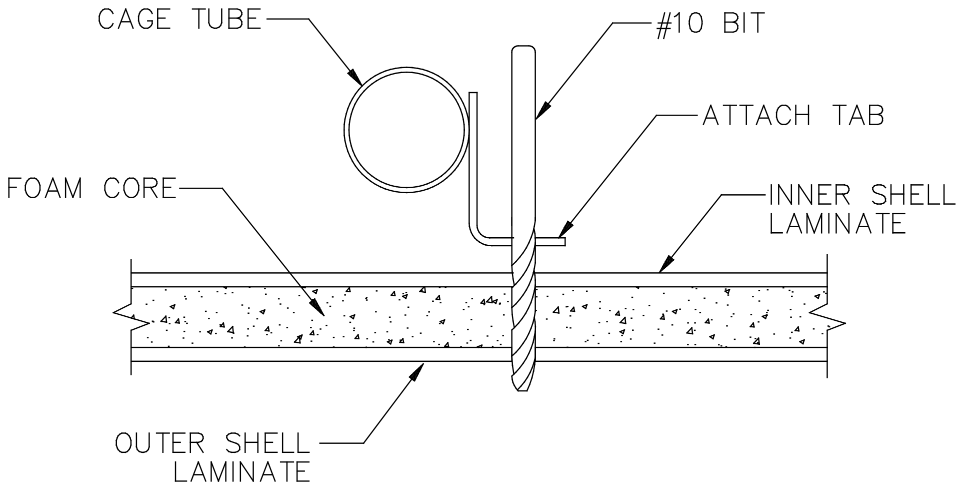

Figure 18: Drilling the Initial Attach Tab Hardpoint Holes

The first step in making the hardpoint voids is to drill through each of the twenty-eight attach tabs on the floor of the cage with a **#10** bit; these are Tabs 17–46 in Figure 19, **excluding** Tabs 21 and 25. As shown in Figure 18, use the holes in the tabs as guides and drill **all the way through** the fuselage shells. You can drill the tabs in any order, but refer to Figure 19 to make sure that you don't miss any.

Note Later cages may have fewer attach tabs than earlier ones. Don't worry if you can't account for all the tabs shown in Figure 19. Simply use them as guides to drill through all the tabs you do have in a systematic fashion.

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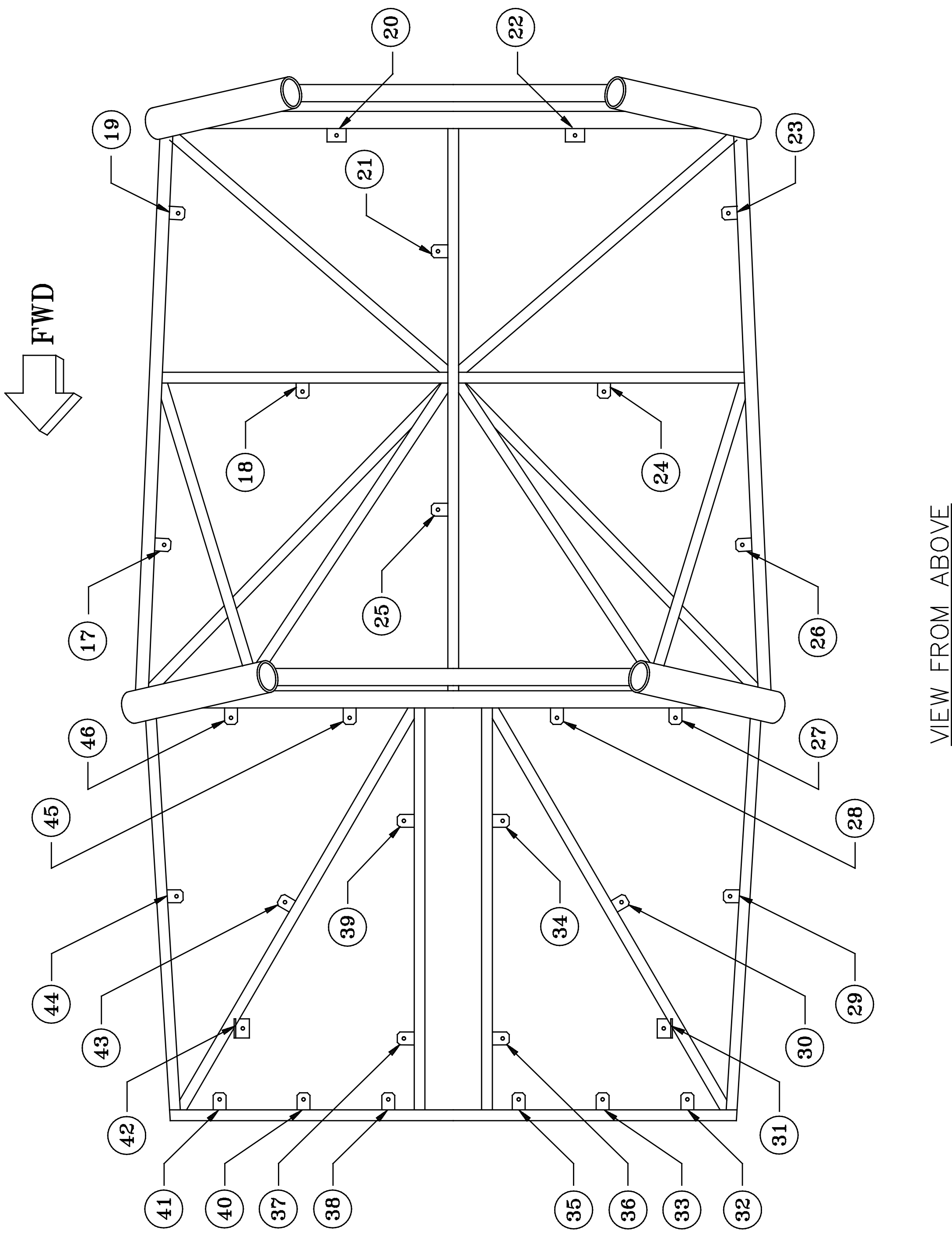

Figure 19: Attach Tab Locations (Cage Floor)

Step 19: Finish the Floor Attach Tab Hardpoints

Now, you can rout out the hardpoint voids and fill them with Q-cell. First, however, you must replace the inner laminate at any location where you relieved the shell to fit the cage. To facilitate this, temporarily unbolt the alignment jigs from the cage and lower the shell a bit to open up space between the shell and any interfering part of the cage. Then, sand the relieved areas smooth and apply a single layer of resin-saturated cloth over each one. The cloth should extend roughly **3/4"** onto the original inner laminates all the way around the relieved area. Work the cloth down into the indentation in the foam core and lap it over the inner shell laminate. Let the patch laminates cure.

In order to rout out the foam to create the hardpoint voids, begin by making a **3/8", right-angle bend** in a piece of piano wire of at least **.050"** diameter. (A bent nail with the head cut off works fine, too.) Chuck the wire in your drill and, as shown in Figure 20, angle the bent wire tool roughly into the center of each of the #10 holes you drilled through the shell and then bring the drill vertical. Run the drill and move it up and down until all the foam in a 3/4" cylinder around the hole has been loosened. Use a shop vac to clean the loose foam particles from the hole.

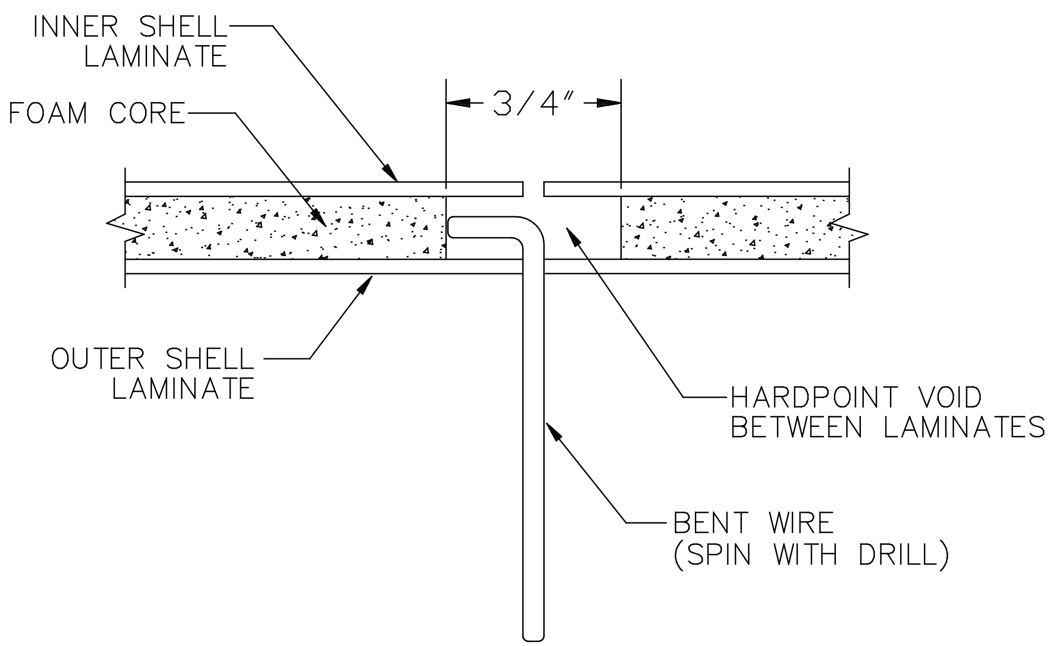

Figure 20: Routing Out the Foam Core for the Attach Tab Hardpoints

Caution Don't remove any of either the inner or outer shell laminates; just remove the foam! Also, do **not** use a high-pressure air hose to blow the loose foam out of the hardpoint voids. The core is a low-density foam, and a high-pressure air stream directed into a hardpoint voids will completely destroy the foam in an area several inches square surrounding the void.

Once all the holes have been routed and vacuumed, mix a moderately thick batch of Q-cell according to the directions in "SECTION II: TOOLS AND TECHNIQUES, FIBERGLASS LAMINATING, *Q-Cell and Mill Fiber Mixture*." When thoroughly blended, use a syringe and a large-gauge hypodermic needle to inject the Q-cell mixture into the voids from the outside. Put a small piece of tape over each #10 hole on the inside of the fuselage to prevent the Q-cell mixture from oozing out the top. Use care to ensure that the entire void is filled with Q-cell; air bubbles inside the hardpoints will defeat their purpose. You may find it helpful to drill a **1/16"** vent hole through the inner fuselage laminates about halfway between the middle and the edge of each hardpoint void. When Q-cell mixture squirts out this vent hole (assuming the #10 hole is taped), then the void is full. Put a tape over the outside of each filled hole to prevent the mixture from running out and let it cure fully.

When the Q-cell hardpoints have fully cured, re-drill the #10 holes through the shell from the outside (again excluding Tabs 21 and 25; see Figure 19).

Note As mentioned above, resin always shrinks slightly in the process of curing, and the resin/Q-cell mixture in the hardpoints is no exception. This is likely to produce a very slight concavity on the outside shell laminate over each hardpoint. This is unavoidable, but it can be minimized by catalyzing the Q-cell with no more than 1% MEKP. When the machine screws are installed, most of these slight depressions will be almost imperceptible.

Hint The needle and syringe used to inject the Q-cell mixture can be obtained from the veterinary-supply section of your local feed store; grind off the needle's point for safety. Stoddard-Hamilton sells a five-pack of 5 cc plastic syringes (but not the needles) that are ideal for the purpose; order P/N 270-0190-001.

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Step 20: Fasten the Shells to the Cage Floor

With the hardpoints for the cage floor ready, reposition the shells relative to the cage, re-bolt the alignment jigs to the cage and re-establish the dihedral angle of the wing-root areas just as you did in Step 17. If necessary, bend the attach tabs to make sure they are parallel with the shells.

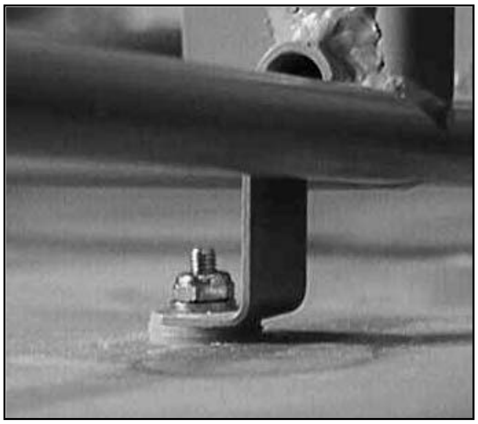

Figure 21: Nylon Washer Shims

The shells are fastened to the cage with AN507-10R16 and -10R20 **flush-head machine screws** [62 and 63] through the attach tabs. Due to slight variations in the placement of the tabs and the thickness of the fuselage shells, there may be gaps of between 1/32" and 5/8" between the tabs and the shells. These gaps are **not** structurally important; as shown in Figure 21, they are easily bridged with **nylon washers**. The kit contains an ample supply of these washers in thicknesses of .032" [26] and .064" [27].

Install the screws as follows: first, countersink each hole on the **outside** of the shell to accommodate a screw. Test your microstop countersink tool on some scrap material to make sure the depth is correct. Particularly avoid countersinking too deeply. Second, insert as many nylon washers as necessary (if any) to completely fill the gap between each tab and the shell; follow up with a screw of appropriate length. Finally, secure the screw with an AN364-1032A **nylon self-locking nut** [46] and one or more AN960-10 **washers** [70] or -10L **thin washers** [71]. At a minimum, one-and-a-half threads of each screw should be visible beyond the nut; screws that protrude more than this can be left as is or can be ground or cut off closer to the nut at your discretion.

> **Note** Be careful to avoid over-tightening these nuts. They should certainly be tightened with a wrench, but because they are so small, they are easy to over-torque. The consequence of this will be a very evident depression of the outer shell surface around the screw head.

Note If you are installing a transponder and/or DME, you will need to install one or more aluminum ground planes, and we have found the inside of the fuselage shell between the shell and the cage to be a convenient location for this. See the article in the Fourth Quarter 1996 issue of the *Stoddard-Hamilton News*, No. 63, for a discussion of the ground plane installation.

Note Be sure to leave **Tabs 21 and 25** (the two tabs on the **center, bottom tube**) undrilled at this point. These tabs cannot be drilled and secured until after the fuselage shells have been seamed together.

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Step 20.1: Fasten the Shells to the Cage Side Attach Tabs

With the cage floor fasteners all installed, verify that the wing root portions of the shells remain at the proper dihedral angle, as described in Step 17. If necessary, fine-tune the shell's position relative to the cage by adjusting the thickness of shims under the cage floor attach tabs.

Note As mentioned previously, to provide the best match-up of the shells to the wings, the cage must be as low as possible relative to the shells at the forward end.

When satisfied, drill the fastener holes, rout out and fill the hardpoints, and install the fasteners for the cage **side** attach tabs (Tabs 1—16 in Figure 22), using the same procedures described for the floor attach tabs in Steps 18—20.

Note As with the floor attach tabs, later cages may have fewer side attach tabs than earlier cages. Don't worry if you can't account for all the tabs shown in Figure 22.

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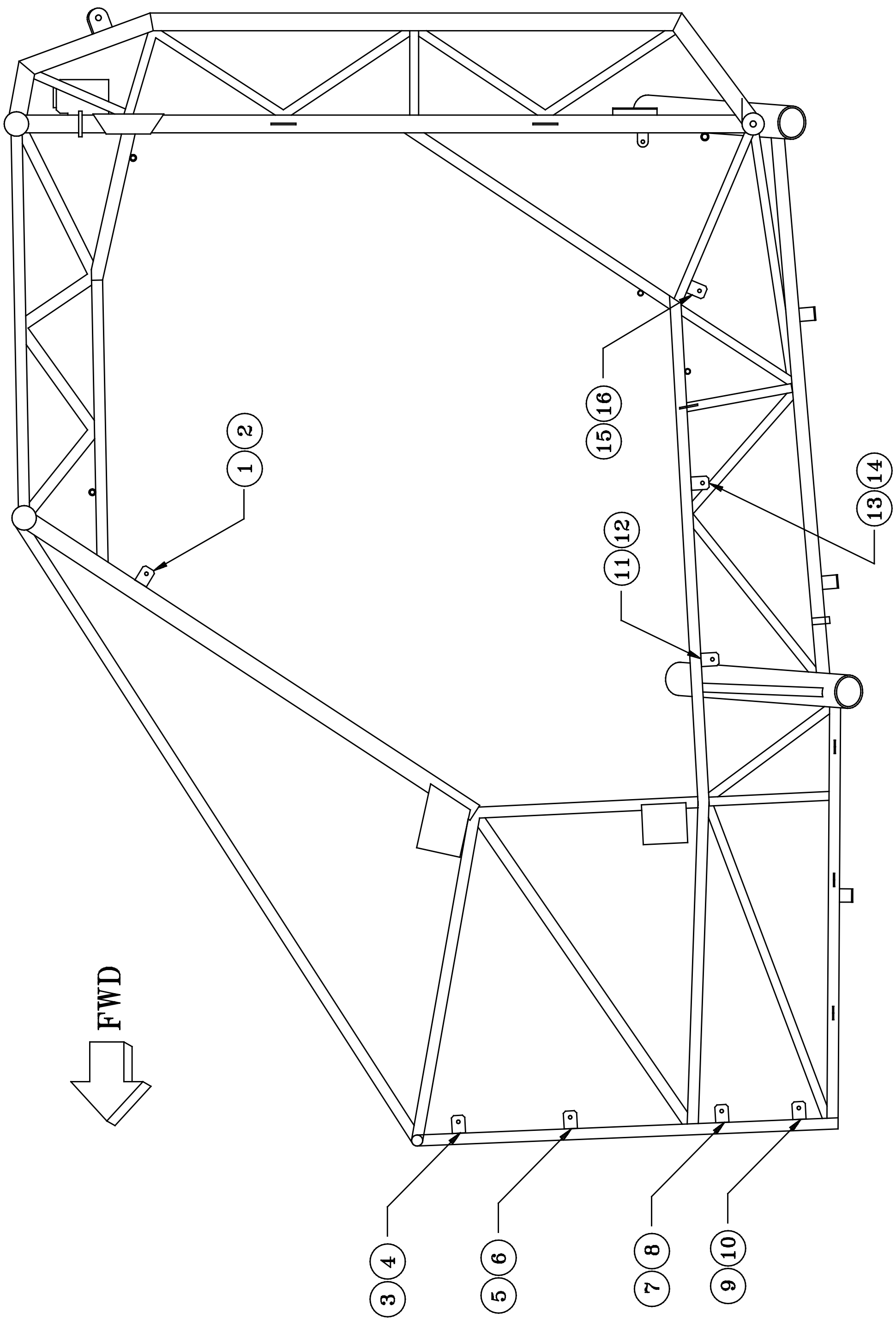
Note At this time, the fuselage alignment jigs can be unbolted from the fuselage shells and returned to Stoddard-Hamilton.



SIDE VIEW

Figure 22: Attach Tab Locations (Cage Sides)

Step 21: Lay Up the Belly Seam

Hint This step really requires an assistant, and a pair of them is even better. It's important to complete the step before the resin begins to cure, and this demands some quick work. Regardless of how many hands are at work on the job, make sure you have all the required tools and materials ready to go at the start.

The fuselage shells are seamed together with a single-layer laminate of **3"-wide DBM cloth** [16] laid the entire length of the shells. A short, two-layer laminate is used to reinforce the center aft cage attach point. Begin by cutting two pieces of DBM, one **222"** long and one **7"** long. Next, check to see that the shells are still taped together as tightly and flushly as possible.

The most effective way to laminate the seam is to saturate the cloth with resin on a table and then to pull it into place along the seam with a string. The ideal situation is to have a small (say, 2' X 4'), portable table covered with plastic sheet that you can place immediately in front of the fuselage.

Note The plastic sheet is simply to ease clean-up, and is entirely optional if you're willing to sacrifice your table top. Avoid styrene-based plastics, as the resin will melt them.

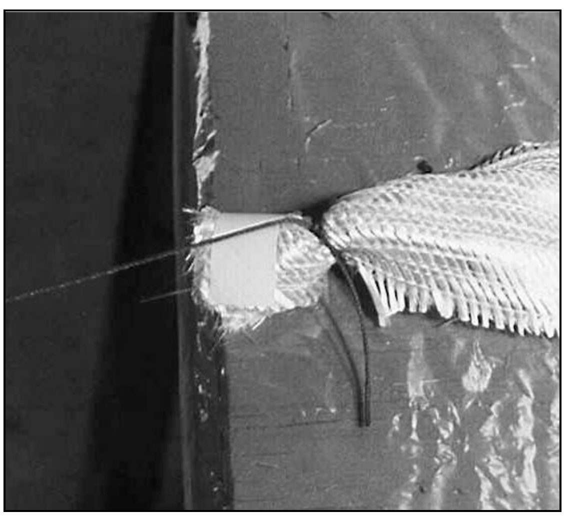
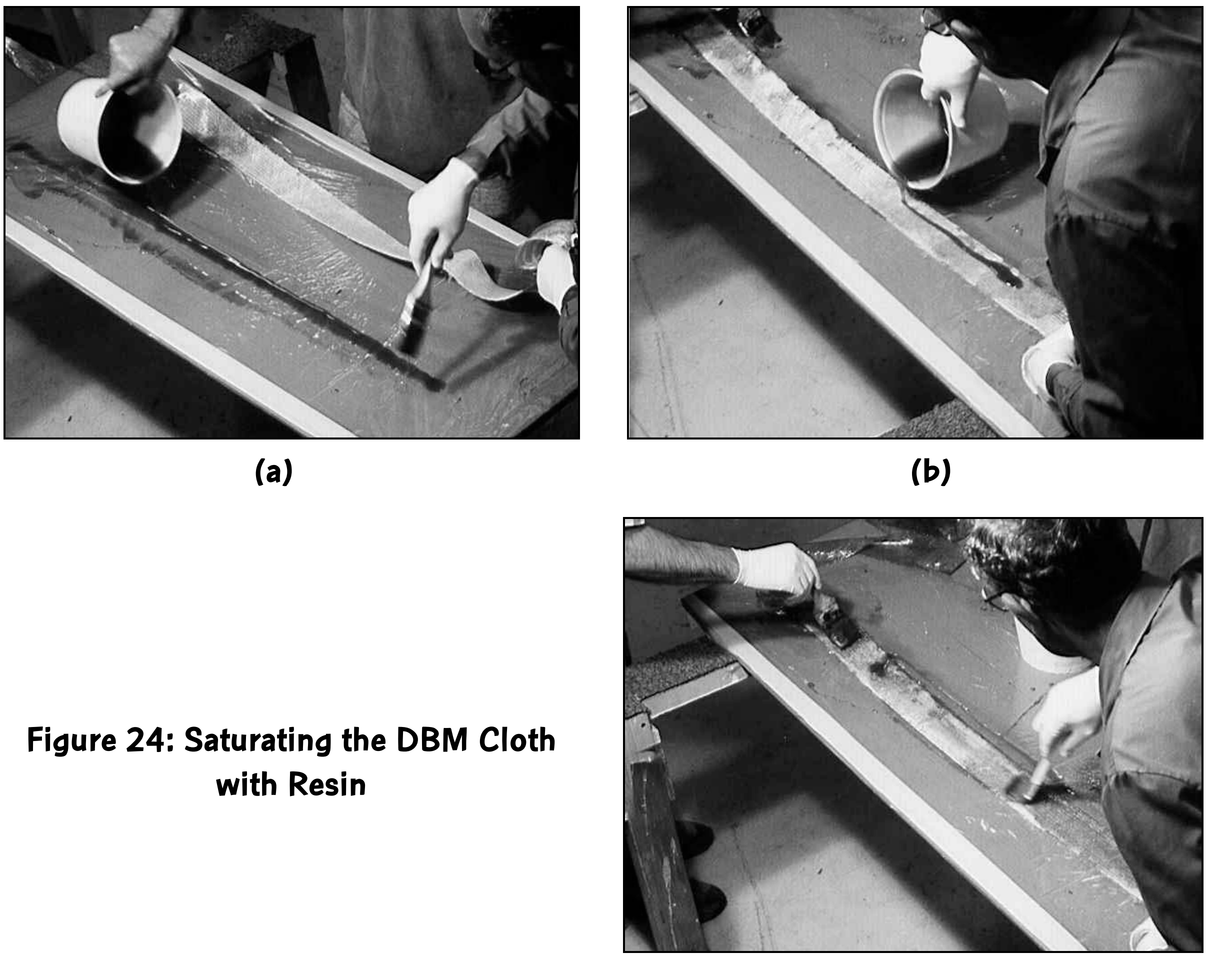


Figure 23: Tying a String to the DBM Cloth Strip

Begin the process by making sure that the seam joggles on both fuselage shells are free of dust, dirt, oil or other contaminants. Wiping the seam areas with acetone is a good way to ensure this. Next, run a stout piece of string through the fuselage and under the cage from the tail to the firewall. Tie the forward end of this string tightly to one end of the long strip of DBM cloth, as shown in Figure 23. Next, measure and catalyze a **750 gram** batch of resin.

The three panels of Figure 24 show how to saturate the DBM. First, pour a line of catalyzed resin directly onto the table top (Figure 24a). Then, beginning with the forward (untied) end of the DBM strip, lay the cloth directly on top of the line of resin and pour an additional line of resin on top of the cloth (Figure 24b). Finally, use a brush to impregnate the cloth with the resin (Figure 24c). Spread the resin liberally, but don't spend too much time trying to achieve perfect saturation of the cloth. You will have further opportunities to work the resin into the cloth once it's in place inside the fuselage.



(a) **(b)** **(c)**

Figure 24: Saturating the DBM Cloth with Resin

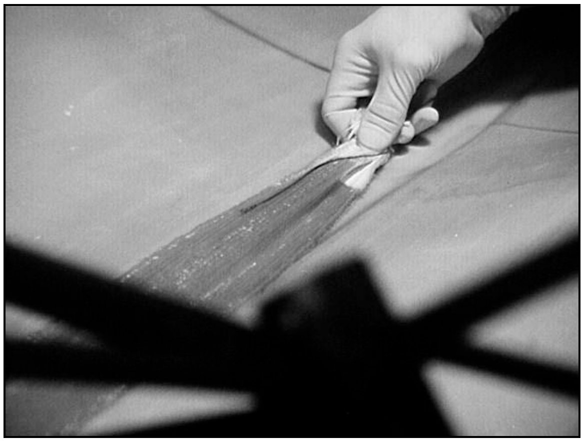
Figure 25: Rolling Up the DBM Cloth

Once you have saturated one table's length of DBM, roll up the impregnated cloth as shown in Figure 25, and then repeat the process until the entire length of DBM is saturated and rolled up. However, don't saturate the very end of the cloth where you tied the string; if it gets wet, the string is liable to slip off. Place the roll on the table at the forward end of the fuselage.

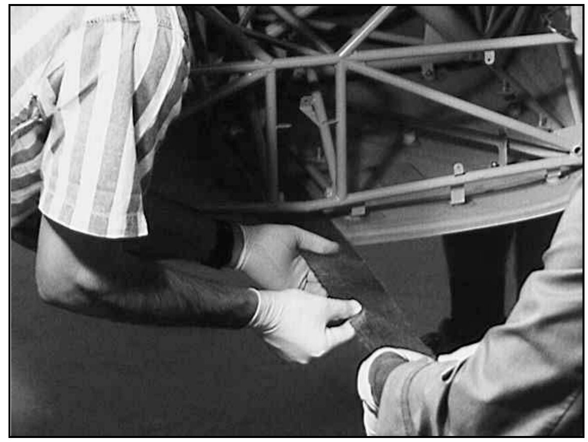
The DBM has a definite top and bottom. The top surface has a very smooth, orderly appearance, with the major strands all lying at 45° to the length of the cloth. The bottom side appears chaotic, with strands lying at all angles. This bottom side—the so-called "mat" side—should be placed down against the shells for the best bond.

As shown in Figure 26a, lay the aft (tied) end of the DBM in the seam joggle at the forward end and slowly guide it aft. Once you've gotten it started, have an assistant pull the strip through with the string while you unroll and guide the cloth at the forward end, as shown in Figures 26b and c.

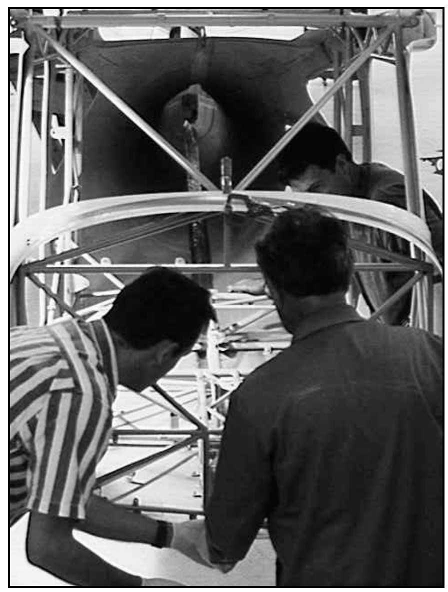
Hint While you're unrolling the DBM, it's likely that strands of cloth along the edges will come loose and get entangled with one another as you try to smooth out the cloth. Have a pair of scissors handy to snip these off as they appear, and you'll avoid a big mess.



(a)



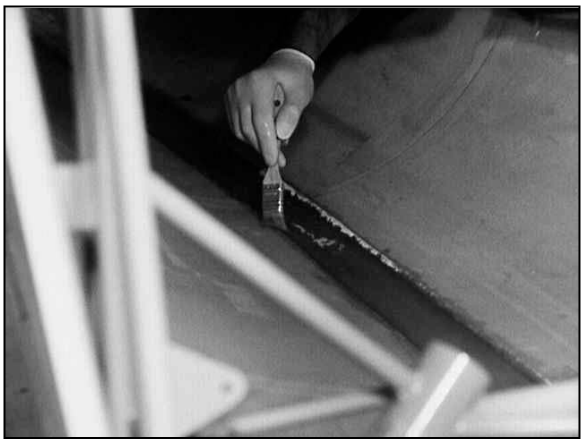
(b)



(c)

Figure 24: Feeding the DBM Cloth Through the Fuselage

Once the cloth is laid out along the full length of the belly seam, make sure it is centered in the seam joggle, adjusting it left or right as necessary. As shown in Figure 27a, use a brush to ensure that the cloth is fully saturated and lying flat against both shells at all points. Use a stippling motion to remove air bubbles trapped under the cloth. To reach the aft portions of the seam that are not easily accessible through the door or baggage door cutouts, secure a brush to the end of a sturdy dowel or piece of tubing or angle stock, as shown in Figure 27b.



(a)

(b)

Figure 27: Finishing the Belly Seam Laminate

When you're finished with the main seam laminate, saturate the 7" piece of cloth and apply it on top of the main laminate at the location shown in Figure 28. The reinforcement strip should **extend aft from about 2" forward** of the aft-most, bottom tube of the cage.

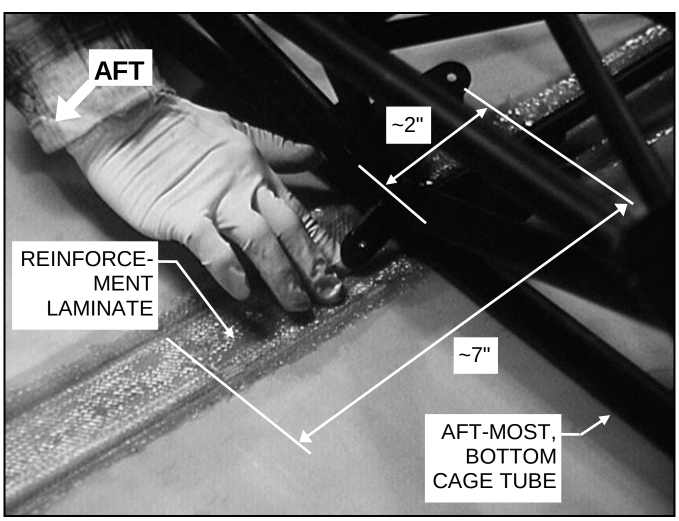


Figure 28: Applying the Center Aft Reinforcement Laminate

Finally, after the reinforcement laminate has been applied, trim both ends of the main DBM laminate to within about 1/4" of the forward and aft ends of the fuselage shells, as shown in Figure 29. It will be easier to trim these ends with greater precision after the laminate has cured. Also, clean up any resin on the cage with acetone or lacquer thinner (but only **after** checking to make sure the solvent doesn't take the paint off)! Keep an eye on the laminate until the resin begins to cure, because bubbles may form during this process even after you thought you'd gotten them all. Let the laminate cure overnight, and then sand any ragged edges smooth.

Completed: [ ]

Figure 29: Trimming the DBM Cloth

Step 22: Mark the Fuselage Centerline

For a number of subsequent steps, you'll need to refer to a marked centerline on the floor of the aft fuselage. Although it may appear to be so, the seam line between the left and right fuselage shells is **not** a reliable centerline. A simple way to establish this line is to sight along a string that has been stretched taut between two points in the forward portion of the fuselage known to be on the centerline.

Begin as shown in the upper panel of Figure 30 by marking the midpoint of the bottom cross-tube at the forward-most end of the cage. Tie a string around this tube on the midpoint. Then run it aft through the hole in the seat track attach tab located on the center tube at the aft end of the cage, as shown in the lower panel of the figure. Run the remaining string through the fuselage and out the aft end.

Then, from the aft end of the fuselage, pull the string taut. Sight forward along the string and move it left or right as necessary until the string aft of the seat track attach tab is perfectly aligned with the string forward of the tab. Mark the string's position at several locations in the aft fuselage, and then use a straightedge to connect these points.

Hint Because the string is several inches above the fuselage floor in the aft fuselage, you'll have to either drop a plumb line or stand a square or ruler alongside the centerline string to mark its location accurately.

Completed: [ ]

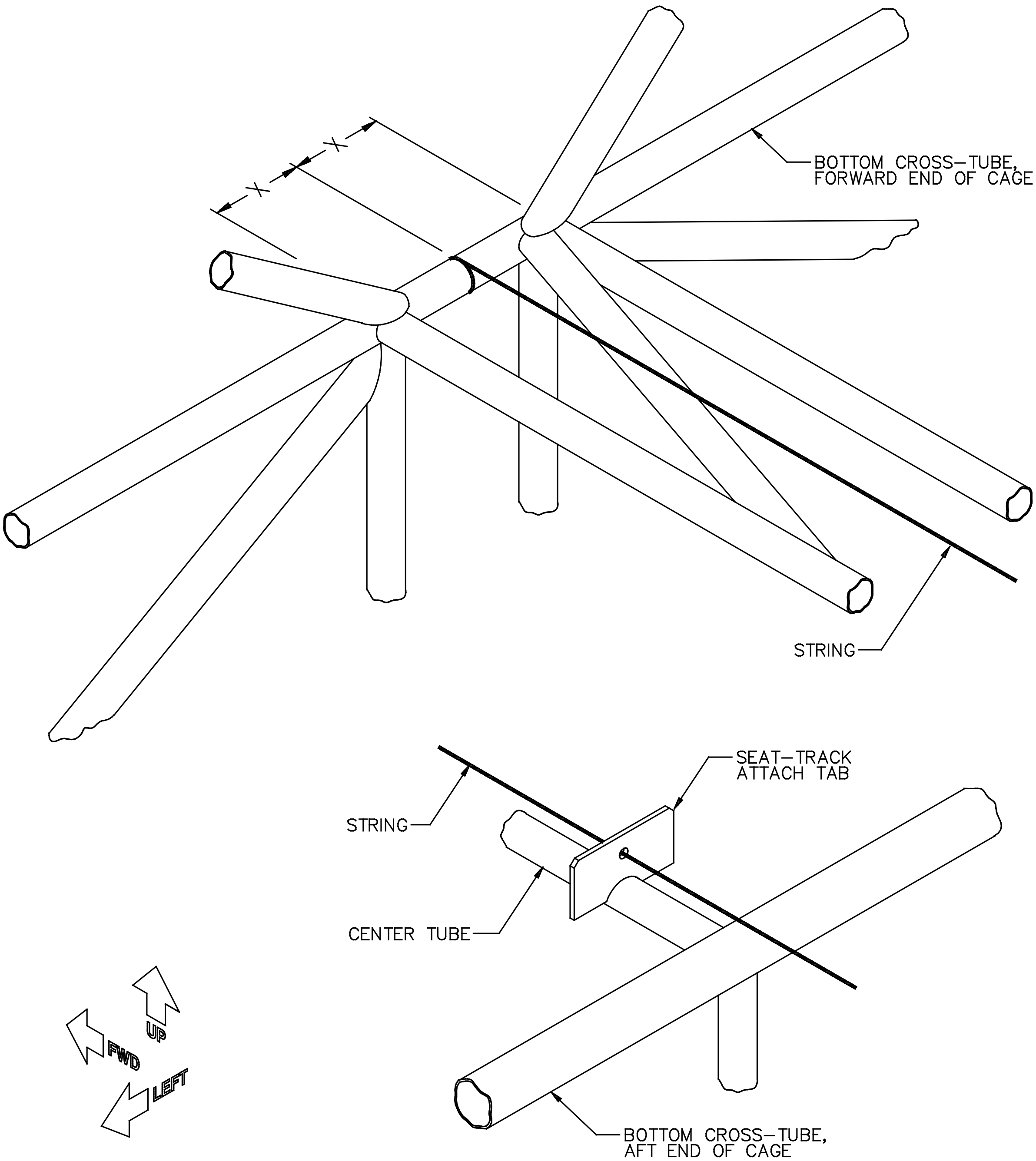


Figure 30: Setting Up the Centerline String

Step 23: Plumb the Vertical Fin

In the next step you will invert the fuselage and lay up the dorsal seam, but before doing so, you need to assure yourself that you have taped the shells together evenly so that no twist has been introduced into the vertical fin.

Begin by checking again to see that the fuselage is still level laterally. Use a level on the major cross-tube between the forward gear sockets as you did in Step 17 and shim the hanging framework as necessary to bring the cage level.

Once you're satisfied that the fuselage is level, drop a plumb line from the forward end of the top of the vertical fin to the centerline you marked on the tailcone floor, as shown in Figure 31. Obviously, it's good news if this falls right on the centerline. If it's off, then you'll have to untape the dorsal seam, realign the shells, retape, and try again.

Hint In the next step you will be instructed to turn the entire fuselage assembly over in order to laminate the dorsal seam. Therefore, you definitely want to make sure that the shells are securely taped along this seam. Remember, use short pieces of wide masking tape or duct tape laid **across** the seam, each piece overlapping the one before it.

Completed: [ ]

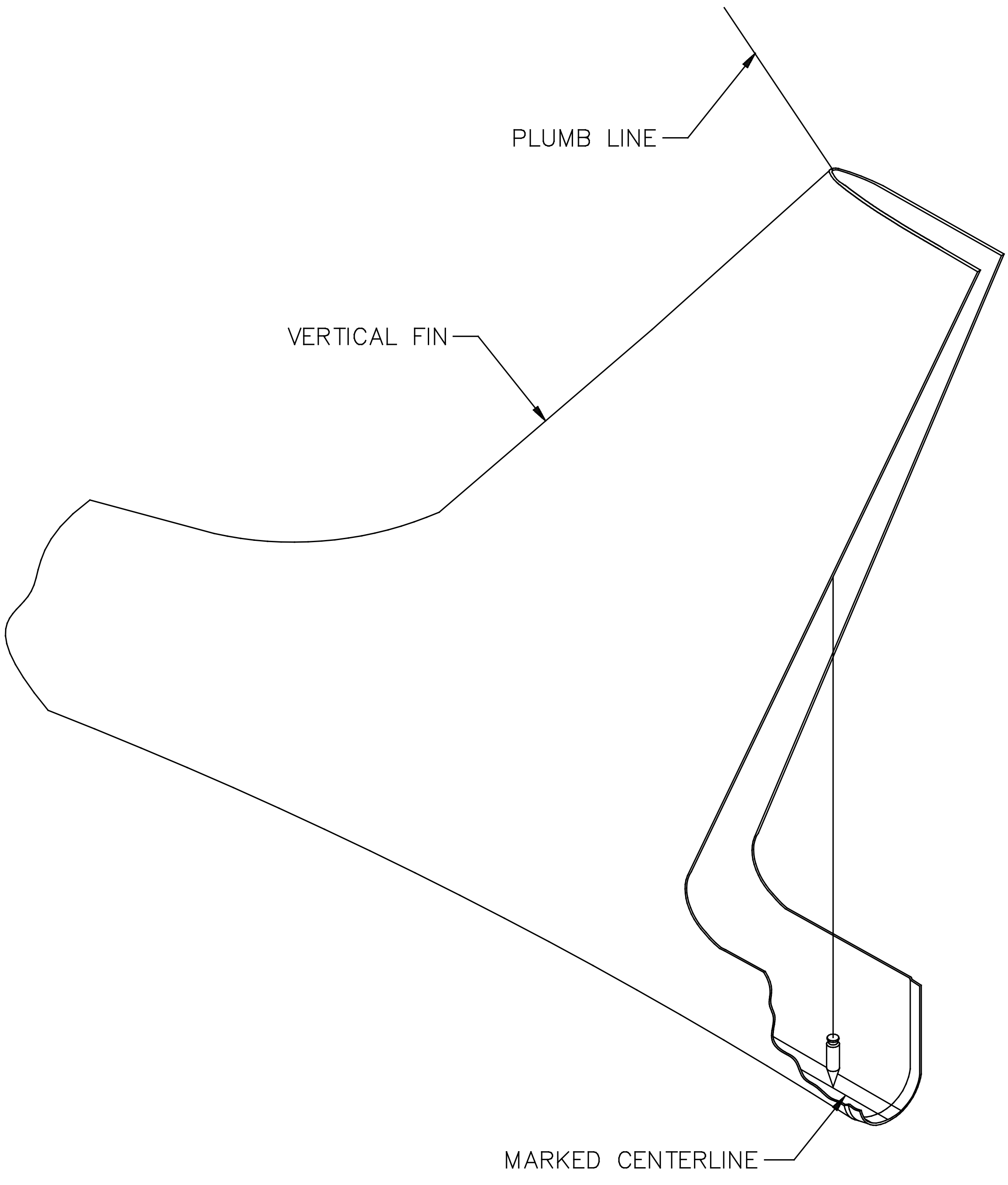


Figure 31: Plumbing the Vertical Fin

Step 24: Lay Up the Dorsal Seam

The dorsal seam is laminated in exactly the same way as the belly seam. The job is much easier, however, if you turn the fuselage assembly over on its back. Remove it from the hanging framework and support it securely on padded sawhorses so that the top of the vertical fin is off the floor by at least a few inches; otherwise, it will be impossible to laminate all the way to the top of the fin.

Note After inverting the fuselage re-check the vertical fin for plumb and make any necessary adjustments. Also, when the wings fold, the inboard ends of the flaps swing into the space in the upper fuselage just aft of the wing roots. In order to prevent interference with the flaps, the perpendicular distance from the fuselage belly to the highest point of the fuselage aft of the wing (the joggled flange where the top deck bonds) must not be more than **37-1/4".** So, measure this dimension as shown in Figure 31.1, using a framing square to keep your tape perpendicular to the belly. Place an additional support under the upper fuselage aft of the wings, if necessary, to hold the dimension to 37-1/4" or less.

Cut a **140"**-long piece of DBM cloth and, as before, tie it to a string run through the fuselage. Have an extension brush ready like the one you used to apply the belly seam laminate in the aft fuselage. Laminating the seam in the vertical fin is virtually impossible without such a brush. Also, as before, make sure the seam areas are properly cleaned and prepped.

Prepare a **500 gram** batch of resin and saturate the DBM with it exactly as you did before. Pull the wet cloth into place, centering it on the seam joggle, and work it down onto the fuselage shells. Take special care to work the air bubbles out of the fin laminate with the long-handled brush. Trim both ends of the DBM.

With the fuselage still inverted, use a single layer of DBM cloth to laminate the short seam at the base of the windshield opening.

When the laminates have cured, sand the ends as necessary. Rehang the fuselage assembly right-side up in the framework and remove all the tape top and bottom.

Completed: [ ]

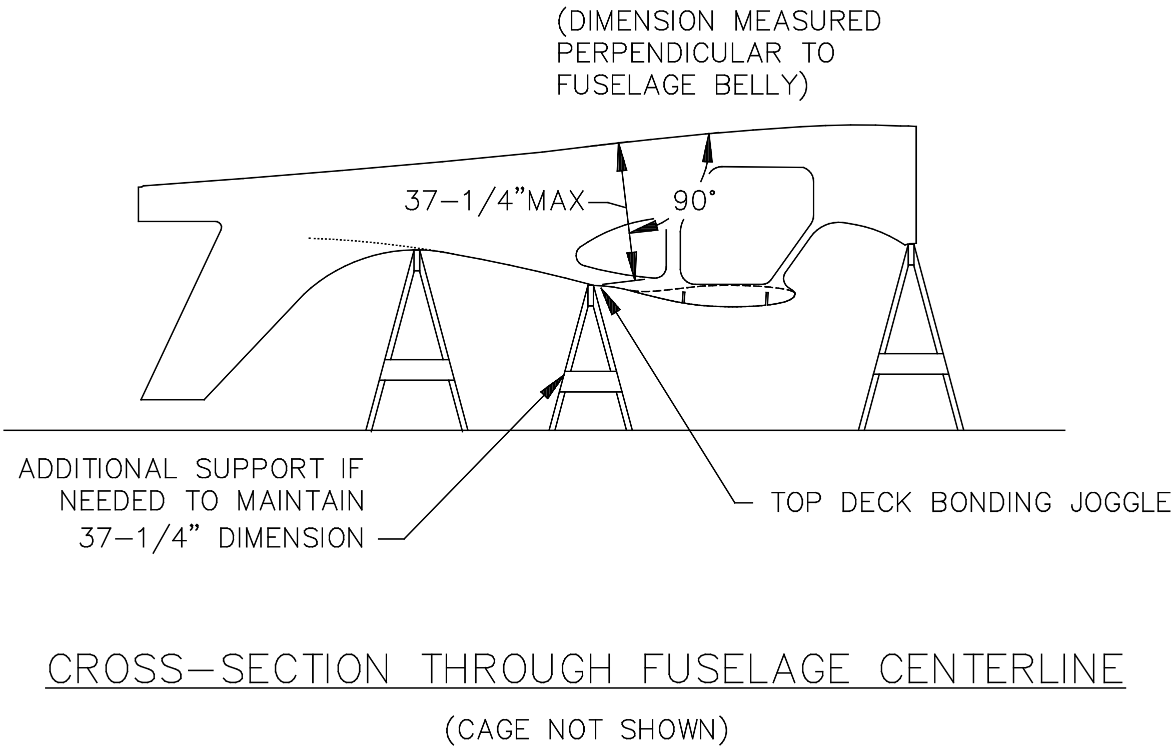


Figure 31.1: Checking the Vertical Dimension of the Fuselage Aft of the Wings

Step 25: Secure the Final Two Cage Tabs

When the shell seam laminates are fully cured, drill, countersink and secure the remaining two cage tabs along the belly seam—Tabs 21 and 25. Use exactly the same procedures and hardware that you used on the other cage tabs, with the exception that no hardpoints need be provided.

Completed: [ ]

Note Revision C moved Step 26 to an earlier stage of the assembly sequence. The former Step 26 is now **Step 3.1**.

Step 27: Position and Drill the Upper Shell Attach Fittings

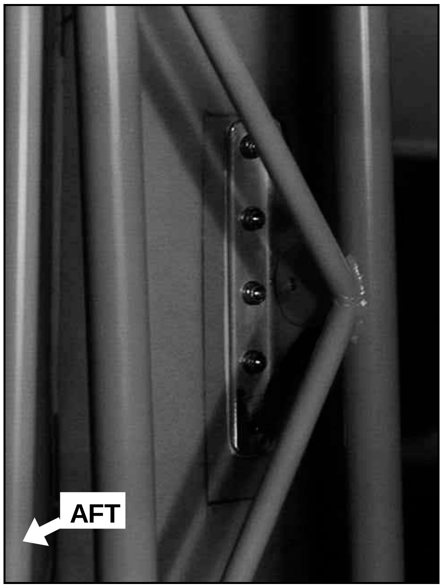


Figure 32: Placement of the Upper Shell Attach Fitting

Figure 32 shows the placement of the left-hand upper shell attach fitting. On both sides, the flange of the fitting that sits against the shell (the one you center punched hole locations on) points **aft**, and the other flange goes on the **forward** side of the corresponding cage tab. These tabs are located a bit below eye level on the main vertical tubes at the aft end of the cage. (These are the same tubes that bear the wing pivot lugs.)

In addition to securing the fuselage shells to the cage, the upper shell attach fittings also support the outside door handles through a bushing pressed into the lowest of the five holes on each side. Before fastening the fittings to the shells, it's necessary to drill pilot holes for these bushings in both the fittings and the shells.

Temporarily position each fitting as shown in Figure 33. The cage tab should be centered on the fitting's triangular flange, and the rectangular flange should be pressed firmly against the shell over one of the rectangular hardpoints; measure to position the two fittings at the same height on both sides. If this flange does not meet the shell squarely, use a mallet to bend the cage tab slightly forward or aft to achieve a good, square fit. When the fitting is in place, clamp it to the cage tab with a small C-clamp or spring clamp. Then, using a 90° drill motor or a long, flexible bit, drill a **#30** hole through the fitting and the shell wall at the **lowest** hole location. **Drill only this hole at this time**.

> **Note** The fitting isn't drilled through the cage tab at this time in order to maintain in-and-out adjustability for fitting the doors in "SECTION X: FINAL ASSEMBLY."

Note On some early GlaStar fuselage shells, the foam hardpoints for the upper and lower shell attach fittings are located slightly too low to accommodate all five of the fitting mounting screws. If, when your fitting is held in position, it appears that the uppermost screw hole will pass above the foam hardpoint, then you will have to provide a Q-cell hardpoint using the same procedures you used for the shell attach tab hardpoints.

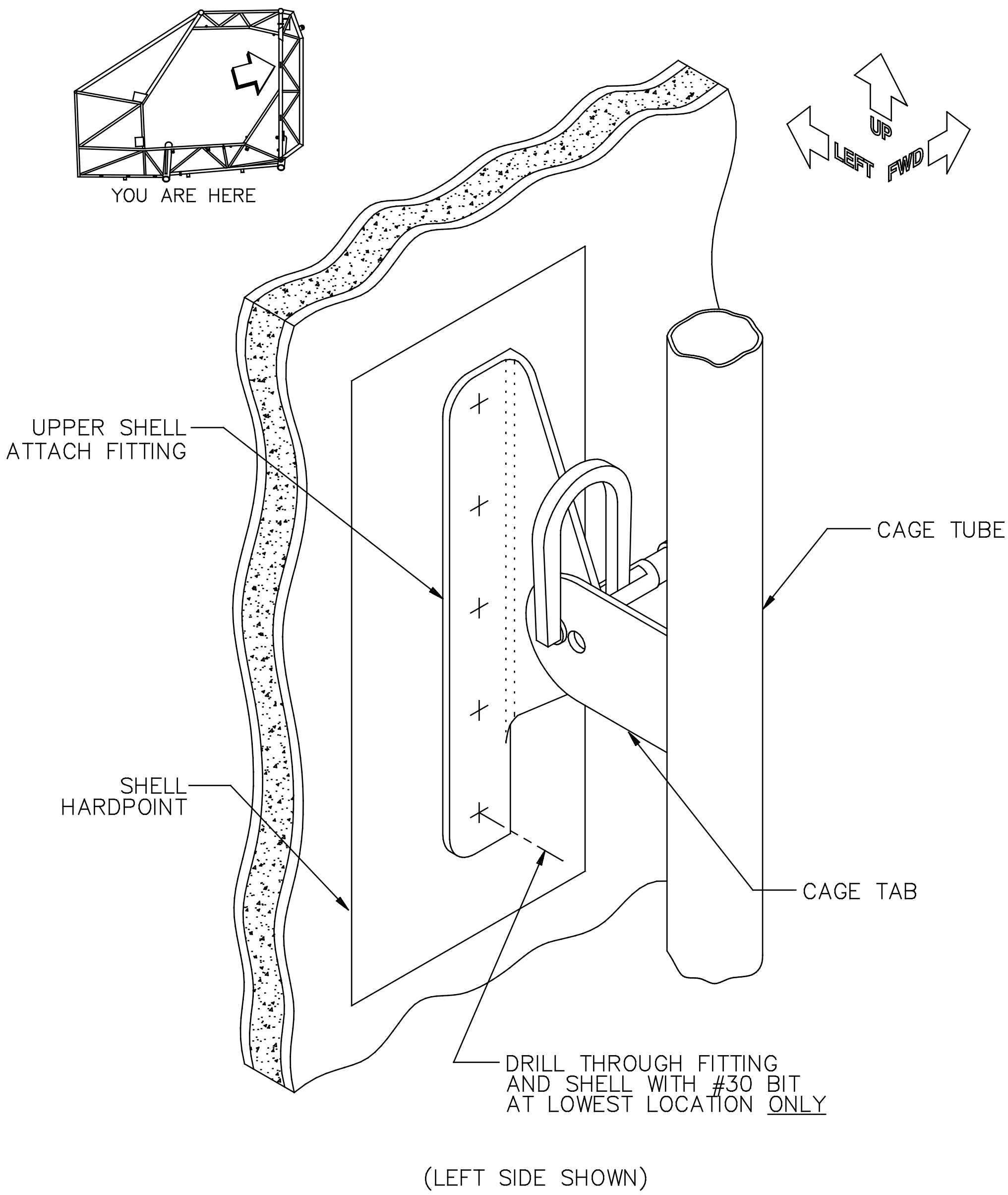


Figure 33: Pilot Drilling for the Door Handle Bushings

Once the lower pilot hole is drilled in each fitting, unclamp the fittings from the cage tabs. As shown in Figure 34, first drill each pilot hole up to **13/32"** diameter, and then ream this hole to final size with a **.4375"** straight reamer. Using a bench vise or a large C-clamp, press an NAS77A5-062 **flanged bronze bushing** [90] into this hole with the flange of the bushing on the **inboard** side of the fitting flange.

Hint If the bushings don't fit tightly, you may wish to "stake" them in place with a center punch, just as you did in "SECTION VI: WING ASSEMBLY" on the aileron hinges. The use of Loctite is also recommended.

Finally, drill the pilot hole in each fuselage shell up to final **1/2"** size; drill these holes in increments, beginning with a **3/16"** bit and progressing through **1/4"** and **3/8"** bits before finishing up with a **1/2"** bit. At each increment, check the position of the hole relative to the bushing in the fitting and shift the hole center as necessary to maintain concentricity.

With these preparations completed, you can now re-position the fittings and drill the remaining holes. As can be seen in Figure 32, a thin layer of Q-cell is used as a kind of "liquid shim" between the fitting and the shell wall. The purpose of the Q-cell is **not** to **bond** the fitting to the shell, but rather simply to provide a perfectly flat mounting surface for bolting. For this reason (and to allow comprehensive corrosion protection later) wax the flanges of the fittings that will bed in the Q-cell and the exterior surfaces of the bushing with mold-release wax. Then mix a small batch of "thick mix" Q-cell and apply a layer about **1/8" thick** to the waxed flanges.

Caution Be careful not to get any of the Q-cell **inside** the bushings!

Position each fitting as you did before (except that now, of course, the bushing will protrude through the 1/2" hole in the shell), pressing each firmly against the shell with enough pressure to cause the Q-cell mixture to ooze slightly from behind the fitting. Be sure that the bushing sticks out **at least 1/32"** beyond the outside shell wall. Clamp the fitting to the cage tab as before.

After the fittings are clamped in place, remove any excess Q-cell to leave a smooth fillet between each fitting and the shell. Also, from the outside of each shell, remove as much as possible of the Q-cell that may have oozed into the gaps around the bushings. These gaps will be filled with Q-cell later, but at this point too much build-up here will make it difficult to remove the fittings from the shell.

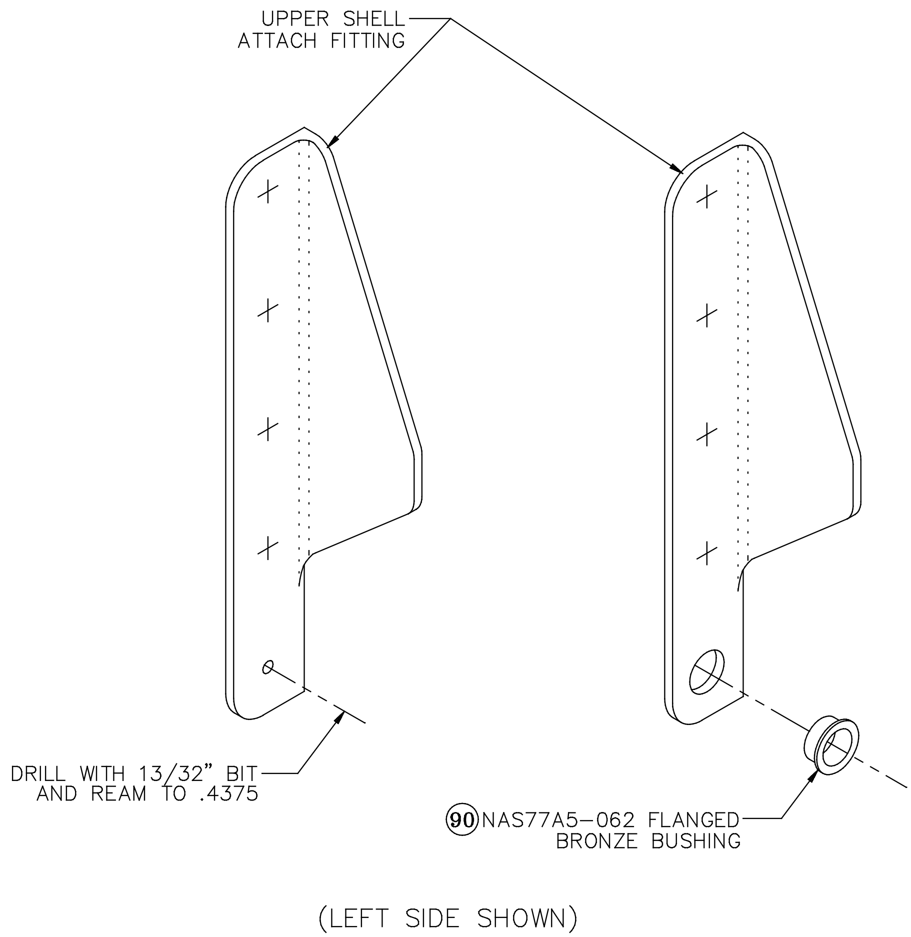


Figure 34: Pressing in the Door Handle Bushings

After the Q-cell has cured, use a 90° drill motor with a **#10** bit to drill through the fitting, the Q-cell shim and the fuselage shell at each of the remaining four center-punched locations. **Do not** drill the hole through the cage tab yet; this will be done after the doors have been fitted in "SECTION X: FINAL ASSEMBLY." Instead, remove the clamp holding the fitting to the cage and "break" the fitting out of its Q-cell bed. If you waxed the fitting and bushing carefully, this shouldn't be too much of a problem, but you may have to rotate the fitting around the bushing or even tap the bushing from outside with a light mallet to get it loose.

Deburr all the holes in the fittings and set them aside.

Completed: [ ]

Step 28: Position and Drill the Lower Shell Attach Fittings

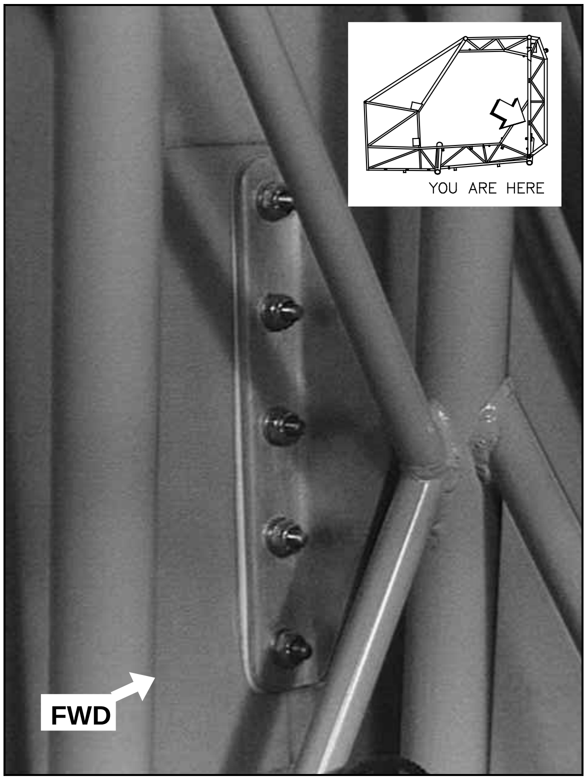


Figure 35: Placement of the Lower Shell Attach Fitting

In most respects, the installation of the lower shell attach fittings is identical to the upper: once again, you will form a shim of Q-cell mixture, position the fitting by clamping it to the cage tab, and drill the mounting holes after the Q-cell has cured. Also, as with the upper fittings, the lower pair is positioned vertically by centering the cage tab on the triangular flange of the fitting.

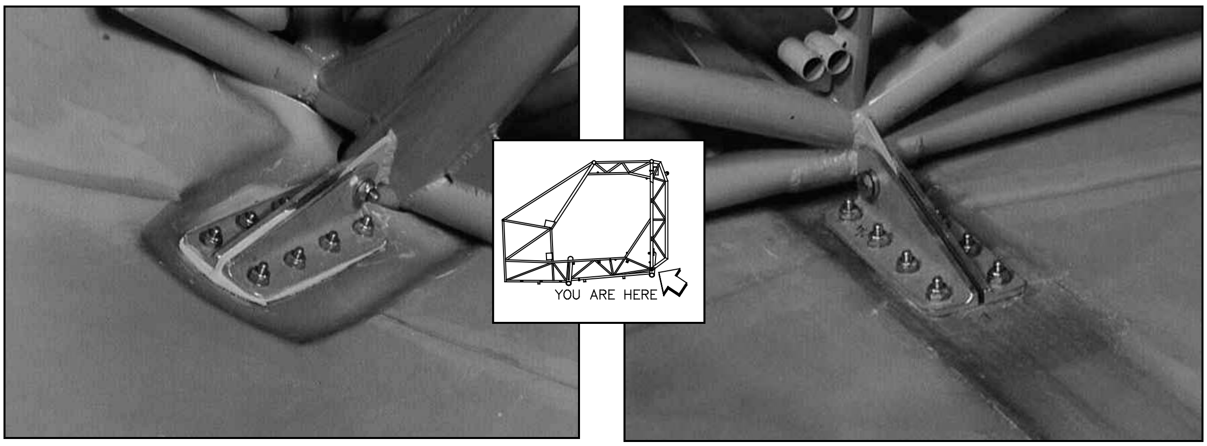
However, as Figure 35 shows, there is one important difference. Whereas the triangular flange of the upper fittings was located **forward** of the cage tab, the opposite is true of the lower fittings; place them on the **aft** side of the cage tabs.

Wax the bearing flanges of the fittings, apply the thick Q-cell mixture and clamp the fittings in place. After the Q-cell has cured, drill the five center-punched holes in each fitting with a **#10** bit, break the fittings loose and deburr the holes. **Do not** drill the cage tab holes at this time.

Completed: [ ]

Step 29: Position and Drill the Aft Shell Attach Fittings

The panels of Figure 36 show the placement of the six aft shell attach fittings. Figure 36a depicts the two left-side fittings and Figure 36b depicts the center pair; the right-side pair is identical to the left pair. The cage tabs to which these fittings are attached are at the aft end of the cage along the bottom-most tube—one at the left end, one at the right end and one on the aircraft centerline.



(a) **(b)**

Figure 36: Placement of the Aft Shell Attach Fittings

These fittings are installed using the same techniques used with the side fittings. However, these will be bolted to the cage tabs in this step, so before securing the fittings to the cage it's necessary to drill bolt holes in the triangular flanges of each fitting.

Begin by pairing the fittings off in sets of left- and right-flange fittings. Clamp one fitting from each pair to one of the aft cage tabs with its rectangular flange firmly against the shell. Then, as shown in the upper panel of Figure 37, use the hole in the tab as a guide to mark a hole location on the fitting. Remove the clamp.

This marked location is **not** where you will actually drill. Instead, the bolt hole must be drilled somewhat lower on the fitting for two reasons: first, as with the other fittings, the aft fittings should be bedded in a layer of Q-cell **at least 1/32"** thick. The position of the hole must be adjusted for the thickness of this bed. Second, the hole must be drilled low enough to leave an edge margin of **at least 3/8"** between the hole and the top of the fitting. Therefore, you must mark a new hole location **at least 1/32" below** the original mark. If necessary to achieve adequate edge margin, you may have to go down further than that. The center panel of Figure 37 shows the specifications of this hole location.

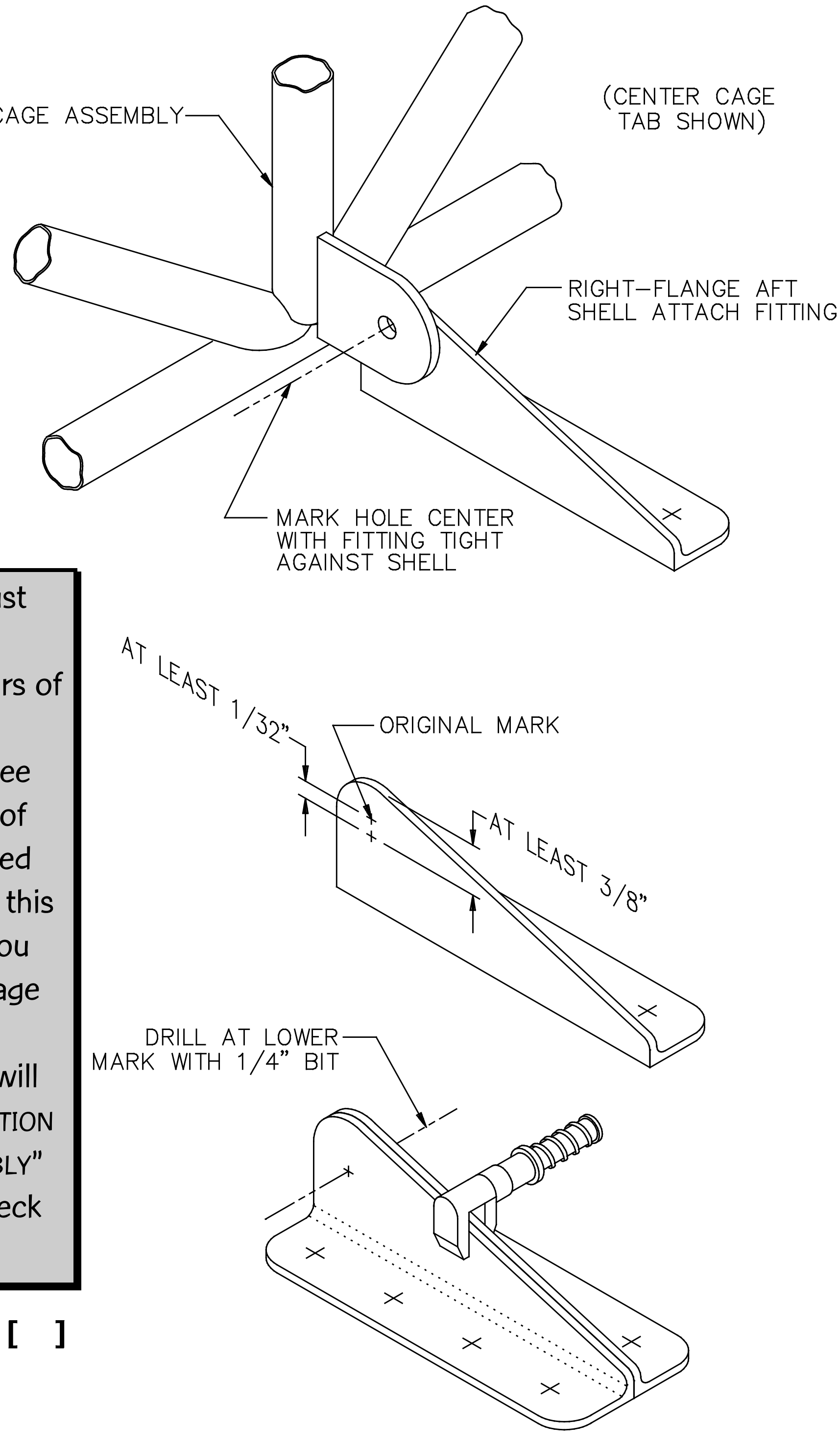
Finally, as the lower panel of the figure shows, clamp the fittings of each pair together back-to-back and drill through both at the lower mark with a **1/4"** bit.

Once all six aft fittings have been drilled, wax the two outer surfaces of each and apply a layer of thick-mix Q-cell of appropriate thickness to the bearing area of the shell. Seat the fittings in the Q-cell and align them with their respective cage tabs with AN4-6A **bolts** [58]. For now, don't bother with any washers or nuts.

> **Note** If the position of the cage tabs dictates a Q-cell shim thicker than **1/8"**, substitute a 50/50 mix of **mill fiber** [35] and Q-cell for the straight Q-cell. This will make a stronger bed that is less liable to crack.

After the bolts are inserted, make sure that the aft ends of both fittings in each pair are pushed down firmly into the Q-cell beds. The fittings should be parallel with the shell floor and with one another. As can be seen in Figure 36a, the Q-cell mixture may be pushed up between the fittings, which is fine. Remove excess Q-cell from around the outside of the fittings, however, leaving a smooth fillet all the way around.

After the Q-cell has cured, use a **#10** bit to drill through the fittings and shell at each of the center-punched locations (four per fitting). Remove the bolts and break the fittings out of the Q-cell. Deburr all the holes.



Note Having just positioned and drilled three pairs of aft fittings, you should have three pairs left. Two of these will be used near the end of this section when you install the fuselage struts; the remaining pair will be used in "SECTION X: FINAL ASSEMBLY" when the top deck is installed.

Completed: [ ]

Figure 37: Drilling the Cage Attach Bolt Holes in the Aft Fittings

Step 30: Corrosion-Proof the Shell Attach Fittings

Before installation, apply the corrosion protection of your choice to all of the shell attach fittings you have drilled, as well as to the four triangular forward shell attach fittings you fabricated in Step 12. Be extra thorough in prepping the fittings to make sure that all the mold-release wax has been removed before priming. Lacquer thinner and Scotch-Brite work best for this task.

Note You should mask the door handle bushings to keep their inner surfaces free of primer. The exterior surfaces of the bushings can be masked or primed at your option.

Completed: [ ]

Step 31: Install the Upper, Lower and Aft Shell Attach Fittings

In positioning and drilling the ten shell attach fittings, you drilled forty-two #10 holes through the fuselage shells. Countersink each of these holes on the **outside** of the shell to accommodate AN509-10 **screws** [64—68]. Be careful to avoid countersinking too deeply.

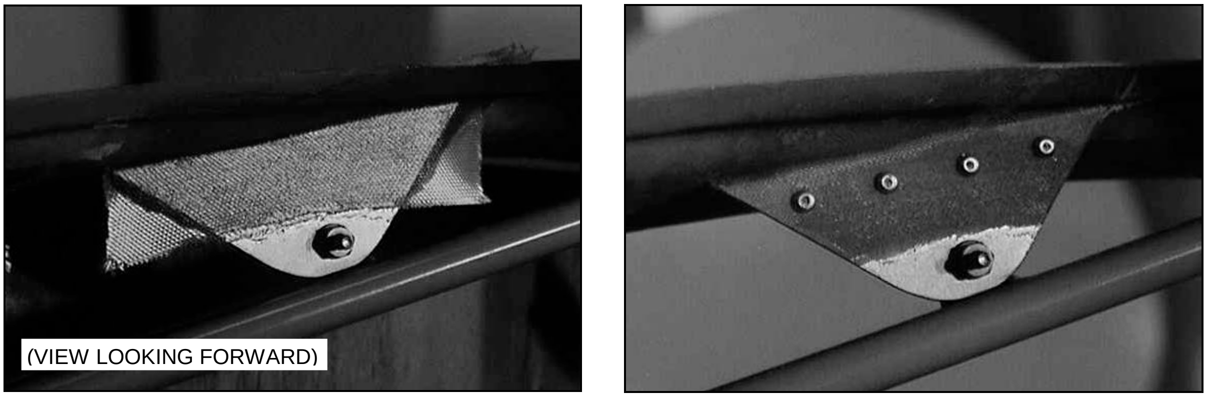
Install the fittings with screws of the appropriate length, AN960D10 **aluminum washers** [76] and AN364-1032A nylon self-locking nuts. Also, secure the aft fitting pairs to the cage tabs with AN4-6A bolts, AN960D416 **aluminum washers** [78] (under both the bolts and nuts) and AN364-428A **nylon self-locking nuts** [47]. Put the nut on whichever side of the fitting pair makes it easiest to tighten.

Note The door handle bushings should protrude slightly beyond the shells. Do not grind or file these flush; the offset is necessary for the door handles to clear. However, you should mix a small batch of Q-cell and fill in the gaps between the bushings and the shells. If a bushing protrudes more than 1/32", make a smooth Q-cell fillet between the shell and bushing.

Completed: [ ]

Step 32: Install the Forward Shell Attach Fittings

The forward shell attach fittings are bolted to tabs on the cage assembly and riveted to fiberglass flanges, which in turn are bonded to the shells. Figure 38 shows the left, inboard fitting in the process of installation (a) and completed (b).



(a) **(b)**

Figure 38: Placement of the Forward Shell Attach Fittings

Begin by bolting each fitting to its respective cage tab. These tabs are arranged vertically on the two firewall tubes at the forward-most, topmost edge of the cage, two tabs per tube. As Figure 38 shows, the fittings are bolted to the **aft** face of each tab. If necessary, trim the wide edges of the fittings so they follow the curve of the shell and bolt them to the tabs with AN3-4A **bolts** [41], AN960D10 aluminum washers (under the nuts only) and AN364-1032A nylon self-locking nuts.

Next, for each fitting cut four small rectangles of bi-directional cloth on the 45° bias. These pieces should be an inch longer and an inch taller than their respective fittings. Mix a small batch of resin and saturate the pieces. Laminate four pieces over the entire aft face of each fitting above the bolt and onto the fuselage shell, as shown in Figure 38a. After the resin has cured, use a **#30** bit to drill four evenly spaced holes in each fitting directly through the laminate. Deburr these holes on the forward side of the fitting and install 1/8" AAPQ-42 blind rivets with the heads on the aft side of the fitting, as shown in Figure 38b. Finally, trim the laminate even with the edges of each fitting and, if necessary, with the edge of the windshield cut-out of the fuselage shell.

Completed: [ ]

Step 33: Mark the Fuselage Waterline

In this section of the fuselage assembly you will install several bulkheads in the fuselage, all of which are positioned with reference to the fuselage waterline—that is, the horizontal axis of the fuselage when the aircraft is in level flight. In this step, you will mark this line on both sides of the fuselage.

First, recheck to see that the fuselage is level laterally by holding a level on the main cross-tube between the forward wing attach lugs. Shim as necessary to bring the cage level.

Figure 39 shows how the endpoints of the waterline are established on the forward and aft ends of the fuselage shell. Hold a long carpenter's level (or a long straightedge with a shorter level attached to it) across the bottom of the fuselage shell at its forward end. As shown in the small side view in Figure 39, the level should be placed at the forward-most point on the shell **excluding the cowling joggle**.

With the level in position and registering level, run a plumb line down the forward-most edge of the shell (again excluding the joggle), past the level. Measure up from the level **20-5/8"** and make a mark. Repeat the process on the other side.

> **Hint** This process is described here rather schematically. Obviously, to do exactly what we have suggested will require more than two hands, and perhaps more than four. You may come up with your own innovative way to make and mark these measurements. Just be sure that you are measuring true vertical distance from the bottom of the shell. One handy trick is to pre-measure the desired vertical distance on your plumb line and mark it with a couple of masking tape “flags”; these make it much easier to measure up from the level.

Perform the same process at the tail, placing the level on the aft-most portion of the shell, **excluding the tailcone joggle**. Measure up along the plumb line **4-17/32"** on each side and make a mark.

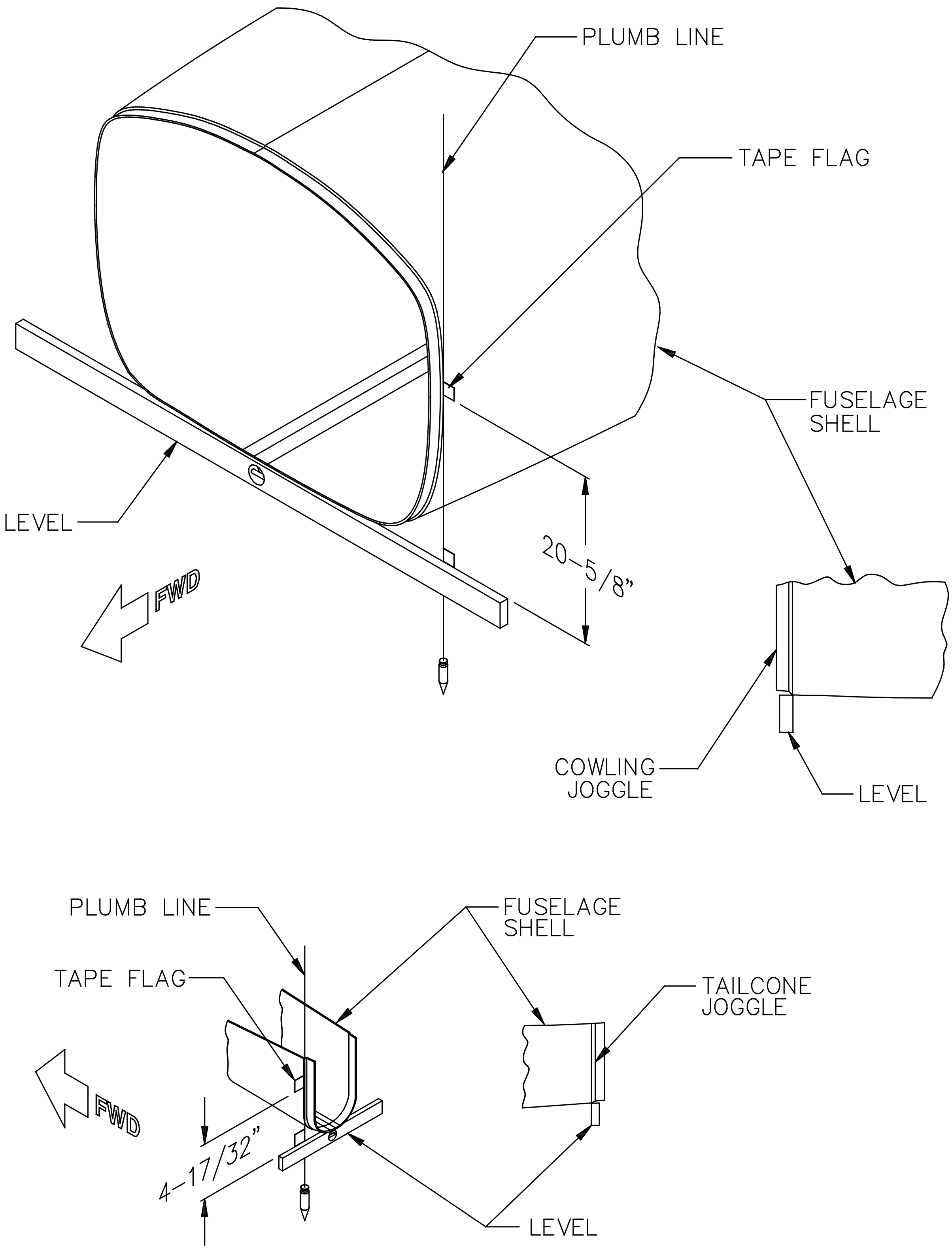


Figure 39: Marking the Waterline Endpoints

With the waterline endpoints marked fore and aft, the next step is to temporarily mount a long straightedge across the forward end of the fuselage between the two marked waterline endpoints, as shown in Figure 41. The straightedge can be metal or wood and of any convenient dimensions, but it should be at least 6' long. (A carpenter's level is ideal.) You can set the straightedge on short support pieces clamped to the shell, as shown in the figure, or you may be able to rest it directly on clamps positioned at an appropriate height. In either case, position the crosspiece such that its **upper** surface is on the waterline marks.

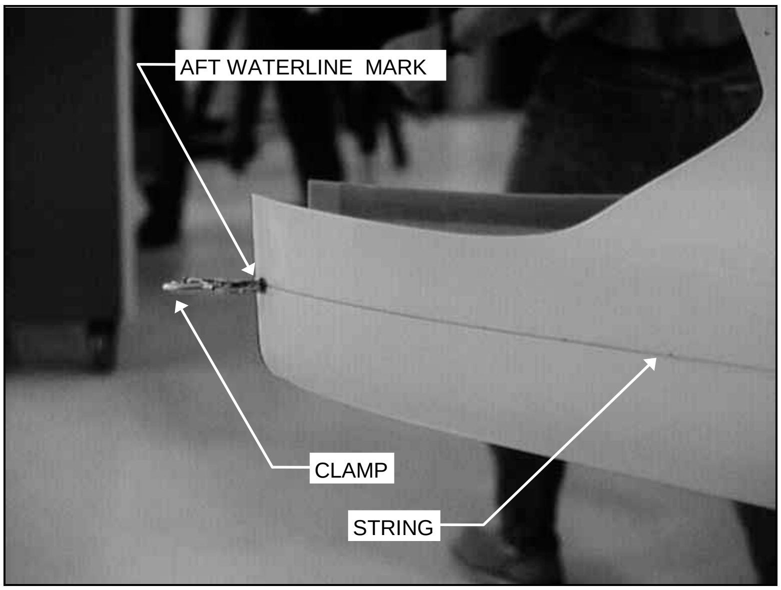


Figure 40: Securing the Aft End of the Waterline String

Next, secure a 20'-long piece of string to the aft end of the fuselage shell **on the waterline mark**. You can do this with a clamp, as shown in Figure 40, or simply by taping it in place with duct tape or masking tape. When the string is attached, have an assistant at the forward end of the fuselage pull this string taut so that it contacts the upper surface of the crosspiece you positioned there. This string is now in the plane of the waterline, and by moving it left and right along the crosspiece, your helper can bring it into contact with the fuselage shell at various points along the waterline. (See Figure 42.)

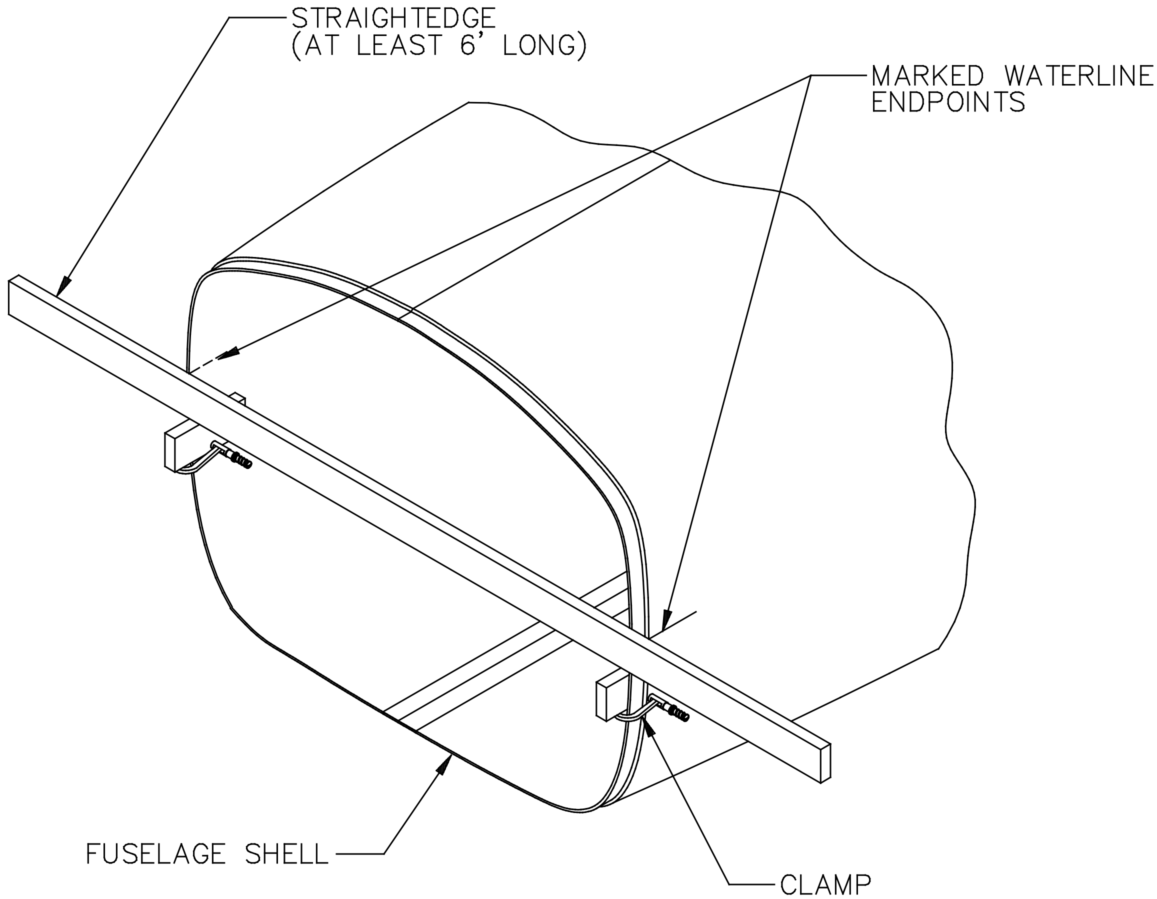


Figure 41: Positioning a Crosspiece on the Waterline

There are only a few locations on each side of the fuselage where you really need to mark the waterline. As your helper moves the string in or out as necessary, mark along the string once every three or four inches in the **aft-most 2'** of the fuselage. Then move forward and mark the waterline on the **forward and aft edges of the door cutouts**.

Hint Because of the curvature of the fuselage (especially in the aft-most section), the string will have a tendency to roll downward as it is moved in against the shell. This is obviously unacceptable, since it introduces a curve into the waterline. To avoid this problem, simply use small pieces of tape to secure the string to the shell every few inches in the aft-most couple feet of the fuselage. Just be careful when applying the tape not to inadvertently shift the string up or down from its natural point of contact with the shell.

After you've made these marks, remove the string and connect the marks at the aft end of the fuselage with a flexible straightedge. Then reattach the string on the other side of the fuselage and repeat the procedure.

Hint It will be useful to have a more-or-less permanently established waterline for future use in weight-and-balance calculations and so on, and you won't be able to rely on pen marks for this purpose. Therefore, it's a good idea to make permanent nicks with a sharp scribe, a hacksaw or the edge of a file at four locations on the waterline on each side of the fuselage: on the firewall joggle, on the inside edges of the door cutouts forward and aft and on the tailcone joggle. On your completed GlaStar, these marks will be covered by the cowling, rubber door seals and tailcone, respectively, but they can easily be uncovered when you need to determine the waterline in the future.

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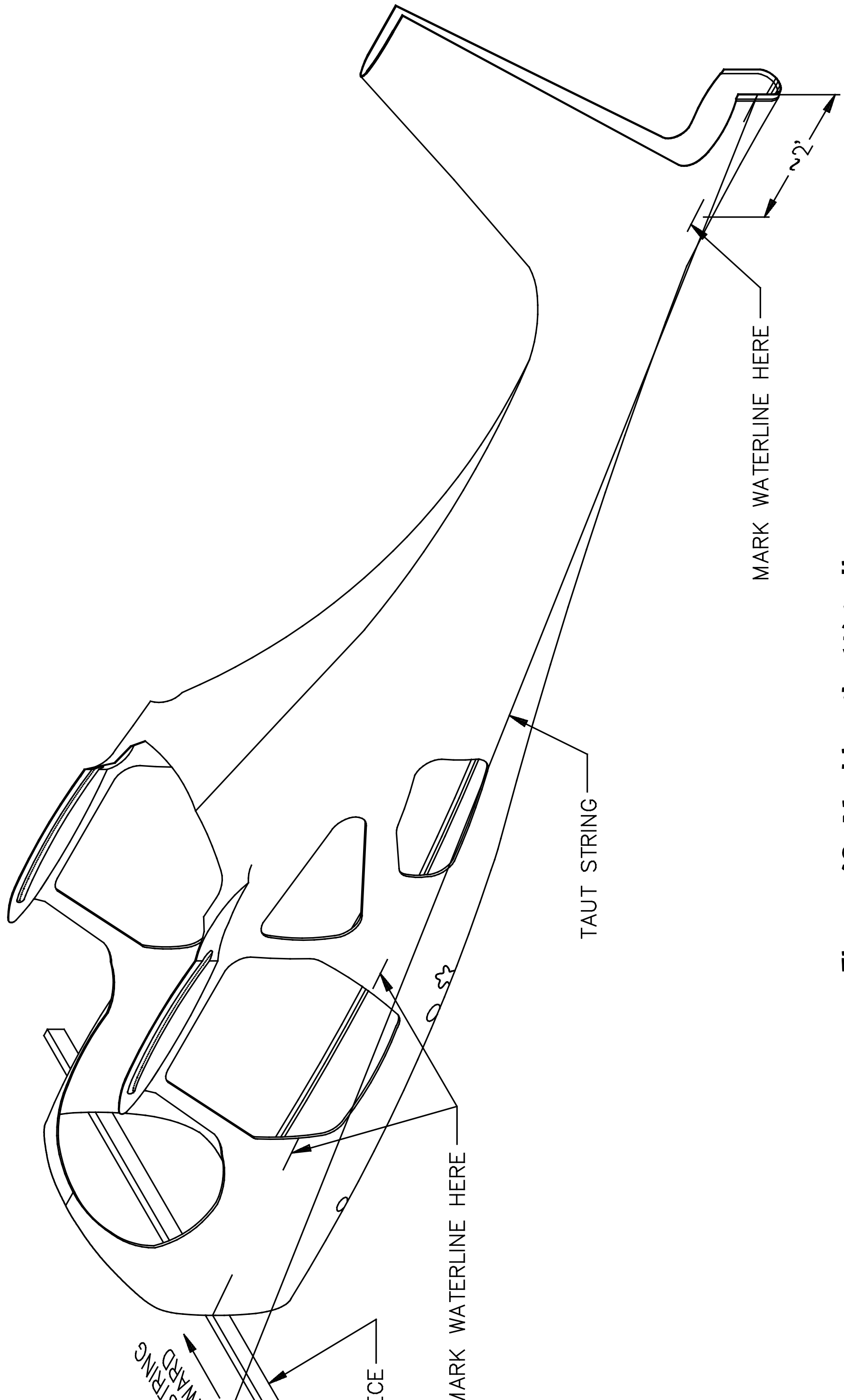

Figure 42: Marking the Waterline

Step 34: Cut Out the Vertical Fin Rib

Cut out the **vertical fin rib template** from the **Bulkheads D & E template sheet** [20], cutting about **1/2"** outside the lines all the way around. Use thumbtacks or push pins to tack this template down flat in one corner of the **1/4" X 24" X 30" sheet of 5-lb. foam** [34]. The long dimension of the template should be laid out parallel to the longer edge of the sheet. Use a utility knife to cut out the rib. Make it slightly oversized—about **1/8"** all around.

Caution The full-sized templates provided in the kit for various parts have all been laid out according to the dimensions of parts used in our prototype GlaStar or in very early customer-built airplanes. However, the precise shape and size of many of the parts represented on templates can vary significantly from GlaStar to GlaStar. As a **general rule**, therefore, wherever the use of a full-sized template is called for, we **strongly recommend** first using the template to cut out a mock-up piece from cardboard for trial fitting. After you have adjusted the mock-up piece to fit, you can use it to cut the final piece from the specified material. In the long run, this will save you time, frustration and expense.

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Hint In the following steps, you will begin laminating and installing the five fuselage bulkheads. Figure 43 provides a schematic view of the general locations of these bulkheads. Precise instructions for positioning them are contained in the text that follows.

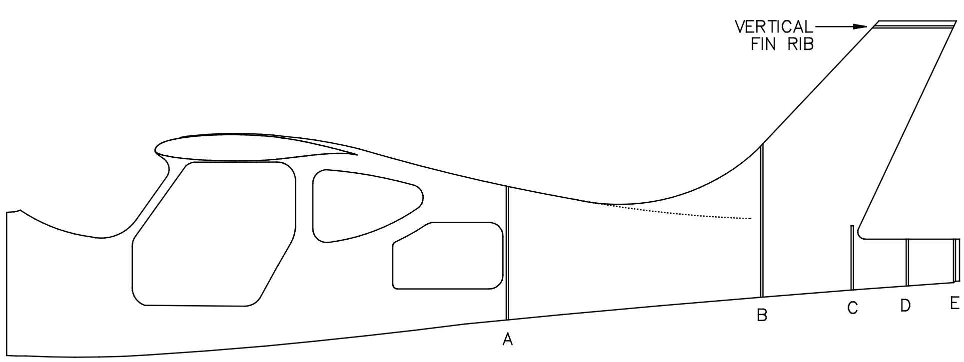

Figure 43: Bulkhead Locations

Step 35: Rough-Cut the Foam Core for Bulkhead B and Cut and Bevel the Center Hole

Cut out the template for Bulkhead B from the **Bulkheads B & C template sheet** [19], leaving **1/2"** or so excess all the way around the pattern. Tack the template flat on the remainder of the 5-lb. density foam left over from the previous step. Concentrate the tacks around the template's center hole in order to keep the paper taut against the foam in that area.

First, use a utility knife to rough-cut the exterior shape of the bulkhead, using the 1/2"-oversized edges of the template rather than the actual pattern lines as your guide. Then cut out the center hole, cutting right on the pattern line, as shown on the left-hand side of Figure 44. Remove the tacks and set the template aside for later use. Finally, using the utility knife and sandpaper, bevel the inside edges of the hole you just cut to approximately **30°**, as shown on the right-hand side of the figure.

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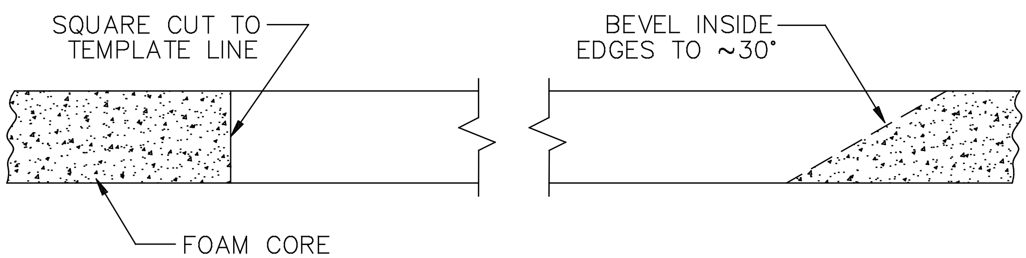

Figure 44: Beveling the Center Hole in the Bulkhead B Foam Core

Step 36: Lay Up and Trim the Bulkhead B Laminate

Bulkhead B is laminated with two layers of bi-directional cloth on one side and one on the other. This forms a three-ply laminate in the center hole. Before beginning the lamination, seal both faces and the beveled edge of the foam with a thin Q-cell mixture, as described in "SECTION II: TOOLS AND TECHNIQUES." Then cut three pieces of cloth on the 45° bias, each about **1/2"** larger all around than the foam.

Figure 45 illustrates the laminating procedure. Begin by laying the foam on a smooth, waxed or plastic-covered laminating surface with the beveled side up.

Hint In a subsequent step, you will need a **30" X 30"** laminating surface to lay up Bulkhead A, so you may as well use such a surface for the smaller bulkhead laminates as well. Formica, Masonite, and sheet metal are all appropriate materials for this surface.

As shown in Figure 45a, apply one layer of cloth, making sure that it follows the bevel all the way down to the surface of the laminating table. Saturate the cloth with resin, both inside the center hole and on the foam. As indicated in the figure, try hard to eliminate any bubbles where the cloth leaves the beveled foam and contacts the table.

After the first ply reaches at least green cure, turn the laminate over and use acetone to remove any residual wax or other contaminants. Then thoroughly roughen the smooth face of the laminate in the center hole with 80-grit sandpaper. Finally, apply two layers of cloth to the other side of the laminate, as shown in Figure 45b.

After the laminate has cured, use spray adhesive to re-affix the Bulkhead B template to the laminate, lining up the center hole of the template with the hole in the foam core. Use a bandsaw or saber saw to cut the laminate to the final outside shape. Finally, remove the template and cut out the three-layer laminate in the center hole to finish the bulkhead. However, don't cut all the way to the edge of the foam core; leave at least a 3/8" lip of three-layer laminate, as shown in Figure 45c. Start this cutout with a large drill bit or hole cutter and proceed with snips. Finish up the hole by rounding the edges with files and sandpaper (Figure 45d).

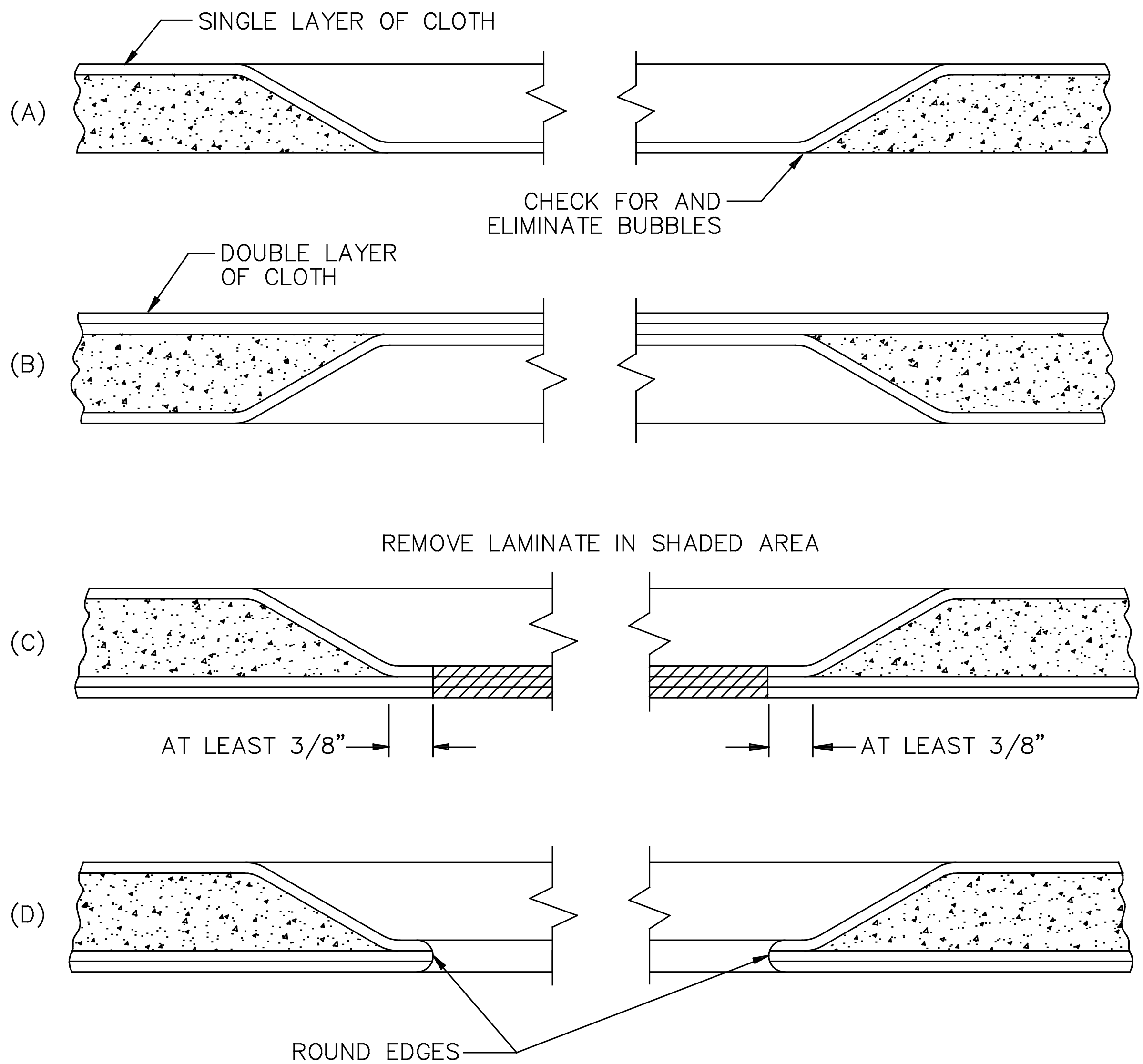

Figure 45: Laying Up and Trimming the Bulkhead B Laminate

Hint Cutting fiberglass laminates is hard on snips and saw blades. You may want either to dedicate a cheap pair of snips and/or a bandsaw blade exclusively to this purpose or else use a saber saw with a carbide grit blade designed expressly for cutting fiberglass.

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Step 37: Lay Up and Trim the Laminate for Bulkheads C, D and E

Bulkheads C, D and E are all cut from a single laminate of 20-lb. density foam with two layers of bi-directional cloth on either side. Begin, therefore, by cutting four pieces of bi-directional cloth on the 45° bias, each large enough to cover the entire **3/16" X 24" X 24" sheet of 20-lb. foam** [17]. Seal the foam with thin Q-cell, apply two layers of cloth to one side of the sheet, let cure, and then apply the remaining two layers to the other side.

After the laminate has cured, use spray adhesive to affix the templates for Bulkheads C, D and E to the laminate. Use a bandsaw or saber saw to cut out all three bulkheads, cutting right on the pattern lines.

Hint When you've finished cutting out a part using a template (either our paper version or a cardboard one), **don't** toss it out. In many cases—especially with these fuselage bulkheads—the template will come in very handy just a few steps down the road for cutting cloth reinforcement laminates for the part in question.

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Step 38: Level the Fuselage Longitudinally

In order to install the bulkheads properly, it's necessary first to make sure that the fuselage waterline is precisely horizontal. You can achieve this using the waterline marks you made at the forward and aft edges of the door cutouts. As shown in Figure 46, clamp a piece of metal angle or a straight piece of wood across the cutout with its ends on the waterline marks. Then, with a level (preferably a digital level) on the crosspiece, raise or lower the tail of the fuselage as necessary to bring it level.

Note The next step will require you or a helper to crawl inside the fuselage shell, and this in turn obviously requires that the shell be supported sturdily enough to take the weight of the person doing the crawling. Don't worry about the shell itself—it's plenty strong! But carefully assess the strength of your hanging framework and tail support and, if necessary, remove the fuselage assembly from the framework and level it on the floor with suitable padded supports. If you do leave it hanging from the framework, monitor the bicycle hanging hooks. We have experienced a couple near-crashes when these hooks have bent under load!

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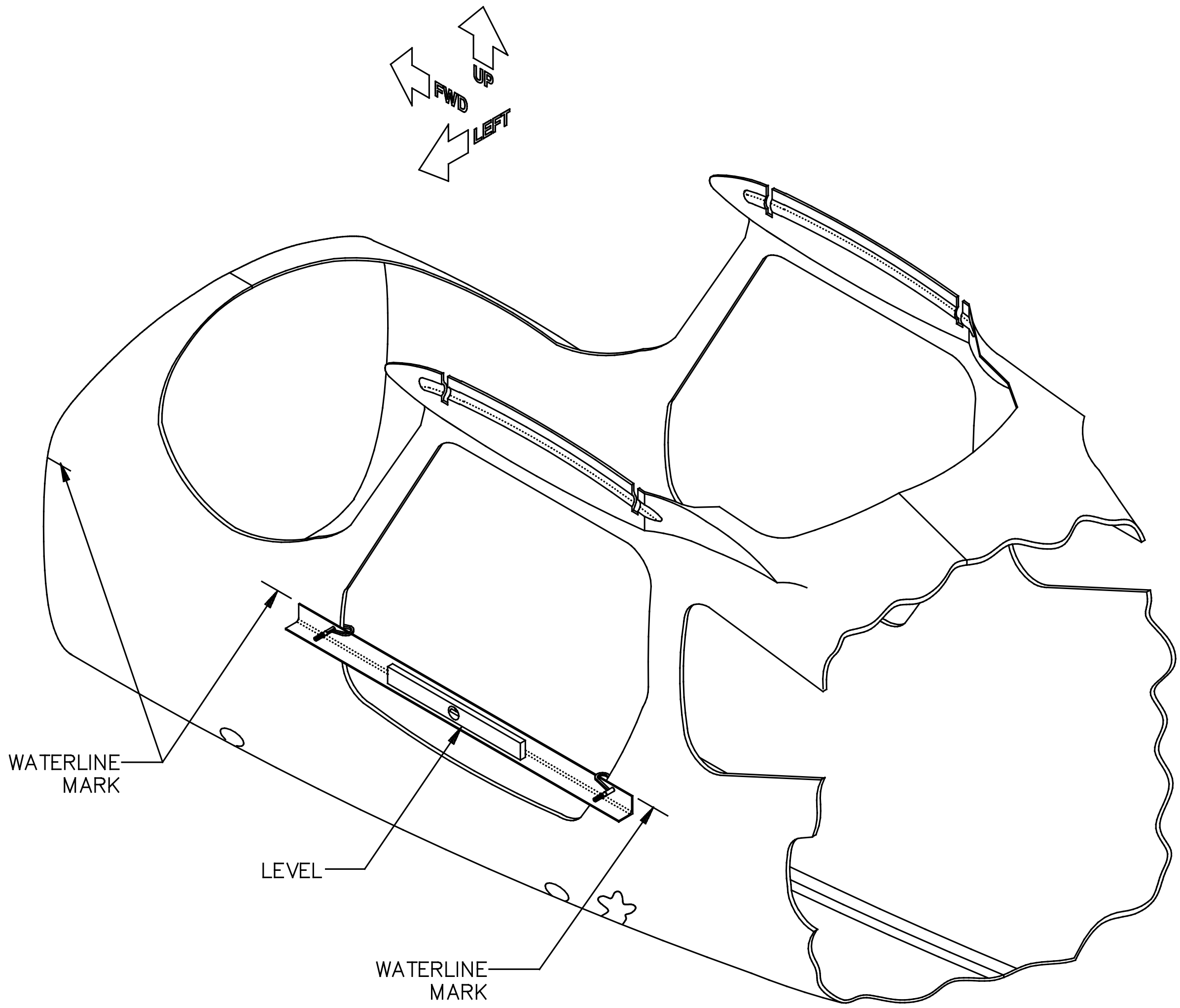
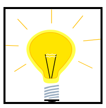


Figure 46: Leveling the Fuselage Longitudinally

Step 39: Install Bulkhead B

Bulkhead B is located in the aft fuselage **approximately 43"** forward of the tailcone joggle. It sits perpendicular to the fuselage waterline and centerline with the narrow projection at the top inserted into the vertical fin, as shown in Figure 47. The precise fore-and-aft position of the bulkhead is not critical; it should simply be placed as far aft as possible without distending the fuselage shells. Neither is it important which way the beveled side faces. Once the bulkhead is roughly positioned, use a level to check for perpendicularity to the waterline. Simply eyeball it for perpendicularity to the centerline.



Hint We would never advocate involuntary child labor, but if you have a trustworthy juvenile assistant, you'll never have a better use for him or her than in installing Bulkhead B! More than any other work on the GlaStar, this step rewards agility and small size. Pick your assistants accordingly!

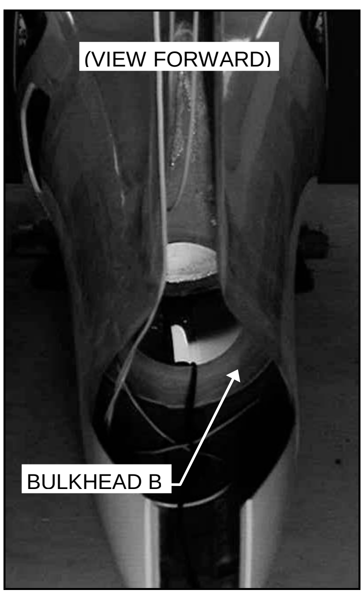


Figure 47: Placement of Bulkhead B

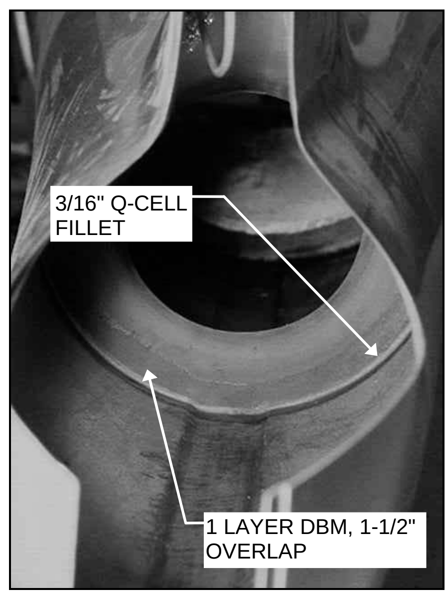


Figure 48: Installing Bulkhead B

When you're satisfied with the position of the bulkhead, tack-glue it into position if necessary with several blobs of hot-melt glue. (The friction fit of the bulkhead may make this unnecessary.) Then mix a thick batch of Q-cell and apply a 3/16"-radius (i.e., a finger's width) fillet around the entire perimeter of the bulkhead on both the forward and aft sides. Before crawling inside the fuselage, test the Q-cell mixture to see that it is thick enough to stick when applied upside down. Use extra Q-cell wherever it's needed to fill in all the gaps between the bulkhead and the shell. This task requires reaching inside the fin and working blind for the upper, forward portion of the bulkhead, but do your best to extend the fillet all the way around. This fillet can be seen in Figure 48.

Hint If you kept your beads of hot-melt glue small enough to be covered by this fillet, then you can Q-cell right over them, but any glue that would protrude beyond the fillet should be removed first. Remember, here and elsewhere, that the less glue you use, the less weight you're adding, and although each blob of glue weighs only a fraction of an ounce, ounces turn into pounds, and pounds cut performance!

Bulkhead B is secured with a single layer of DBM cloth on both the forward and aft faces. Cut eight strips of DBM, each about **20"** long. Catalyze a batch of resin and laminate these strips end to end into the angle between the bulkhead and the shell around the entire perimeter of the bulkhead, four on the forward side and four on the aft. The strips should overlap equally onto both bulkhead and shell, and each strip should overlap the one next to it by an inch or two. As usual, be sure to press the cloth tightly into the corner radii and see that all air bubbles are relieved. Again, this will require working by touch in the fin portion.

Hint You'll find it easier by far to pre-saturate the DBM pieces outside the fuselage. Remember, the mat side of the DBM goes down.

Hint As shown in Figure 49, we recommend the use of a small exhaust fan to draw air through the aft fuselage while working there with resin. Position the fan to blow aft.

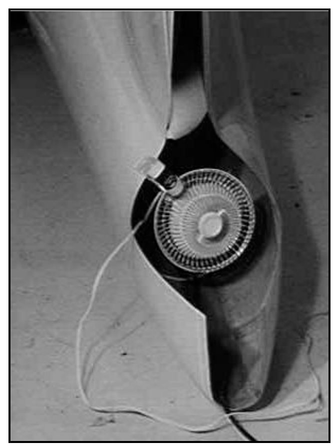


Figure 49: Ventilating the Aft Fuselage

After the DBM laminates have cured, cut a drain hole in the bottom center of the bulkhead. This is necessary to allow any water that gets inside the fuselage to flow out of the aircraft rather than pooling behind sealed bulkheads. The hole should be about **1/2" high X 1" wide**. Start it by drilling two **3/8"** holes about **3/4"** apart on either side of the centerline. Use a 90° drill motor to keep the holes as low on the bulkhead as possible. Then use a rotary cutter or files to remove the material between the holes.

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Step 40: Trim the Vertical Fin Spar

Before installation, the lower end of the **vertical fin spar** [2] must be trimmed. The spar comes from the factory with notched flanges to allow for the bend in the web, as shown in Figure 50. The flanges below the notches must be removed and then the sharp corners of the notches must be radiused to eliminate potential stress risers in the part.

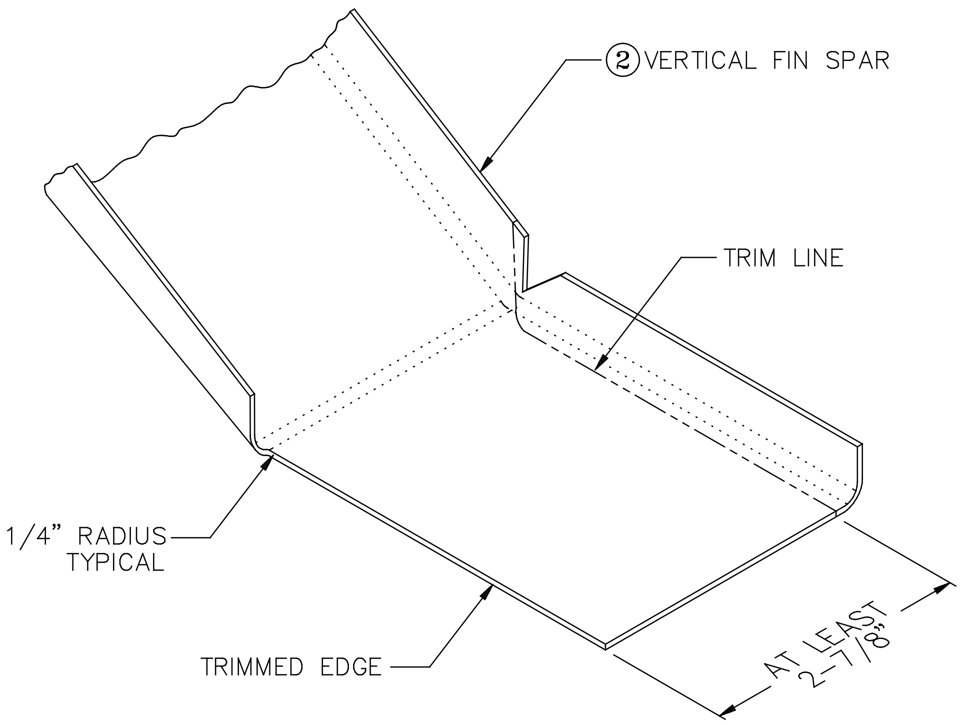

Figure 50: Trimming the Vertical Fin Spar

Use a bandsaw or hacksaw to cut off the flanges. Make the cuts just inboard of the bend radii; your goal should be to leave as wide a flat spar web as possible. The minimum acceptable width is **2-7/8"**.

After the flanges have been cut away, you will be left with sharp corners where the main flanges begin. These must be eliminated with a file or rotary cutting tool. As the figure shows, it's acceptable to trim back the main flanges a bit if necessary to achieve a minimum corner radius of **1/4"**.

Use a fine-toothed file and/or coarse sandpaper to smooth all the cut edges.

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Step 41: Press In the Upper Rudder Hinge Bushing

The rudder pivots at its upper hinge on an NAS77A4-025 **flanged bronze bushing** [89]. Press this bushing into the **upper rudder hinge** [3], as shown in Figure 51.

Note The upper rudder hinge is, for practical purposes, vertically symmetrical. However, once the bushing is pressed in, the end of the hinge that has the bushing flange becomes the **top** of the hinge.

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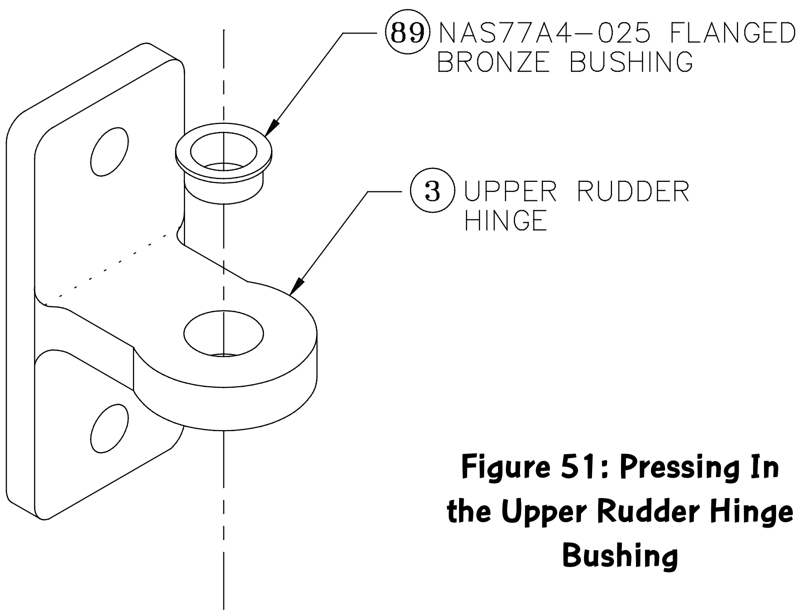

Figure 51: Pressing In the Upper Rudder Hinge Bushing

Hint As always, the use of Loctite is recommended.

Step 42: Temporarily Mount the Lower Rudder Hinge on the Rudder Yoke

As shown in Figure 52, the tongue of the rudder yoke fits between the two tongues of the **lower rudder hinge** [1] with two AN960D416L **thin aluminum washers** [79] as spacers. Note that the tongues of the hinge angle **downward** so that the base of the hinge is vertical when the rudder yoke tongue is in place.

> **Note** You may need more than one AN960D416L spacer washer on one or both sides of the bearing in the rudder yoke. Install as many as necessary to minimize play. To simplify installation, use wheel bearing grease to stick the washers to each other and to the yoke bearing prior to sliding the whole assembly between the tongues of the hinge.

The hinge and yoke are then held together with an AN4-10 **drilled-shank bolt** [54], an AN960D416L thin aluminum washer and an AN310-4 **castle nut** [43]. At this point, you need only finger-tighten the nut.

> **Note** The hinge pivot bolt will be secured ultimately with an AN380-2-2 **cotter pin** [51], but there is no reason to install this now.

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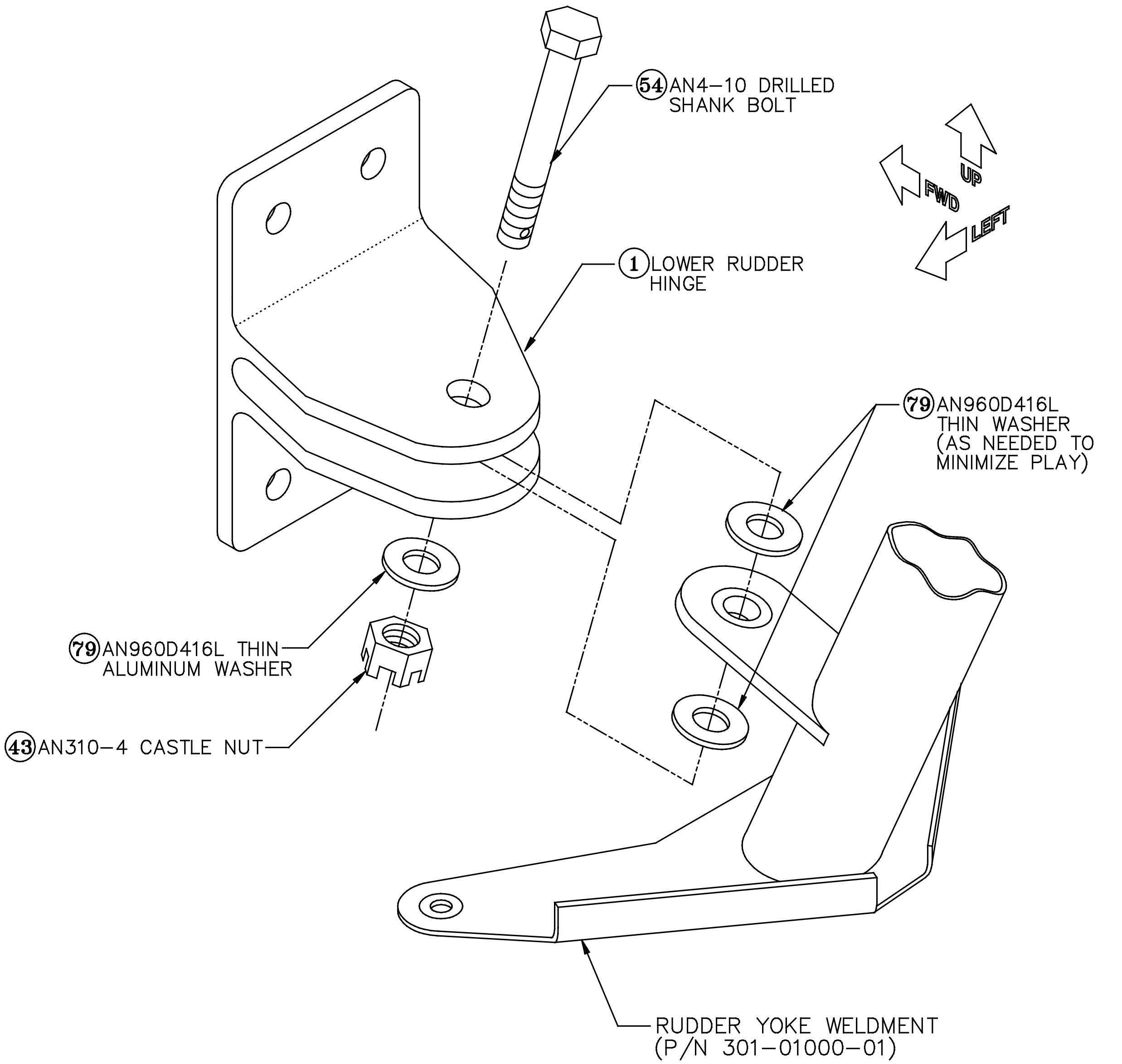

Figure 52: Mounting the Lower Rudder Hinge on the Rudder Yoke

Step 43: Temporarily Mount the Upper Rudder Hinge on the Vertical Fin Spar

Temporarily mounting the upper rudder hinge on the vertical fin spar facilitates positioning the spar and hanging the rudder. Begin, as shown in Figure 53, by marking a centerline on the web of the spar. The line should be marked on the face of the web **inside** the flanges and should extend at least **4"** or so down the spar from the tip. Next, mark a hole location on the centerline **1.6"** down from the tip of the spar. Center punch this location and drill a **1/4"** hole there.

Once the 1/4" hole has been drilled, try to insert an AN4-5A **bolt** [57] through the upper rudder hinge and the spar, as shown in Figure 54. The bolt should fit through both holes with a moderately tight press fit. If you are unable to push the bolt through either or both of the two parts with finger pressure, then use a **letter "F"** bit to ream out the offending hole.

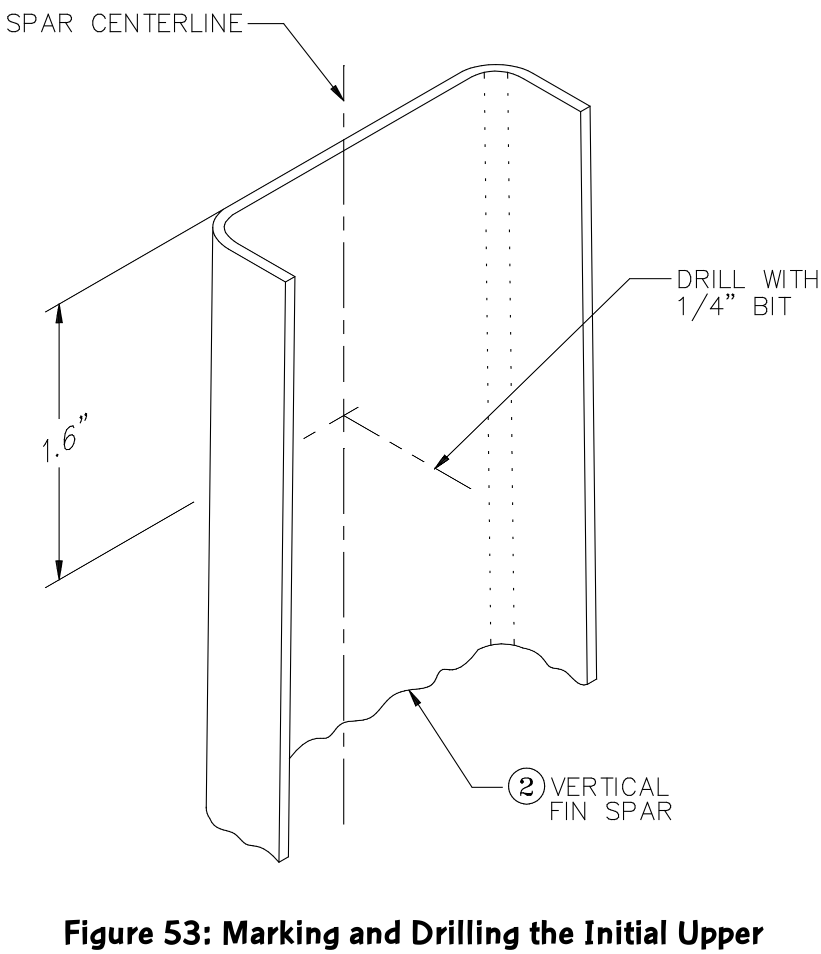

Figure 53: Marking and Drilling the Initial Upper Rudder Hinge Hole

After you have inserted the bolt, secure it temporarily with an AN960D416L thin aluminum washer and an AN316-4R **jam nut** [45], as shown in the figure. Just make this nut finger-tight.

Finally, rotate the hinge as necessary to center the lower hole over the spar centerline, as shown in Figure 54, and use the hinge hole as a guide to drill through the spar web. Once again, begin with a **1/4"** bit, try inserting an AN4-5A bolt, and ream the holes with an **"F"** bit as necessary. Secure the bolt temporarily with an AN960D416L thin aluminum washer and an AN316-4R jam nut as before.

Note The hinge will be permanently secured with nutplates in a later step.

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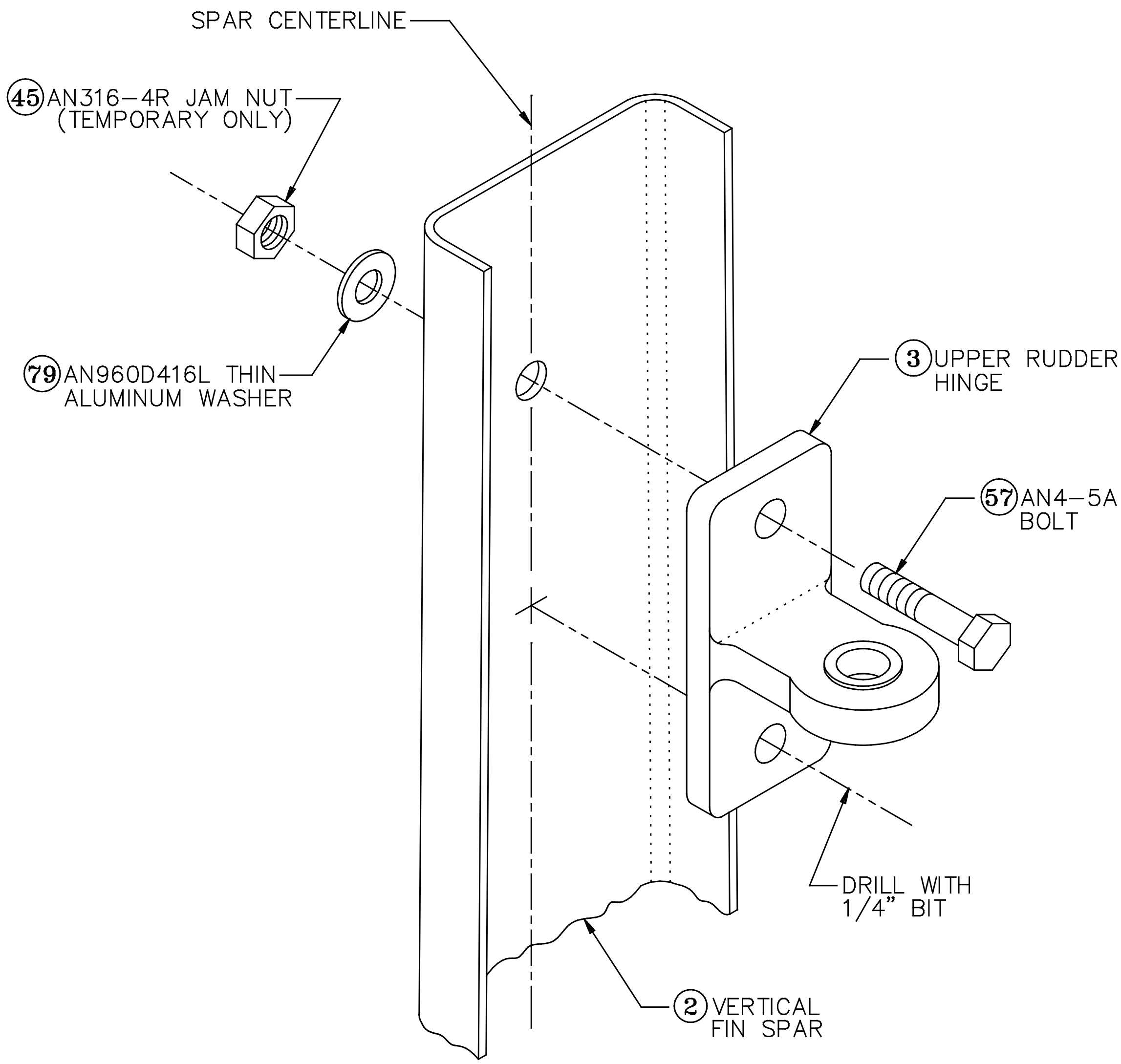

Figure 54: Mounting the Upper Rudder Hinge

Step 44: Temporarily Join the Upper Hinge Halves

In this step you will temporarily mount the upper hinge on the rudder, thereby positioning the vertical fin spar relative to the rudder in preparation for positioning the spar between the composite fin shells.

As shown in Figure 55, the tongue of the upper rudder hinge fits between the two tongues of the rudder-side hinge with two AN960D416L thin aluminum washers as spacers. The hinge halves are then held together with an AN4-10 drilled-shank bolt, a third AN960D416L washer and an AN310-4 castle nut. At this point, you need only finger-tighten the nut.

Note The hinge pivot bolt ultimately will be secured with an AN380-2-2 cotter pin, but there is no reason to install this now.

Note The base of the lower rudder hinge ultimately will be bolted through the flat, lower flange of the vertical fin spar to Bulkhead C. At this point, however, it is simply functioning as a spacer, holding the spar the proper longitudinal distance away from the rudder leading edge.

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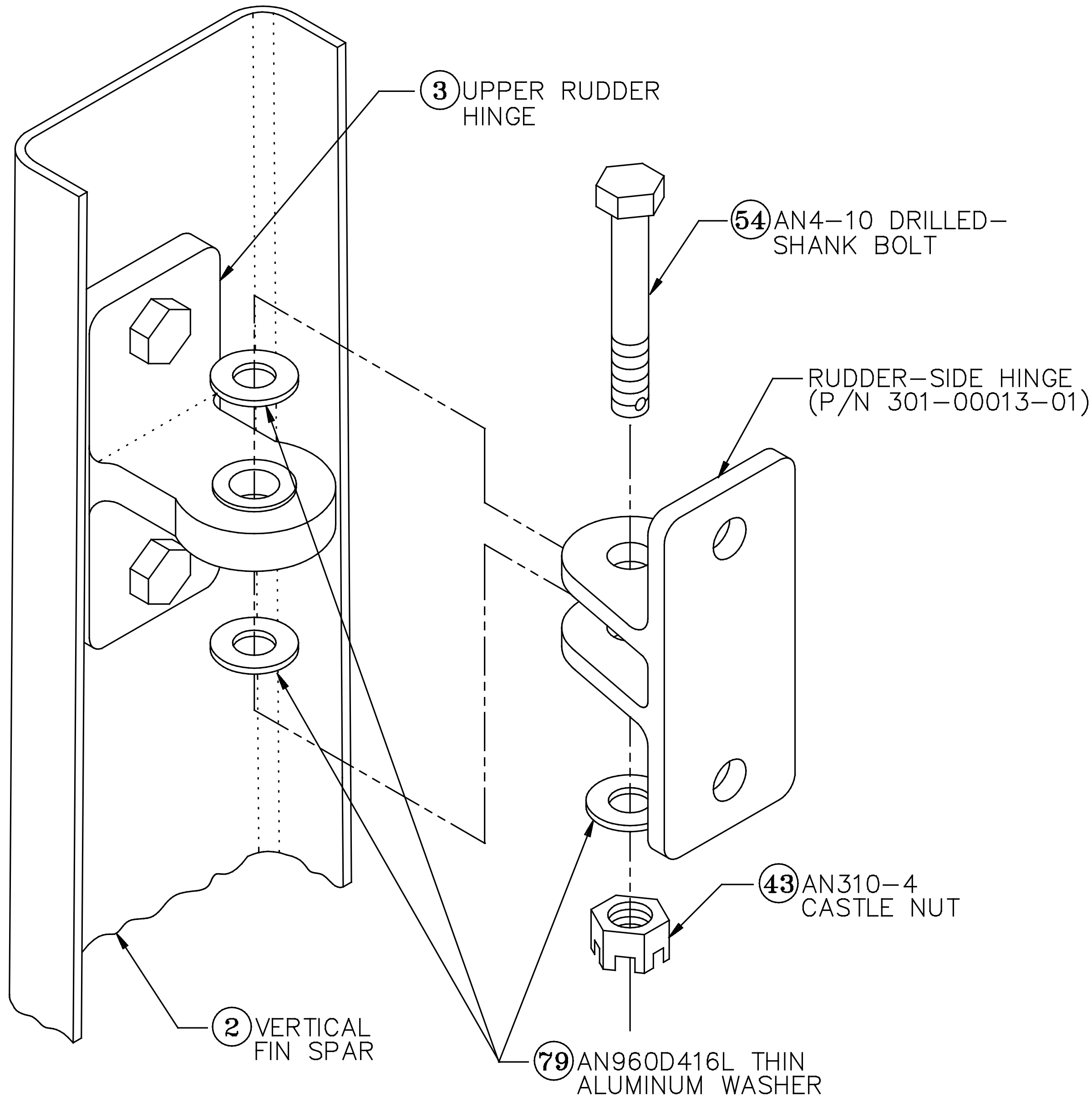

Figure 55: Joining the Upper Rudder Hinge Halves

Step 45: Sand the Tops of the Vertical Fin Shells

In the next step, you will "hang" the rudder by its counterweight rib from the tops of the vertical fin shells to position the vertical fin spar between the shells. In order for this method to provide accurate positioning, it's necessary that the tops of the fin shells be parallel with one another and with the waterline plane of the aircraft.

Using a long sanding block, sand as necessary in the directions shown in Figure 55 to make the shell edges parallel. Use a level both along the lengths of the shells and across them to check for parallelism.

Note Remove as little material from the shells as possible, but be sure that you at least get rid of any mold lip, as described earlier in this section. Continue to ignore the trailing edges of the fin shells, however; they'll be dealt with a few steps down the road.

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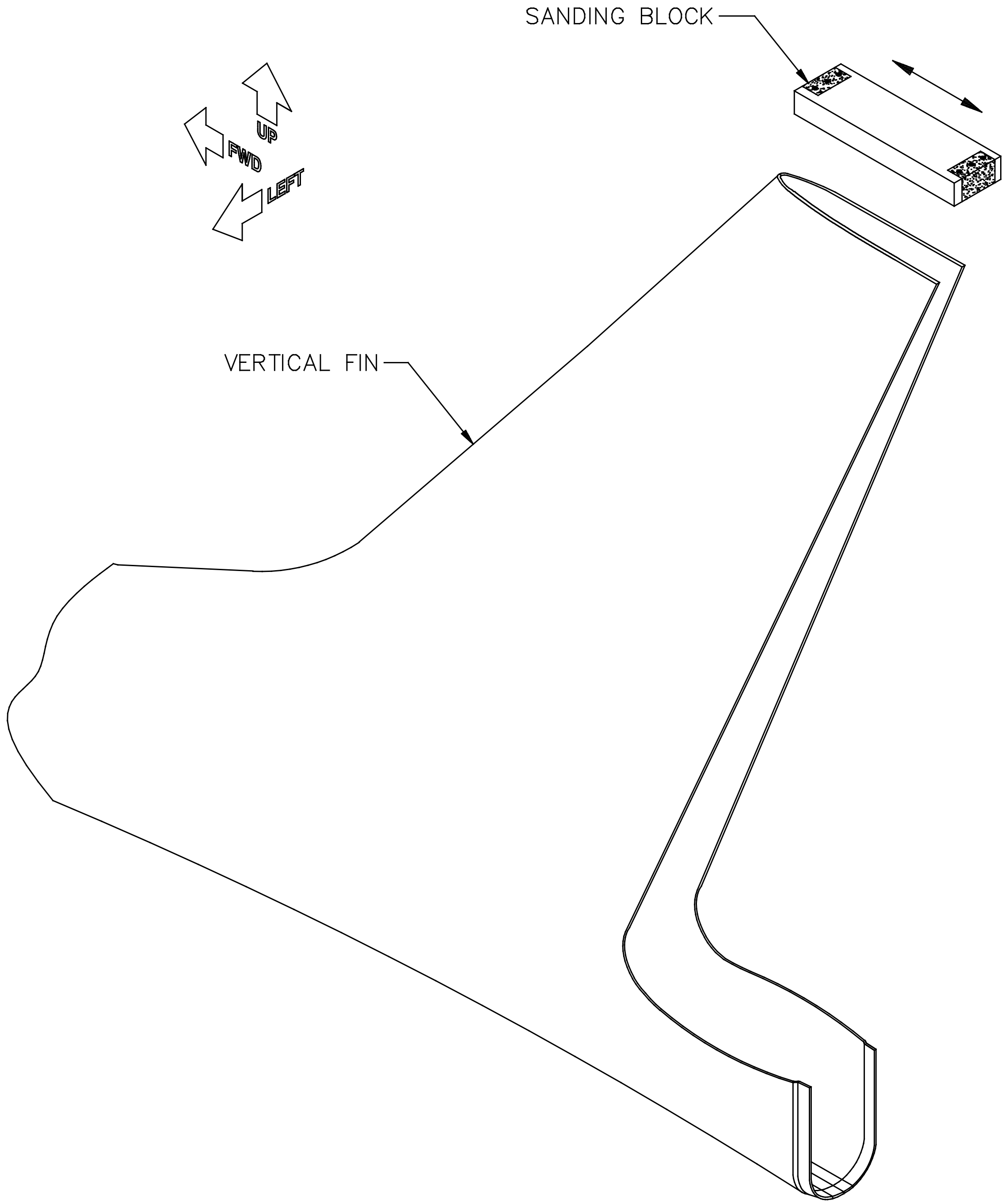

Figure 56: Sanding the Tops of the Vertical Fin Shells

Step 46: "Hang" the Rudder Assembly from the Tops of the Vertical Fin Shells

Note This step will be very difficult to accomplish without an assistant and a step ladder.

Positioning the vertical fin independently would be a tremendous challenge because of the absence of firm points on the fuselage shells from which to take measurements. For this reason, you will essentially use the rudder assembly as a jig to hold the spar in position relative to the vertical fin shells until some index holes can be drilled.

Begin by arranging two shims across the tops of the vertical fin shells, as shown in Figure 57. These shims should be **1/8"** thick. The other dimensions are completely non-critical, as long as the shims are long enough to span the top of the fin. Place one shim near the leading edge of the fin and one near the trailing edge. Again, these placements are not critical.

Hint Two tongue depressors or popsicle sticks stacked together make a fine shim.

With the shims in place, have your assistant move the rudder assembly (with the vertical fin spar attached) into position, as shown in Figure 57. Hold the trailing edges of the vertical fin shells apart to allow the spar to nest in between them. Push the rudder assembly forward until its leading edge is even with the leading edge of the fin. Then lower the assembly until it contacts the shims.

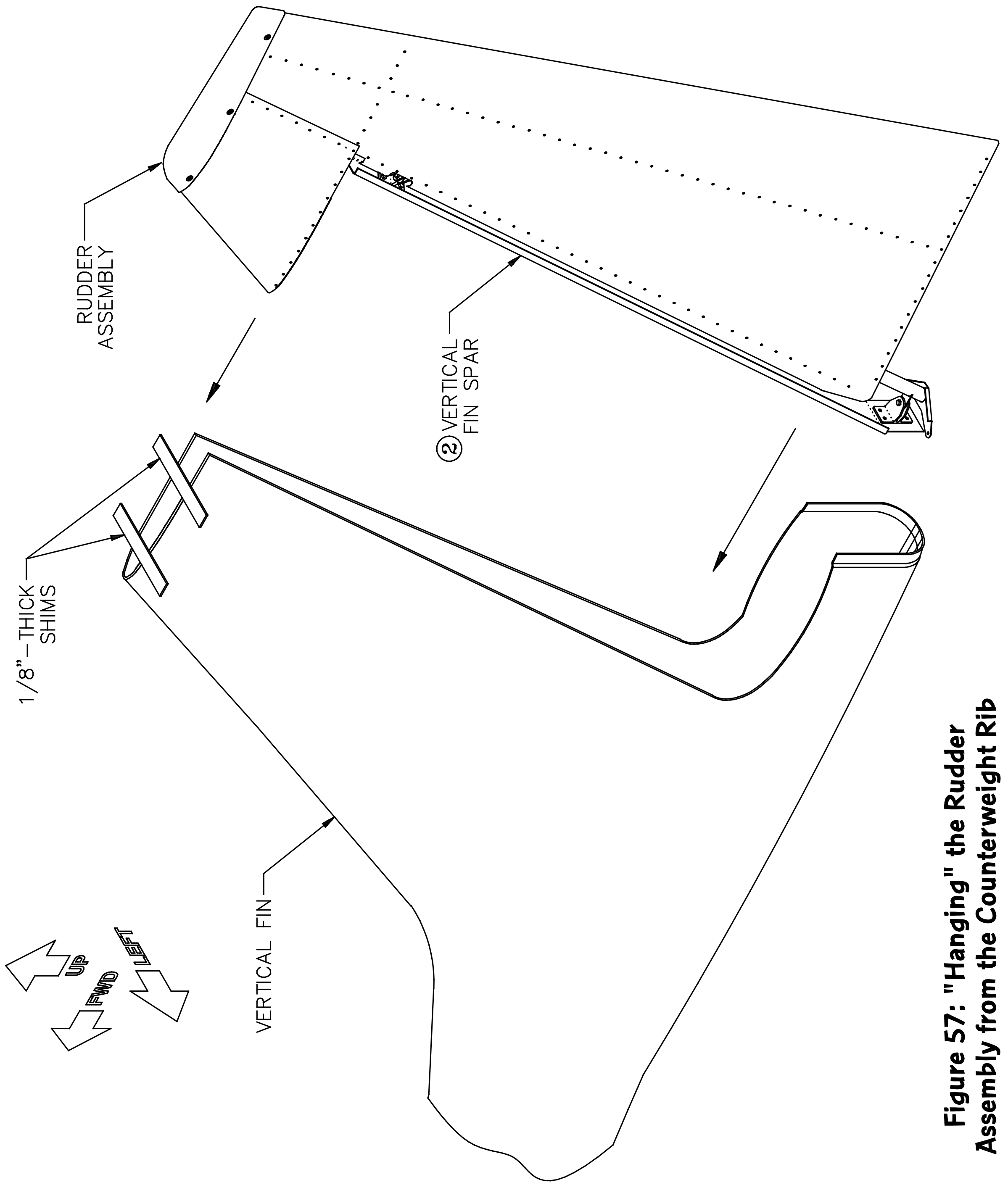

Figure 57: "Hanging" the Rudder Assembly from the Counterweight Rib

Note For the forward rudder skin to perform its function of positioning the vertical fin spar and rudder assembly relative to the fin shells, it's important that its lower edges—the ones that contact the tops of the fin shells—be level and parallel. It's not unusual for minor misalignments of the skin to result in one edge hanging down a little lower than the other or in a small downward projection at the very leading edge. Such misalignments are shown (exaggerated for clarity) in Figure 58. Use a fine-toothed file or a sander to dress these out. Avoid contacting the underside of the counterweight rib, but take off as much skin below the rib as necessary.

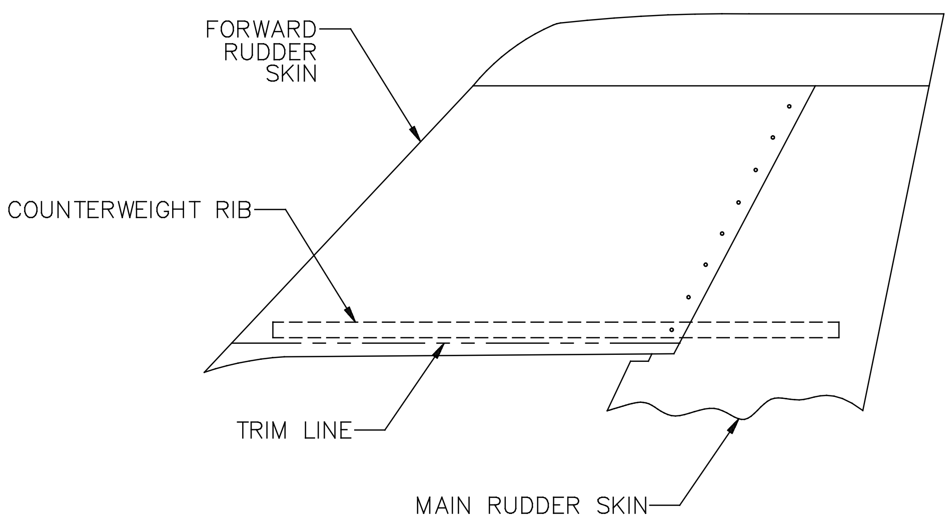

Figure 58: Trimming the Forward Rudder Skin

As Figure 59 shows, the **fore-and-aft** position of the vertical fin is set by the alignment of the leading edges of the rudder and fin. Before drilling index holes through the spar, it's necessary to lock in this reference relationship. A simple and effective method for doing this is to tape a length of aluminum angle stock across the gap between the two parts. As shown in Figure 59, simply slide the rudder assembly forward or aft on the shims until its leading edge forms a continuous line with the leading edge of the fin and then use duct tape or wide masking tape to secure a piece of angle stock across the gap. The longer the angle stock and the more tightly you tape it in place, the better your results will be.

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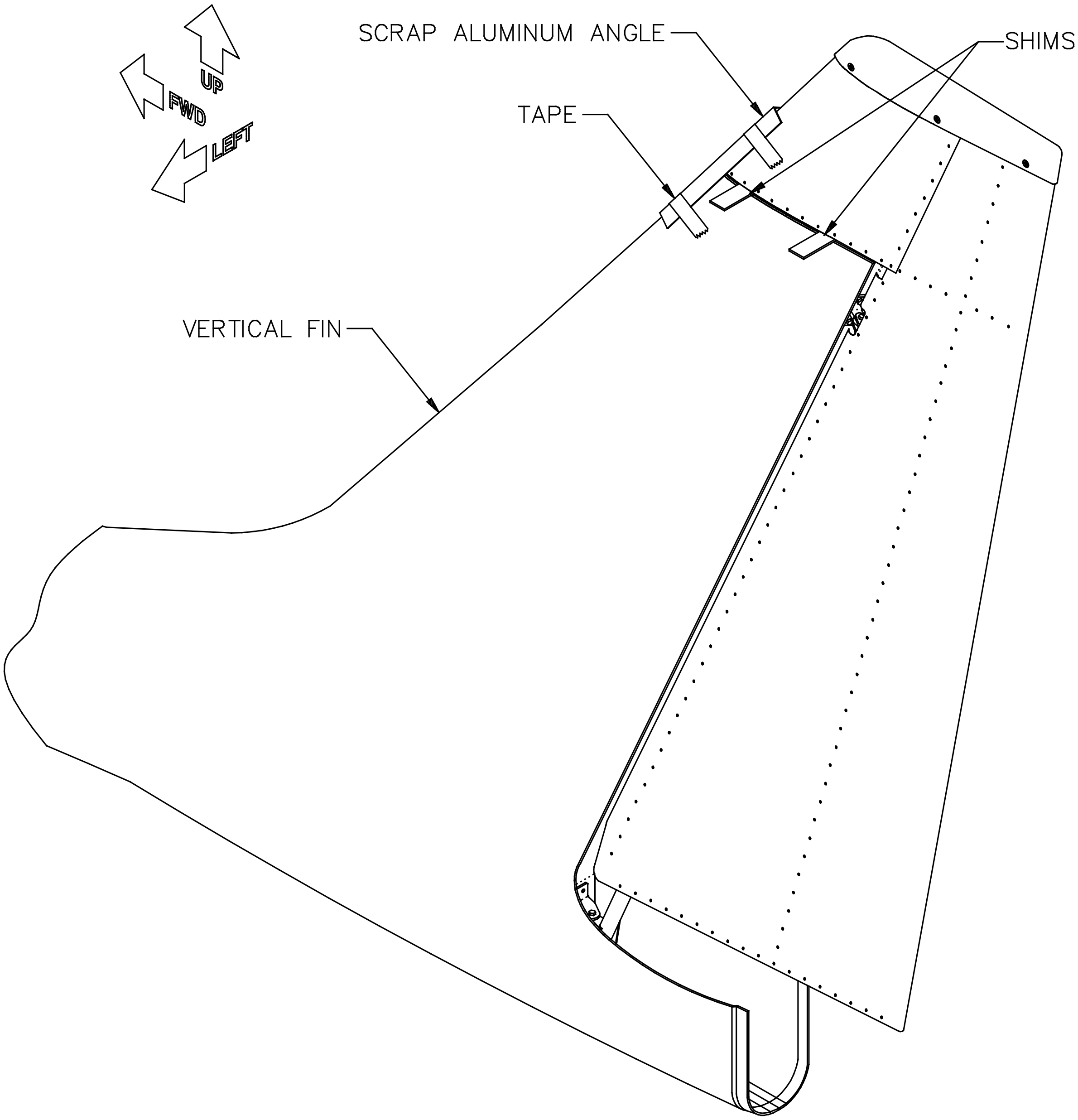

Figure 59: Aligning the Rudder and Fin Leading Edges

Step 47: Drill Index Holes Through the Flanges of the Vertical Fin Spar

With the fin spar positioned, you can now drill holes through the fin shells and spar flanges to lock the spar in place.

> **Note** At this stage it may not appear that the rudder assembly and fin spar are properly positioned relative to the shells because the trailing edges of the shells likely extend aft quite a ways, perhaps even riding up over the rudder skin. Obviously, this isn't an acceptable final outcome. However, in a subsequent step, you'll trim a fair bit of material off the fin trailing edges to ensure sufficient rudder travel and a uniform gap, so at this point, you should simply ignore these trailing edges and let the leading edges be your guide in positioning the rudder and spar.

Begin by ensuring that the web of the fin spar is perpendicular to the fin shells. Check it both at the top and at the bottom and turn it as necessary to bring it into alignment.

Next, mark the point at the bottom of the spar on each side at which the flare of the fuselage shells departs from the flat surface of the spar flanges; these points are denoted by the bold arrows in Figure 60. You'll be able to reach alongside the rudder yoke to feel with your fingertips where the shells begin to flare.
From this point, mark a short line perpendicular to the trailing edge of the fin shell; this line is labeled Line A in the side-view panel of Figure 60. Measure upward from this line **1/4" along the trailing edge** and mark a second perpendicular line (Line B in the figure). On this second line, drill one **#40** hole through the shell and the spar flange on each side. These holes should fall roughly on the centerline of the spar flanges. Unfortunately, with the rudder in the way, there's no convenient way to measure the location of this centerline precisely. However, measuring along Line B approximately **1-9/16" forward** of the **forwardmost** vertical line of rivets on the rudder will put you on the approximate center of the flange.

After each hole is drilled, insert a Cleco.

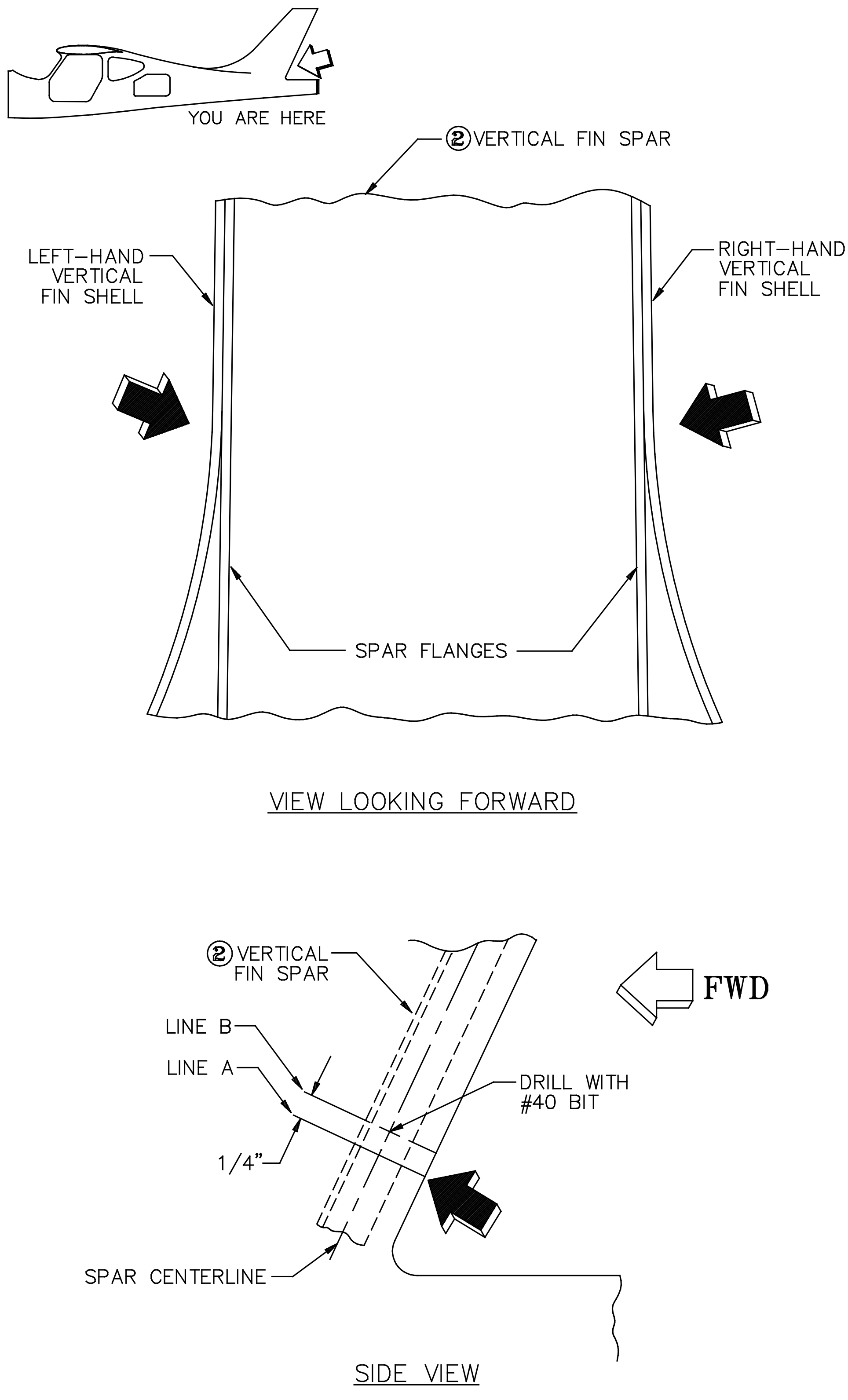

Figure 60: Marking and Drilling the Bottom Index Holes Through the Spar Flanges

Drill another index hole near the top of the spar on each side. Like the bottom holes, these should be on the centerline of the spar flange. As shown in Figure 61, the holes should be located **1/4" below the tip of the spar**. Once again, there is no way to measure the fore-and-aft dimension to the spar centerline precisely, but about **15/16"** forward of the forwardmost vertical line of rivets on the rudder will be close. Drill **#40** holes at the marked locations.

Cleco these holes after drilling.

Completed: [ ]

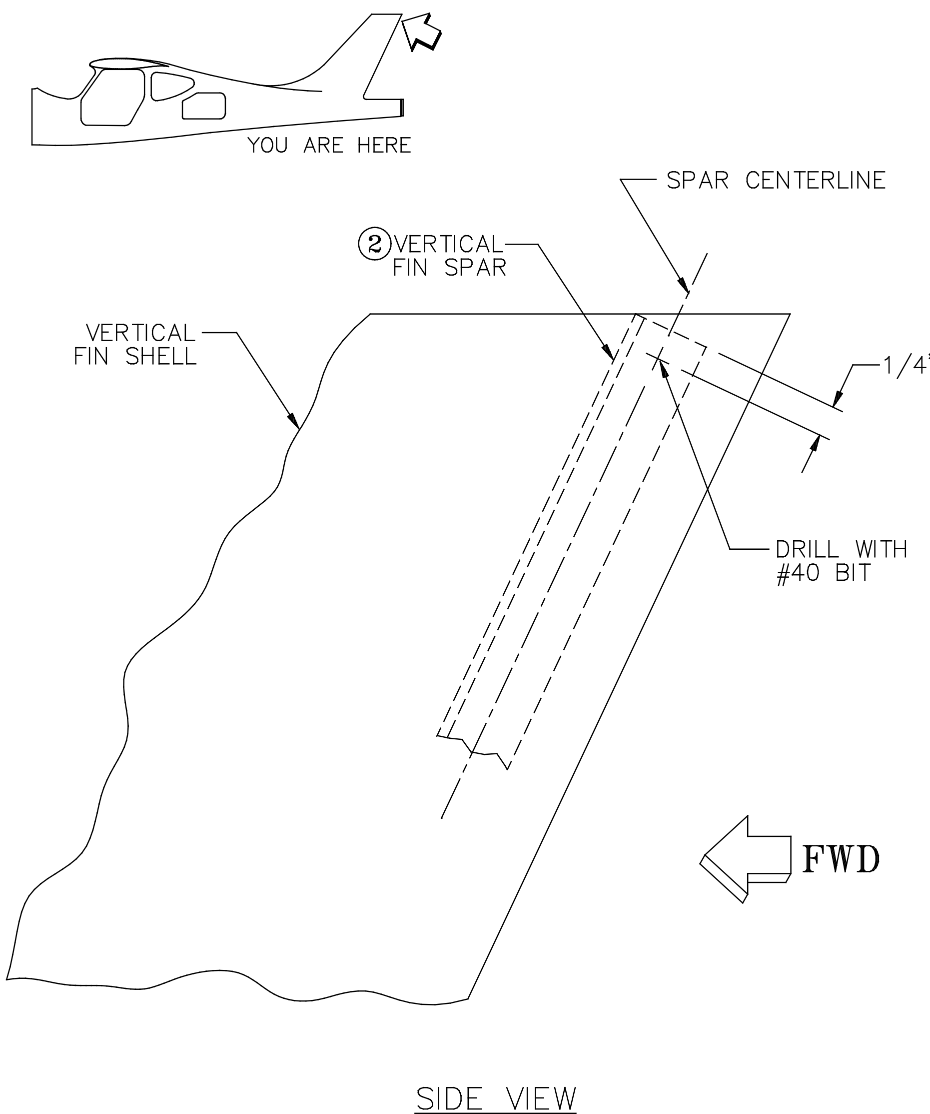

Figure 61: Marking and Drilling the Top Index Holes Through the Spar Flanges

Step 48: Center the Rudder Between the Fin Shells and Mark the Lower Hinge Location on the Fin Spar

Since the lower rudder hinge is not yet attached to the vertical fin spar, the rudder assembly as a whole is free to pivot left and right around the upper hinge. For aesthetic as well as aerodynamic reasons, you want the rudder centered between the fin shells along the entire length of the hinge line.

As Figure 62 shows, this can be achieved by taping a pair of stiff wooden or metal slats (two yardsticks would work fine) across the gap between the bottom of the fin and rudder on each side. These slats will force the rudder to center itself between them.

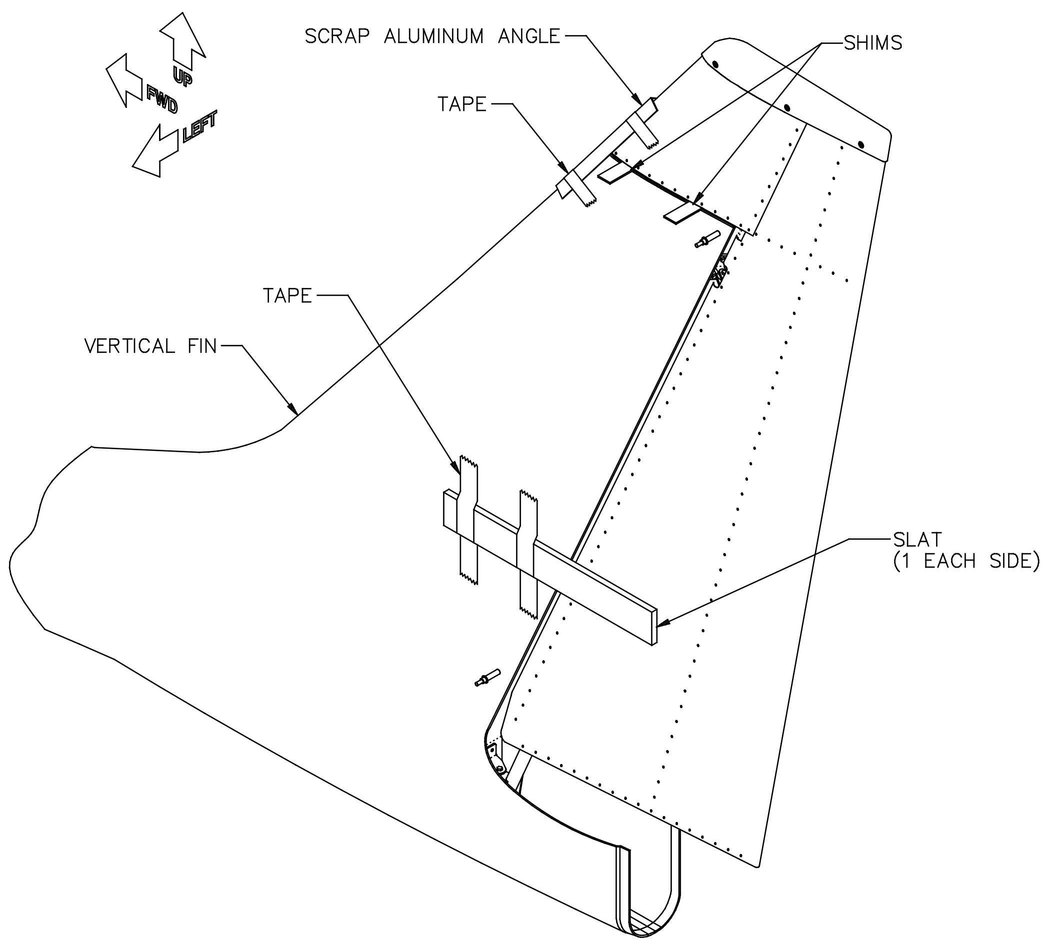

Figure 62: Centering the Rudder Assembly Between the Fin Shells

Once the rudder is centered, use a marking pen to mark the outline of the lower rudder hinge on the lower flange of the vertical fin spar.

Note Because of slight misalignments in the rudder yoke, the hinge may be obviously off center on the spar when the rudder is centered between the shells. Figure 63 shows a clear example of this. **There is no need to worry about this!** It's much more important that the rudder assembly as a whole be centered, and having the hinge line off center even by a fair amount will have no discernible effect on the function of the rudder. In fact, once the rudder is hung and the fairings are in place to hide the yoke weldment, the misalignment will be almost impossible to detect visually.

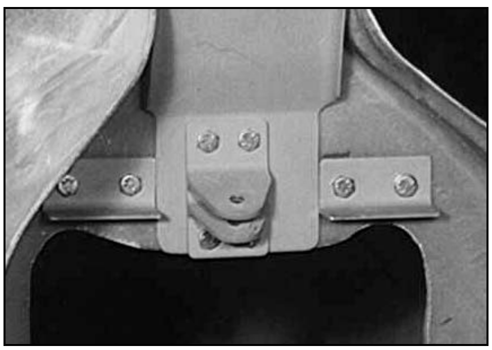

Figure 63: Acceptable Misalignment of the Lower Rudder Hinge

After the location of the lower hinge has been carefully marked, remove the rudder assembly and fin spar from the fuselage and disassemble the hinges. Then replace the spar by itself between the shells, holding it in place with Clecos through the four index holes.

Completed: [ ]

Step 49: Position and Install Bulkhead C

Bulkhead C is located just forward of the lower flange of the vertical fin spar. File or sand the bulkhead as necessary to achieve a good friction fit against the fuselage shells with the aft face of the bulkhead in contact with the forward face of the lower spar flange. If the fit is tight enough that the bulkhead will stay in position by itself, you can go ahead and remove the fin spar at this point. If the fit is a bit too loose for the bulkhead to stay in place, clamp it to the spar flange, as shown in Figure 64, and tack it to the shells with hot-melt glue. Then remove the clamps and the spar. **Make sure** that the top part of Bulkhead C holds the vertical fin trailing edges far enough apart to permit reinstalling the spar after laminating the bulkhead.

Note There is no **structural** reason a friction fit is necessary for any of the bulkheads. Gaps of up to **3/16"** can easily and safely be filled with Q-cell.

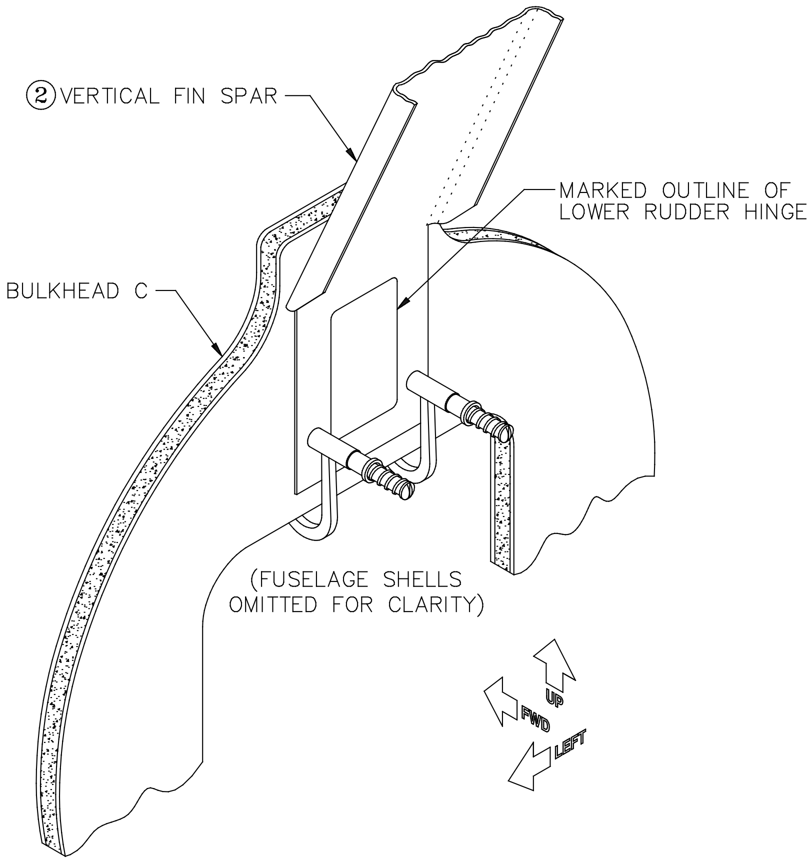

Figure 64: Clamping Bulkhead C to the Fin Spar

Bulkhead C is installed slightly differently than Bulkhead B, but you begin in the same way—with a 3/16" Q-cell fillet front and back (see Figure 65). Also as with Bulkhead B, follow the Q-cell with one layer of DBM cloth on the **forward** side of the bulkhead; use four strips end to end, each about 12" long.

However, on the **aft** side of Bulkhead C, rather than DBM you will apply two plies of bi-directional cloth cut on the 45° bias, each one covering the entire face of the bulkhead and overlapping 1" onto the shells. Use the Bulkhead C template to cut these pieces, making each one about 1" larger all the way around than the bulkhead itself.

After the aft layers have cured, retrim the center cutout in the bulkhead. Also, just as you did in Bulkhead B, cut a **1/2" X 1"** drain hole in the bottom center of the bulkhead.

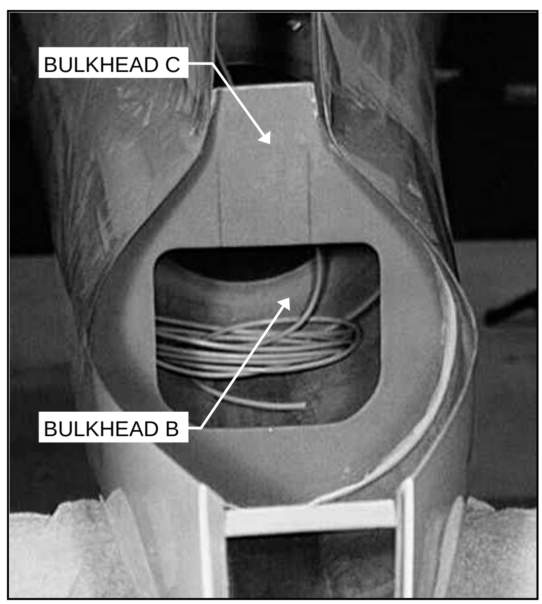

Figure 65: Bulkhead C Installation

Note You may note that the two layers of cloth applied to the aft face of Bulkhead C will have the effect of moving it aft and thus impinging on the lower flange of the vertical fin spar. As a practical matter, however, the layers will add no more than 1/32" to the thickness of the bulkhead, and given the flexibility of the spar flange, this is essentially negligible.

Completed: [ ]

Step 50: Drill the Lower Rudder Hinge Mounting Holes in the Vertical Fin Spar and Bulkhead C

With the vertical fin spar off the fuselage and separated from the rudder, use a C-clamp to clamp the lower rudder hinge in position against the lower spar flange according to the outline you marked in Step 48. Use a **3/16"** bit to drill through the spar flange at each of the four holes in the base of the hinge.

Hint Because of the downward-projecting tongues of the hinge, you will have difficulty getting a drill bit into the lower two holes. To avoid this problem, simply drill the upper two holes first, then unclamp the hinge and turn it around, inserting a couple Clecos through the newly drilled upper holes in the spar flange and the lower holes in the hinge. Now you can once again use the upper hinge holes as guides, but you'll be drilling the lower flange holes.

Reinstall the spar (without the rudder) between the fin shells with the four index Clecos and re-clamp the lower flange to Bulkhead C, as shown in Figure 66. Use a **#10** bit to drill through the spar flange and Bulkhead C at each of the four pilot holes.

After drilling, remove the spar and deburr the holes in the lower flange.

Completed: [ ]

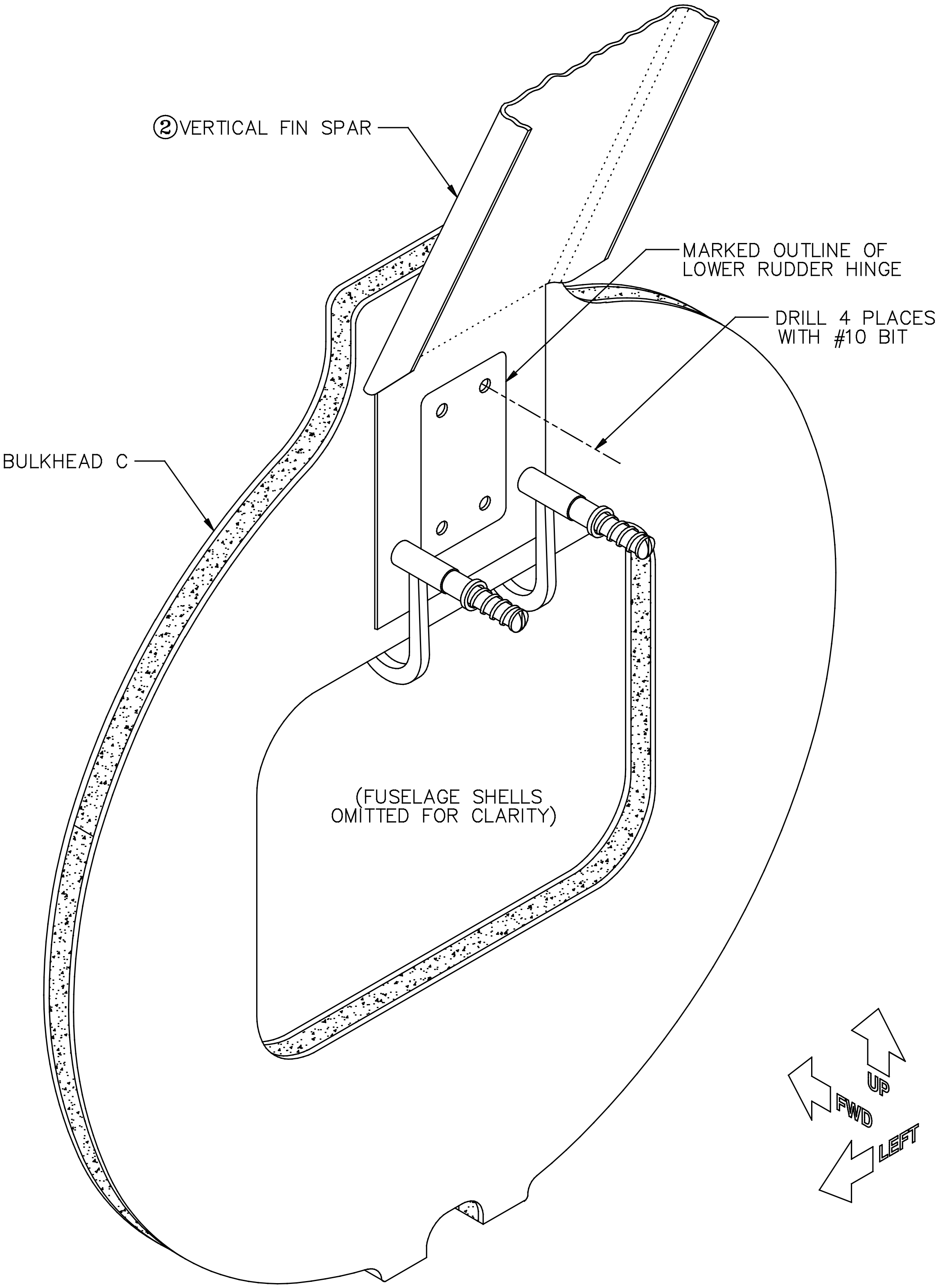

Figure 66: Drilling the Lower Hinge Mounting Holes

Step 51: Position and Drill Nutplates for the Upper Hinge

The upper rudder hinge must be secured to the vertical fin spar with nutplates since the forward face of the spar web will be inaccessible after the spar is riveted to the fin shells. You have already drilled the two bolt holes; at this time, remove the hinge from the spar, position two K1000-4 **nutplates** [84] and drill the **#40** mounting holes. As shown in Figure 67, countersink the aft face of the spar web to accommodate flush-head 3/32" rivets.

Note Figure 67 shows the nutplates oriented horizontally across the spar, but this is not at all critical.

After drilling and countersinking, deburr all four rivet holes in both the spar and the nutplates, as well as the two bolt holes in the spar.

Completed: [ ]

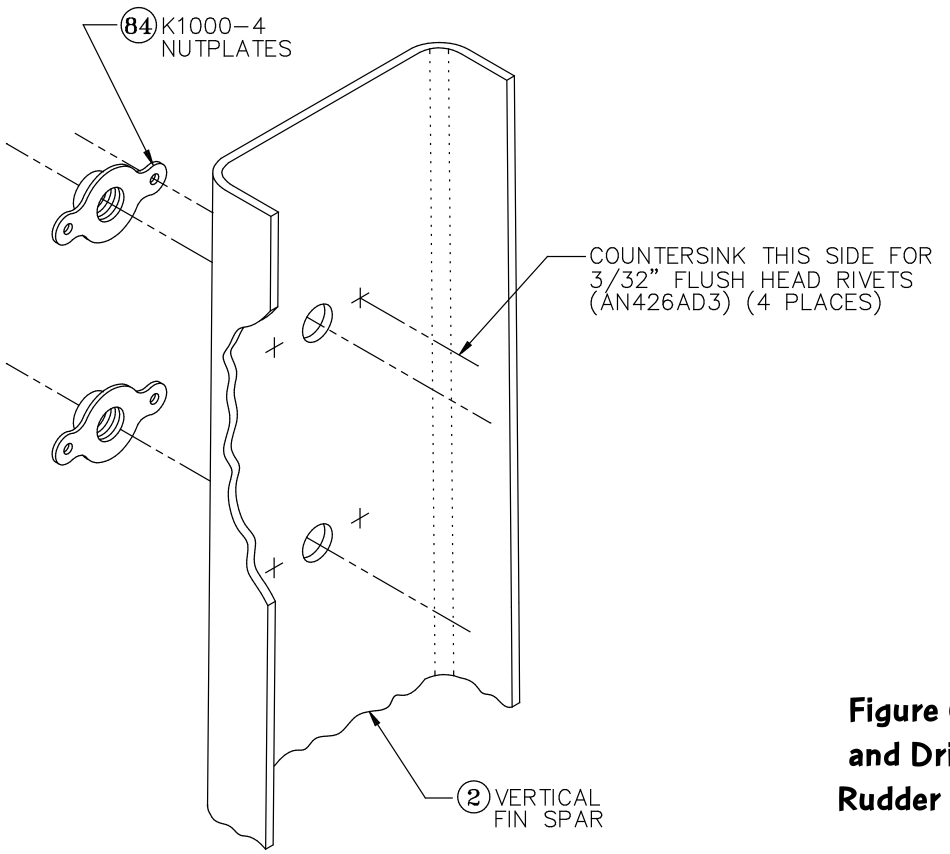

Figure 67: Positioning and Drilling the Upper Rudder Hinge Nutplates

Step 52: Bed the Vertical Fin Spar Between the Fin Shells

In this step you will use a mixture of resin and Q-cell to bed the vertical fin spar between the fin shells. As with the shell attach fittings, the purpose of this is not mainly to provide structural strength, but rather to form a smooth, uniform bed for the spar so that the rivets that do carry the structural loads can do their job.

While the resin is curing, the spar will be held in place with—among other clamps—Clecos through the four index holes. In order to prevent the Clecos from becoming a permanent part of your GlaStar, you should liberally coat the tips of them with mold-release wax. Likewise, wax the flanges of the spar itself.

Prepare the fin shells for bonding by, first, sanding the bonding surface of the shells coarse sandpaper and wiping them down with acetone to remove any dirt or grime. Second, insert a short block of scrap wood between the tops of the shells as shown in Figure 68. This will spread the shells out slightly to make it easier to slip the spar into place without displacing all the Q-cell mixture forward.

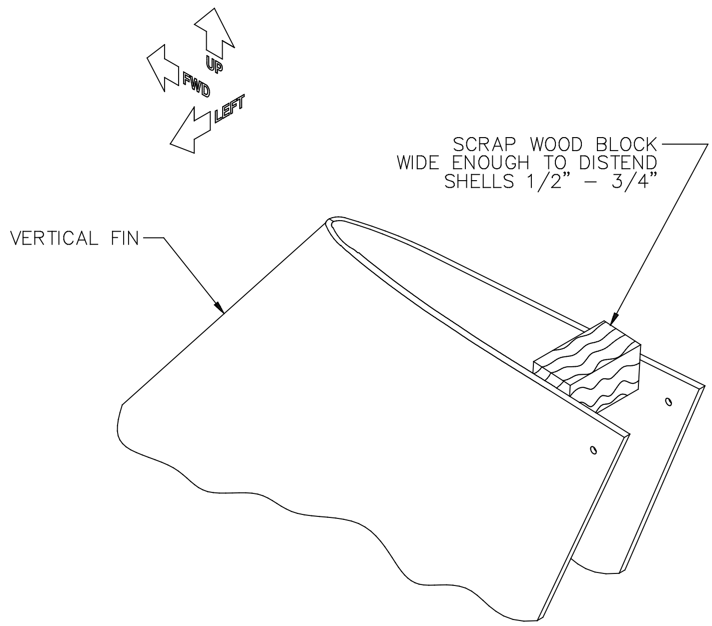

Figure 68: Spreading the Fin Shells

Catalyze a **25–50 gram** batch of resin and add Q-cell to form a medium-thick mixture. Spread this liberally on the inside trailing edges of the fin shells. Be sure to extend your coverage far enough forward and far enough downward to ensure that the entire flange of the spar on both sides will be bedded in the mixture. If you have mixed a thick enough batch, you should be able to apply a layer approximately **1/16"** thick. This will be ample to take care of any irregularities in the inner surfaces of the shells.

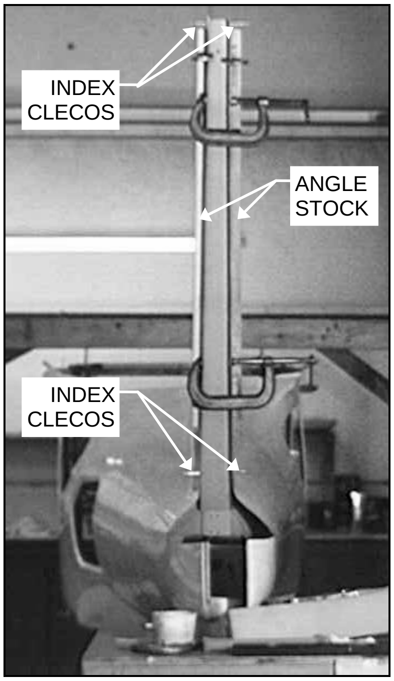

Figure 69: Clamping Procedure for Bedding the Vertical Fin Spar Between the Fin Shells

With the Q-cell spread on both shells, slide the waxed vertical fin spar between the shells. Cleco it in place through the index holes on one side, remove the spreader block to allow the shells to close together, and then Cleco the index holes on the other side.

With the Clecos in place, you will probably observe that the shells are pulled in more tightly around the Clecos than elsewhere, and if the Q-cell were allowed to cure in this condition, you'd end up with wavy fin trailing edges. To prevent this, you need to apply clamps all the way down the trailing edge between the Clecos on each side. As shown in Figure 69, a pair of long boards or lengths of angle stock is useful to distribute the clamping pressure evenly along the length of the spar.

Don't over-tighten these clamps; make sure the clamps don't deform the vertical fin. The object is not to squeeze all the Q-cell out from between the shells and spar flanges but rather to provide even pressure along the entire spar. Clean up any Q-cell that does ooze out and let the remainder cure thoroughly. Then remove the clamps and clamping angles, but leave the four index Clecos in place.

Completed: [ ]

Step 53: Mark and Drill the Vertical Fin Rivet Holes

With the spar bedded in between the fin shells, the next step is to drill the rivet holes through the shells and spar flanges. First, mark a rivet line down the trailing edge of each fin half. This line should be positioned over the spar flange **1/4" forward of the spar flange trailing edge**. Since this distance may or may not bear a fixed relationship to the trailing edges of the fin shells themselves, you'll have to determine the distance to the rivet line from the fin trailing edge **for each flange top and bottom**. This dimension is labeled "x" in Figure 70.

Once you've determined the "x" dimension for each side of the spar both top and bottom, transfer these measurements to the outside of the fin shells and mark lines between them along each side. On these lines, you must lay out and mark rivet hole positions. Space the holes evenly between the upper and lower #40 index holes on each side with **no more than 1-1/4" spacing**. You should wind up with roughly forty holes per side.

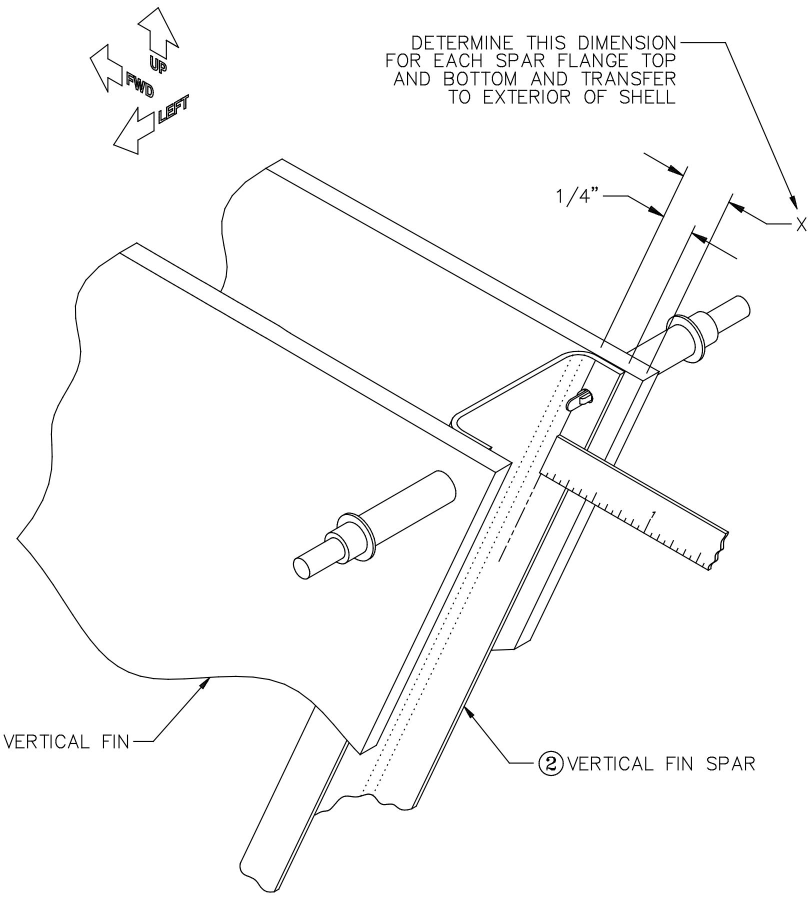

Figure 70: Measuring to Mark the Vertical Fin Rivet Lines

Once the hole locations are marked, drill them all through the shell and spar with a **#30** bit. Cleco as you go. Don't forget to drill the four index holes up to #30 size as well. After all the drilling is completed, remove the Clecos and gently break the spar loose from the Q-cell bed. Thoroughly remove any wax residue from the spar flanges and deburr all the holes.

The vertical fin spar will be secured to the fin shells with 1/8" flush-head rivets. To accommodate these, you must countersink the holes on the outside of the fin shells. Be sure to test the depth of your microstop on scrap material before drilling into the shells. Additionally, it would probably be a good idea to squeeze or drive one rivet before countersinking additional holes just to double-check the depth setting.

Hint Fiberglass is just as tough on countersinks as it is on other tools. If you have one, a carbide-tipped cutter will hold up to the abuse much better than standard steel cutters and will produce cleaner results.

Completed: [ ]

Step 54: Corrosion-Proof the Vertical Fin Spar and the Rudder Hinge Halves

Apply the corrosion protection of your choice to the vertical fin spar and the upper and lower rudder hinge halves. Mask the bronze bushing in the upper rudder hinge half with small circles of masking tape before priming.

Caution Remember, if you plan on float operations, especially on saltwater, the tail is the place that needs corrosion protection most, since it will get a good bath on every takeoff!

Completed: [ ]

Step 55: Rivet the Upper Rudder Hinge Nutplates to the Vertical Fin Spar

Use 3/32" AN426AD3 flush-head rivets to rivet the two K1000-4 nutplates to the **forward face** of the vertical fin spar web. The rivet heads should be on the aft, countersunk face of the web.

Completed: [ ]

Step 56: Bolt the Lower Rudder Hinge and the Fin Spar to Bulkhead C

Slide the vertical fin spar into place between the shells and use AN3-7A **bolts** [42], AN970-3 **large washers** [81], and AN365-1032A **nylon self-locking nuts** [49] to mount the lower rudder hinge to the lower flange of the spar and Bulkhead C. As shown in Figure 71, be sure that the tongues of the hinge point **downward**.

> **Note** The edges of the AN970-3 washers must be relieved so they don't interfere with each other. Use a belt sander or a grinder.

Completed: [ ]

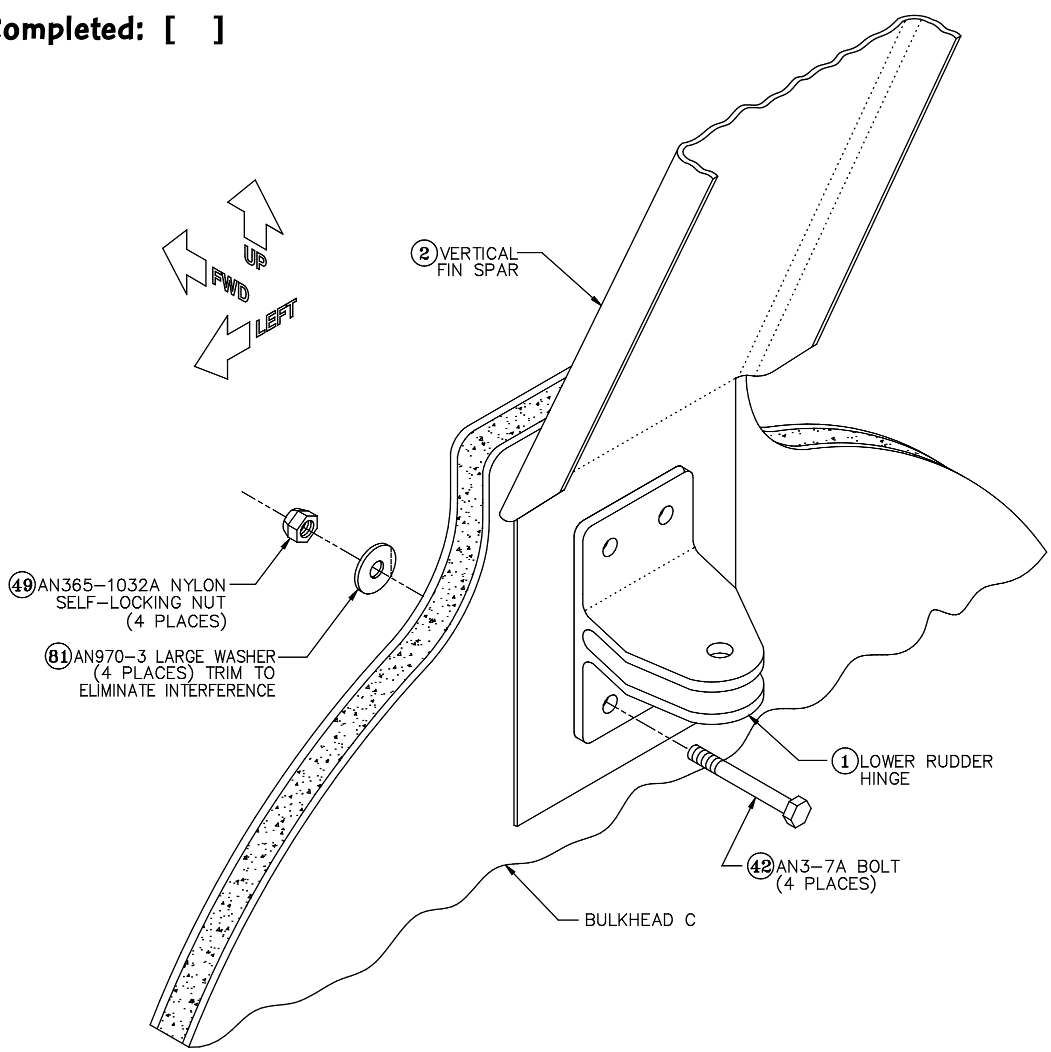

Figure 71: Mounting the Lower Rudder Hinge

Step 57: Rivet the Vertical Fin Spar to the Fin Shells

Using 1/8" AN426AD4 flush-head rivets, rivet the vertical fin spar into place between the fin shells. Use a rivet squeezer here if you have one.

Hint Either now or later, you may want to consider daubing corrosion-proofing primer on the shop heads of these rivets, especially if you plan on float operations.

Completed: [ ]

Step 58: Install the Vertical Fin Rib

You've already cut the vertical fin rib to rough size (Step 34); now it's time to install it. The purpose of this rib is mostly just to close out the open top of the fin, and since it plays little structural role, it can be installed with a single layer of cloth on the top side only.

Note If you are installing a "cat whisker" VOR antenna, you'll need to apply an **additional** layer of cloth on **top** of the rib and **two** layers of cloth to the **bottom** of the rib to provide sufficient mounting strength. Apply two layers of bi-directional cloth cut on the 45° bias to the bottom side of the fin rib **before** trimming it to final size. Drill whatever mounting holes are necessary, secure nutplates, etc., and then follow the remaining instructions in this step. Be aware, however, that for some antennas, the rib may need to be mounted somewhat lower than the 3/4" below the fin tops called out below in order to provide adequate clearance between the rudder and the antenna.

Trim the rib so that it fits between the fin shells and the web of the fin spar with a firm friction fit **3/4" below the tops of the fins**, as shown in Figure 72. Tack the rib in place with a little hot-melt glue if necessary.

Secure the rib with a Q-cell fillet followed with one layer of bi-directional cloth cut on the 45° bias. Cut this cloth large enough to extend all the way up to the top of the fin and the spar. Saturate it thoroughly, taking special care to relieve air bubbles at the forward end where the left and right fin shells join.

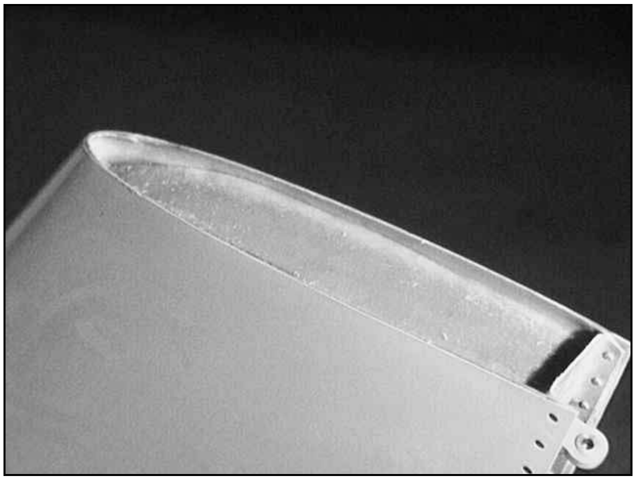

Figure 72: Vertical Fin Rib Installation

After the laminate has cured, trim off the excess cloth and sand the tops of the fin shells smooth. Also, like the fuselage bulkheads, the fin rib demands a drain hole to prevent water from collecting. In this case, drill a **1/4"** hole through the vertical fin spar web just above where it meets the rib

Completed: [ ]

Step 59: Bolt the Upper Rudder Hinge to the Vertical Fin Spar

As shown in Figure 73, use AN4-5A bolts and AN960D416L thin aluminum washers to mount the upper rudder hinge to the vertical fin spar. Be sure that the bushing flange is **up**.

Caution Take extra care not to cross-thread the nutplates!

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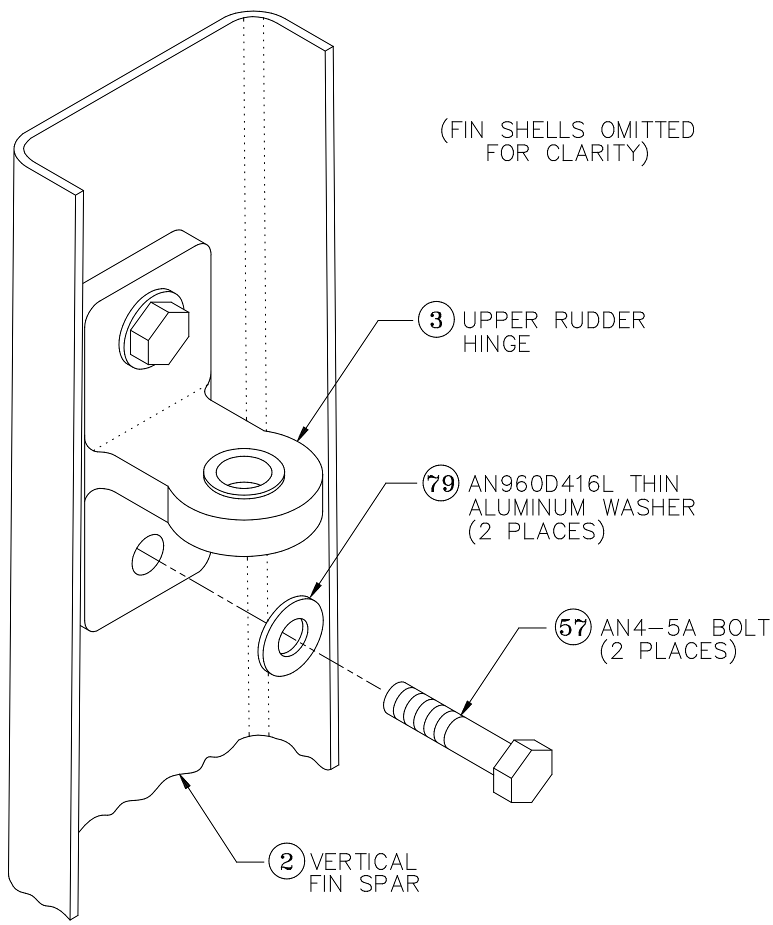


Figure 73: Mounting the Upper Rudder Hinge

Step 60: Finish the Trailing Edges of the Fin and Fit the Rudder

The trailing edges of the fin may still have mold lip, and they almost certainly extend too far aft to allow full rudder travel. In this step, you will sand them to their finished condition. As a first step, use a long sanding block with coarse sandpaper to remove the mold lip and make the two trailing edges parallel with one another, as shown in Figure 74.

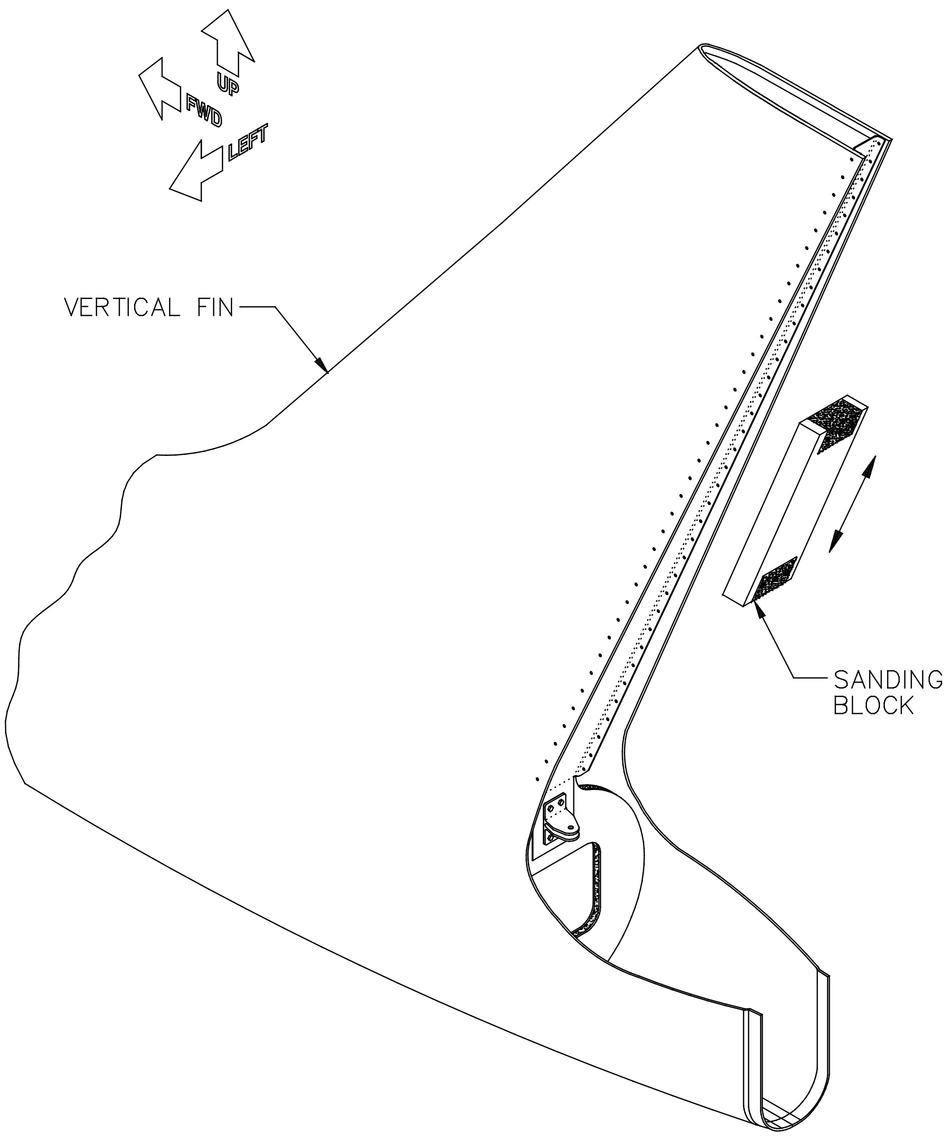
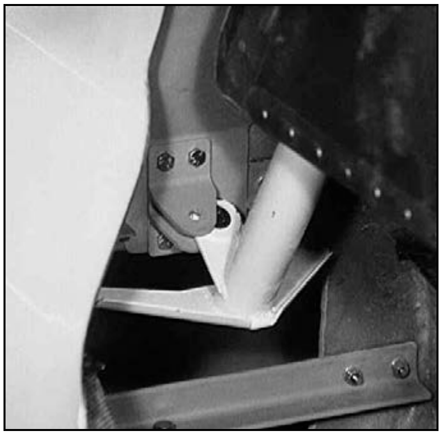


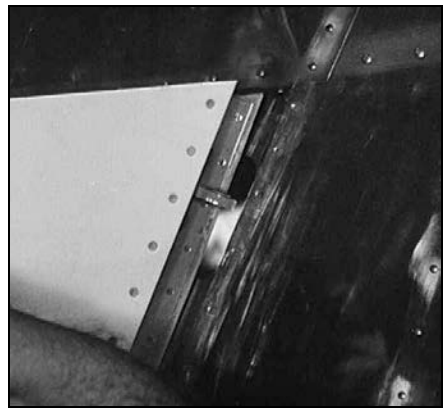
Figure 74: Sanding the Trailing Edges of the Vertical Fin Shells



(a)

Figure 75: Hanging the Rudder

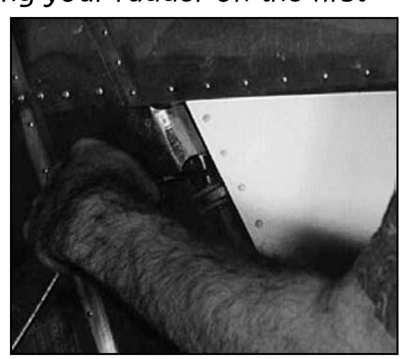
Next, temporarily hang the rudder. At first glance, this may seem like an insoluble puzzle, since the angle of the hinges prevents sliding the rudder in from behind as seems natural. Instead, the proper technique is to slide the rudder in from one side. Figure 75 illustrates this procedure. Begin by sliding the tongue of the rudder yoke in between the tongues of the lower hinge from one side (Figure 75a). Note that the top of the rudder remains off to one side and angled slightly aft while the yoke tongue slides into the lower hinge (Figure 75b). Next, tilt the rudder forward until the bottom of the rudder counterweight rib comes parallel with and then clears the top of the fin (Figure 75c). Finally, move the top of the rudder sideways until the upper rudder hinge halves mesh. Once the rudder is in place, drop a 1/4" bolt (AN4) into both hinges; the length of this bolt is not important. The lower bolt should go in easily, but the upper one is more of a challenge. Swing the rudder as far to one side as you can, and then use a small pair of needle nose pliers or forceps to maneuver the bolt into place through the access cutout (Figure 75d).



(b)

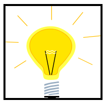
(c)

It may well be impossible for you to hang your rudder on the first try. You may have to sand more material off the top and/or the trailing edges of the fin. Keep experimenting until you can hang your rudder as shown, but try not to remove any more material than necessary to achieve this.



(d)

Once your rudder is hung, you need to determine whether it has the necessary degree of travel, which is **25° each way**. This can most easily be checked by using a bevel gauge set to **155°**, as shown in Figure 76.



Hint If you don't have a bevel gauge, a cardboard template cut to 155° will work just as well.

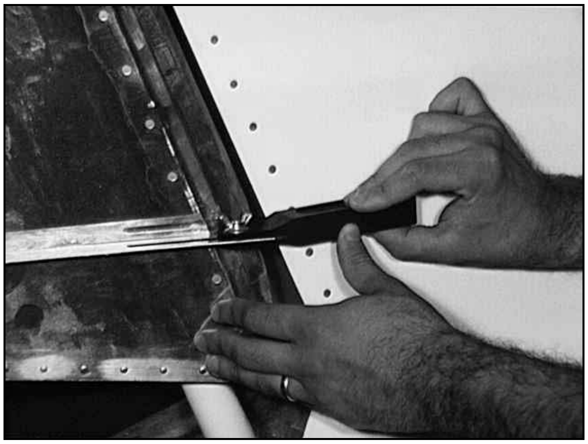


Figure 76: Checking Rudder Travel

It's very unlikely that you'll have full rudder travel initially. You'll likely have to shave more material off the trailing edges and enlarge the cutout in Bulkhead C so the rudder yoke will clear, as shown Figure 77. This is simply a trial-and-error process: keep taking a little material off, rehanging the rudder and checking the angle until you hit the desired value.

Once you've achieved 25° of free travel each way, you should take a slight additional amount—between **1/16"** and **1/8"**—off each trailing edge. You don't want the fin trailing edges scraping your rudder's paint job. The cutout in Bulkhead C, on the other hand, should be enlarged even more. Because there will be cable attach hardware on the ears of the rudder yoke, you should provide at least **1/4"** of clearance all around them when the rudder is at its extreme of travel. Figure 77 shows the extent to which this cutout will typically have to be enlarged. Use a file or a sanding drum in a rotary tool to make this enlargement.

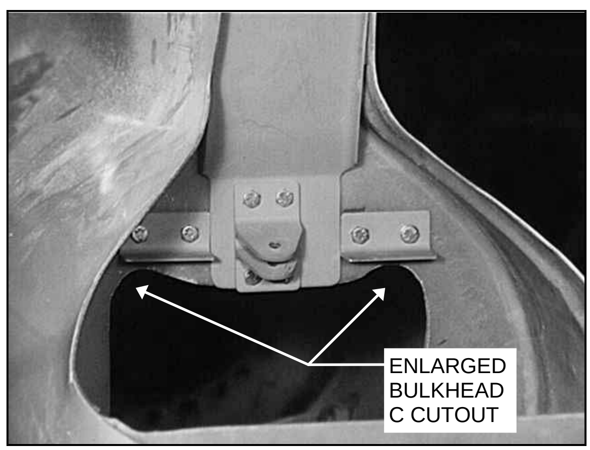


Figure 77: Bulkhead C Cutout Enlargement

When you're satisfied with your results, remove the rudder assembly and set it aside.

Completed: [ ]

Step 60.1: Fabricate the Rudder Stop Plate

As mentioned in the previous step, the specified rudder travel is **25° (±1°)** in each direction. To prevent damage to the rudder from traveling too far, a 1/8" thick aluminum **rudder stop plate**, with arms that contact Bulkhead C, will be riveted to the rudder yoke to limit the rudder's travel to no more than the specified value.

Use rubber cement or artist's spray adhesive to affix the full-sized rudder stop plate template shown in Figure 77.2 to the supplied **.125" X 3" X 10" aluminum sheet** [25.1]. Use a bandsaw to cut out the stop plate. Peel off the template and use acetone or lacquer thinner to remove any residual adhesive.

> **Note** The template is slightly oversized. Since the stop plate will be trimmed to its final size during installation, there is no need to smooth and deburr the cut edges at this time. The edges will be smoothed after the fit-up procedures have been completed.

Bend the outboard ends of the stop plate **down** about **15°–20°** along the dashed bend lines shown on the template, as shown in Figure 77.1. (This puts the ends of the arms roughly horizontal at full left and right rudder deflection, as shown in Figure 77.5.) To do this, clamp the plate in a vise between two scrap aluminum angles (to prevent the vise jaws from marring the plate) and use a hammer to bend the arms. The aluminum angle on the lower side of the plate should have a **1/8"** radius to avoid a sharp corner in the bend.

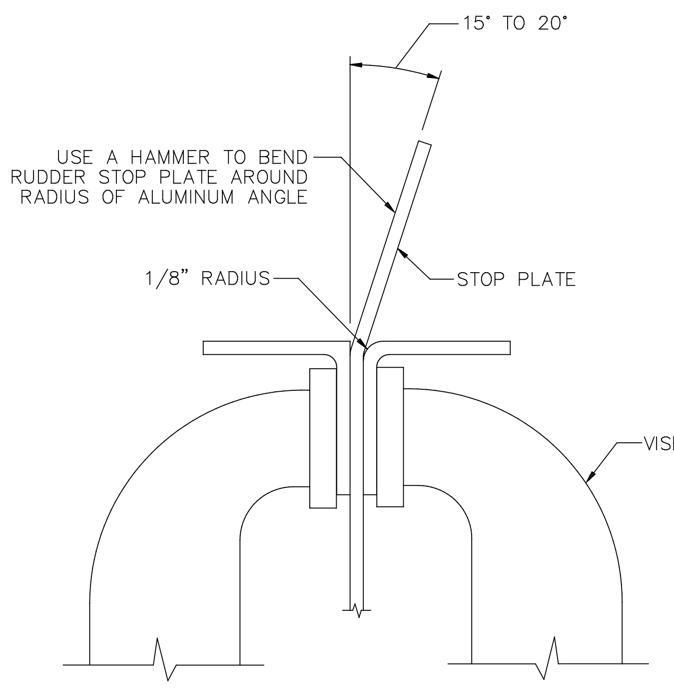


Figure 77.1: Bending the Stop Plate Arms

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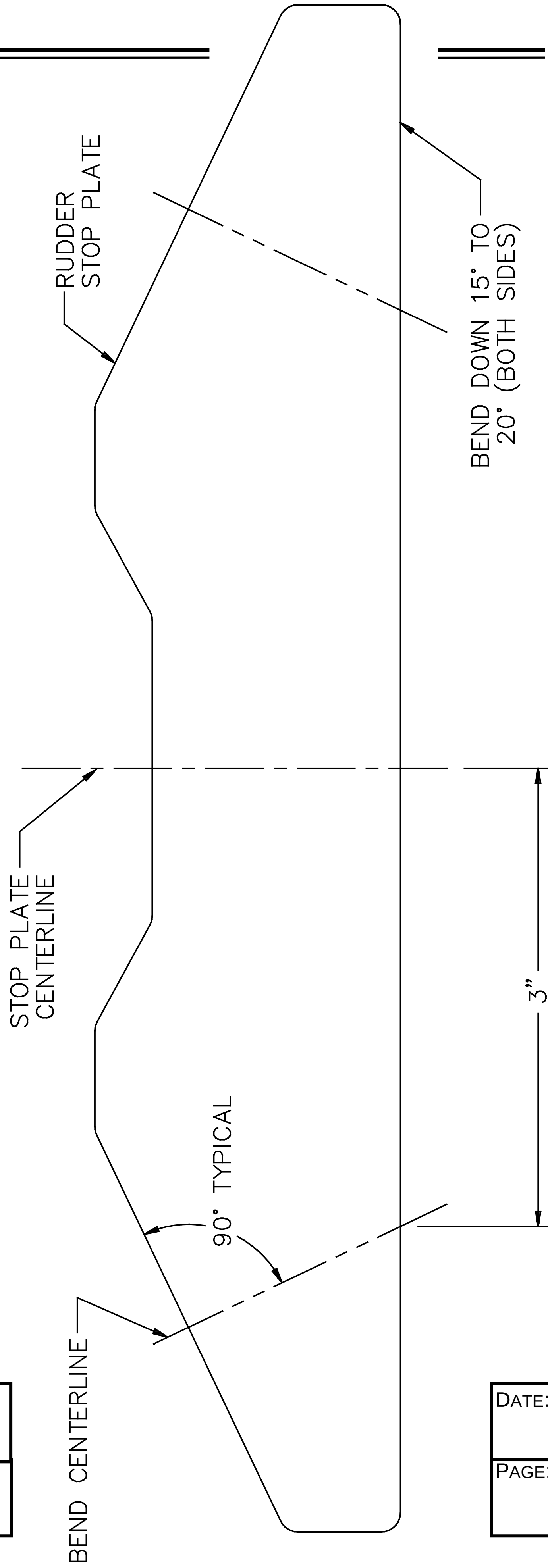

Figure 77.2: Rudder Stop Plate Template (Full Size)

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Step 60.2: Fasten the Stop Plate to the Rudder Yoke

Clamp the stop plate to the bottom of the rudder yoke, as shown in Figure 77.3, with the forward edge of the stop plate aligned with the shape of the rudder yoke and with the bent arms of the plate angled **downwards**.

Lay out and center punch the rivet pattern shown in Figure 77.3 onto the underside of the rudder stop, being careful to maintain a minimum **1/4"** edge distance from the centers of the rivet holes to the edges of both parts. Also maintain a 1/4" edge distance to the bent-up flange and other parts of the rudder yoke to provide access for bucking the rivets.

Use a **#30** bit to drill the ten rivet holes through the assembly. Cleco the first couple of holes to maintain alignment while drilling the rest. When finished, deburr the holes in both parts.

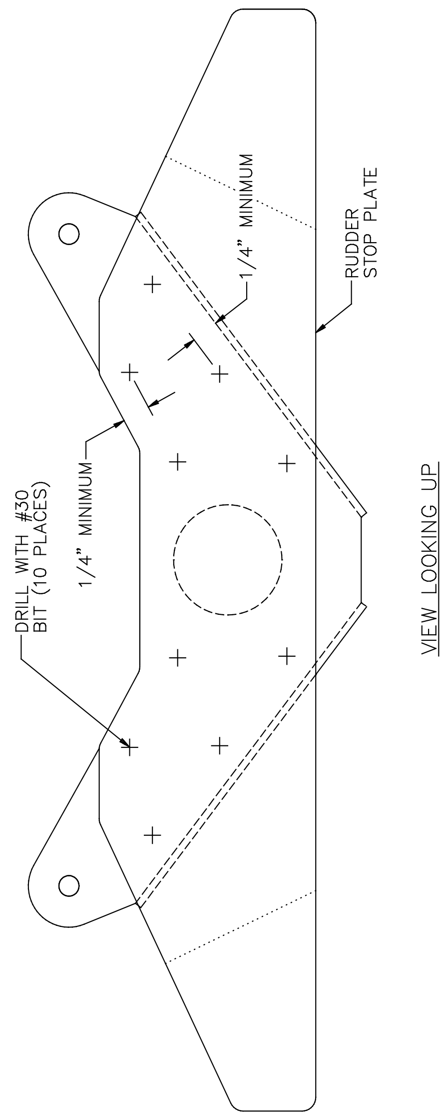


Figure 77.3: Drilling the Rudder Stop Plate Rivet Holes

Install the rudder and use two Clecos to fasten the stop plate to the underside of the rudder yoke. Insert the Clecos from the bottom so they won't contact Bulkhead C when the rudder swings.

Completed: [ ]

Step 60.3: Adjust the Rudder Travel

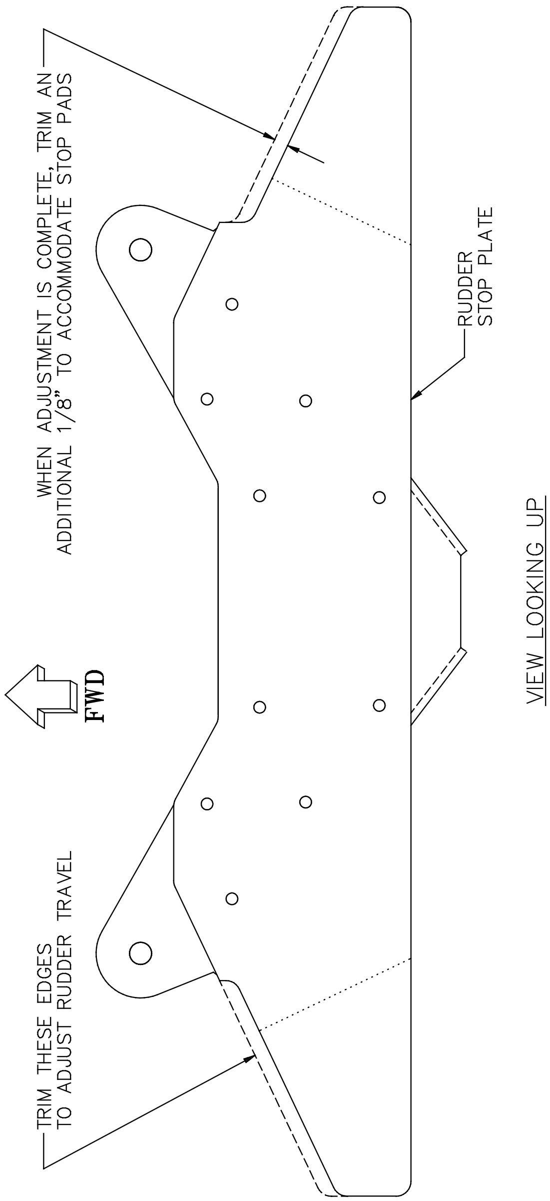


Figure 77.4: Adjusting the Rudder Stop

Set a bevel gauge to **155°** to use for checking the rudder travel, as described in Step 60, or make a rudder travel gauge by cutting a 155° angle on the edge of an 8" long piece of 1/4" plywood.

As shown in Figure 77.4, trim the **forward** edges of the stop plate arms until they contact the aft side of Bulkhead C just as the rudder reaches its 25° travel limit. This will require several cycles of checking the rudder travel, removing the stop plate for trimming, reinstalling the plate and rechecking the travel. When satisfied with the adjustment, check that the outboard ends of the stop plate arms are roughly horizontal when they contact the bulkhead; adjust the angles of the bends, if necessary, to accomplish this.

Remove the stop plate and trim an **additional 1/8"** from the forward edges of both arms, as shown. This will provide space for the 1/8" thick polyethylene stop plate pads that will be fastened to the aft side of Bulkhead C in the next step.

Smooth the saw-cut edges of the stop plate and thoroughly deburr them.

Completed: [ ]

Step 60.4: Install the Stop Plate Pads

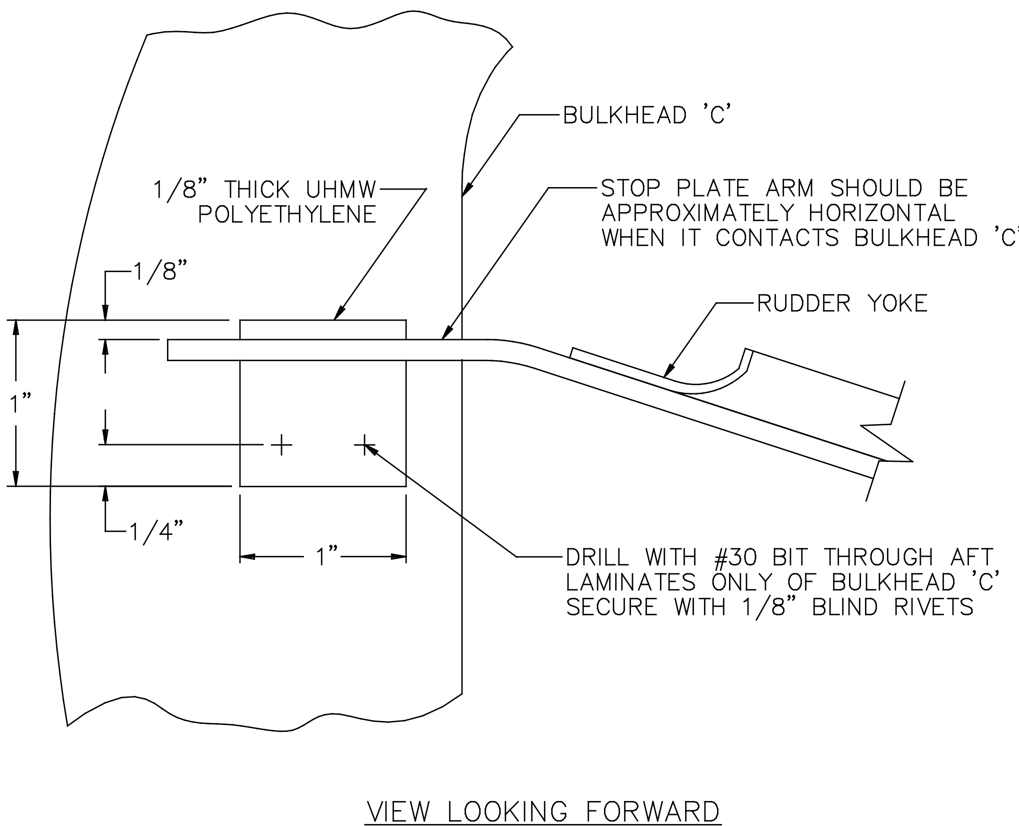


Figure 77.5: Installing the Stop Plate Pads

Cut two **1" square** pieces from the supplied **1/8" X 2" X 2" UHMW polyethylene sheet** [15.1]. Drill two **#30** rivet holes in each piece **1/4"** from one edge, as shown in Figure 77.5. These pieces will pad the aft side of Bulkhead C to prevent wear where the stop plate arms contact.

Note Later, in "SECTION X: FINAL ASSEMBLY," you will have to cut another pair of wear pads for a similar stop plate to be installed on the elevator bellcrank. Since all four of these pads must be cut from the 2" X 2" stock supplied, each will obviously end up slightly smaller than 1" X 1"; don't worry about this, but be sure not to lose the piece that remains after you cut out your rudder stop pads.

Mark the stop pads “left” and “right” to keep them straight. Hold each pad in place on Bulkhead C under its proper arm with the two rivet holes down and the top of the pad about **1/8"** above the top of the arm. (The pads must be positioned as low as possible while still providing full contact for the arms to provide clearance for the inter-bulkhead shearweb attach angles that will be installed later.) Check that the rudder still reaches its 25° travel limit with the pads in place; trim the stop plate arms further if necessary. When satisfied, use a fine-point pen to mark around each pad onto Bulkhead C and then remove the rudder from the airplane.

Hold each stop plate pad in its marked position on Bulkhead C and use the holes in the pad as guides to drill **#30** holes through the **aft laminates only** of Bulkhead C. Use **1/8" aluminum blind rivets** [40.1] to secure the pads to Bulkhead C.

Completed: [ ]

Step 60.5: Drill Holes for the Tailwheel Steering Cable Bushings (Taildragger Only)

For the GlaStar taildragger, the tailwheel steering cables will fasten to the rudder stop plate. Drill **5/16"**-diameter holes through the stop plate in the locations shown in Figure 77.6. For best results, start with smaller holes (about 1/8") and gradually enlarge the holes in steps. Bushings will be installed in these holes for the steering cable fasteners.

> **Note** If, after trimming to adjust the rudder travel, there isn't enough material in the locations shown in Figure 77.6 to drill the holes for the bushings, drill the holes just **inboard** of the bends in the arms.

Completed: [ ]

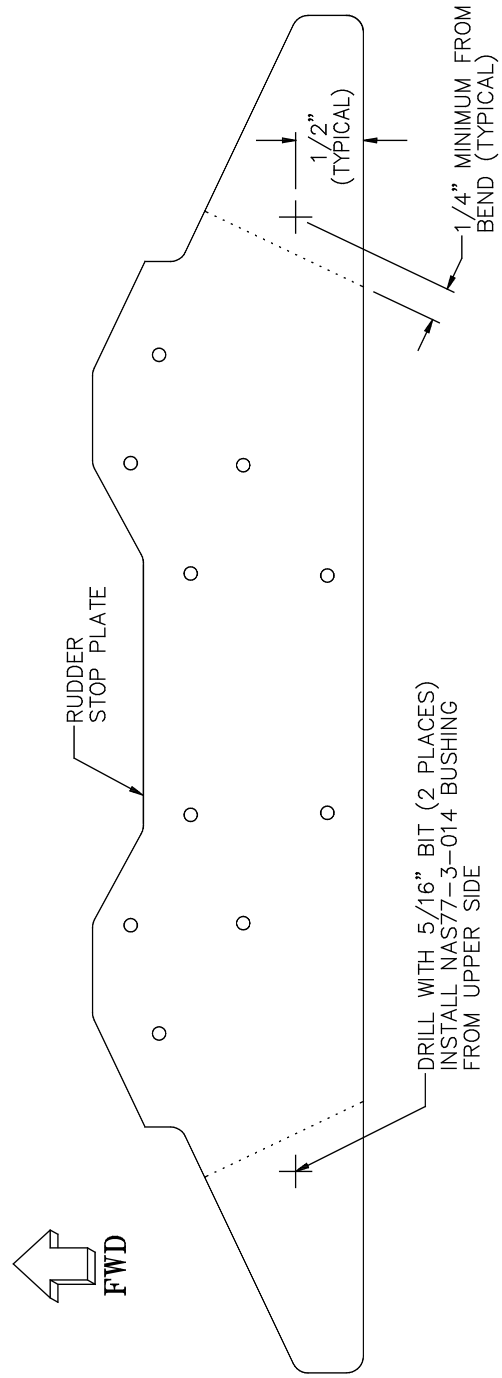


Figure 77.6: Drilling Holes for the Tailwheel Steering Cable Bushings (Taildragger Only)

Step 60.6: Rivet the Rudder Stop to the Rudder Yoke

Apply the corrosion-protection of your choice to both the stop plate and the holes drilled in the rudder yoke. When the corrosion protection has cured, Cleco the rudder stop to the rudder yoke. Make sure the stop plate is right-side-up (with the arms angled downward) before riveting.

Rivet the rudder stop to the rudder yoke with 1/8" AN470AD4 **universal-head rivets**. Because of limited access for your rivet gun, you'll have to install the rivets with the heads down.

If you are building a taildragger, proceed to the next step; otherwise, set the rudder assembly aside.

Completed: [ ]

Step 60.7: Install the Tailwheel Steering Bushings (Taildragger Only)

Use a small C-clamp to press the NAS77-3-014 **flanged steel bushings** [91] into the 5/16"-diameter holes drilled through the stop plate arms in Step 60.5. Place the bushing flanges on the **top** side of the stop plate.

Set the rudder assembly aside.

Completed: [ ]

Step 61: Cut an Inspection Hole in the Lower Aft Fuselage

Both to provide construction access and to facilitate inspection of control linkages in your completed GlaStar, it's useful to cut an inspection hole in the bottom of the aft fuselage. As Figure 78 shows, this hole should be centered **4-3/4" aft** of Bulkhead C. Mark this location and drill a **#30** pilot hole from **inside** the fuselage. Then drill from **outside** with a hole saw. The diameter of the hole is not critical, but **3-5/8"** is ideal and you should probably keep it smaller than 5".

Hint If you don't have a hole saw this size, use a saber saw to cut the opening and finish the cut with a rotary sanding drum. Save the plug of the inspection hole. In "SECTION X: FINAL ASSEMBLY" we'll suggest a way to use it as an inspection hole cover.

Completed: [ ]

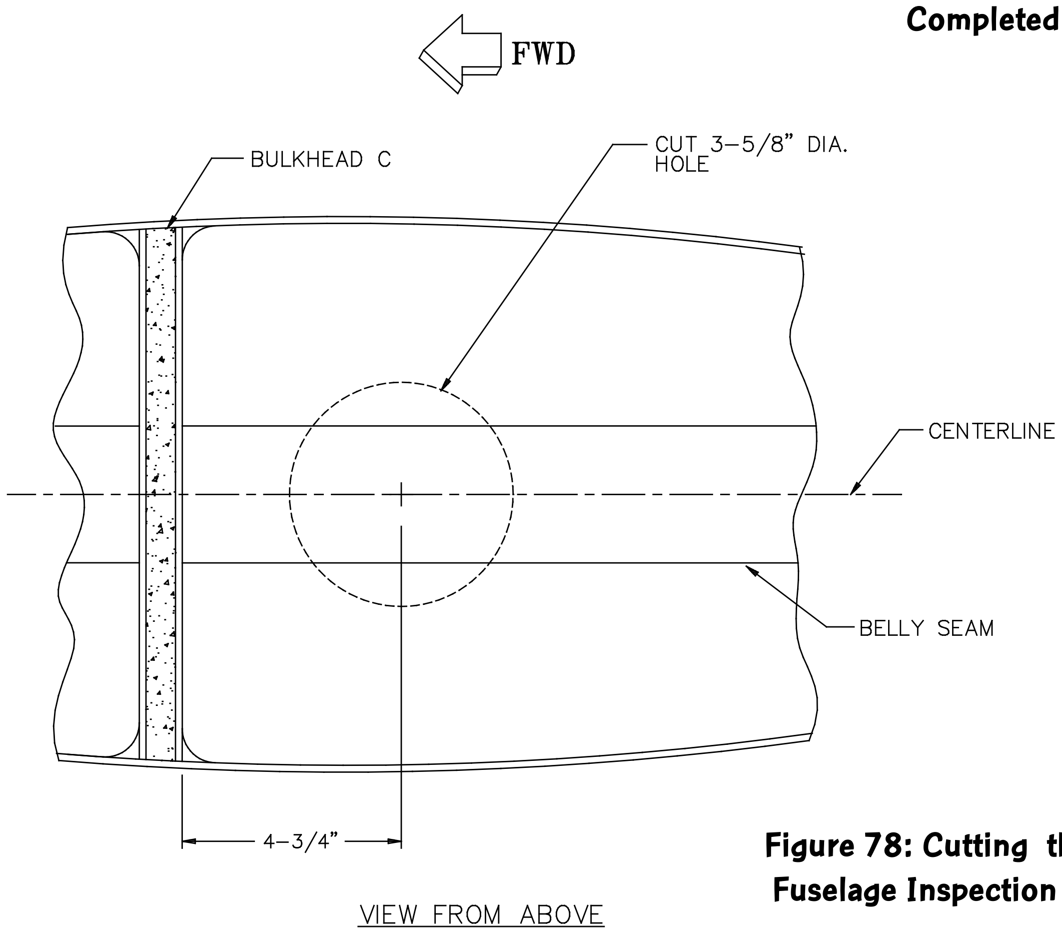


Figure 78: Cutting the Aft Fuselage Inspection Hole

Step 62: Trim, Position and Drill the Lower Elevator Bellcrank Bracket

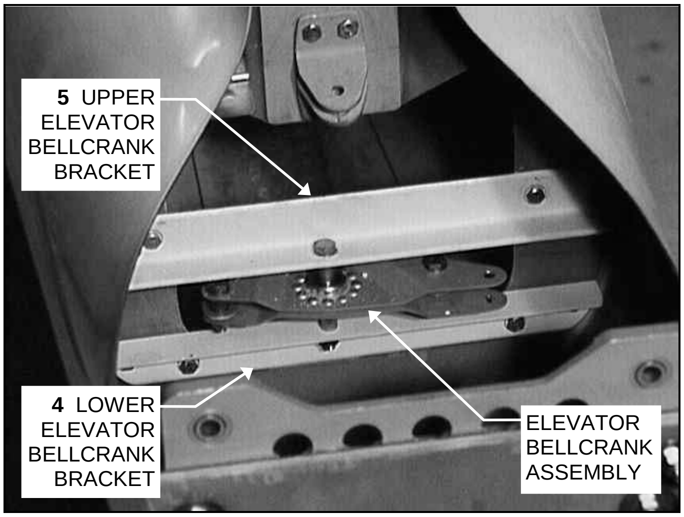


Figure 79: Elevator Bellcrank Assembly and Brackets

Pitch control in the GlaStar is transmitted from the control sticks via cables to a bellcrank mounted between two aluminum angles bolted to Bulkhead C. A rigid pushrod runs from this bellcrank aft to the elevator. Figure 79 shows the completed bellcrank and its brackets.

> **Note** Figure 79 shows a later stage of assembly; for the moment, ignore the parts in the foreground.

The **upper** [5] and **lower** [4] **elevator bellcrank brackets** can be distinguished from one another by the location of the pre-drilled bellcrank pivot hole—as can be seen in Figure 78, these holes are slightly to the left of the aircraft centerline. Compare your brackets to the photo until you're confident you have them straight and mark them before proceeding.

The lower bracket must be trimmed a bit to fit between the shells. The left-hand end of Figure 80 shows the dimensions of the cuts that should be made at **both ends** of the bracket: first cut off **1/2"**, and then cut the vertical flange off at **45°**. Use a hacksaw, bandsaw or scroll saw to make these cuts, and then smooth the cut edges and round the corners with a belt sander or a fine-toothed file.

After the bracket has been trimmed, mark four bolt hole locations according to the dimensions shown in the right-hand end of Figure 80.

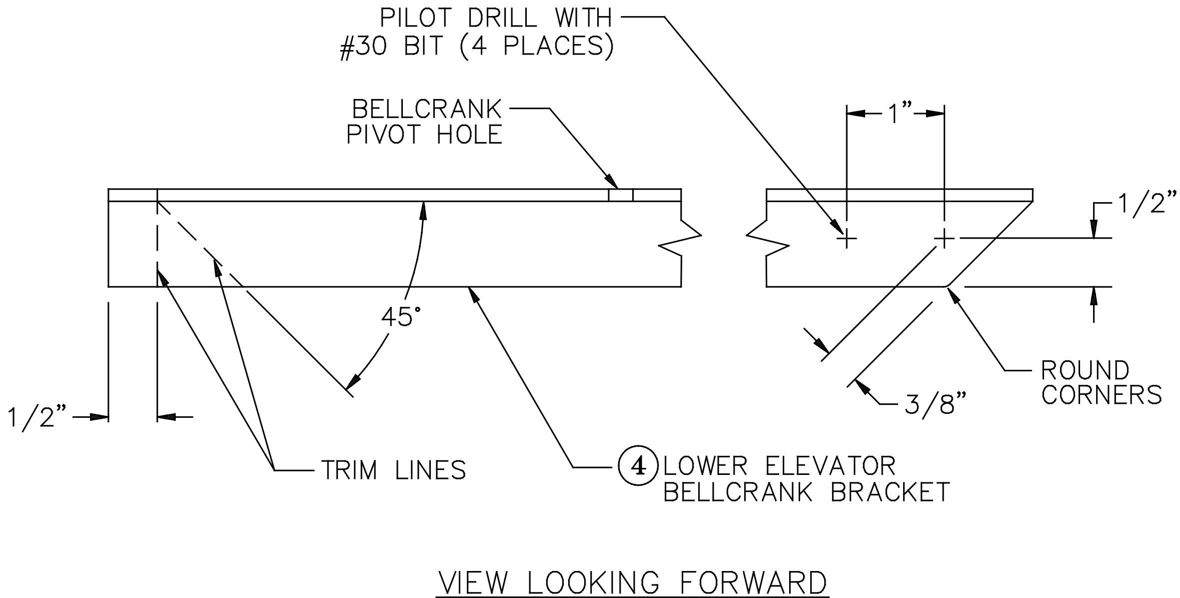


Figure 80: Trimming and Marking Hole Locations on the Lower Elevator Bellcrank Bracket

Use two small C-clamps to clamp the bracket to the aft face of Bulkhead C in the position shown in Figure 79. The bracket should be visually centered between the left and right fuselage shells and leveled. The top of the bracket's horizontal flange (i.e., the flange with the pivot hole in it) should be approximately **3-3/4" above the fuselage floor**. This should place the top of the bracket roughly **1/2"** above the bottom of the cutout in Bulkhead C.

With the bracket in place, verify that the marked positions of the two **inboard** bolt holes will fall at least **3/8" outboard** of the edges of the cutout in Bulkhead C. Shift the hole position marks as necessary to satisfy this condition. When satisfied, remove the bracket and center punch the four hole locations. Pilot drill each of these locations with a **#30** bit.

Return the bracket to its position on the aft face of Bulkhead C and clamp it in place, as before. Use the #30 pilot holes as guides to drill through the bracket and Bulkhead C with a **#10** bit. If the clamps interfere, drill the two accessible holes, insert a temporary pair of 3/16" (AN3) bolts, and drill the remaining two holes.

Remove the bracket and deburr the holes.

Completed: [ ]

Step 63: Position and Drill the Upper Elevator Bellcrank Bracket

Begin by marking four bolt hole locations on the vertical flange of the upper bellcrank bracket, as shown in Figure 81. The dimensions given at the right-hand end of the figure are typical for both ends.

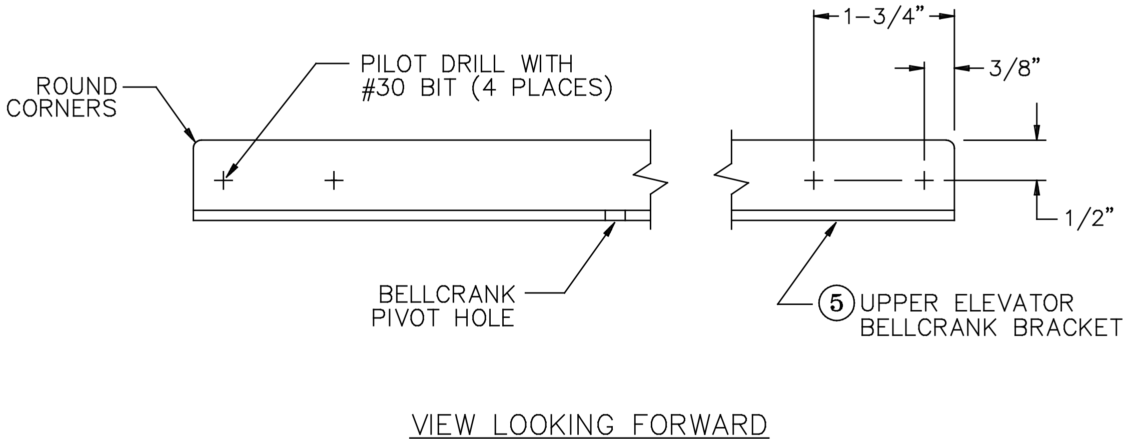


Figure 81: Marking Hole Locations on the Upper Elevator Bellcrank Bracket

Next, temporarily assemble the main components of the bellcrank assembly to set the vertical distance between the upper and lower brackets. As shown in Figure 82, insert the **bellcrank bearing** [31], two NAS43DD4-39 **aluminum spacers** [85], an AN960D416 aluminum washer and an AN960D416L thin aluminum washer between the brackets on an AN4-25 **drilled-shank bolt** [56]. Secure this bolt with AN960D416 aluminum washers under the bolt head and an AN310-4 castle nut. For now, just tighten the assembly finger tight.

Temporarily bolt the lower bellcrank bracket to Bulkhead C with at least one bolt at each end. With the hardware stack-up holding the upper bracket at the proper height, again verify that the two **inboard** hole locations fall at least **3/8" outboard** of the cutout in Bulkhead C. Reduce the 1-3/4" dimension as necessary to satisfy this condition. When satisfied, remove the bracket assembly, center punch the hole locations in the upper bracket and pilot drill the holes with a **#30** bit. Bolt the bracket assembly into place once again, press the upper bracket tightly against Bulkhead C by hand, and drill the four bolt holes up to final size—**#10**. After drilling the first hole, insert a 3/16" bolt to hold the bracket in place for the remaining drilling.

Note Although the hardware sets the vertical position of the upper bracket, you still need to adjust it to make sure it's parallel to the lower bracket.

After all the holes have been drilled, remove both brackets, disassemble the hardware and deburr all the holes.

Completed: [ ]

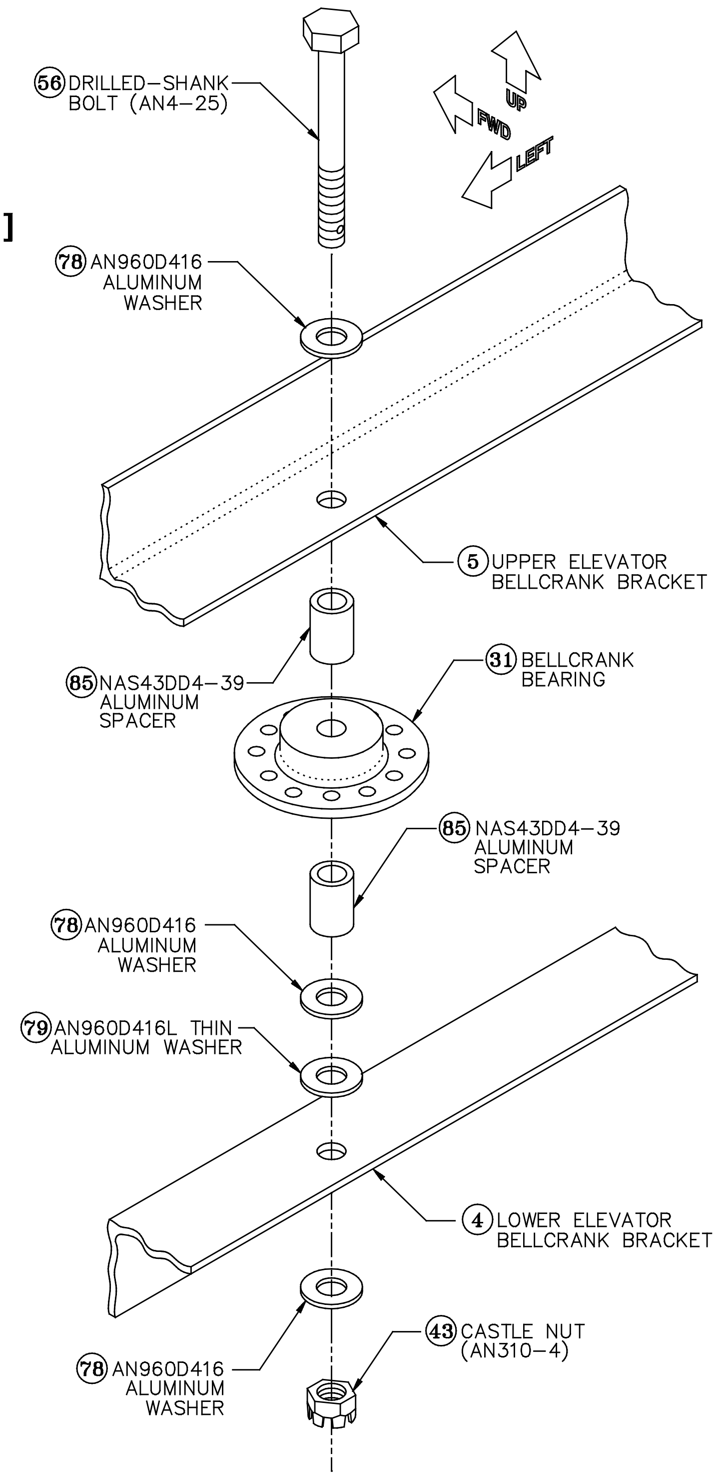


Figure 82: Elevator Bellcrank Hardware Stack-Up

Step 64: Drill the Elevator Bellcrank Assembly

The elevator bellcrank assembly goes together just like the aileron bellcranks—with the bearing sandwiched between an upper and a lower bellcrank half. As shown in Figure 83, the **upper elevator bellcrank half** [15] is the one on which the ends bend upward when you hold it with the longer arm on the right and the 3/16" hole away from you; the **lower half** [14] is opposite.

Stack the bellcrank bearing on top of the two halves as shown in the figure and Cleco them together through the 1/8" holes in the two halves. After centering the bearing in the large center hole in each half and making sure the halves are aligned with one another, drill through the bearing and both halves at **every other one of the twelve bearing pilot holes** with a **#30** bit. Insert a second Cleco after drilling the first hole and then juggle the Clecos as necessary to complete the drilling.

Note Don't forget to remove the initial Cleco and drill that hole up to final size, because it's slightly undersized to begin with.

After all six holes have been drilled, disassemble and deburr the parts.

Completed: [ ]

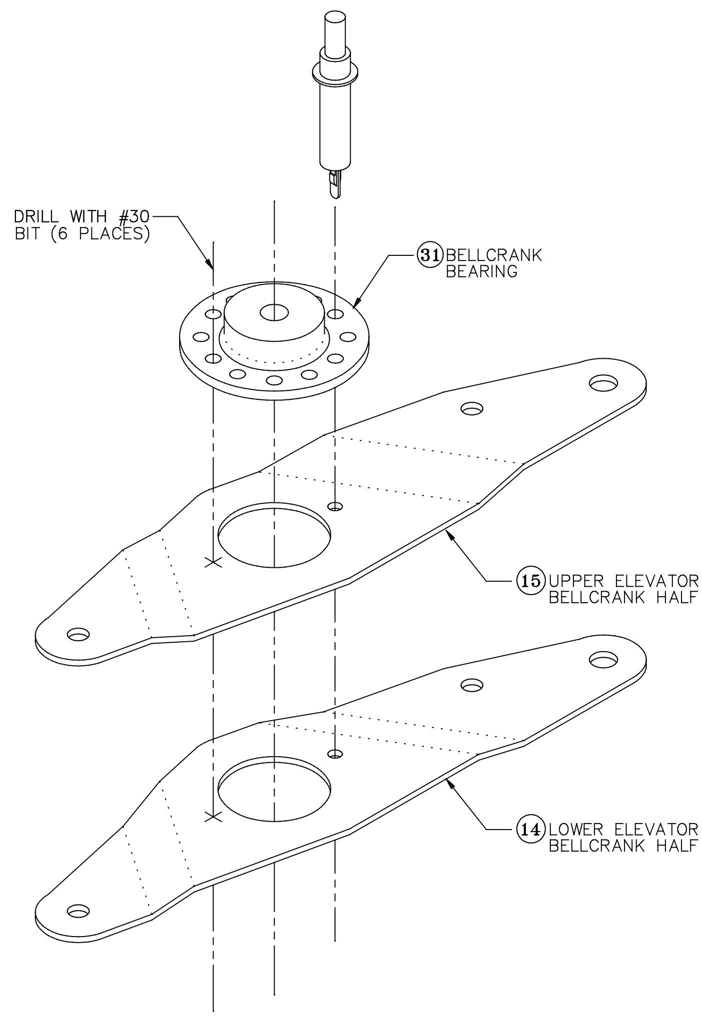


Figure 83: Drilling the Elevator Bellcrank Assembly

Step 65: Corrosion-Proof the Elevator Bellcrank Assembly and Brackets

Inspect both bellcrank brackets, bellcrank halves and the bearing for proper deburring and surface finishing, and then apply corrosion protection.

> **Caution** The bellcrank bearing itself should be well protected against contamination with any of the chemicals used in prepping or priming the bearing flange. You may wish to prime the flange with a small brush rather than risk spraying.

Completed: [ ]

Step 66: Rivet the Elevator Bellcrank Assembly

As shown in Figure 84, use 1/8" AN470AD4 universal-head rivets to rivet the bellcrank assembly together with the bearing sandwiched between the halves. The manufactured heads of the rivets should be on the upper half.

Completed: [ ]

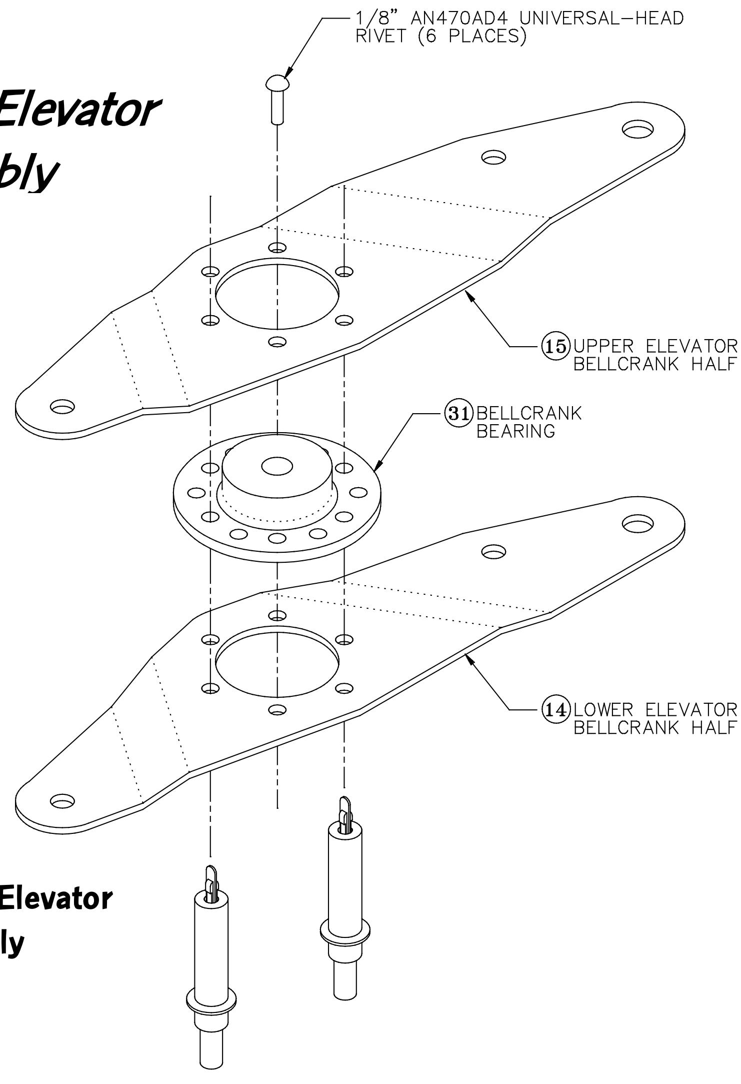


Figure 84: Riveting the Elevator Bellcrank Assembly

Step 67: Install the Elevator Bellcrank/Bracket Assembly

Assemble the bellcrank/bracket assembly as shown in Figure 85. Tighten the nut until the spacers are clamped firmly against the bearing, and then secure it with an AN380-2-2 cotter pin.

Bolt the entire assembly to Bulkhead C through the holes drilled previously. Use AN3-6A **bolts** [41.1], AN970-3 large washers and AN364-1032A nylon self-locking nuts, with the washers and nuts forward.

Completed: [ ]

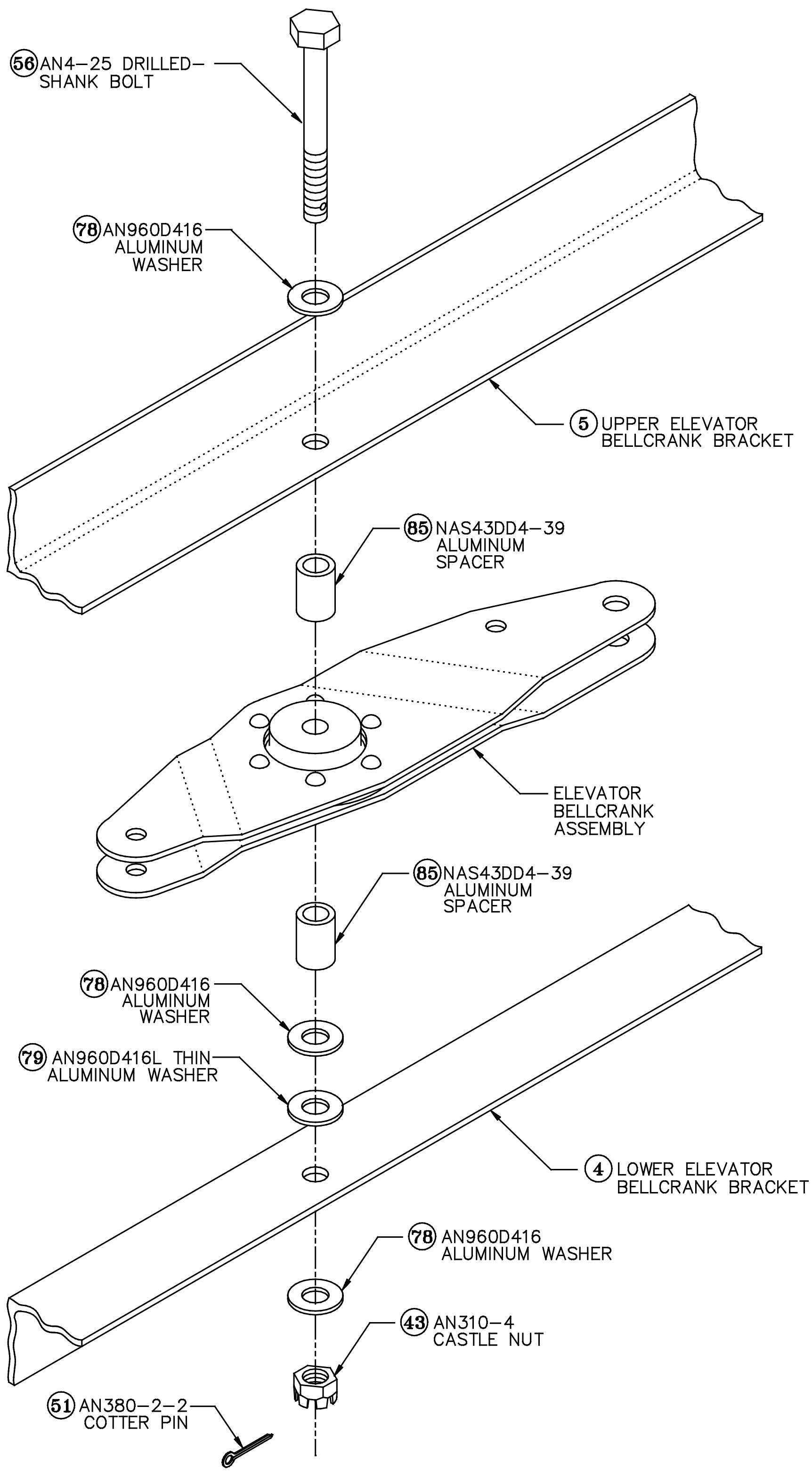


Figure 85: Installing the Elevator Bellcrank Assembly Between the Brackets

Step 68: Position and Install Bulkhead D

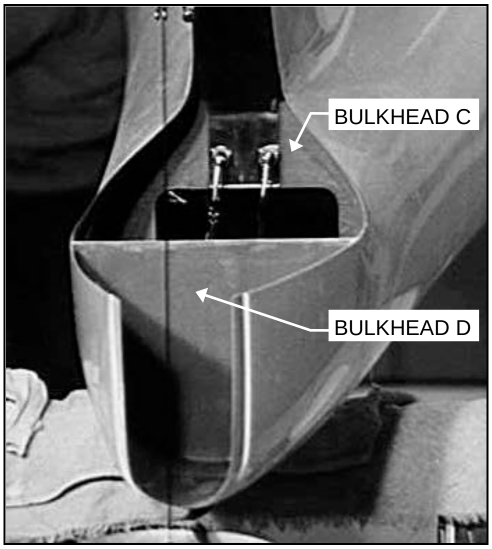


Figure 86: Bulkhead D

Figure 86 shows that Bulkhead D is positioned aft of Bulkhead C in the wide, flared portion of the aft fuselage. The precise dimension from the tailcone joggle to the aft face of the bulkhead (prior to lamination) should be **11-9/16"**, as shown in Figure 87. Measure this distance straight forward along the centerline, not along the shells.

Bulkhead D must be positioned perpendicular to both the waterline and centerline with as much precision as possible, since it bears the **horizontal stabilizer forward attach bracket** [13], which in turn determines the alignment of the stabilizer. You can check for perpendicularity to the waterline by holding a level (preferably a digital one) against the face of the bulkhead. Perpendicularity to the centerline can best be checked with a try square, as shown in Figure 88: hold the body of the square against the bulkhead and sight along the blade down to the centerline. Or measure from the wing strut attach lugs to the bulkhead on each side, in a similar manner as shown in Figure 107.

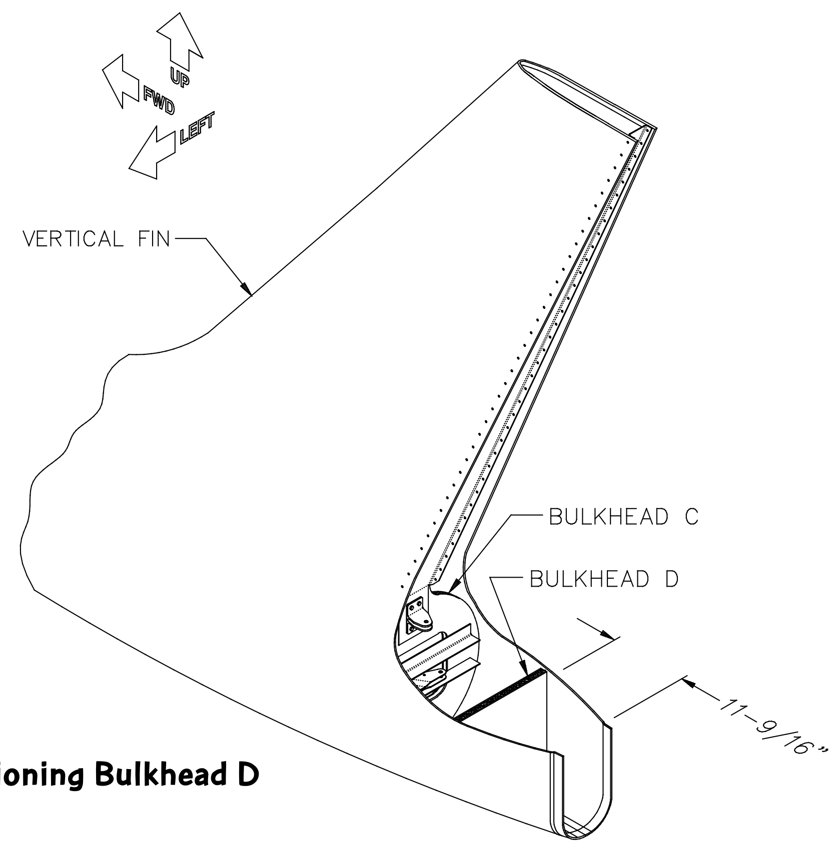


Figure 87: Positioning Bulkhead D

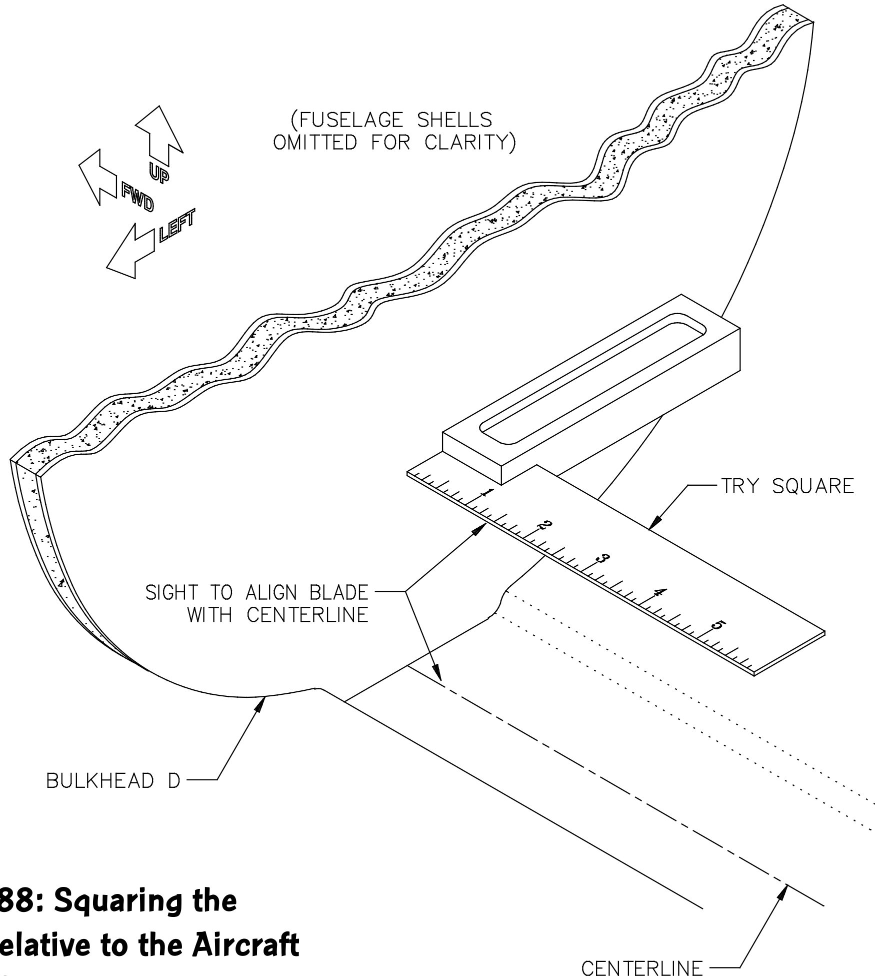


Figure 88: Squaring the Bulkhead Relative to the Aircraft Centerline

When the bulkhead is as square as you can make it in both directions, tack it in place with hot-melt glue.

After positioning, apply a 3/16" Q-cell fillet all around the forward and aft edges, followed by **four** laminates of bi-directional cloth cut on the 45° bias—two layers on the forward face and two on the aft—all of which should cover the **entire face of the bulkhead** and lap approximately **1"** over onto the shell all the way around.

Use the Bulkhead D template that you saved from Step 37 as a guide to cut out these four pieces, leaving a generous margin around all the edges except the top. Take special care to keep these laminates flat and free of bubbles on the forward face of the bulkhead. After the laminates have cured, trim them even with the top of the bulkhead and cut a **1/2" X 1"** drain hole in the bottom center of the bulkhead.

Completed: [ ]

Step 69: Position and Drill the Horizontal Stabilizer Forward Attach Bracket

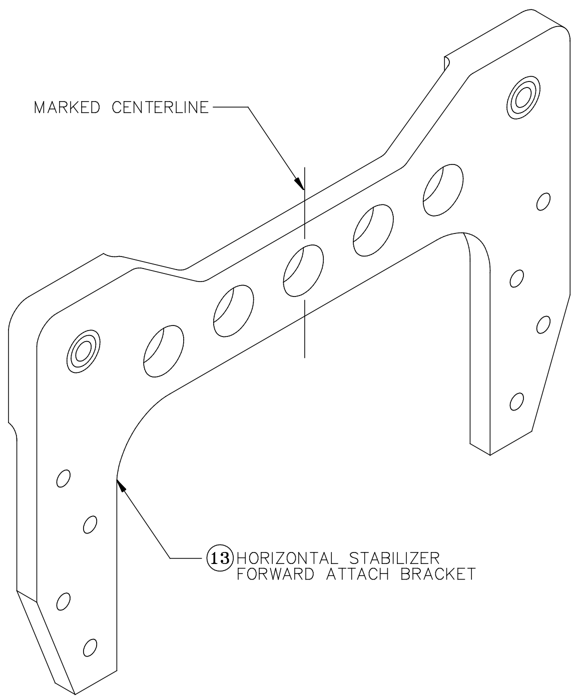


Figure 89: Marking a Centerline on the Stabilizer Attach Bracket

You used the horizontal stabilizer forward attach bracket in "SECTION IV: HORIZONTAL STABILIZER ASSEMBLY." You'll probably find it underneath all that scrap metal and those back issues of *Sport Aviation* under your bench—dig it out and dust it off for installation!

The first step is to mark a centerline on the **aft** face of the bracket. As shown in Figure 89, the aft face is the flat face without the machined, raised areas around the bearings. Next, transfer the aircraft centerline you marked on the floor of the aft fuselage to the upper edge of Bulkhead D by hanging a plumb bob down the aft face of the bulkhead. (This mark is visible in Figure 91.)

The bracket is positioned by aligning the centerline mark on the bracket with the one on the bulkhead, and then setting the height of the bracket relative to the waterline, as shown in Figure 90.

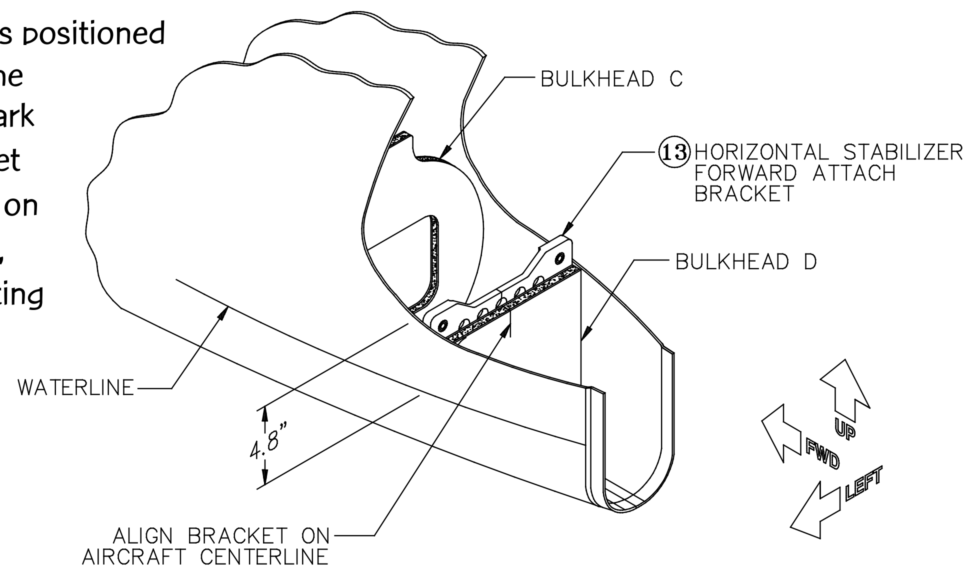


Figure 90: Positioning the Stabilizer Attach Bracket

Begin by clamping the bracket to the **forward** face of Bulkhead D using the method shown in Figure 91. The small C-clamp shown passes through one of the lightening holes in the bracket; this is necessary to keep the clamp out of the way during the subsequent measuring and leveling procedures. Be sure to use one of the holes to either side of the center hole, since the clamp would obscure the marked centerline if the center hole were used. Use a strip of wood or a piece of angle stock to bridge the legs of the bracket on the forward side, and use a block of wood on the aft side to prevent crushing the foam core of Bulkhead D.

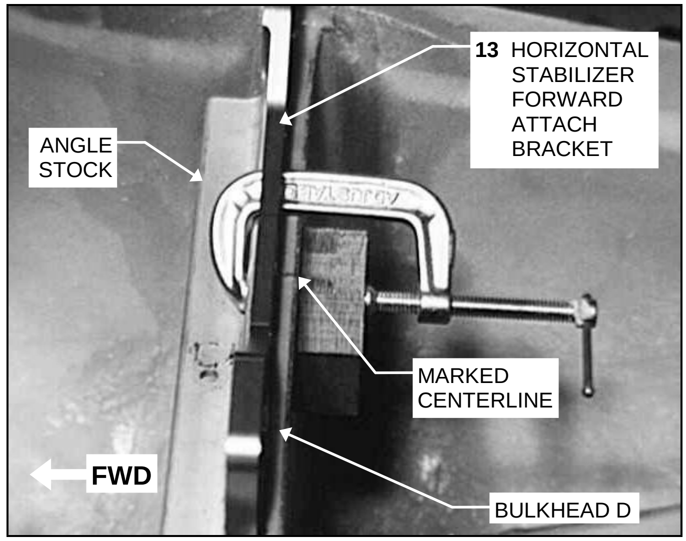


Figure 91: Clamping the Stabilizer Attach Bracket to Bulkhead D

Note In order for the bracket to be properly positioned, it's essential that the fuselage be level laterally. You may wish to check this again before proceeding.

Next, adjust the height of the bracket relative to the waterline, as shown in Figure 92. This distance should be **4.8"** and should be measured as precisely as possible. To get an accurate measurement, be sure to read the ruler from eye level. With the height set, you next need to level the bracket, as shown in Figure 93. Obviously, moving the bracket to make it level may change its distance from the waterline as well, so you'll probably have to run through several iterations of measuring and leveling until both conditions are met.

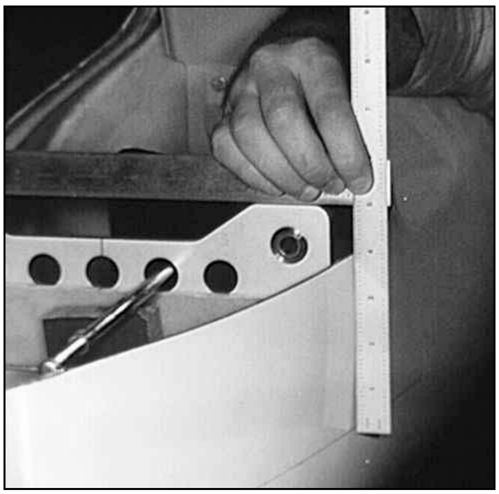


Figure 92: Measuring the Height of the Stabilizer Attach Bracket from the Waterline

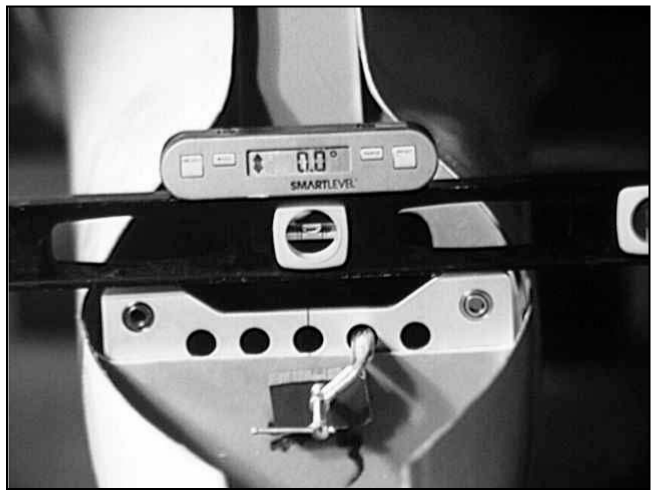


Figure 93: Leveling the Stabilizer Attach Bracket

Hint Although your waterline marks on each side of the fuselage are theoretically parallel with one another when the fuselage is level laterally, in the real world there's likely to be some small discrepancy from side to side. For this reason, it would probably be a good idea to measure the height of the bracket on both sides. If the distance doesn't measure 4.8" when the bracket is level, then split the difference and readjust the height of the bracket. In any case, the bracket should **always** be leveled according to the technique shown in Figure 93 rather than according to the waterlines.

Note Don't worry if your stabilizer attach bracket doesn't protrude as far above the top of Bulkhead D as shown in Figures 92 and 93. The fuselage sides (and the top of Bulkhead D, if necessary) will be trimmed later, in Step 78.

Once the bracket is positioned to your satisfaction, use a 90° drill motor to drill the eight bolt holes with a **1/4"** bit from the forward side of the bracket. Be careful to hold the drill perpendicular to the bracket to avoid enlarging the pre-drilled holes. Insert 1/4" (AN4) bolts in the first couple holes to help maintain alignment.

Finally, remove the clamp, wood block and angle stock, but keep the bracket pinned to the bulkhead with a pair of bolts. Use a marking pen to trace the inner outline of the bracket onto the forward face of the bulkhead, as shown in Figure 94. You will make use of this line in the next step. When you're done, remove the bracket and set it aside.

Completed: [ ]

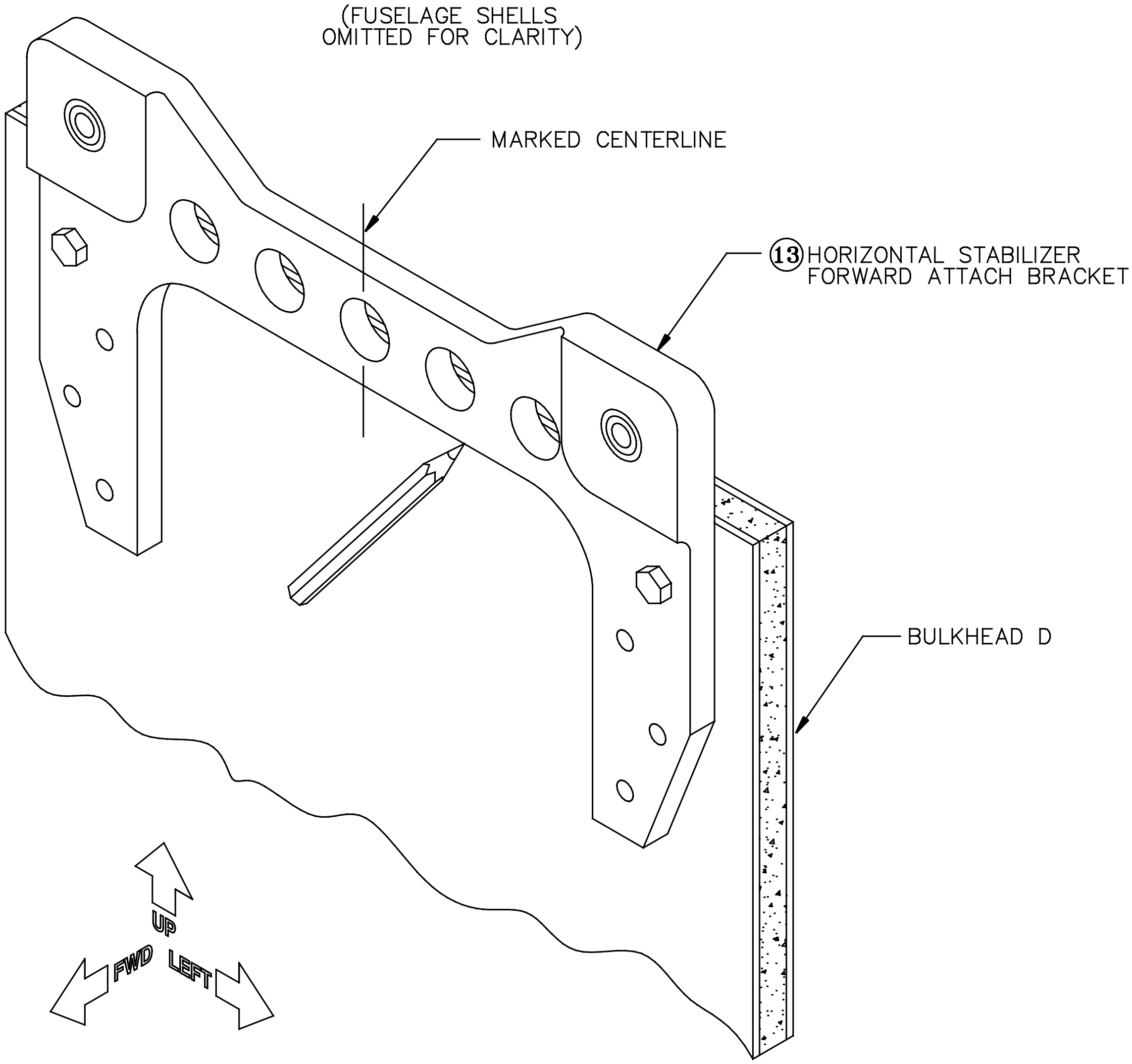


Figure 94: Tracing the Outline of the Stabilizer Attach Bracket onto Bulkhead D

Step 70: Laminate the Aft Attach Flange for the Forward Inter-Bulkhead Shearweb

Torsional strength is added to the aft fuselage by a .050"-thick aluminum shearweb installed horizontally between Bulkheads C and D and the two fuselage shells. Figure 95 shows the completed web. In this and the next two steps, you will install the attach angles and flanges to which this shearweb is bolted. The forward angles will be cut from aluminum stock, but the side and aft flanges are laminated in place. Figure 96 shows the position and appearance of the completed aft flange.

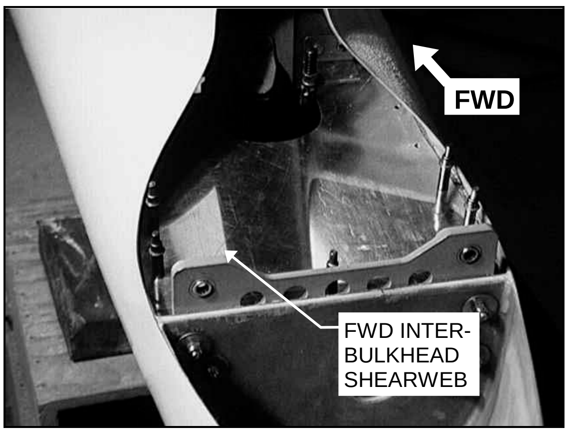


Figure 95: Forward Inter-Bulkhead Shearweb

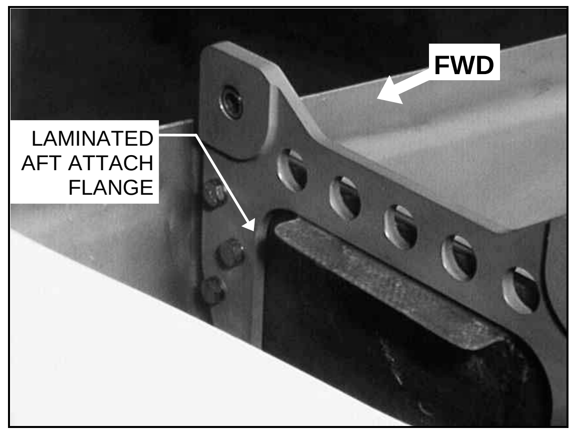
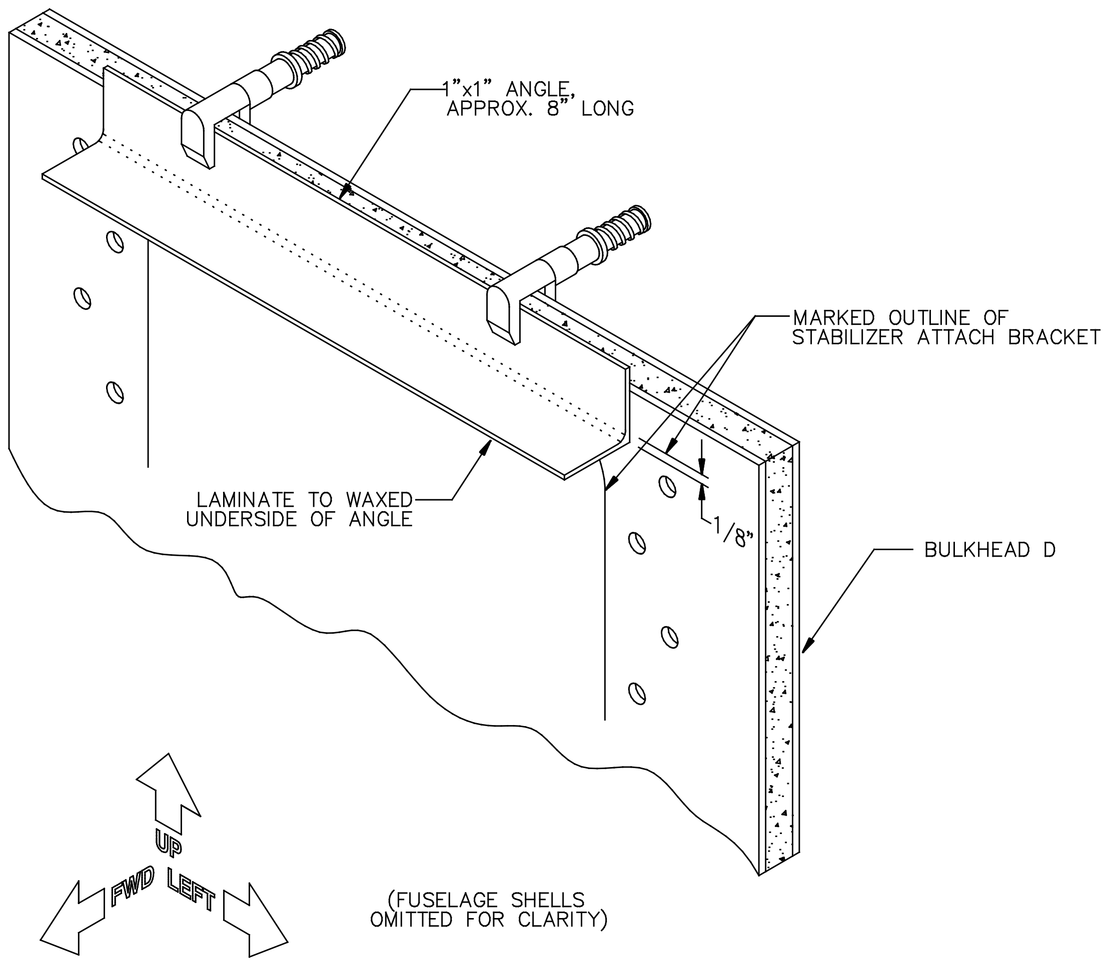


Figure 96: Aft Attach Flange for the Shearweb

The flange consists of a two-layer DBM laminate made against the underside of a scrap 1" X 1" angle stock form. First, clean the forward face of Bulkhead D with acetone. Then, as shown in the upper panel of Figure 97, cut a piece of angle about **8"** long and apply mold-release wax to one flange. Clamp this angle centered across the top of Bulkhead D with the waxed flange down. The waxed surface should be about **1/8" below** the marked outline of the stabilizer attach bracket. This provides clearance for the shearweb between the bracket and the attach angle.

With the angle clamped in place, two layers of DBM cloth, each of which should overlap equally onto the angle and the bulkhead. These pieces of cloth should be about **6-1/2"** long and centered between the lines you marked indicating the inside edges of the bracket legs.

Hint Laying a small mirror on the fuselage floor will make this laminating task easier.



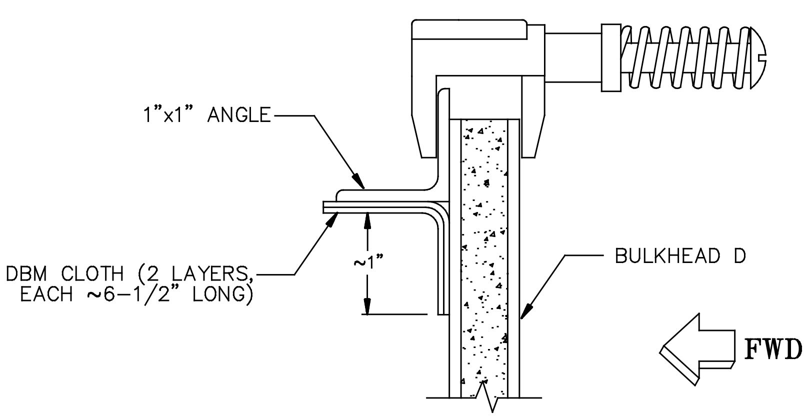


Figure 97: Laminating the Aft Attach Flange for the Forward Shearweb

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> **Note** Don't worry if the DBM cloth extends a bit beyond the angle flange in the forward direction or a bit beyond the bracket leg lines in an outboard direction. You will be trimming this laminate after it cures in any case.

After the laminate has reached at least green cure, trim its forward edge even with the angle flange. Then remove the angle. After the laminate has cured completely, grind the ends down as necessary to provide clearance for the stabilizer attach bracket, and then round the corners of the flange (as shown in Figure 96).

Completed: [ ]

Step 71: Position and Drill the Forward Attach Angles for the Forward Shearweb

As mentioned previously, the forward attach angles are cut from aluminum stock rather than being laminated in place. From the 6" length of **.063" X 1" X 1" aluminum angle stock** [30], cut two 2"-long pieces; smooth the ends and round the corners as usual.

As shown in the upper panel of Figure 98, mark, center punch and drill four **#10** holes in each angle. Note that the two pairs of holes are **not** equidistant from the edges of the angle flanges: the two holes in the **vertical** flange should be **1/2" below** the upper edge of the flange, and the holes in the **horizontal** flange should be **3/8" forward** of the aft edge of the flange.

The lower panel of Figure 98 illustrates the placement of these angles on Bulkhead C: each should be **1/4" outboard** of the edges of the vertical fin spar and **5/8" below** the top edge of the lower rudder hinge. Clamp or hold the angles in position and use the holes in the angles as guides to drill **#10** bolt holes through Bulkhead C.

After both angles have been drilled, temporarily bolt them in place with 3/16" (AN3) bolts.

Completed: [ ]

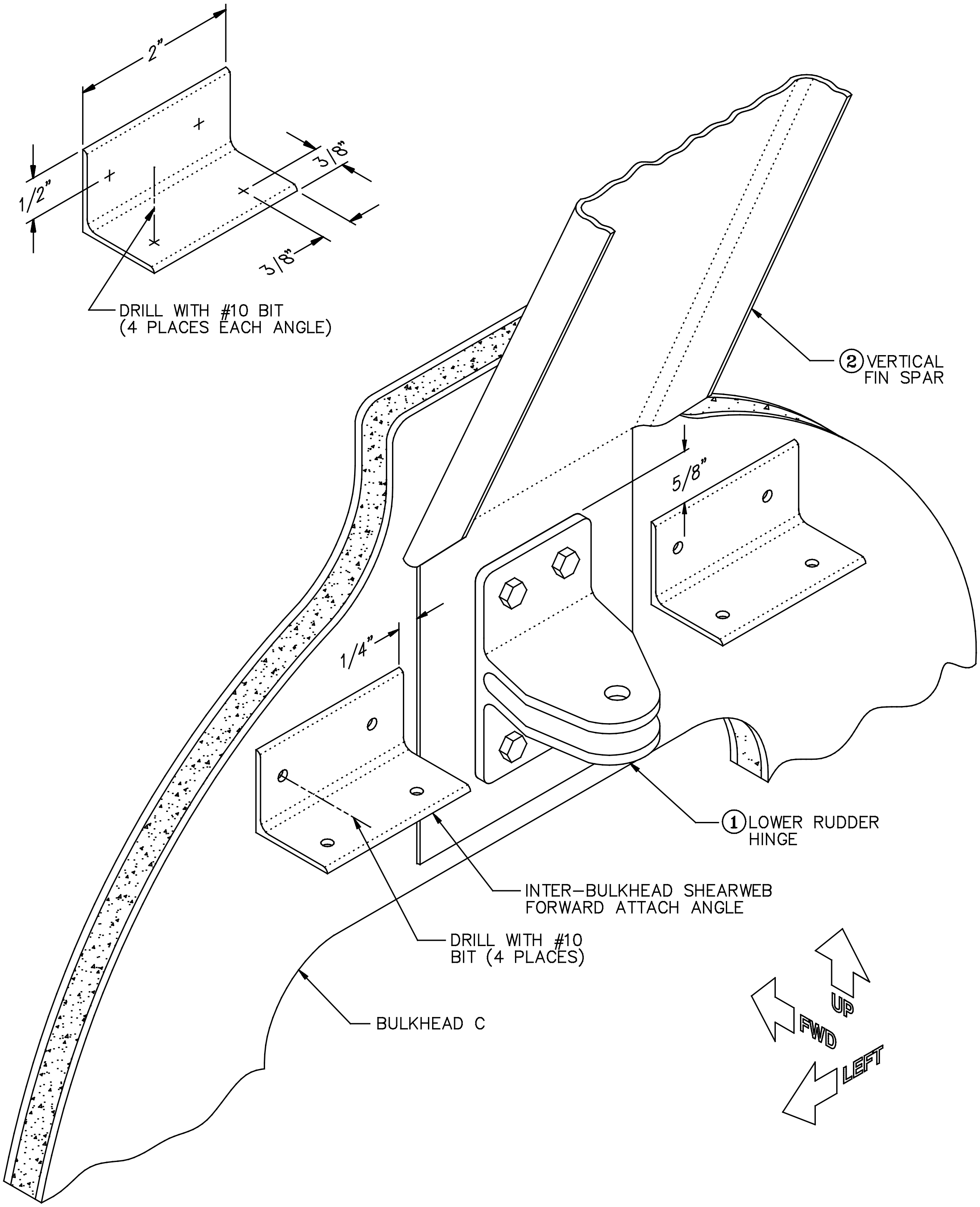

Figure 98: Positioning and Drilling the Forward Attach Angles for the Forward Shearweb

Step 72: Cut Out the Forward Shearweb

The forward inter-bulkhead shearweb must be cut from the **.050" X 12" X 12" aluminum sheet** [25]. A pattern for the shearweb is given on the **inter-bulkhead shearweb template** [22].

By this point in the assembly process, every GlaStar is going to be a little bit different, and this is particularly true in the aft fuselage area, where precise measurements are difficult and the fiberglass work produces a lot of variation in results. Therefore, it's best to use the template only as a general guide to size and shape and to fit your shearweb precisely to your GlaStar through a process of trial and error. To minimize the cost of errors, we recommend fitting a dummy shearweb of stiff cardboard first before cutting the real one out of the aluminum sheet. Begin by tacking the template to your cardboard piece and cutting it out a good bit oversized—say, **1/4"** extra all the way around.

The upper panel of Figure 99 is a cross-sectional side view of the aft fuselage that shows how the forward shearweb should ultimately fit relative to Bulkheads C and D, the forward attach angles and the aft attach flange. Note that the web lies on **top** of the aft flange but slides **below** the forward angles.

The first step in fitting the dummy shearweb is to trim it to width. Try sliding the web between the shells from the aft end and trim one or both side as necessary to get a good fit. When finished, the web should slide easily in and out from between the shells (i.e., it should **not** be a friction fit), but it should also follow the contours of the left and right shells as closely as possible. It should **not** be necessary to bend the shearweb to get it into place.

Once the left and right sides are close to being correct, begin trimming to length. As the upper panel of Figure 99 shows, both the forward and aft ends of the shearweb will be bent at a slight angle to keep them flat against their respective attach angles/flanges. This bending will effectively shorten the shearweb a bit, but this amount is so slight that you can achieve good results by simply trimming the shearweb to fit flat between the bulkheads, as shown in the lower panel of Figure 99.

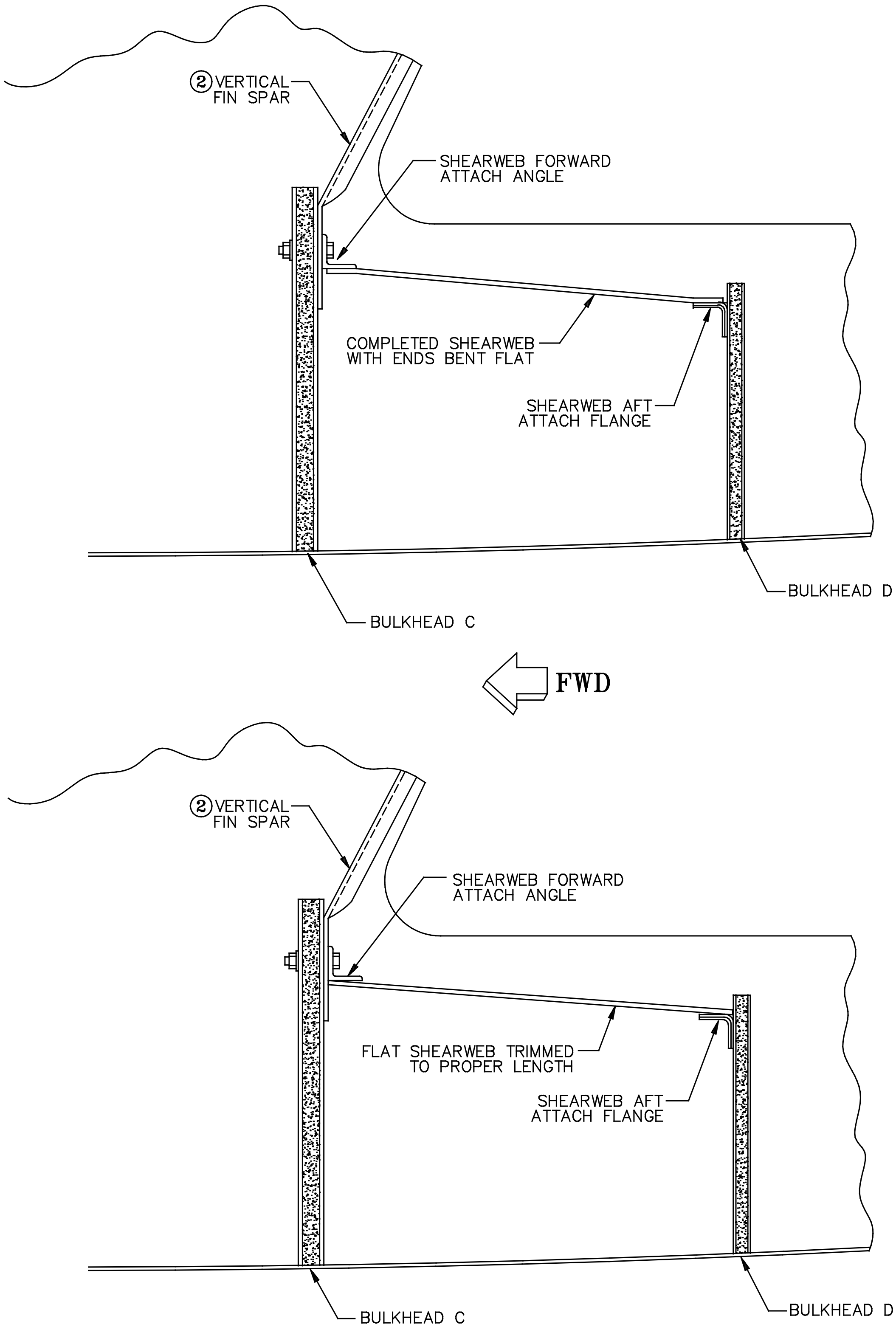

Figure 99: Fitting the Forward Shearweb

With the dummy shearweb fit to your satisfaction, transfer its outline to the aluminum and cut out the shearweb. A scroll saw is really the ideal tool for this job, although a bandsaw will also work reasonably well. In dire emergency (i.e., an exhausted tool budget!), the shearweb can also be roughed out with heavy-duty snips and filed to final shape.

When the shearweb is cut out, mark, center punch and pilot drill the seven bolt hole locations around the perimeter of the shearweb as shown on the template. Use a **#30** bit. Next, bend the ends of the shearweb to match the forward attach angles and aft attach flange. These bends should be equal in size and will probably turn out to be around **5°** apiece. However, as with the overall size of the shearweb, you'll have to use trial and error to determine the exact bend appropriate to your GlaStar.

Mark bend lines **1"** in from each end, as shown on the template. Mark the **forward** line on the **top** of the web and the **aft** line on the **bottom**. Because these bends are so slight, you don't need to worry much about establishing a proper bend radius. Simply clamp the web flat with the line on the edge of your bench, and apply pressure on the overhanging part with a scrap of 2 X 4 to make the bend.

Caution Try to avoid bending the ends **beyond** the required angle. It's much better to have to increase the bend three or four times before getting it right than to go too far initially and then have to bend the ends back.

After the shearweb is bent to final shape, slide it into place under the forward attach angles and on top of the aft attach flange. Holding the web tightly against the forward angles, drill through each of the four pilot holes in the angles with a **#10** bit, as shown at the left-hand end of Figure 100. Insert a 3/16" Cleco in each newly drilled hole. Finally, as shown at the right-hand end of Figure 100, drill through the shearweb and the aft attach flange at each of the three pilot-drilled locations along the aft edge of the shearweb, again using a **#10** bit. After drilling, remove the shearweb from the fuselage.

Completed: [ ]

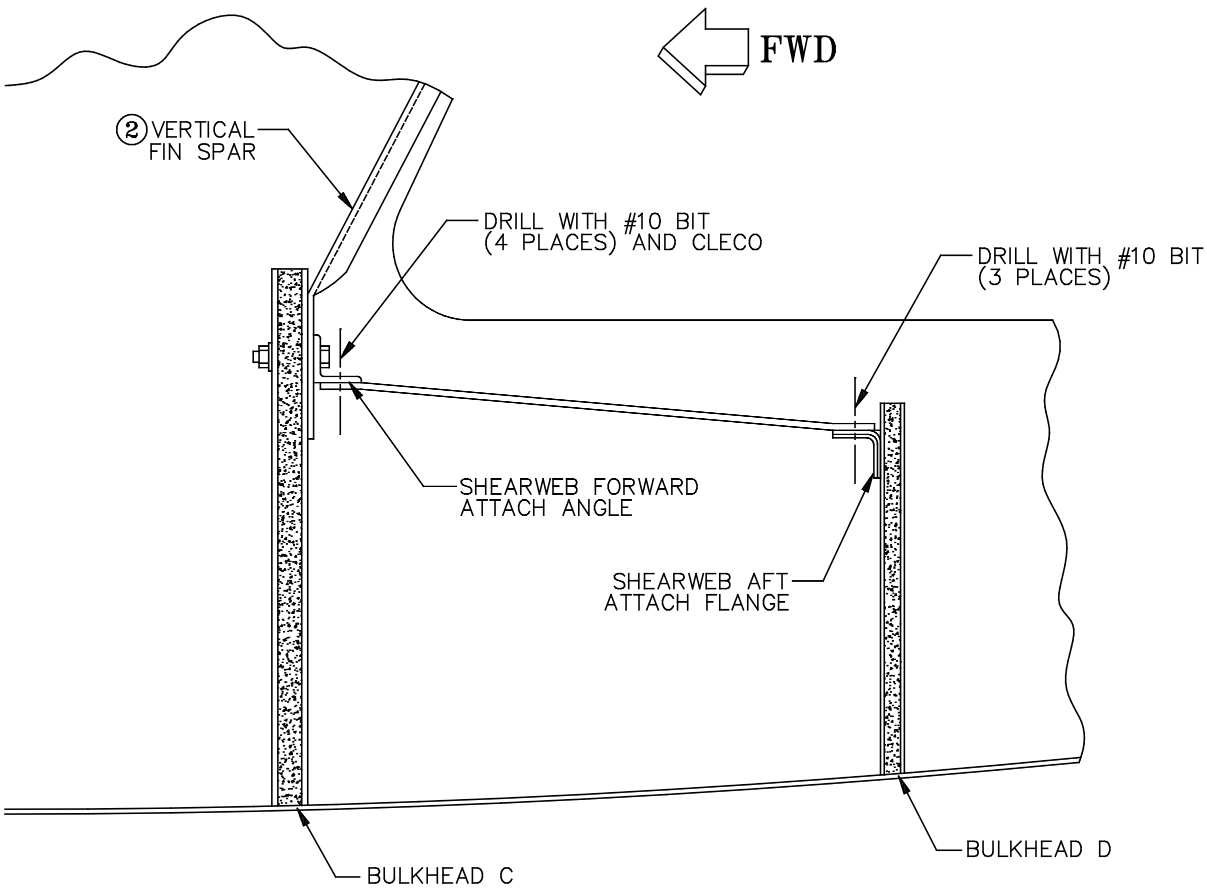

Figure 100: Drilling the Forward Attach Angles and Aft Attach Flange

Step 73: Laminate the Side Attach Flanges for the Forward Shearweb

The side attach flanges are laminated with two layers of DBM cloth just like the aft flange was. However, because of the curvature of the fuselage shells, it's impossible to use a piece of angle as a form for these laminates as you did before. Instead, you will use the shearweb itself as the form.

Begin by waxing the **entire underside** of the shearweb. You'll only be laminating purposely on the first 2" or so on each side, but count on being messy, since you'll be working by feel through the inspection hole in the bottom of the fuselage. Also, wipe down the sides of the fuselage shells between Bulkheads C and D with acetone. Replace the shearweb in the fuselage and Cleco it securely fore and aft.

The attach flanges are laminated exactly as the aft flange was: with two layers of DBM overlapped equally onto the fuselage shell and the shearweb. The strips of DBM should be about **1" shorter** than the distance between Bulkheads C and D.

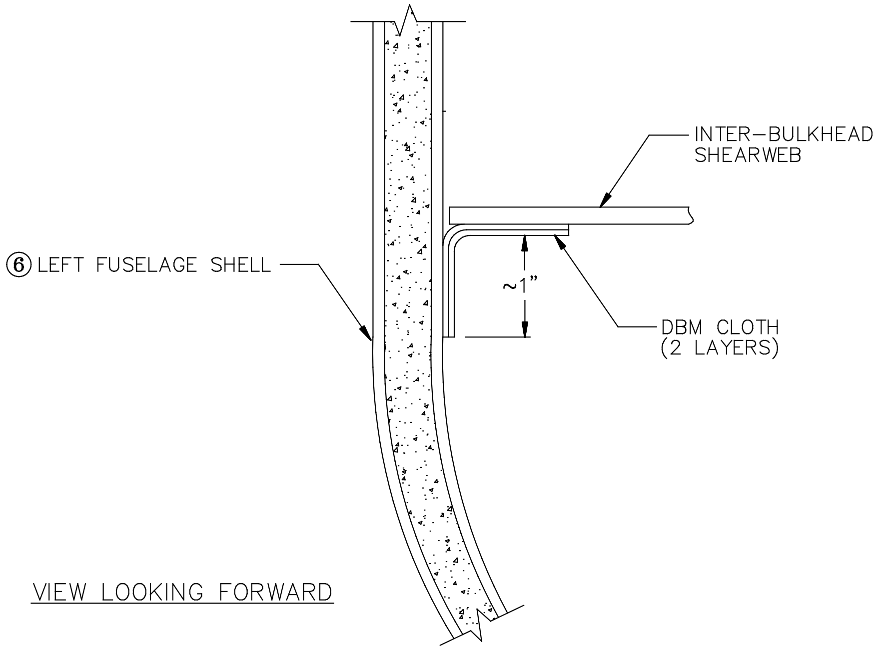

Figure 101: Laminating the Side Attach Flanges for the Forward Shearweb

Hint Obviously, the tricky aspect of doing the side flanges is having to work from underneath the fuselage through the inspection hole. You'll find it much easier to lay up the DBM strips if you pre-saturate them with resin before placing them under the shearweb. Double them up and install both together.

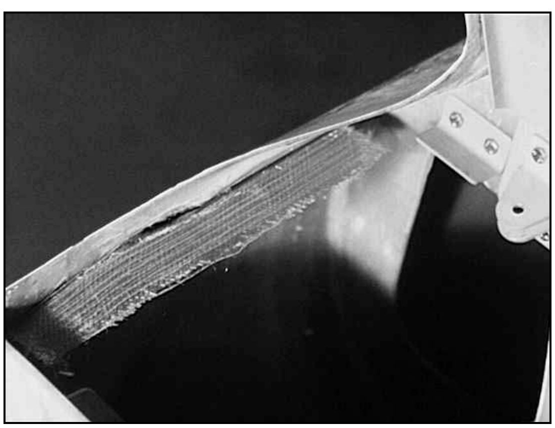

Figure 102: Left-Hand Attach Flange

When completed, the side attach flanges should be **1"** wide and should end **1"** aft of Bulkhead C and **1"** forward of Bulkhead D. Remove the shearweb and trim and grind the side angles to final size after they've cured. Figure 102 shows the finished left-hand flange laminate just prior to trimming.

Completed: [ ]

Step 74: Drill the Bolt Holes Along the Sides of the Forward Shearweb

Replace the forward shearweb and Cleco it in place with several Clecos through the forward attach angles and aft flange. Use a **#10** bit to drill through the shearweb and side attach flanges at each of the four pilot holes along the sides of the shearweb.

Four more #10 holes must be drilled along the sides of the shearweb forward of the four you just drilled. However, because of the way the fuselage shells fair into the vertical fin, there is no way to get either a straight drill or even a 90° motor in from above. Therefore, you'll have to drill these holes from below.

Remove the shearweb and mark two additional hole locations on the **top** of each side attach flange. As shown in Figure 103, space these holes about **2-1/4"** apart fore and aft and the same distance from the inboard edges of the flanges as the two aft-most holes. Then use a 90° drill motor to drill **up** through the flanges with a **#10** bit at each of the marked locations. Since the flanges are narrow and translucent, you should be able to eyeball the position of the drill bit quite accurately.

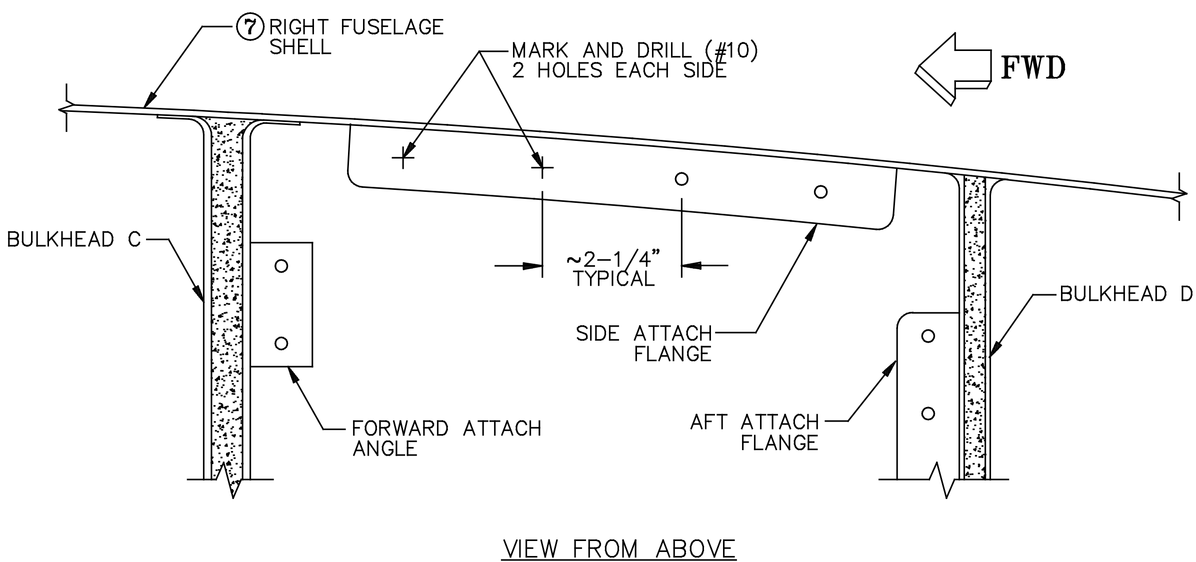

Figure 103: Marking and Drilling the Forward Bolt Hole Locations in the Side Attach Flanges

Finally, once these holes are drilled through the flanges, replace the shearweb, mark the four new holes from underneath, remove the shearweb, center punch the marked locations, and drill them with a **#10** bit.

Completed: [ ]

Step 75: Deburr and Corrosion-Proof the Forward Shearweb and Attach Angles

Remove the shearweb and the forward attach angles from the fuselage. Thoroughly deburr the holes, smooth the cut edges and apply corrosion protection. Set the shearweb aside; it will be installed in "SECTION X: FINAL ASSEMBLY."

> **Note** The horizontal stabilizer forward attach bracket is anodized and thus requires no further corrosion protection.

Completed: [ ]

Step 76: Install the Forward Shearweb Forward Attach Angles

Install the forward attach angles for the inter-bulkhead shearweb using the hardware shown in Figure 104: AN3-7A bolts, AN970-3 large washers, AN960D10 washers and AN364-1032A nylon self-locking nuts.

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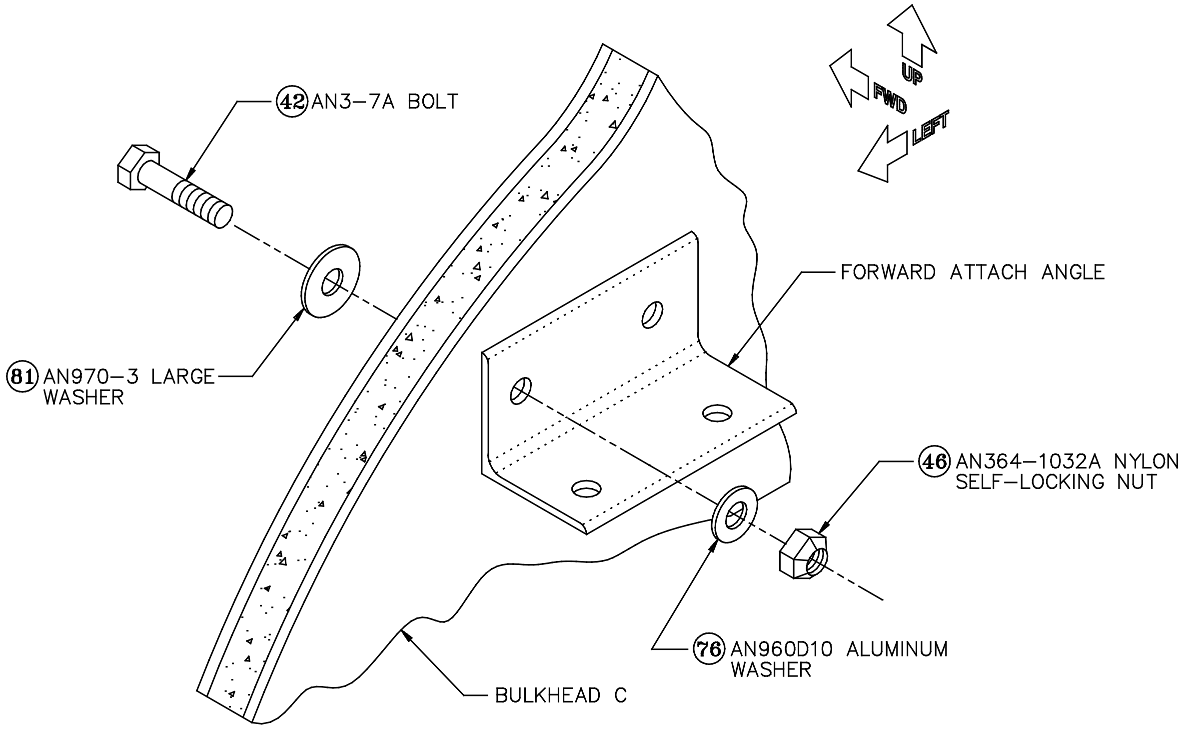

Figure 104: Installing the Forward Attach Angles

Step 77: Install the Horizontal Stabilizer Forward Attach Bracket

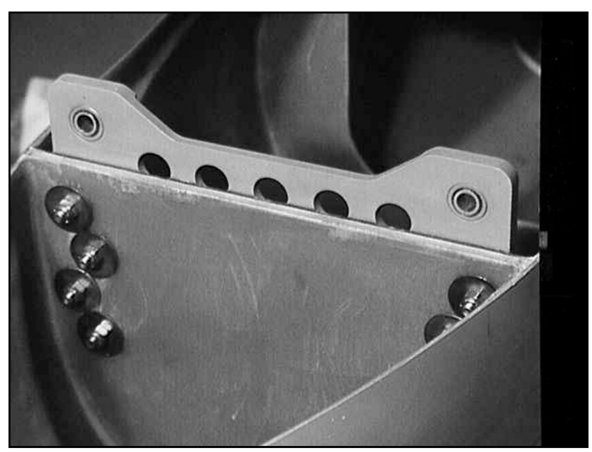

Figure 105: Installing the Horizontal Stabilizer Forward Attach Bracket

Install the horizontal stabilizer attach bracket. Insert AN4-11A **bolts** [55] from the forward side of Bulkhead D, with AN960D416 aluminum washers under the heads. On the aft side of the bulkhead, secure the bolts with AN970-4 **large washers** [82] and AN364-428A nylon self-locking nuts, as shown in Figure 105. If the large washers interfere with the Q-cell radius around the aft side of Bulkhead D, grind their edges as necessary to allow them to lie tightly against the bulkhead.

Completed: [ ]

Step 78: Rough-Cut the Fuselage Shells to Fit the Horizontal Stabilizer

DISTANCE FORWARD FROM TAILCONE JOGGLE	DISTANCE VERTICALLY ABOVE WATERLINE
0"	3-5/8"
2"	3-1/2"
4"	3-3/8"
6"	3-1/4"
8"	3-1/8"
10"	3-1/4"
12"	3-1/4"
14"	3-3/8"
16"	4-3/8"

Table 1: Approximate Dimensions for the Horizontal Stabilizer Cutout

In the next step, you'll mount the horizontal stabilizer and use it to position Bulkhead E. First, you must cut away some material from the fuselage shells to provide clearance for the stabilizer. Table 1 gives some rough dimensions for making these cuts. Each GlaStar will be a little bit different, but these dimensions should get you into the ballpark.

Begin by marking off eight 2" increments along the waterline on each side measured **forward from the tailcone joggle**. Then measure vertically the distance specified in the table for each station, and make a mark. (Don't be concerned if the shell is already lower than the given vertical distance at any horizontal location.) Mark a smooth curve connecting these points and then cut the shell down to this line. Also trim the top of Bulkhead D as necessary to match the fuselage sides. The ideal tool for this job is a pneumatic die grinder with a small sanding drum, but files and a hacksaw or saber saw will work as well.

Once you have cut down to the line, test fit the stabilizer. Lower it over the forward attach bracket and try to insert the alignment pins into the bushings in the bracket. Note where the shells still interfere and grind away more material as necessary. Continue this process of trial and error until you can insert the stabilizer pins in the bracket without any contact between the stabilizer and the shells.

Caution Fiberglass is extremely abrasive to aluminum. If allowed to remain in contact with the stabilizer in a flying GlaStar, the shell edges could abrade through the thin aluminum skins in a matter of hours! Shoot for a uniform gap between the shells and the stabilizer of **between 1/16" and 1/8"**.

Completed: [ ]

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Step 79: Position Bulkhead E

Bulkhead E is located at the very aft end of the fuselage, where it provides the aft attach point for the horizontal stabilizer. Because it's very important to have a precise fit between the bulkhead and the aft attach bracket of the stabilizer, you will use the stabilizer as a "jig" to set the position of the bulkhead.

Begin by sliding the horizontal stabilizer into place, inserting the alignment pins into the bushings in the forward attach bracket. Push the stabilizer forward as far as possible. This may take a bit of force, so don't be too timid. It's a strong stabilizer!

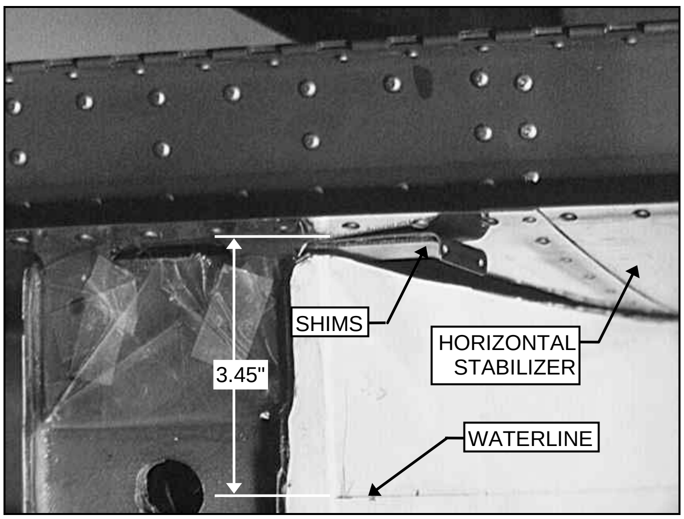

Figure 106: Setting the Angle of Incidence of the Horizontal Stabilizer

Next, temporarily set the angle of incidence of the stabilizer by placing shims between the lower skin of the stabilizer and the top of the fuselage shell, as shown in Figure 106. You can use any handy scrap material—aluminum, wood, cardboard, etc.—as shims. Shim the stabilizer until the distance from the lower skin to the waterline (measured along the trailing edge joggle) is **3.45"**. Check this dimension on both sides, and if there is a difference, split it between left and right.

Note Use the 3.45" dimension **only** if the top of the stabilizer forward attach bracket is the correct 4.8" above the waterline. Otherwise, shim the lower stabilizer skin **1.35"** closer to the waterline, measured at the joggle, than the top of the forward attach bracket. These dimensions position the stabilizer at its required angle of incidence—between **1.25°** and **1.5° nose down** relative to the waterline—although great precision isn't necessary at this time. The incidence angle will be double-checked before drilling the aft stabilizer attach bracket bolt holes in Step 81, below.

The stabilizer is now in position to help locate Bulkhead E. The bulkhead should be located immediately **forward** of the downward-projecting ears of the stabilizer aft attach bracket. In order to get it positioned tightly against these ears, you'll have to insert it into the fuselage on edge, passing it between the ears, and then turn it perpendicular to the centerline and pull it back into place.

Hint To facilitate maneuvering Bulkhead E back tightly against the stabilizer aft attach bracket ears, drill a finger-sized hole through the center of the bulkhead—i.e., roughly **3-1/2"** below the top. This hole will later be enlarged to accommodate the elevator pushrod.

As cut according to the template, Bulkhead E will likely seem too wide to fit between the fuselage shells. It is intended to distend them slightly at the top to better match the shape of the **tailcone** [8]. Experiment by holding the tailcone in place against the tailcone joggle to see if Bulkhead E is too wide, and trim as necessary. Also, in order to get a tight fit between the edges of the bulkhead and the fuselage shells, you may need to bevel the bulkhead edges slightly. Continue this trial and error process until the width of the tailcone joggle matches the tailcone and Bulkhead E is positioned tightly against the ears of the stabilizer aft attach bracket.

Note A 'U'-shaped notch will be cut in the upper surface of the tailcone during its final installation; this will make the tailcone more flexible to fit the joggle at the aft end of the fuselage more easily. Take this into account when fitting Bulkhead E. Also, the tailcone is made of fiberglass in early GlaStar kits and ABS plastic in later kits. From the builder's point of view, the only significant difference between the parts is the Part Number: the early, fiberglass tailcone is P/N 101-01005-**01**, while the later, ABS tailcone is **-03**.

You're almost ready to install Bulkhead E at this point, but one more check needs to be made first. Earlier, you squared Bulkhead D relative to the aircraft centerline, and in theory, this should guarantee that the stabilizer forward attach bracket is square, which in turn should keep the stabilizer itself perpendicular to the centerline. In practice, however, it's possible that the stabilizer might be slightly skewed, and if not corrected now, the placement of Bulkhead E will make this permanent.

At this time, therefore, check the stabilizer for perpendicularity by running a tape measure from the wing strut attach lugs on each side of the fuselage cage back to the outboard, leading-edge corners of the stabilizer, as shown in Figure 107.

Hint To get the most accurate measurement possible, place the end of the tape measure inside the wing strut attach holes and have an assistant hold the tape so that you can pull it good and taut. See the detail view in Figure 107.

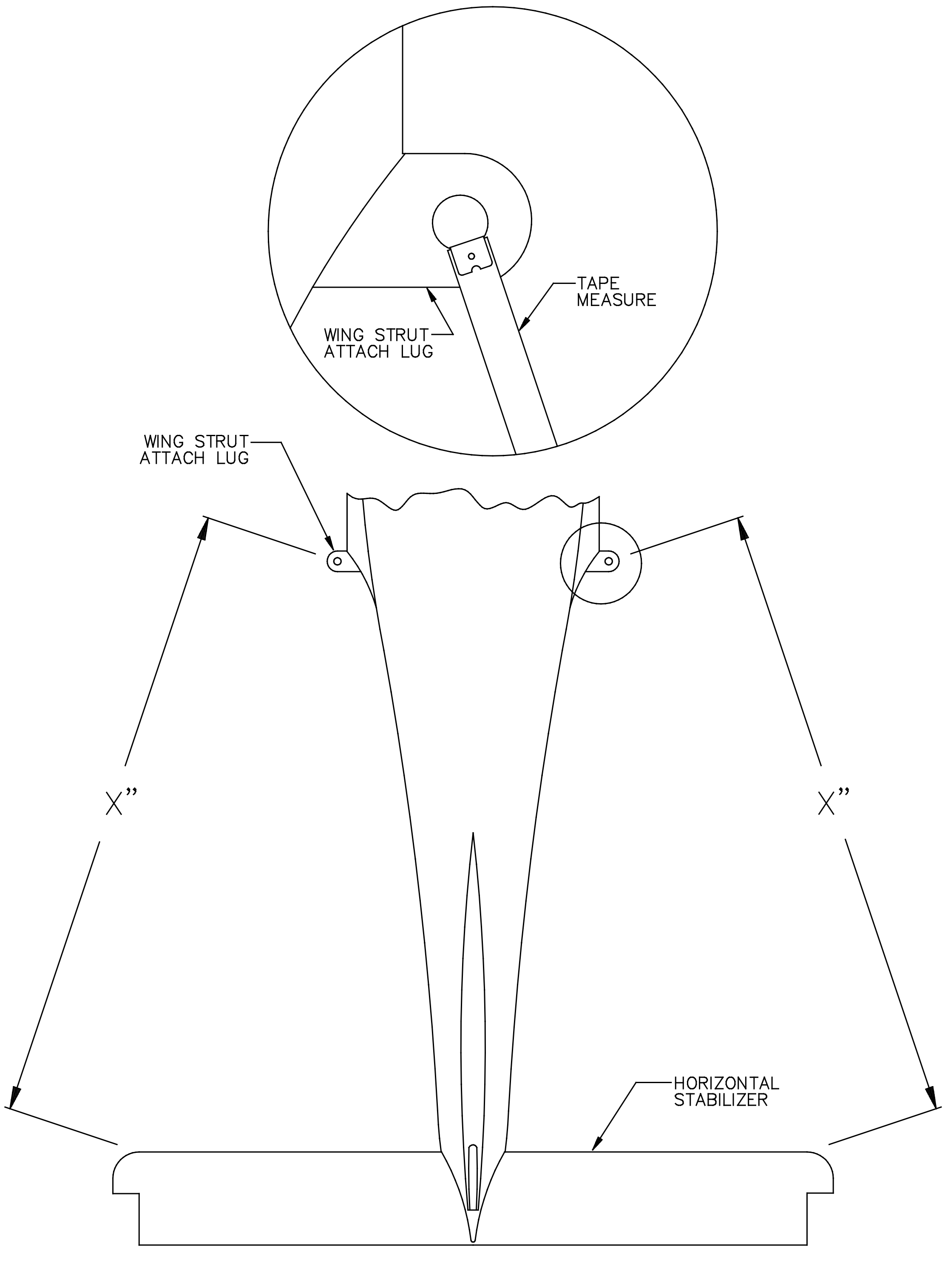

Figure 107: Checking the Horizontal Stabilizer for Squareness to the Centerline

It's unlikely that your stabilizer will be off the perpendicular by much, but it's also unlikely that it will be perfect. A misalignment of less than 1° at Bulkhead D translates into an inch of displacement at the tips. If you find a misalignment of more than 1", check to make sure that your stabilizer alignment pins are fully inserted into the forward attach bracket. If they are and the misalignment persists, remove the stabilizer and check to see if the forward attach bracket is seated squarely against Bulkhead D. Chips of fiberglass or blobs of Q-cell between the bracket and the bulkhead can skew the stabilizer. Remove any such material, reinstall the bracket and recheck the stabilizer.

If the stabilizer is still out of alignment but **by less than 1"**, go ahead and adjust its position, and then reposition Bulkhead E to bring it once again tightly against the ears of the aft attach bracket. Because of the small size of the misalignment, the position of the stabilizer can be corrected by repositioning Bulkhead E alone, and the alignment pins will still penetrate the forward attach bracket bushings far enough to provide a secure mounting of the stabilizer.

However, if the misalignment is **greater than 1"**, you should probably realign the forward attach bracket by laminating one or more extra shim layers of cloth under one or the other of the bracket legs, as shown in Figure 108. After this laminate has cured and the forward attach bracket has been reinstalled, check the stabilizer again and adjust further as necessary.

> **Note** As a rough approximation, one layer of bi-directional cloth under a leg of the forward attach bracket will move the tip of the stabilizer forward about 3/16".

When the stabilizer is finally perpendicular to the aircraft centerline and Bulkhead E is positioned firmly against the attach bracket ears, mark the bulkhead's location on the fuselage shells and remove the stabilizer. Chances are the bulkhead will remain in position due to the pressure of the shells, but if necessary, tack it in place with some hot-melt glue.

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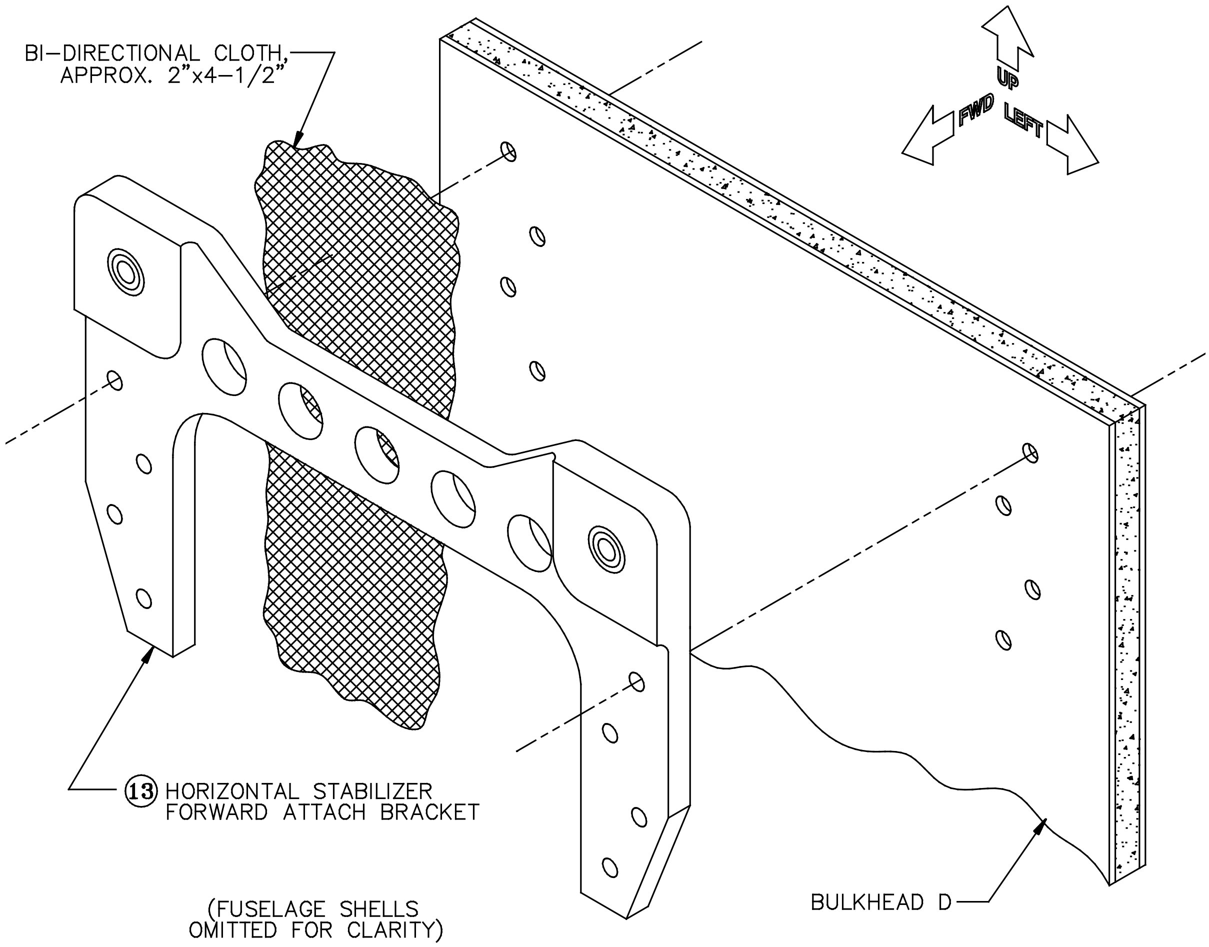

Figure 108: Adjusting the Horizontal Stabilizer Forward Attach Bracket

Step 80: Install Bulkhead E

Unlike Bulkhead D, Bulkhead E is installed with a 3/16" Q-cell fillet followed by two complete layers of bi-directional cloth on the **aft side only**. On the **forward** side, the laminates and foam core will be relieved around the entire perimeter of Bulkhead E to provide a solid, glass-to-glass bond for maximum strength and stiffness. Additionally, the forward laminates and foam core will be removed entirely from the upper **2-1/2"** of Bulkhead E. Alternating laminates of bi-directional and DBM cloth will then be applied in this area to provide a solid, durable mounting point for the horizontal stabilizer aft attach bracket.

So, with Bulkhead E in the position that was determined in the previous step, begin by applying a **3/16"** Q-cell fillet around the perimeter of Bulkhead E on the **aft side only** in the corner where the bulkhead meets the inside of the fuselage. Then apply a two-layer, 45° bi-directional laminate on the **aft side only** of Bulkhead E. The laminate should cover the entire aft surface of the bulkhead and extend all the way to the aft end of the shells. Let the laminate cure.

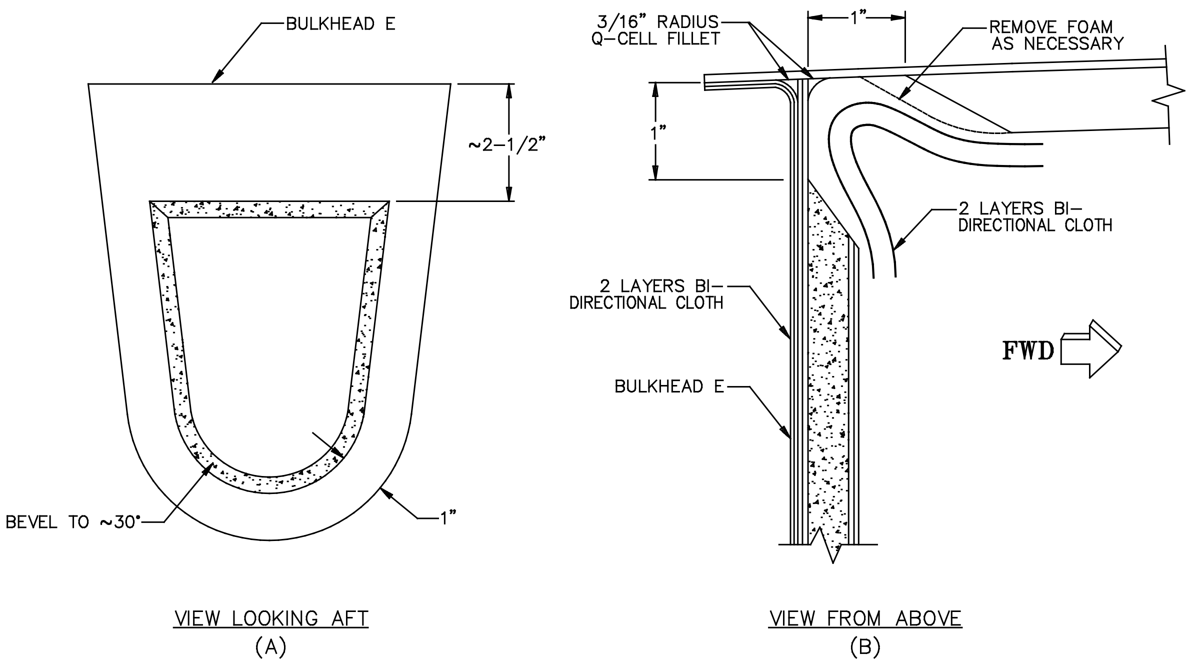

Figure 108.1: Relieving the Forward Side of Bulkhead E

Next, as shown in Figure 108.1, grind away the laminates and the foam core on the **forward side** of Bulkhead E, leaving a **1"**-wide band around the perimeter of the bulkhead in which **only** the **aft** laminates of the bulkhead remain. Across the top of the bulkhead, extend the band downward a total of about **2-1/2"**, as shown. Bevel the remaining foam core to approximately **30°** all around. A rotary file in a die grinder is probably the best tool for this job.

Note Be **very careful** not to damage the laminates on the aft face of the bulkhead. Also, do **not** remove the laminates on the forward face of the remaining foam core.

As shown in Figure 108.1b, there must be a **1"**-wide foam-less band on the fuselage as well as on Bulkhead E so that the bonding laminates go from solid glass to solid glass. It may be necessary to grind away a bit of the foam core on the sides of the fuselage shells to achieve this, but this depends on precisely where your Bulkhead E is located. Check this out and, if necessary, grind away and bevel the fuselage foam core as shown in Figure 1b. Again, be careful not to damage the **outside** fuselage laminates.

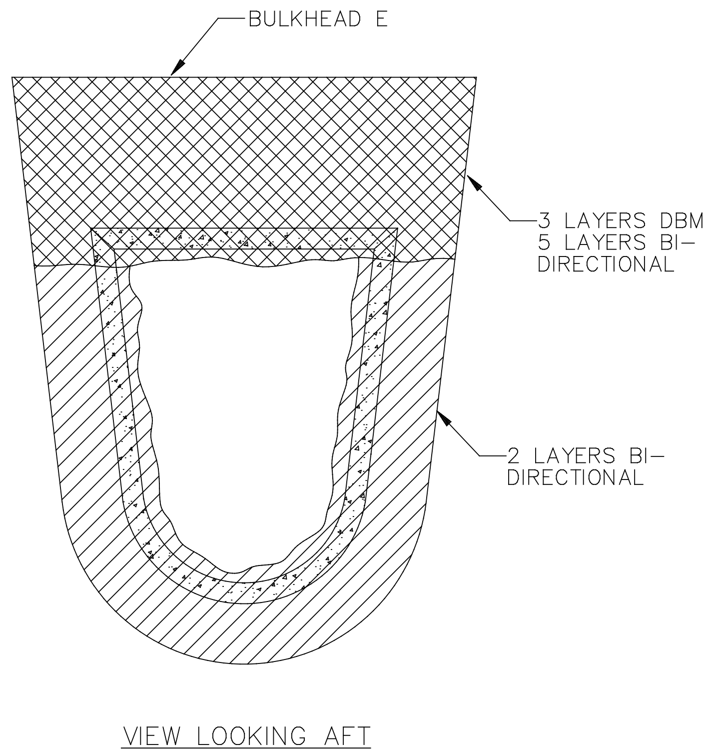

Figure 108.2: Bulkhead E Forward Laminates

Next, as shown in Figure 108.1b, apply a **3/16"**-radius Q-cell fillet around the perimeter of the bulkhead on the forward side. Then cut **3"**-wide strips of bi-directional cloth on the 45° bias and apply two strips to the junction between Bulkhead E and the fuselage **below** the 2-1/2"-wide solid glass band across the top of the bulkhead. These strips should lap equally onto the bulkhead and the fuselage shell, and because of their width should lap up onto the foam-core portion of both parts, as shown in Figure 108.1b. Reinforcement laminates will be applied to the top 2-1/2" of the bulkhead on the forward side, as shown in Figure 108.2 and as described in detail below.

Figure 108.3 illustrates the schedule of laminates to be applied to the forward face of Bulkhead E from the foam core upward to the top of the bulkhead. These layers can all be applied in a single laminating session, or you can let the resin cure between layers or groups of layers at your discretion. All told, the laminates will bring the thickness of the solid fiberglass upper half of the bulkhead to something over **1/4"**.

Note that the layers of DBM cloth called out in Figure 108.3 cover the upper portion of the bulkhead but do **not** lap over onto the fuselage shells. By contrast, the layers of bi-directional cloth do lap over, and each succeeding layer of bi-directional cloth laps over **3/4" further** than the preceding layer. Also, the DBM cloth should simply butt up against the beveled foam core that remains on the forward face of the bulkhead, whereas the bi-directional cloth should lap downward about **1"** onto the foam core. All the bi-directional cloth should be cut on the 45° bias.

After the laminates have cured, drill a **1/4"**-diameter drain hole through the fuselage belly on the centerline just forward of Bulkhead E.

Note You may note that the two layers of cloth on the aft face of Bulkhead E will effectively change the position of the ears of the stabilizer aft attach bracket. However, the thickness of the double-layer laminate amounts to only about thirty thousandths of an inch, which is a negligible amount.

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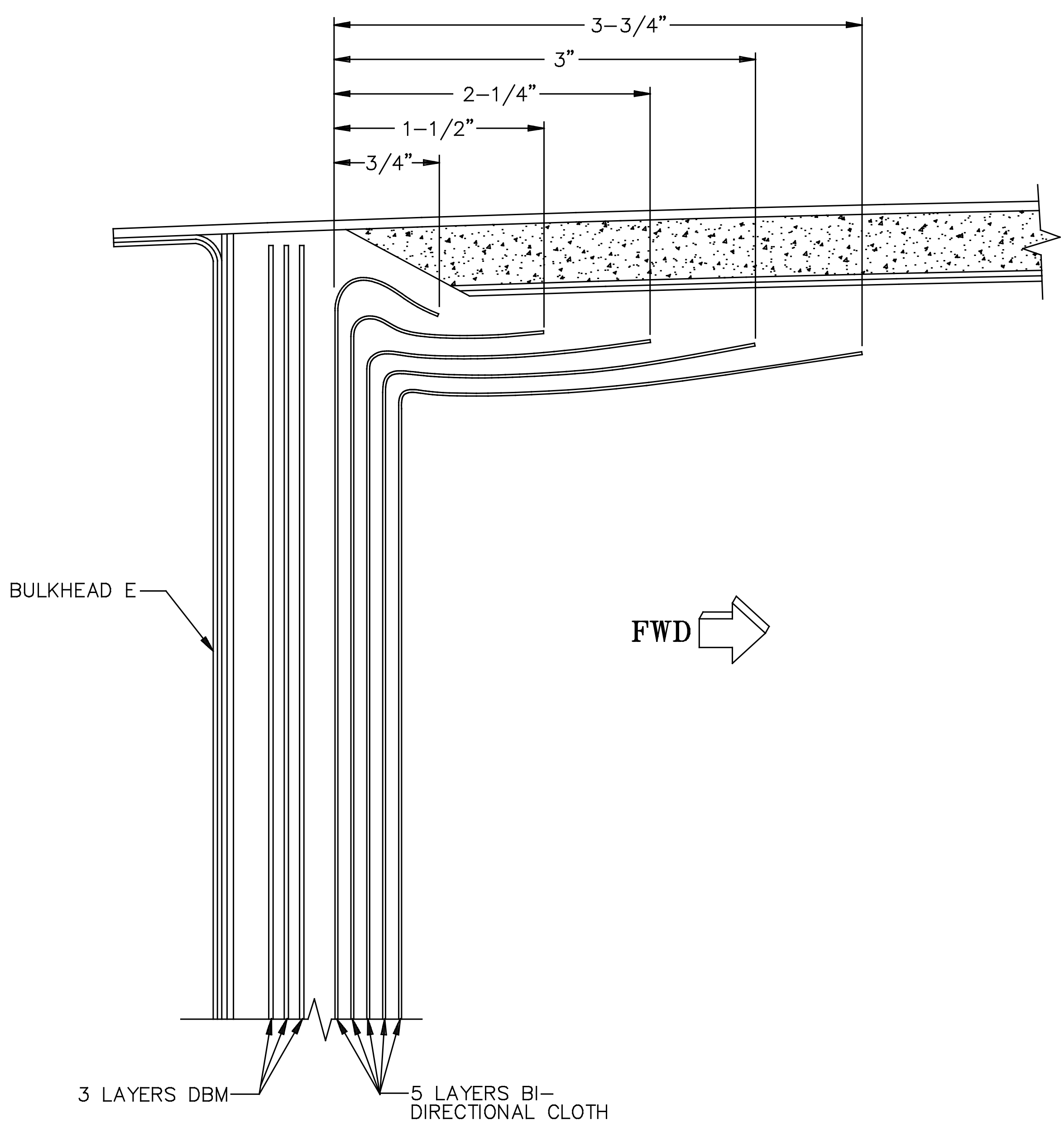


Figure 108.3: Reinforcement Laminates for the Upper Portion of Bulkhead E

Step 81: Drill the Horizontal Stabilizer Aft Attach Bracket Bolt Holes

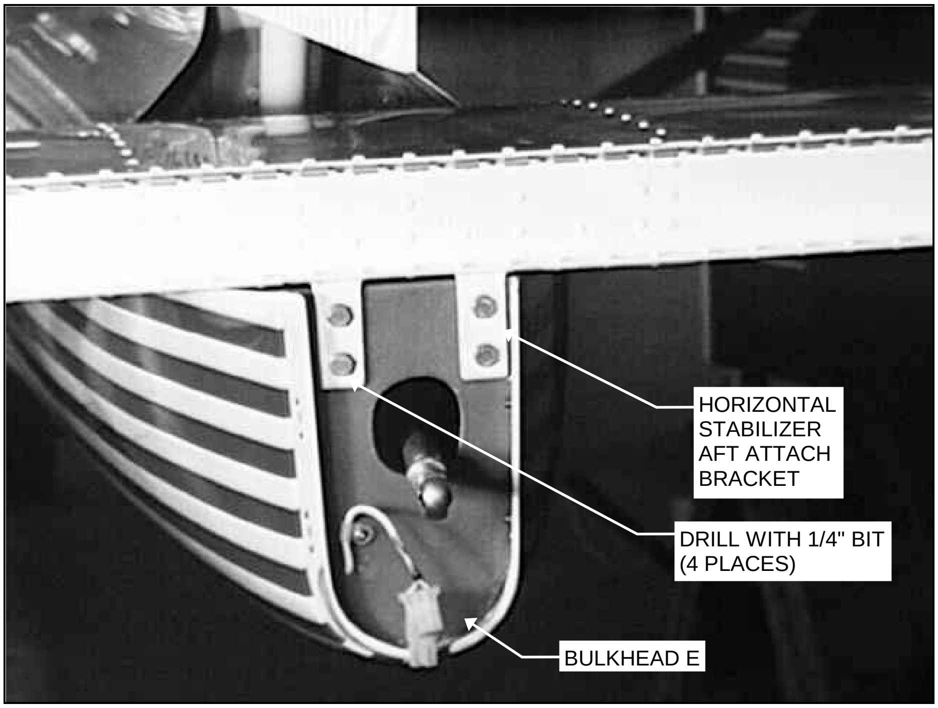


Figure 109: Drilling the Horizontal Stabilizer Aft Attach Bracket Bolt Holes

After Bulkhead E has cured, remount the stabilizer. As before, shim the stabilizer until the distance from the waterline to the lower skin is exactly **3.45"**. Level the fuselage longitudinally using the procedures described in Step 38 of this section, and then use a digital level to confirm that the angle of incidence is between **1.25°** and **1.5° nose down**. Check this at both ends of the stabilizer by holding the level on the chord line of the stabilizer—i.e., on the line that bisects the airfoil shape. Adjust the shims as necessary to achieve an angle of incidence in the specified range. With the angle of incidence thus set, you're ready to drill the four bolt holes through the aft attach bracket and Bulkhead E. Use a **1/4"** bit to drill these holes, as indicated in Figure 109. After the drilling is complete, remove the stabilizer and set it aside.

Completed: [ ]

Step 82: Install the Stabilizer Mounting Nutplates

The four bolts holding the stabilizer aft attach bracket to Bulkhead E are secured by nutplates riveted to the forward side of the bulkhead. Position and drill four F5000-4 **floating nutplates** [83] now, using a **#40** bit to drill the rivet holes. Countersink the holes on the **aft** side for 3/32" flush-head rivets. After the holes have been drilled and countersunk, use 3/32" AN426AD3-7 universal-head rivets to secure the nutplates.

Note The stabilizer will ultimately be secured with four AN4-10A bolts. Mounting the stabilizer to the fuselage with these bolts will be described in "SECTION IX: SYSTEMS INSTALLATION." Until then, store the stabilizer in a safe place.

Completed: [ ]

Step 82.1: Laminate Attach Flanges for the Aft Inter-Bulkhead Shearweb

A second aluminum shearweb—the **aft inter-bulkhead shearweb**—is installed between Bulkheads D and E in a similar manner to the forward shearweb already installed between Bulkheads C and D. The aft shearweb requires attach flanges on both bulkheads and on the fuselage sides. All four of these flanges will be laminated, as were the side flanges for the forward shearweb.

Make a cardboard template the shape of the area between Bulkheads D and E and the fuselage sides. (Because this area of the fuselage is quite open, this is an easy template to make yourself.) Trim the template to fit snugly about **3/4"** below the top edges of the fuselage shells and bulkheads. Make relief cutouts in the corners of the template as necessary to clear the forward stabilizer attach bracket bolts and the aft stabilizer attach nutplates.

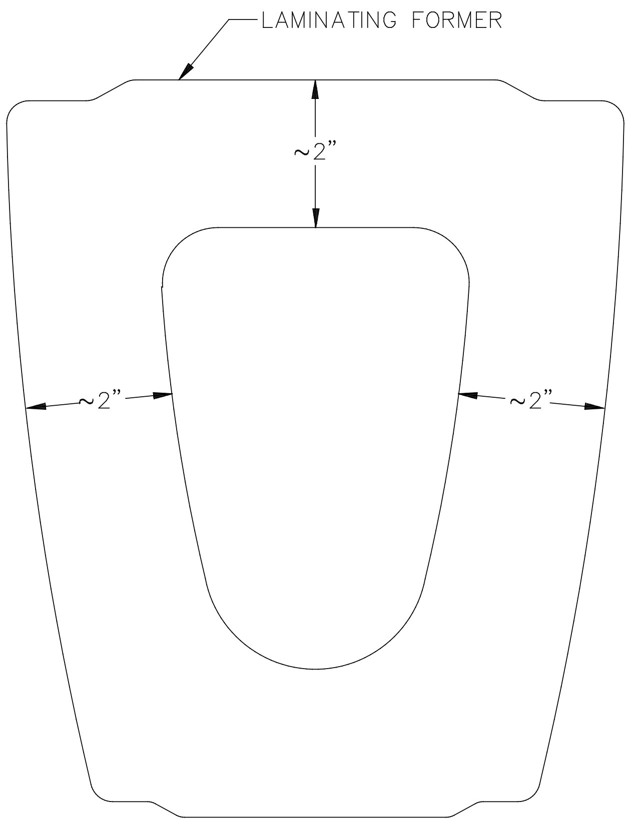


Figure 109.1: Laminating Former

Transfer the final shape of the template to a scrap piece of .032"–.063" sheet metal or Formica and cut the shape out of that material. Then, cut a hole in the middle of the piece about **2"** inside the perimeter. This piece will serve as a former against which to laminate the attach flanges.

Using 60–80-grit sandpaper, thoroughly roughen the insides of the fuselage shells, the aft face of Bulkhead D and the forward face of Bulkhead E from the tops down about **2"**. Clean the sanded fiberglass with acetone. Then apply mold-release wax to the entire underside of the former and use hot-melt glue and/or tape to position it between the bulkheads, once again about **3/4"** below the tops of the bulkheads and shells.

For **each of the four sides** of the laminating former, cut **two** strips of DBM cloth, each just a bit shorter than the side of the former it's intended for in order to clear the bolts and nutplates in the corners. Laminate these strips against the underside of the former just as you did the side attach flanges for the forward inter-bulkhead shearweb in Step 73.

When the flanges have cured, remove (but do not discard) the former. Trim the flanges to an even width of **1"** and slightly round the corners.

Completed: [ ]

Step 82.2: Cut and Install the Aft Inter-Bulkhead Shearweb

Using the laminating former as a pattern, cut the actual aft inter-bulkhead shearweb from the second .063" X 12" X 12" aluminum sheet. (You used part of the first sheet to cut out the forward shell attach fittings in Step 12 of this section.) Do **not** cut out the center of the shearweb, however. Use files and/or a belt sander to reduce the outside dimensions of the shearweb by **1/16"–1/8"** all the way around so that the shearweb will slip easily into place between the fuselage shells and Bulkheads D and E. Fifteen AN3-4A bolts will be used to secure the shearweb to the underlying attach flanges. Figure 109.2 shows the suggested layout of these holes. Mark the locations on the shearweb, position it and drill through the shearweb and the attach flanges with a **#10** bit, Clecoing as you go.

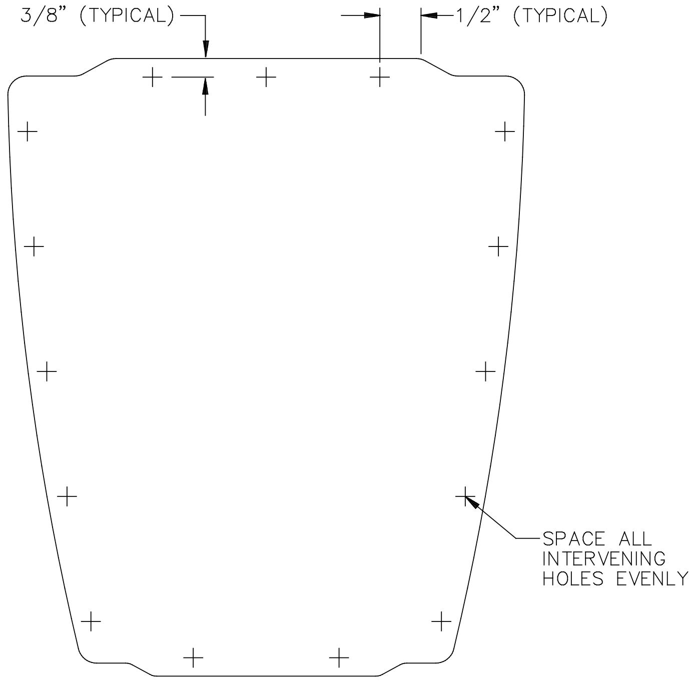


Figure 109.2: Aft Shearweb Bolt Hole Pattern

Thoroughly deburr the shearweb and corrosion-proof it as you see fit.

Because there is a large inspection hole in the fuselage bottom between Bulkheads C and D, you were able to use regular nylon self-locking nuts on the bolts securing the forward shearweb. For this aft one, however, nutplates are required. Use standard procedures to position, drill and install MF5000-3 **floating nutplates** [84.1] under the attach flanges at each hole location.

The aft shearweb will ultimately be installed after the final government airworthiness inspection prior to first flight. Set it aside for now.

Completed: [ ]

Step 83: Lay Up and Trim the Bulkhead A Laminate

Bulkhead A forms the aft end of the baggage compartment. Unlike the other four bulkheads, it's laid up without a foam core. In order to make the laminate, you will need a flat, very smooth surface **30" square**. A large piece of sheet metal, Formica or Masonite is ideal.

Begin by cutting out the **Bulkhead A template** [18]. Cut both the inner and outer perimeters right on the template line, rather than cutting oversized as you have on some previous templates. Tack this template to your laminating surface with spray adhesive or rubber cement and then mark both the inner and outer perimeters onto the surface with a marking pen. Then remove the template, setting it aside for later use. Clean off any residue from the adhesive and wax the laminating surface thoroughly with mold-release wax.

As shown in Figure 110, the Bulkhead A laminate is a hybrid—it consists of three layers of bi-directional cloth sandwiched between two layers of DBM. Cut two strips of DBM, each about **90"** long. Cut the three layers of bi-directional cloth on the 45° bias to match the shape of the lower part of the bulkhead, as shown in Figure 110, but make them each about **1" oversized** all around.

Hint The DBM is used to form the outer ring of the bulkhead because, when saturated, it follows curves quite well. Nevertheless, you may find it easier to apply if you cut the 90" strips into 3—5 shorter segments and overlap them end to end by an inch or so. This is perfectly acceptable.

Saturate the cloth and lay it up using standard laminating procedures. You may lay up all five layers at once or do them individually, at your convenience, but the strongest, lightest bulkhead will result if you do them all at once. Regardless, be sure that all five layers of cloth exceed the margins of the pattern marked on the laminating surface.

After the laminate has cured hard, remove it from the laminating surface and spray-glue the template to the laminate. Then use snips or a bandsaw to cut it to final size.

Completed: [ ]

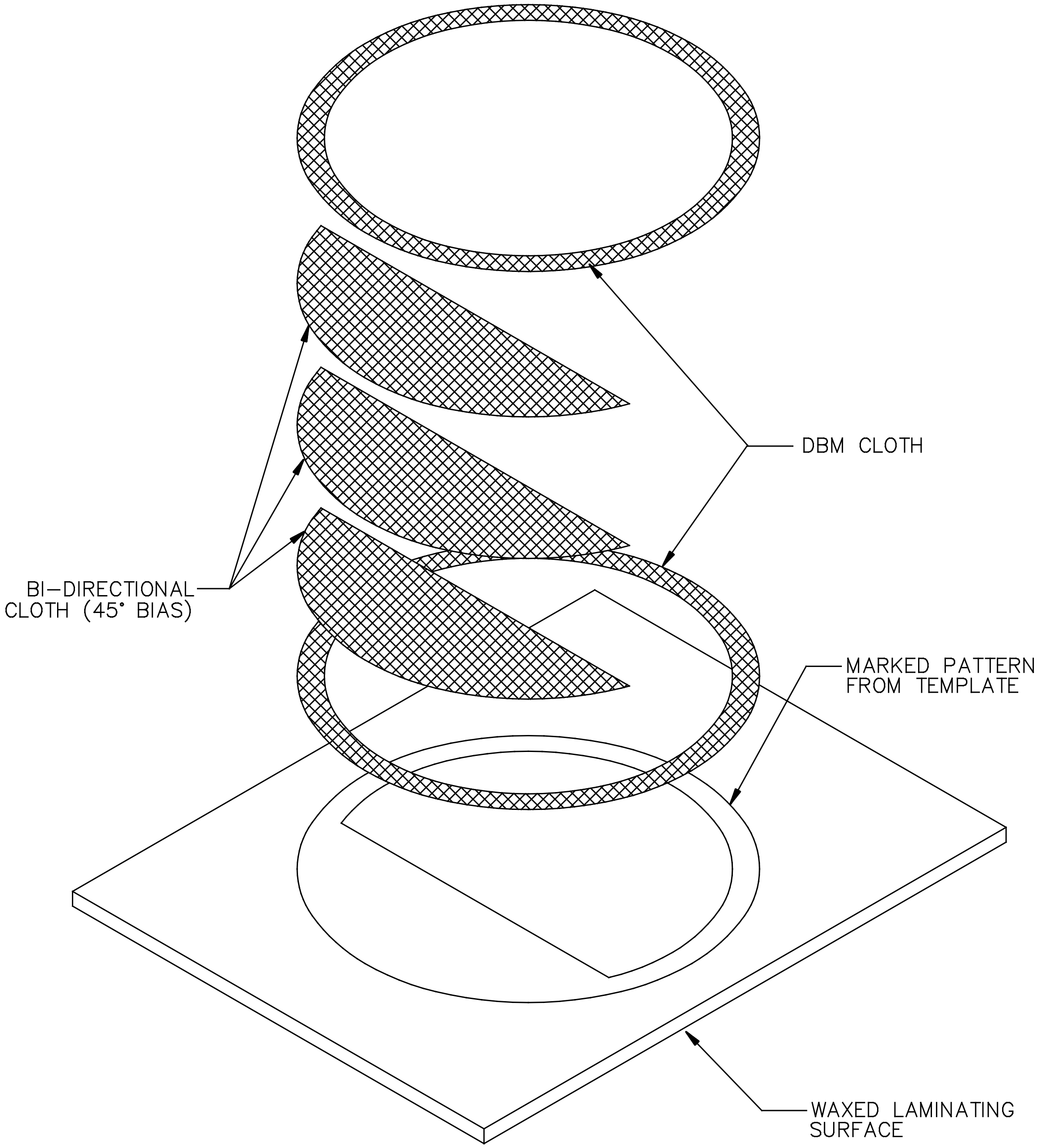


Figure 110: Laminating Bulkhead A

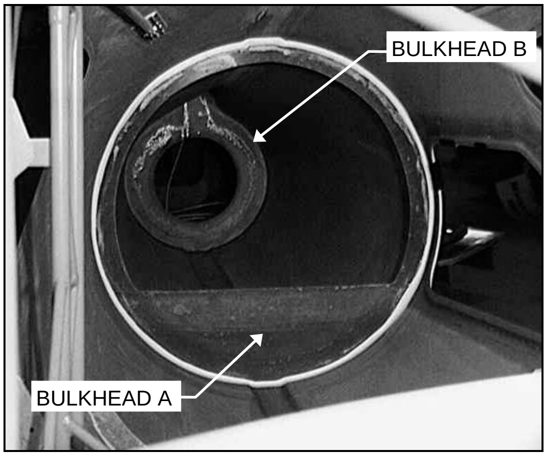


Figure 111: Bulkhead A

Step 84: Install Bulkhead A

As shown in Figure 111, Bulkhead A is installed just aft of the baggage door. Its exact placement is simply determined by its diameter—it is placed as far aft as it will go.

Because the Bulkhead A laminate is so flexible, it would be difficult to position it in the fuselage by itself. An easier solution is to cut a wooden former the same shape and size as the bulkhead, temporarily attach the bulkhead to the former, and then use the former to hold the bulkhead in position until it has been bonded in. This procedure is shown in Figure 112.

Cut the plywood (or paneling, chipboard, Masonite, etc.) to match the inside and outside dimensions of Bulkhead A, using the trimmed laminate as a template. Then use large loops of wide masking tape or duct tape to fasten the bulkhead to the former, with the **smooth** face of the bulkhead against the former.

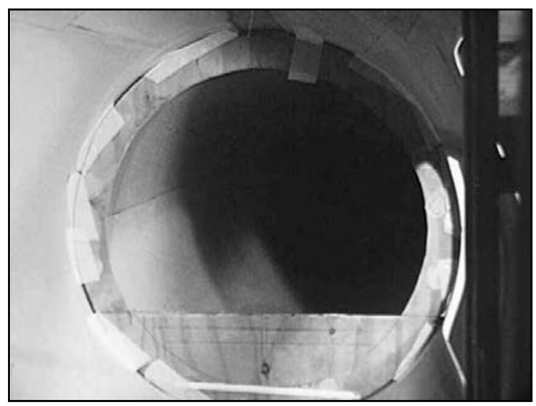


Figure 112: Bulkhead A Former

Place the former in the fuselage with the bulkhead aft and slide it back until it contacts the shells. This should place the bulkhead itself about **2"** (±1/4") aft of the lip of the baggage door. Square the former relative to the aircraft waterline and centerline, and then lock it in place with tape, as shown in Figure 112. Use enough tape to hold the former fairly securely, as you will be applying a laminate to the aft side of the bulkhead.

Bulkhead A is installed with Q-cell fillets forward and aft and a single layer of DBM cloth on the aft side. Begin with the aft fillet, followed by the DBM. After these have cured, remove the former and apply the forward fillet. Finally, drill **1/4"** drain holes through the bottom of the fuselage on the centerline just **forward** and **aft** of Bulkhead A.

Completed: [ ]

Step 85: Install the Fuselage Struts

As Figure 113 shows, **left** [11] and **right fuselage struts** [12] extend back from the upper aft corners of the cage into the aft fuselage, where they are tied into the shells via pairs of shell attach fittings. These struts and fittings are vital in transferring flight loads from the fuselage shells to the cage assembly.

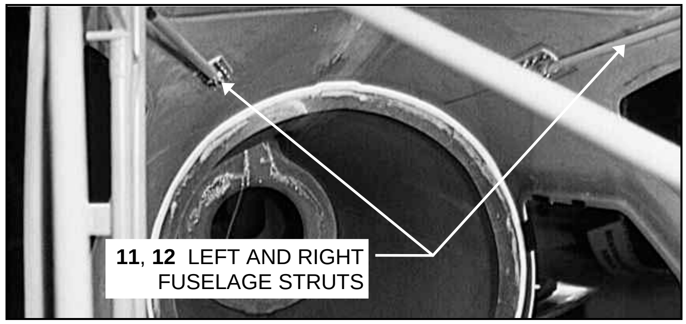


Figure 113: Fuselage Struts

The first step in installing the struts is to drill bolt holes in two pairs of the triangular aft shell attach fittings you fabricated way back in Step 11. Begin by pilot drilling each of the four marked locations on the rectangular flanges of all four fittings with a **#30** bit, as shown in Figure 114. Next, mark and center punch a bolt hole location on the triangular flange of one fitting from each pair according to the dimensions shown in the figure. Finally, clamp the two fittings from each pair together back to back as shown and drill at the marked location with a **5/16"** bit. Deburr all the holes.

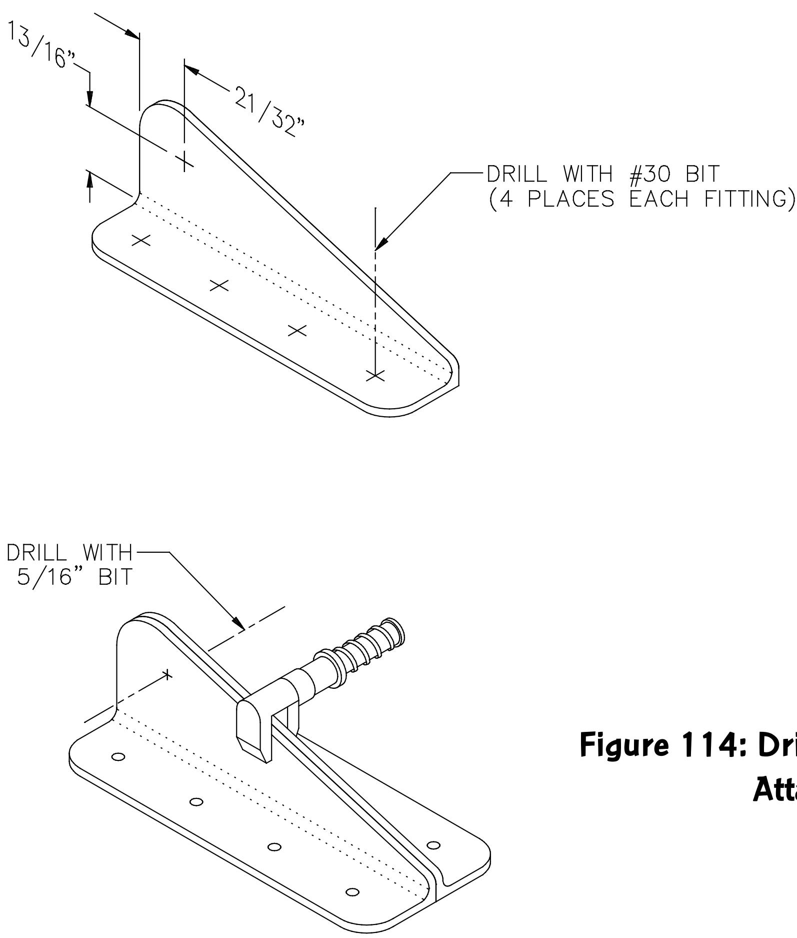


Figure 114: Drilling the Fuselage Strut Attach Fittings

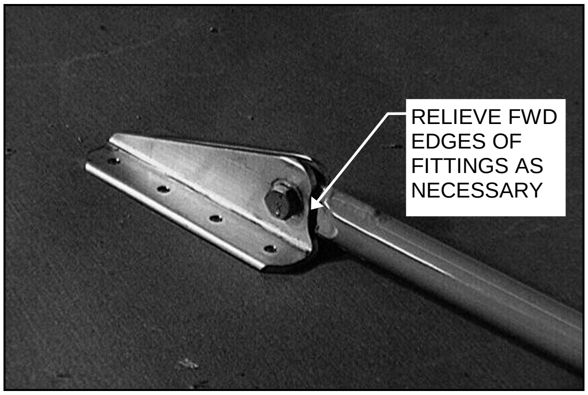


Figure 115: Mounting the Shell Attach Fittings on the Fuselage Strut

The next step is to fit the fittings to the struts. As Figure 115 shows, you will probably have to grind away a little bit of material from the forward edge of each fitting to allow it to clear the welds on the strut. Remove as much material as necessary to allow the fittings to fit freely, leaving a smoothly filed finish. Then fasten a pair of fittings to one end of each strut using an AN5-6A **bolt** [61], AN960D516 **aluminum washers** [80] (under both bolt and nut) and an AN364-524A **nylon self-locking nut** [48]. Don't tighten the hardware down at this point.

Note The left- and right-hand fuselage struts **are** different, but they are difficult to distinguish except by holding them in position relative to the cage assembly and the fuselage shells. So, for now, they can be considered interchangeable. Also, the ends of each strut are truly interchangeable; fasten the pair of fittings to either end.

With the fittings mounted on the struts, the struts can now be mounted to the cage. The tab at the free end of each strut must be inserted between the double tabs on the cage assembly at the locations shown in Figure 116. Use trial and error to distinguish between the left and right struts at this time: with the strut tab inserted between the cage tabs, the rectangular flanges of the fittings should lie nearly flat against the inside surface of the fuselage shell. If they don't, then you have the strut on the wrong side.

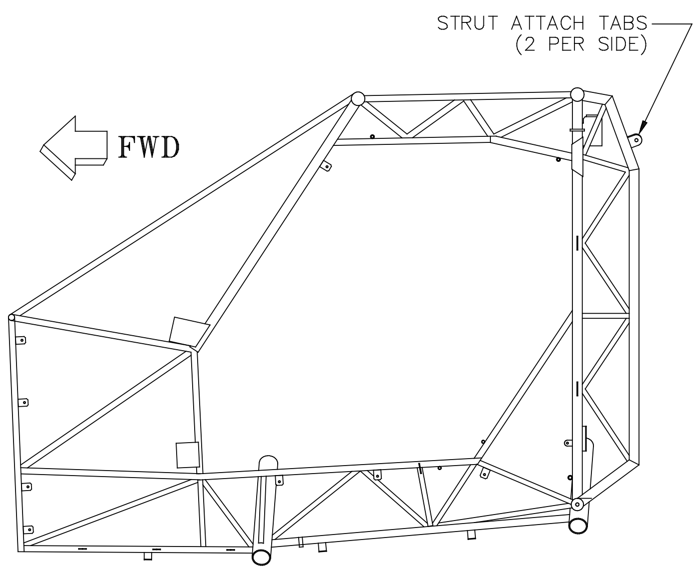


Figure 116: Fuselage Strut Cage Tabs

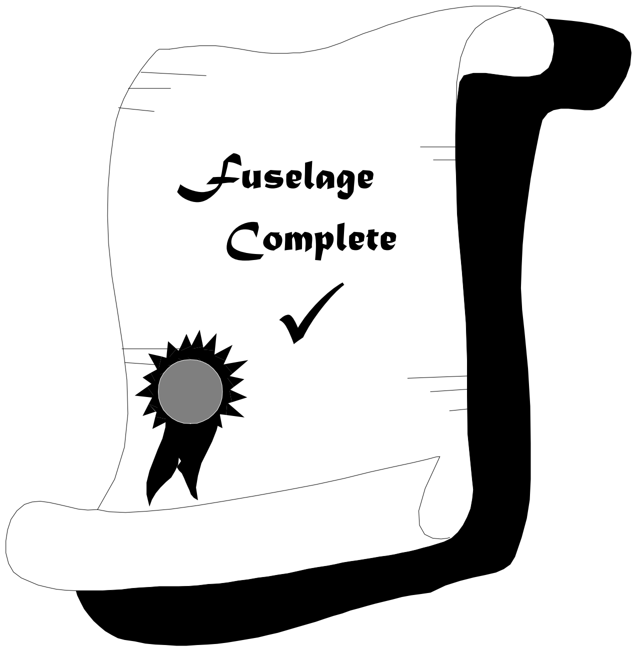
When you have the left- and right-hand struts distinguished, mount them to their respective cage tabs with AN5-6A bolts, AN960-516 **washers** [74] (under the nuts only) and AN364-524A nylon self-locking nuts. As with the fitting hardware, don't tighten these down yet.

Note The shell attach fittings will eventually be drilled through the fuselage shell, bedded in Q-cell and secured with screws just as the lower shell attach fittings were. However, we recommend that you defer fastening the fittings to the shell until after the wings have been folded. This will give you a chance to assess clearance between the flaps and the fuselage and make adjustments, if necessary. Thus, the final fastening of the strut fittings is specified in Step 136.1 of "SECTION X: FINAL ASSEMBLY.")

Completed: [ ]

CONGRATULATIONS!

Your GlaStar fuselage is complete! Now it's time to give it wings (and wheels and brakes and control cables and pulleys and pedals and sticks and pitot tubes and fuel tanks and nav lights and . . . you get the picture). On to systems installation!



SECTION IX: SYSTEMS INSTALLATION

MAIN PARTS LIST

Key No.:	Part Name:	Qty:	Part No.:
1	Roller bearing	8	017-00002-01
2	Rod end bearing, 1/4"	2	017-00003-01
3	Brass elbow	6	032-00401-01
4	Swagelok union tee	1	032-00601-01
5	Swagelok female branch tee	1	032-00602-01
6	Fuel shut-off valve	1	033-00601-01
7	Push nut	4	064-00002-01
8	Fairlead	4	067-00001-01
9	Polyethylene block, 5/16" X 1" X 24-1/2"	1	067-00375-01
10	Blind rivet, 1/8"	12	070-00003-01
11	Aluminum sheet, .040" X 6" X 6"	2	075-01004-01
12	Aluminum sheet, .063" X approx. 6" X 12" [from Section VIII]	1	075-01011-01
13	Aluminum sheet, .125" X 4" X 8"	1	075-01250-01
14	Steel sheet, .090" X 3/4" X 6"	1	075-02010-01
15	Rubber tubing, 5/8"	42 in.	083-00001-01
16	Nylon washer, .032" [from Sect. VIII]	16+	085-00003-01
17	Nylon washer, .064" [from Sect. VIII]	16+	085-00004-01
18	Master cylinder	2	090-00001-01
19	Brake reservoir	1	090-00005-02
20	Aluminum tee, .125" X 1-1/8" X 1-5/8"	10"	100-0640-010
21	Forward spar attach pin [from Sect. VIII]	2	101-03000-01
22	Rod end bearing	6	170-3414-002
23	Rod end bearing	2	170-4519-001
24	Cable retainer clip	4	201-05504-01
25	Clamp-up bushing	8	201-10008-01
26	Wing strut	2	201-25001-01
27	Fuselage wing strut attach fitting	2	201-25002-01
28	Inspection hole doubler, 4.45"	4	201-33002-01

29	Inspection hole doubler, 6.2" X 4.7"	2	201-34002-01
30	Inspection hole doubler, 5.75"	4	201-35002-01
31	Left fuel tank	1	201-40000-01
32	Right fuel tank	1	201-40000-02
33	Fuel tank filler neck	2	201-40002-01
34	Cable tie, 4"	25	210-0018-001
35	Nylon male tubing connector	2	320-0250-001
36	Nylon tubing connector insert	2	320-0259-001
37	Drain valve	1	320-0334-001
38	Axle spacer	2	351-0115-001
39	Main gear leg	2	401-00001-01
40	Axle washer	2	401-01503-01
41	NicoPress sleeve	12	450-0002-004
42	Roll pin, 3/16" X 1/2"	1	450-0012-001
43	Rod end insert	2	521-0490-001
44	Cable retainer strap stock	8	600-00001-01
45	Rudder pedal pivot angle	1	601-01102-03
46	Rudder pedal brake actuator angle	1	601-01103-03
47	Left rudder control weldment	1	601-01200-01
48	Right rudder control weldment	1	601-01200-02
49	Elevator/aileron control yoke	1	601-01300-05
50	Control stick pivot bracket	2	601-01400-01
51	(Part deleted by Revision C)		
52	Control stick interconnect rod	1	601-01600-01
53	Control yoke bearing block	2	601-02000-03
54	Formed aluminum angle, .063" X 1" X 2-3/4"	1	602-01001-03
55	Flap handle ratchet plate	1	602-02001-01
56	Flap handle plunger extension	1	602-02002-01
57	Flap handle plunger	1	602-02003-01
58	Flap handle	1	602-02010-03
59	Flap pushrod	2	602-03000-01
60	Formed alum. angle, .063" X .88" X 2.5"	1	602-04101-03
61	Control cable attach tab	6	602-06002-01
62	Aileron pushrod	2	602-07000-01

63	Forward rudder cable	2	618-01001-01
64	Empennage cable	4	618-01002-01
65	Elevator down cable	1	618-01003-01
66	Elevator up cable	1	618-01004-01
67	Flap primary cable	3	618-01006-01
68	Flap primary retraction cable	1	618-01007-01
69	Flap final deployment cable	2	618-01010-01
70	Flap final retraction cable	2	618-01011-01
71	Aileron primary actuation cable	2	618-01012-01
72	Aileron secondary actuation cable	2	618-01013-01
73	Aileron left crossover cable	1	618-01014-01
74	Aileron right crossover cable	1	618-01015-01
75	Flap handle button	1	620-1321-218
76	Monel blind rivet	12	700-0042-001
77	Rudder control spring	2	771-0525-001
78	Flap handle spring	1	772-0310-001
79	Aluminum tubing, 3/8"	216 in.	820-0524-001
80	Aluminum tubing, 3/4"	2 ft.	820-0638-004
81	Nylon tubing, 3/16"	30 ft.	830-0370-001
82	Spiral wrap, 3/8"	18 in.	830-0598-002
83	Nylon tubing, 1/4"	25 ft.	830-0600-001
84	Cable thimble	10	AN100C-4
85	Shackle (8 ea. supplied with early cages)	6	AN115-21
86	Pulley	5	AN210-3A
87	Pulley	18	AN210-4A
88	Drilled-shank bolt	7	AN3-10
89	Drilled-shank bolt	3	AN3-11
90	Drilled-shank bolt	8	AN3-12
91	Bolt	1	AN3-17A
92	Bolt	4	AN3-24A
93	Drilled-shank bolt	2	AN3-35
94	Drilled-shank bolt	3	AN3-5
95	Bolt	4	AN3-5A
96	Drilled-shank bolt	2	AN3-6
97	Bolt	6	AN3-6A

98	(Part deleted by Revision C)		
99	Bolt	4	AN3-7A
100	Castle nut	27	AN310-3
101	Castle nut	16	AN310-4
102	Castle nut	2	AN310-5
103	Castle nut	2	AN310-7
104	Castle nut	2	AN310-8
105	Jam nut	10	AN316-4R
106	Jam nut	2	AN316-5R
107	High-temperature self-locking nut	2	AN363-524
108	Nylon self-locking nut	31	AN364-1032A
109	Nylon self-locking nut	1	AN364-428A
110	Nylon self-locking nut	8	AN364-624A
111	Nylon self-locking nut	4	AN365-1032A
112	Nylon self-locking nut	2	AN365-524A
113	Cotter pin	67	AN380-2-2
114	Cotter pin	2	AN380-3-3
115	Cotter pin	2	AN380-3-4
116	Cotter pin	6	AN380-4-6
117	Cotter pin	2	AN380-4-8
118	Clevis pin	5	AN392-17
119	Clevis pin	8	AN393-11
119.1	Clevis pin	4	AN393-13
120	Clevis pin	2	AN393-17
121	Clevis pin	1	AN393-19
121.1	Bolt	4	AN4-10A
122	Drilled-shank bolt	1	AN4-12
123	Drilled-shank bolt	8	AN4-14
124	Bolt	1	AN4-14A
125	Drilled-shank bolt	4	AN4-17
126	(Part deleted by Revision C)		
127	Drilled-shank bolt	2	AN4-21
128	Drilled-shank bolt	1	AN4-43
129	Lock pin	2	AN415-2
130	Clevis fork	2	AN486-4P

131	Drilled-head bolt	2	AN4H14A
132	Drilled-head bolt	4	AN4H20A
133	Drilled-shank bolt	2	AN5-20
134	Bolt	2	AN5-23A
135	Bolt	8	AN6-24A
136	Drilled-shank bolt [from Sect. VIII]	2	AN7-12
137	Drilled-shank bolt	2	AN8-22
138	Reducer bushing	1	AN912-1D
139	Plug	2	AN913-2D
140	Washer	8	AN960-10
141	Thin washer	45	AN960-10L
142	Washer	6	AN960-416
143	Thin washer	14	AN960-416L
144	Washer	6	AN960-516
145	Thin washer	2	AN960-516L
146	Thin washer	2	AN960-716L
147	Washer	2	AN960-816
148	Thin washer	4	AN960-816L
149	Aluminum washer	31	AN960D10
150	Thin aluminum washer	28	AN960D10L
151	Aluminum washer	14	AN960D416
152	Aluminum washer	10	AN960D616
153	Thin aluminum washer	1	AN960D616L
154	Large washer	12	AN970-3
155	Large washer	2	AN970-5
156	Nutplate	2	K1000-3
157	Dowel pin	1	MS16555-341
158	Pulley	2	MS20220-3
159	Turnbuckle barrel	11	MS21251-B5S
160	Cable eye	4	MS21255-5LS
161	Rubber grommet, 7/16"	6	MS35489-6
162	Strap shackle	4	NAS1435K4
163	Aluminum spacer	3	NAS42DD6-15
164	Aluminum spacer	2	NAS42DD8-19
165	Aluminum spacer	2	NAS42DD8-27

166	Aluminum spacer	4	NAS42DD8-31
167	Aluminum spacer	2	NAS42DD8-58
168	Clamp-up bushing	1	NAS73-4-14
169	Plain steel bushing	4	NAS75-8-016
170	Plain steel bushing	2	NAS75-8-018
171	Flanged steel bushing	6	NAS77-3-006
172	Flanged steel bushing	2	NAS77-4-009
173	Flanged steel bushing	2	NAS77-4-012
174	(Part deleted by Revision C)		

Common Parts List for Standard Landing Gear

Note The instructions in this section cover installation procedures for the standard, 5.00 X 5 tricycle **and** taildragger landing gear options, and the following list includes parts that are common to these two installations. The 6.00 X 6 and 8.00 X 6 taildragger installations are covered in separate option instructions. Landing gear-related parts that are common to **all** installations are included in the Main Parts List above.

Key No.:	Part Name:	Qty:	Part No.:
175	Axle nut	2	371-0465-101
176	Axle spacer	2	401-00002-01
177	Brake mounting flange	2	401-01000-03
178	Aluminum sheet, .090" X 12" X 12"	1	075-01091-01
179	Tire, 5.00 X 5	2	800-0660-01
180	Tube, 5.00 X 5	2	800-0675-001
181	Main wheel and brake kit	1	902-0678-501
182	High-temperature self-locking nut	8	AN363-428
183	Nylon self-locking nut	1	AN365-524A
184	Bolt	6	AN4-13A
185	Bolt	2	AN4-5A
185.1	Bolt	2	AN5-21A
186	Thin washer	2	AN960-416L
187	Thin aluminum washer	6	AN960D416L

188	Floating nutplate	2	MF5000-4
189	Aluminum spacer	6	NAS43DD4-39

TRICYCLE LANDING GEAR PARTS LIST

Note The following list contains parts that are unique to the standard, 5.00 X 5 tricycle landing gear installation.

Key No.:	Part Name:	Qty:	Part No.:
190	Steel sheet, .063" X 1" X 8"	1	075-02060-01
191	Spring washer	2	085-00103-01
192	Axle nut	1	351-0460-001
193	Laminated washer	1	361-5914-001
194	Nose gear leg	1	401-05001-01
195	Lower nose gear trunnion	1	401-05100-01
196	Upper nose gear trunnion	1	401-05200-01
197	Nose gear stop assembly	1	401-06000-01
198	Nose wheel axle spacer	2	401-07001-01
199	Nose wheel axle	1	401-07002-01
200	Nose gear fork	1	401-07100-01
201	Tire, 11.4 X 5	1	800-0655-001
202	Tube, 11.4 X 5	1	800-0670-001
203	Nose wheel assembly	1	900-0040-077
204	Castle nut	1	AN310-5
205	Nylon self-locking nut	2	AN364-524A
206	Nylon self-locking nut	2	AN364-720A
207	Cotter pin	1	AN380-2-2
208	Cotter pin	1	AN380-4-8
209	Bolt	1	AN5-17A
210	Bolt	1	AN5-20A
211	Drilled-shank bolt	1	AN5-53
212	Bolt, 7/16"–20	2	015-01001-01
213	Thin washer	4	AN960-516L
214	Washer	4	AN960-716

215	Thin washer	4	AN960-716L
216	Floating nutplate	2	MF5000-3

PARTS LIST FOR STANDARD TAILDRAGGER LANDING GEAR

Note The following list contains parts that are unique to the standard, 5.00 X 5 taildragger landing gear installation.

Key No.:	Part Name:	Qty:	Part No.:
217	Aluminum block, 1/4" X 1-1/2" X 1-1/2"	1	075-01251-01
218	Aluminum block, 1/2" X 1-1/2" X 2"	1	075-01500-01
219	Tailwheel assembly	1	091-01000-01
220	Tailwheel spacer	1	091-01175-01
221	Steering spring kit	1	091-01500-01
222	Lower tailwheel spring	1	401-09001-07
223	Middle tailwheel spring	1	401-09001-09
224	Upper tailwheel spring	1	401-09001-11
225	Forward tailwheel spring attach bracket	1	401-09002-01
226	Aft tailwheel spring attach bracket, left	1	401-09003-01
227	Aft tailwheel spring attach bracket, right	1	401-09003-02
228	NicoPress sleeve	2	450-0002-004
229	(Part deleted by Revision C)		
230	Steering cable	2	618-01020-01
231	Thimble	2	AN100C-4
232	Bolt	8	AN3-10A
233	Nylon self-locking nut	8	AN365-1032A
234	Nylon self-locking nut	5	AN365-428A
235	(Part deleted by Revision C)		
235.1	Nylon self-locking nut	1	AN365-624A
236	Nylon self-locking nut	1	AN365-820A
237	Cotter pin	2	AN380-2-2
238	Clevis pin	2	AN393-13
239	Bolt	4	AN4-10A
240	Bolt	1	AN4-20A

241	Bolt	1	AN5-15A
242	(Part deleted by Revision C)		
243	Bolt	1	AN8-23A
244	Washer	8	AN960-10
245	Washer	6	AN960-416
246	(Part deleted by Revision C)		
246.1	Washer	1	AN960-616
247	Washer	1	AN960-816
248	Large washer	4	AN970-4
249	Strap shackle	2	NAS1435K4

MANUAL TRIM SYSTEM PARTS LIST

Note The following list contains parts that are unique to the manual trim installation. The electric trim installation has a separate parts list contained in the option instructions.

Key No.:	Part Name:	Qty:	Part No.:
250	Snap bushing	1	021-02001-01
251	Trim gear box	1	045-01000-01
252	Cable clamp	2	045-02001-01
253	Aluminum sheet, .032" X 6" X 6"	1	075-01003-01
254	Rod end bearing	1	170-0110-003
255	Cable tie, 4"	10	210-0018-001
256	Nylon loop clamp, 3/8"	12	450-0006-375
257	Nutclip, 8-32	4	450-0210-081
258	Trim cable	1	618-02001-01
259	Drilled-shank bolt	1	AN3-10
260	Castle nut	1	AN310-3
261	Jam nut	1	AN315-3R
262	Cotter pin	1	AN380-2-2
263	Aluminum loop clamp, 5/8"	4	AN742D10
264	Round-head machine screw	4	AN526-8R8

265	Self-tapping screw	12	AN530-6R4
266	Washer	3	AN960-10
267	Aluminum washer	12	AN960D6
268	Large washer	1	AN970-3

PARTS LIST ERRATA

Note The following list contains parts that were inadvertently omitted from the preceding PARTS LISTS when Part 1 of this section was initially published.

Key No.:	Part Name:	Qty:	Part No.:
269	Brass union tee	1	032-00301-01
270	Inspection hole cover, 4.45"	4	201-33001-01
271	Inspection hole cover, 6.2" X 4.7"	2	201-34001-01
272	Insection hole cover, 5.75"	4	201-35001-01
273	Brass union	1	320-0268-302
274	Castle nut	2	AN310-7
275	Nylon self-locking nut	2	AN364-832A
276	Nylon self-locking nut	1	AN365-624A
277	Cotter pin	2	AN380-3-3
278	Round-head machine screw	2	AN526-8R8
279	Bolt	1	AN6-21A
280	Washer	1	AN960-616
281	Washer	2	AN960-8
282	Nutplate	84	K1000-08

TOOL LIST

1. Tape measure
2. 12" rule, graduated in 32nds of an inch
3. Pencil and fine-point marking pen
4. Scriber or awl
5. Small (3") try square
6. Try square or carpenter's square
7. Protractor
8. 18" steel rule or comparable straightedge
9. Center punch
10. Carpenter's level
11. Digital level (recommended) or short spirit level (acceptable)
12. Transit, digital level or protractor level to set wing dihedral
13. Plumb bob
14. Bandsaw or scroll saw
15. Saber saw with carbide grit blade (optional)
16. Single-bladed hacksaw
17. Belt sander (highly recommended)
18. Drill press (recommended)
19. Edge deburring tool
20. Hole deburring tool
21. Electric or pneumatic drill motor, with #40, #30, #10, 1/4", 9/32", 19/64", 5/16", 11/32", 23/64" and 3/8" bits
22. Drill stop, #30
23. 90° drill motor or adapter
24. Unibit and/or hole cutter, 1/2", 9/16", 5/8", 11/16", 7/8", 1", 1-3/8" (optional), 1-5/8" and 2-1/4"
25. Heavy-duty, variable speed electric drill motor
26. Cobalt drill bits, #30 or 1/8"; #10 or 3/16"; 1/4"; and 5/16" (highly recommended)
27. 7/8" paddle bit (spade bit) for drilling wood (recommended)
28. Narrow rat-tail file
29. Assorted flat and round files
30. Die grinder with rotary cutting wheels and files (recommended)
31. Small sanding drum for drill motor, die grinder or drill press (optional)

TOOL LIST (CONTINUED)

32. Clecos, 3/32" and 1/8", approximately 25 each
33. Cleco pliers
34. Rivet gun, air compressor, bucking bars
35. Universal-head and flush-head rivet sets
36. Blind rivet puller
37. Large C-clamps, 4
38. Cleco side-grip clamps, 5
39. Small C-clamp, 1
40. Bench vise
41. Small adjustable wrenches, 2
42. Socket wrenches and open-end wrenches (sizes 3/8" to 3/4")
43. Torque wrench (optional)
44. Needle-nose pliers
45. Vise-grip pliers, 2 pairs
46. Large Phillips screwdriver
47. Medium-size standard screwdriver
48. Small hammer
49. Rubber mallet
50. Heavy-duty scissors and/or rotary cloth cutter
51. Cable cutter or sharp cold chisel
52. 1/8" cable clamps (4 should be enough)
53. NicoPress swaging tool
54. Tubing cutter
55. Tubing bender, 3/8" (highly recommended)
56. Tubing beader (borrow, if possible)
57. Utility knife
58. Air chuck for inflating tires
59. Fisherman's pocket spring scale (recommended)
60. Safety goggles (highly recommended for use while sanding or grinding fiberglass)
61. Respirator or dust mask (highly recommended for use while sanding or grinding fiberglass)
62. Wing strut drill jig kit (available on a rental basis from Stoddard-Hamilton). The kit includes a fixture that fits over the end of the wing strut, an 11/32" drill bit, a 3/8" step reamer, drill bushings to guide the drill bit and reamer, and a length of 11/32" drill rod. (See Step 33 for details.

ADDITIONAL MATERIALS

1. Corrosion-protection materials
2. Acetone
3. Loctite bearing retaining compound
4. Mold release wax or equivalent
5. Modeling clay
6. Thread sealant (e.g., Permatex High Tack Adhesive Sealant, sold in automotive stores)
7. RTV silicone sealant
8. Hot glue and gun
9. Super glue
10. Bearing grease
11. Cutting oil
12. Anti-seize compound
13. Rubber cement or spray adhesive
14. Assorted scrap wood for form blocks and temporary jigs, including a piece approximately 3/4" X 5" X 12"
15. 2-1/8" length of 3/4" wooden dowel (or equivalent) (See Step 11.)
16. Anti-chafe tape (Order P/N 062-01001-01 direct from Stoddard-Hamilton.)
17. Vinyl tape
18. Wide masking tape or duct tape
19. Tall padded sawhorses or other supports for the wings
20. Nylon cable ties, various sizes (optional)
21. Polyethylene tubing, approximately 3/4"-diameter, 40' (optional)
22. Assorted old blankets or foam padding material
23. Sand or shot bags, 4–6
24. 8' length of 2" X 2" angle stock, aluminum (preferable) or steel (acceptable)
25. Two scrap pieces of .063" aluminum, approximately 1" X 1"
26. Sandpaper, coarse and medium grits
27. Rigid piece of scrap metal, approximately 1" X 2", for use as a straightedge
28. Resin mixing sticks
29. Latex surgical gloves
30. 2" varnish-type brushes

WORKSPACE

Since the wings will be mounted to the fuselage to set the wing dihedral and install the control cables, quite a large space will be required for these procedures. The wing span is 35', the fuselage length is 22' and, with the fuselage on the tricycle gear, the tail height is about 11'. Very few people will have home workshops large enough to accommodate the assembled GlaStar, so this work will have to be accomplished at a hangar or outside. Only items 7, 10 and 11 in the ASSEMBLY SEQUENCE listed on the next page truly require the wings to be mounted to the fuselage, however. If you have gathered all the necessary tools and materials and have studied the applicable *Assembly Manual* sections in preparation, items 7–11 will take just a few days' work, so most builders will choose to simply move the airframe outside temporarily rather than transporting it to a hangar. (Only items 10 and 11 require both wings to be mounted at the same time. If you have room inside your shop to mount one wing at a time for items 7–9, you may do so.)

Note When you have finished items 1–6 of the ASSEMBLY SEQUENCE, you will be ready to mount the wings to the fuselage, after which your first task will be to drill the outboard ends of the wing struts for attachment to the strut attach arms in the wing. To accomplish this task, you will need the **Wing Strut Drill Jig Kit** (P/N 981-03000-01), which is available on a rental basis from Stoddard-Hamilton. Especially if you are making steady progress, you should consider ordering the drill jig kit soon, so you will have it on hand when you need it.

ASSEMBLY SEQUENCE

At this stage of assembly, your GlaStar wings have the lower main skins and leading edge skins installed and the basic fuselage structure is completed. Now it's time to install the fuselage flight control systems. Then the wings can be mounted to the fuselage so that the flap and aileron control cables can be installed. The fuel tank vent lines, fuel tanks, pitot lines and (optional) navigation light wiring are also fitted to the wings at this time in preparation for final wing closure. Finally, the landing gear, the brake system and parts of the fuel system are installed in the fuselage.

The outline of the complete systems installation procedures is as follows:

1. Rudder Control Assemblies Installation
2. Control Stick Assembly Installation
3. Flap Handle Assembly Installation
4. Fuselage Control System Pulleys Installation
5. Rudder Control Cables Installation
6. Elevator Pushrod and Control Cables Installation
7. Mounting the Wings to the Fuselage
8. Mounting the Flaps to the Wings
9. Mounting the Ailerons to the Wings
10. Flap Control Cables Installation
11. Aileron Control Cables Installation
12. Control Cable Retainers Fabrication and Installation
13. Preliminary Fuel Tank Installation
14. Wing Plumbing, Wiring and Other Miscellaneous Stuff
15. Main Gear Leg Installation
16. Main Gear Wheel and Brake Installation
17. Nose Gear Installation (Optional)
18. Tailwheel Installation (Optional)
19. Brake System Plumbing
20. Fuselage Fuel System Plumbing
21. Manual Trim System Installation (Optional)
22. Miscellaneous Fuselage Plumbing and Wiring

RUDDER CONTROL ASSEMBLIES INSTALLATION

The outboard ends of the **left** and **right rudder pedal control weldments** [47 and 48] pivot in tabs welded to the fuselage cage; the inboard ends pivot in support brackets (fabricated from tee stock and sheet aluminum) that are fastened to the inside of the fuselage shell, as shown in Figure 1. The two rudder control weldments are installed basically parallel to each other, with the left weldment just forward of the right. The base of each rudder control support bracket is bedded in a "liquid shim" of thick Q-cell mixture to level the mounting surface in the fuselage so that the bracket will be perpendicular to the pivot axis of the weldment.

Dual Brake Option The standard GlaStar kit includes brake pedals and wheel brakes for the pilot's side only. A **Dual Brake Option Kit**, which supplies all the necessary parts, material and hardware for brakes on the copilot's side, is available; order P/N 991-01000-01. The instructions in this section describe only the standard, pilot-side brake installation.

Note If you did not corrosion-proof the steel control system components when you corrosion-proofed the fuselage cage, do so now. Refer to Step 7 in "SECTION VIII: FUSELAGE ASSEMBLY" for a list of parts that need corrosion protection and a description of corrosion-protection procedures. "INTERIOR CORROSION PROTECTION" in "SECTION II: TOOLS AND TECHNIQUES" provides further details.

Note Use light grease to lubricate all moving parts throughout the entire GlaStar control system (except for the control system pulleys and bellcrank bearings, which are already lubricated). Lubrication is needed not only to prevent wear between components but also to minimize friction, which can reduce aerodynamic stability (besides making the airplane less pleasant to fly). Use grease wherever rotation occurs between parts: bushings, shackles and cable terminal ends that rotate on bolts or clevis pins, for example. If you have extras of the nylon washers left over from "SECTION VIII: FUSELAGE ASSEMBLY," you can install them strategically between moving parts to reduce friction further.

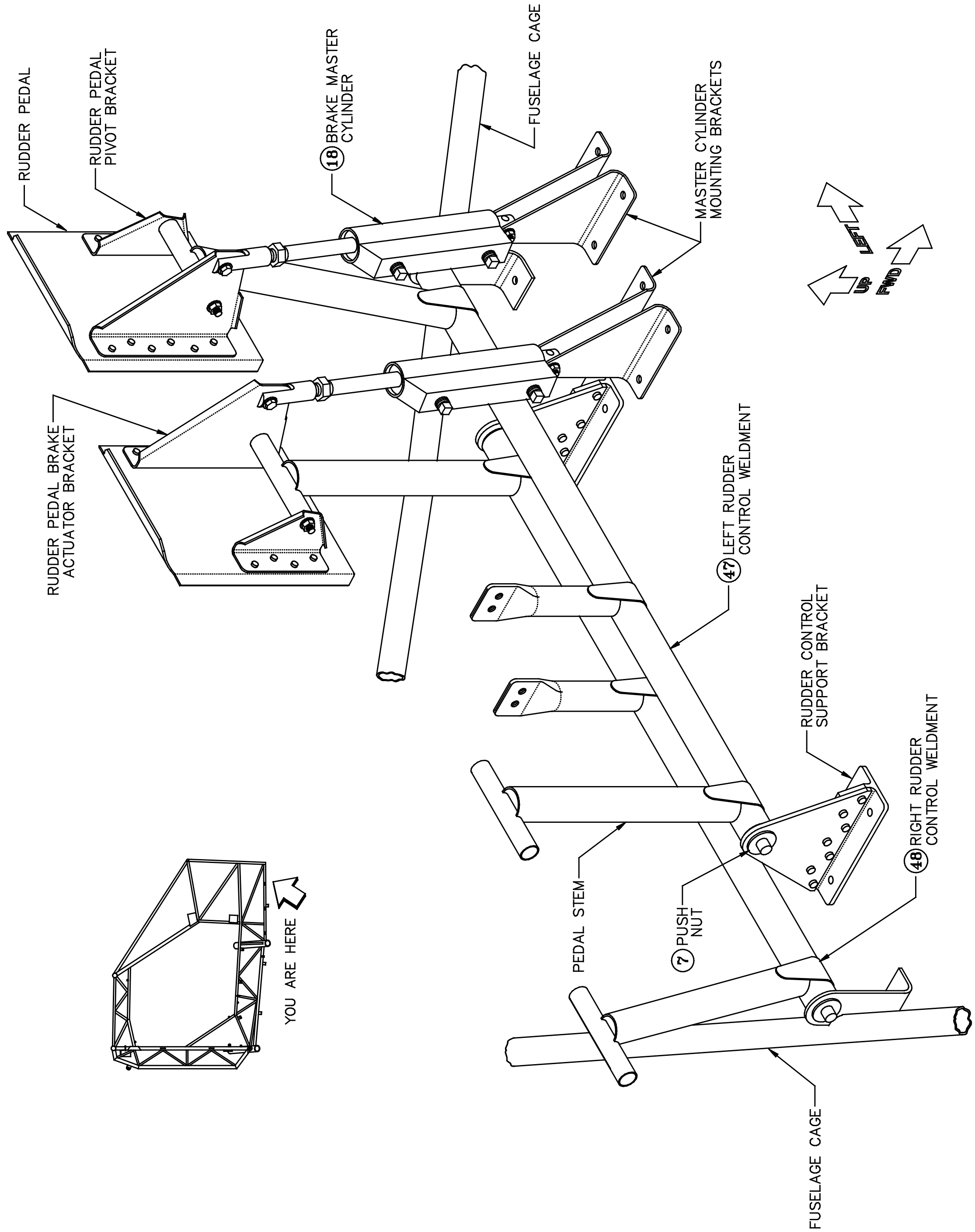


Figure 1: Rudder Control System

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Step 0.1: Reinforce the Rudder Control Mounting Area of the Fuselage Shell

The **inside** of the fuselage shell must be reinforced with DBM cloth to stiffen the mounting locations of the rudder control and brake master cylinder mounting brackets. Begin by prep sanding and cleaning the area of the fuselage floor between the two rudder control support tabs on the cage (see Figure 1).

Cut two pieces of DBM cloth **32"** long. Position the first strip of cloth centered laterally on the fuselage and centered longitudinally on the **right-hand** rudder control support tab on the cage. (The right-hand tab is 1" aft of the left-hand tab.) Cut notches in the cloth to clear both rudder control support tabs, and laminate the strip in place. Laminate the second strip of cloth **immediately forward** of the first strip; the two strips should **not** overlap one another.

Let the laminates cure.

Completed: [ ]

Step 1: Fabricate the Rudder Control Support Brackets

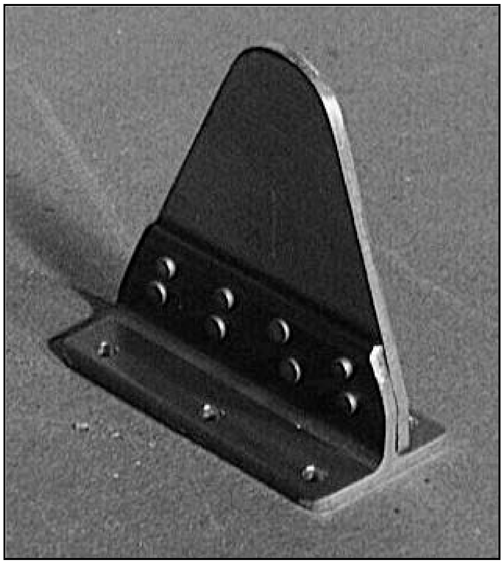

Figure 2: Rudder Control Support

Fabricate the two rudder control support brackets from the **.125" X 1-1/8" X 1-5/8" aluminum tee stock** [20] and **.125" X 4" X 8" aluminum sheet** [13], as shown in Figure 3. The brackets support the left end of the right rudder control and the right end of the left rudder control.

Use a bandsaw or a hacksaw to rough-cut the parts from the supplied material. Clamp the aluminum sheet for each bracket to the extruded tee stock, and use a belt sander or files to trim the edges of the bracket assemblies to the final contours.

Lay out and center punch the rivet pattern shown in Figure 3 onto one side of each bracket assembly, being careful to maintain the standard minimum edge distance (1/4" or twice the rivet diameter) from the centers of the rivet holes to the edges of the parts. Use the pattern to drill **#30** rivet holes through each assembly, inserting Clecos to maintain alignment. Also, lay out and center punch the locations of the mounting bolt holes on the bottom flanges of the extruded tee pieces, as shown. (Figure 2 shows three mounting holes on each flange of the tee; the middle hole is not needed. The figure also shows eight rivets securing the sheet to the tee; only seven are required.) Drill the mounting bolt holes with a **#10** bit.

Disassemble, deburr and corrosion-proof the parts. Rivet each bracket assembly together with 1/8" AN470AD4 universal-head rivets; place the rivet heads on the aluminum sheet side of the assembly as this will provide more room for installing the mounting hardware later.

Note Do not drill the rudder control pivot holes in the brackets at this time. The holes will be located and drilled in the next step.

Completed: [ ]

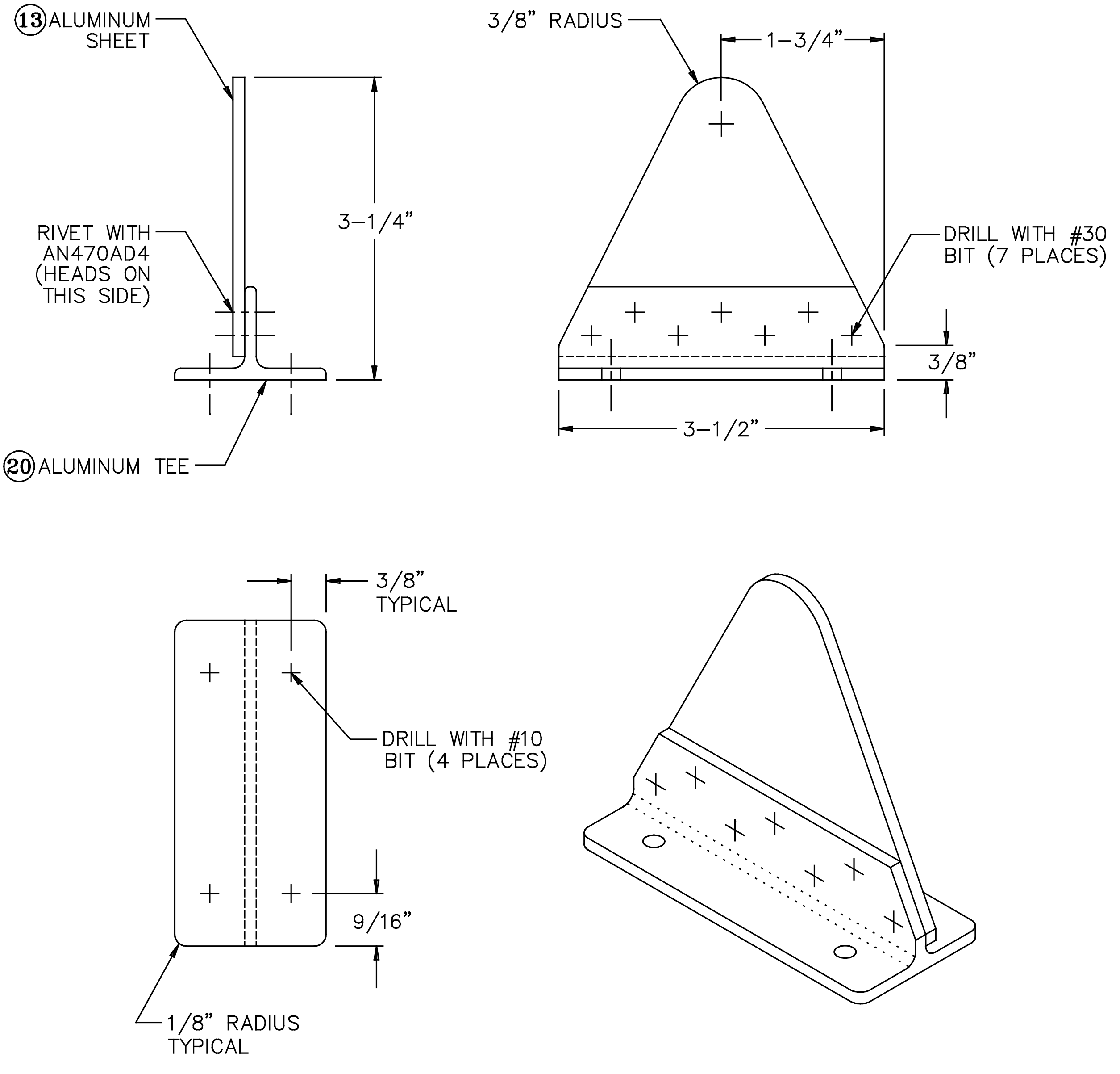

Figure 3: Rudder Control Support Bracket Assemblies

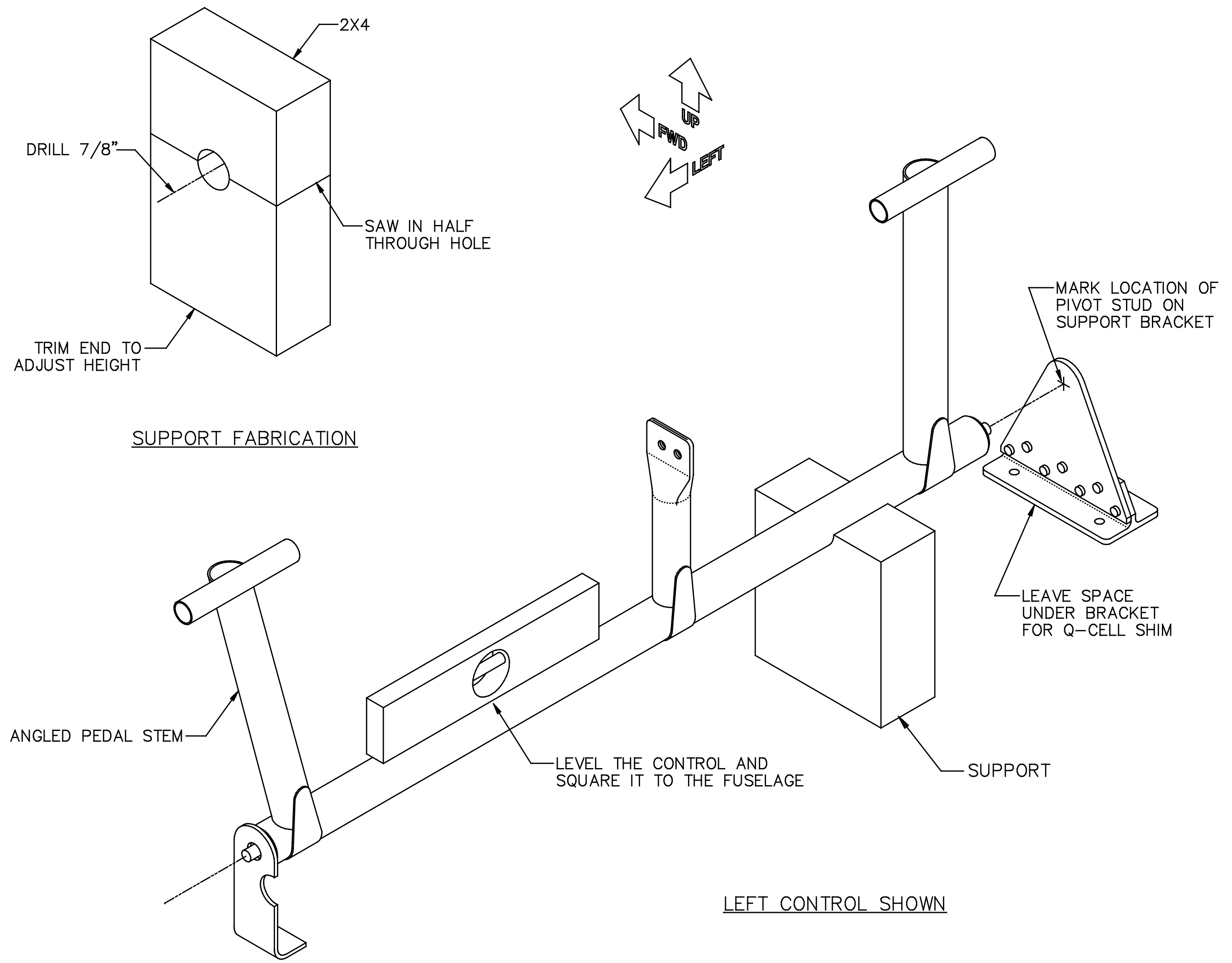

Figure 4: Rudder Control Installation

Step 2: Mount the Rudder Controls

Hint It will be easiest to install the rudder controls by working from the open, forward end of the fuselage. Hanging the fuselage from the support structure used in "SECTION VIII: FUSELAGE ASSEMBLY" with the tail supported on a padded sawhorse will position it at a convenient height for installing all the fuselage controls and cables.

Use a large C-clamp to press the NAS77-4-009 **flanged steel bushings** [172] into the holes in the rudder control support tabs of the fuselage cage. Position the bushing flanges on the **inboard** sides of the tabs. Secure the bushings by applying Loctite bearing retaining compound before pressing them in.

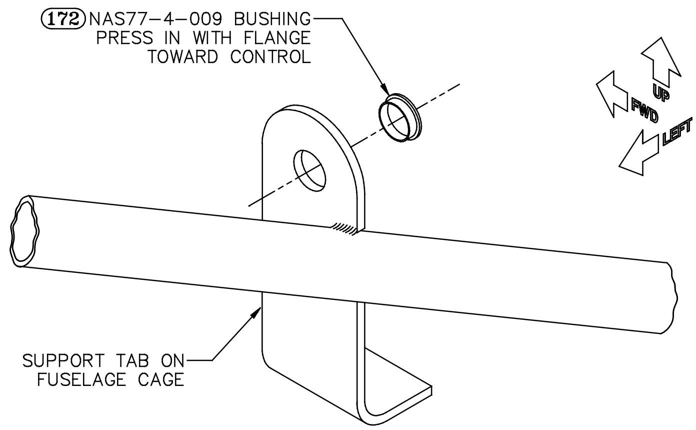

Figure 5: Bushings in Fuselage Cage Tabs

Level the fuselage laterally, using a carpenter's level on the main cross tube between the tricycle landing gear sockets.

Insert the **right-hand** pivot of the **right** rudder control weldment into the flanged bushing in the support tab on the **right** side of the fuselage cage, as shown for the left control in Figure 4. (The right control is installed first so the left control won't be in the way for installing the right.)

Note To distinguish between the left and right rudder control weldments, notice that the **angled** pedal stem is located at the **outboard** end of the weldment and the small, rudder pedal pivot tube at the top of each pedal stem is positioned toward the **aft** side of the stem (the side closest to the tail of the airplane).

Level the rudder control laterally and square it to the longitudinal centerline of the fuselage; support the rudder control in this position.

Note Because of the extra width of the finger straps around the control weldments where the pedal and actuation stems are welded to the main tube, the tubes of the left and right weldments cannot be set **precisely** parallel to one another or perpendicular to the fuselage centerline without interference. It is necessary and perfectly acceptable to angle the left weldment slightly forward and the right weldment slightly aft to achieve clearance. This slight angle will be undetectable once the rudder pedals are installed.

Hint One way to make a support for the rudder control is to drill a **7/8"-** diameter hole through a short piece of scrap 2 X 4 and then saw the 2 X 4 in half through the hole. This makes a support block with a 7/8" semicircular notch in one end for the rudder control tube to rest in. (Or, more simply, you could just saw a V-shaped notch in the end of a block.) Trim the other end of the support at the proper length to hold the rudder control in the level position; you can make fine length adjustments by belt-sanding the end of the support or by shimming it. Once the proper size and position of the support block have been determined, use hot glue to secure it temporarily in place on the inside of the fuselage shell. (To remove hot glue, use a heat gun to soften it; clean up any remaining residue with acetone.)

With the rudder control resting in its temporary support, hold one of the support brackets fabricated in Step 1 against the left-hand pivot of the control. Hold the bracket perpendicular to the pivot axis of the control and just high enough above the inside of the fuselage shell to provide space under the bracket for a Q-cell liquid shim.

Note Provide just enough Q-cell shim space to achieve a flat mounting surface for the support bracket (no more than 1/16" is necessary). An excessively thick shim will just add unnecessary weight.

With the support bracket held in its proper position, mark the location of the rudder control end pivot onto the bracket. Remove the bracket and center punch the location of the pivot hole in the bracket. Drill the pivot hole through the bracket with a **23/64"** drill bit and then ream to **3/8"** diameter (.375" maximum, .374" minimum).

Use a bench vise or a large C-clamp to press an NAS77-4-012 **flanged steel bushing** [173] into the support bracket assembly. Secure the bushing by applying Loctite bearing retaining compound to its circumference before pressing it in.

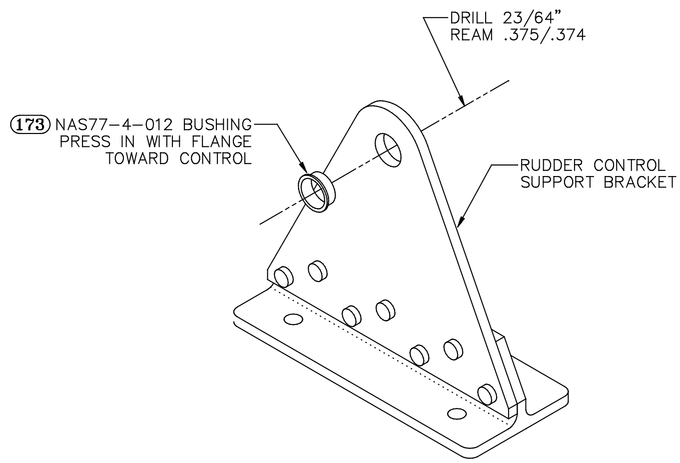

Figure 6: Bushings in Rudder Control Supports

Note The bushing flange is located on the **inboard** side of the support bracket, next to the rudder control tube.

Slip the support bracket over the inboard end pivot of the rudder control, with the bushing flange next to the rudder control. Hold the support bracket perpendicular to the pivot axis of the rudder control and mark around the base of the bracket onto the inside of the fuselage shell. Remove the support bracket and thoroughly wax its base with mold release wax so it won't stick to the liquid shim.

Mix a small batch of **thick** Q-cell and apply it to the area marked on the inside of the fuselage shell for the base of the support bracket.

Hint Use a **very thick** Q-cell mixture for the liquid shim. Not only will a thick mixture add the least additional weight but, since it won't tend to ooze out before it cures, it will be much easier to work with.

Raise the rudder control up slightly out of its temporary support, slip the support bracket over the inboard end pivot and, while holding the bracket perpendicular to the control, lower the control back into its support, pressing the base of the bracket into the Q-cell shim. Clean up excess Q-cell mixture, and let cure.

When the Q-cell shim has cured completely, use the #10 holes in the base of the support bracket as guides to drill **#10** holes through the fuselage shell. Countersink the holes on the outside of the fuselage and use AN509 flush-head machine screws and AN364-1032A **nylon self-locking nuts** [108] to secure the bracket to the shell. Adjust the fit of the nuts with AN960D10 and/or AN960D10L **aluminum washers** [149 or 150].

Caution Be careful not to over-countersink the screw holes. For maximum strength, the screw heads must bear against the outside laminates of the fuselage shell. If the holes are countersunk too deep, the screw heads will bear against just the foam core, rather than the shell laminates.

Note The AN509 screws used to install the rudder control support brackets are the same screws used to install the shell attach fittings in "SECTION VIII: FUSELAGE ASSEMBLY." The lengths of the screws needed for each bracket depend on the thickness of the Q-cell shim; use standard practices to choose screws of the correct grip length—just the unthreaded shanks of the screws, and not their threads, should contact the insides of the mounting holes. There should be an adequate supply of assorted screws left over from fuselage fabrication to satisfy all your needs.

Repeat the procedures in this step for the **left** rudder control weldment.

Note Trim the sides of each support bracket to provide a minimum of **1/16"** clearance for the other rudder pedal control; then deburr and corrosion-proof areas of the support brackets where trimming was required.

Install both rudder pedal controls into the fuselage. At final assembly, secure the pivot pins at each end of the rudder controls with **push nuts** [7], as shown in Figure 1.

Completed [ ]

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Step 3: Fabricate the Rudder Pedals

The rudder pedals are first cut from aluminum sheet. The corners of the pedal blanks are then trimmed, as shown in Figure 7, and the resulting side and top flanges are bent to complete the pedals.

Dual Brake Option The standard GlaStar airframe kit includes material to make the rudder pedals for the pilot's side only (two pedals). The GlaStar Dual Brake Option Kit supplies extra material to fabricate two additional pedals for the co-pilot's side. If you are installing dual brakes, fabricate the extra pedals at the same time as the pilot's pedals.

Hint If you are not going to install dual brakes, we recommend fabricating extensions for the right-side rudder control weldment pivot tubes to provide a wider surface for the co-pilot's feet. These extensions could consist of short lengths of steel tubing bolted to the ends of the pivot tubes with a long through-bolt and with large-diameter washers on the ends to keep the co-pilot's feet from slipping off. We'll let you devise your own pedal extensions if you want them; material for these is not supplied.

Cut the two 6" X 5-1/4" rudder pedal blanks from the supplied **.063" X 6" X 12" aluminum sheet** [12], as shown in Figure 7.

Note Part of this aluminum sheet was already used in "SECTION VIII: FUSELAGE ASSEMBLY" to make the forward shell attach fittings.

Lay out the trim lines, as shown in Figure 7, at the corners of the rudder pedal blanks. To trim the corners, start by drilling two **5/16"-**diameter holes in the **upper two** corners centered **9/16"** in from the edges. Then cut along the tangents of these holes straight out to the two closest edges. Finally, trim the **45° X 1/4"** angles on the six corners, as shown.

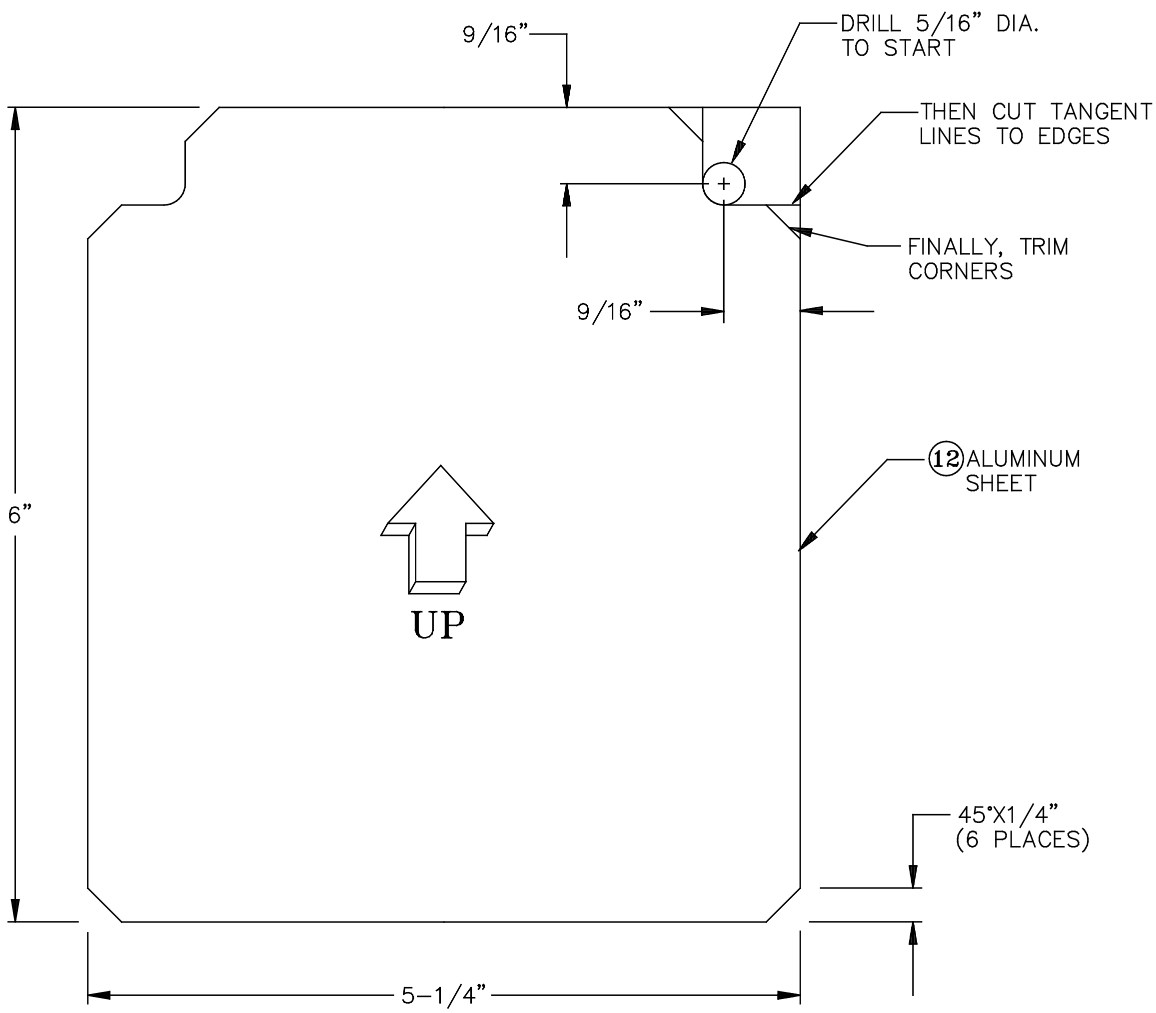

Figure 7: Trimming the Rudder Pedal Blanks

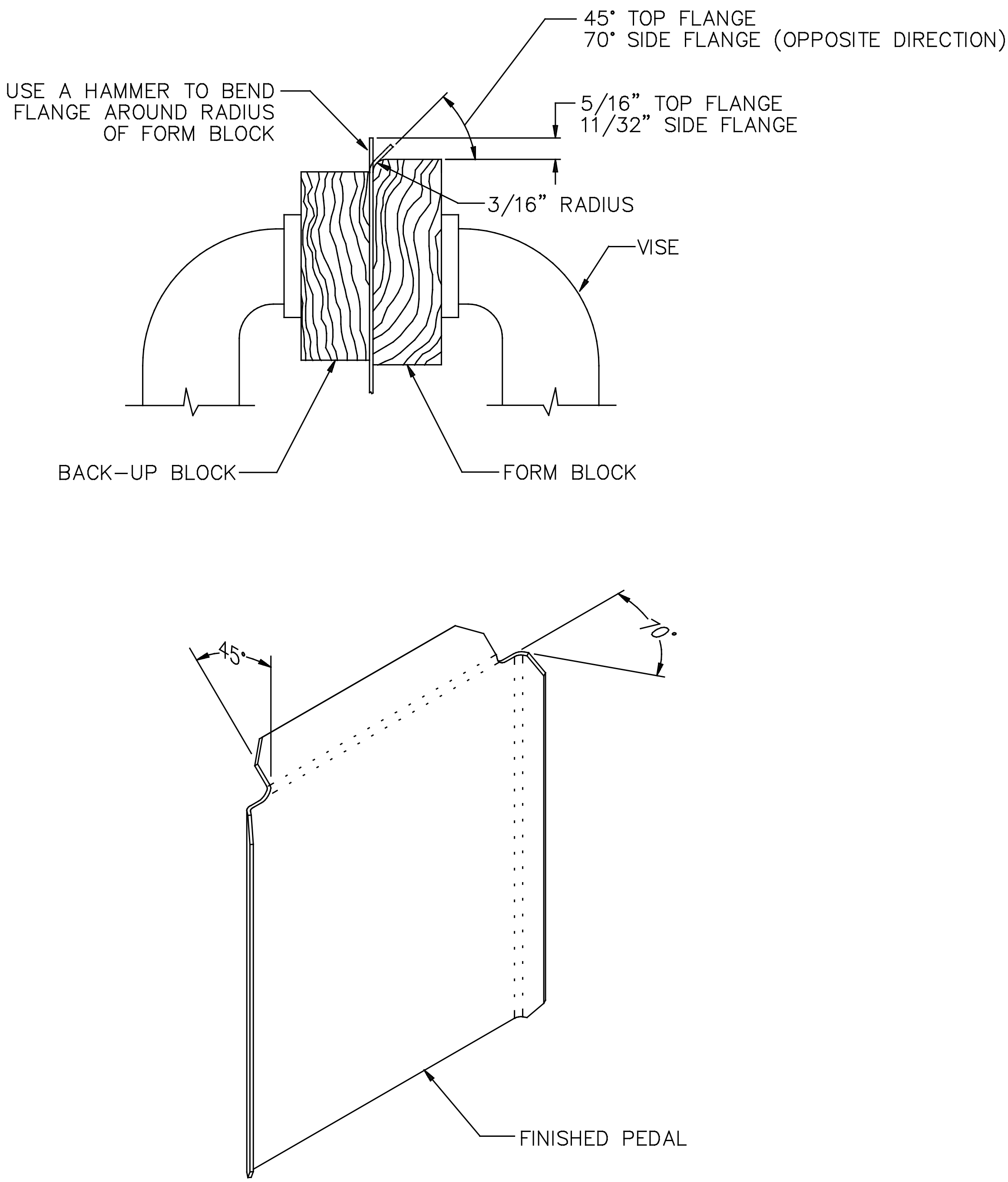

Figure 8: Bending the Rudder Pedal Flanges

The easiest way to bend the flanges on the rudder pedal blanks is to take them to a sheet-metal shop and have them use their bending brake. Otherwise, use scrap wood to make a form block with a **3/16"** radius along one edge, as shown in Figure 8. Also, make a wooden back-up block, as shown.

First, form the bend at the top by placing the rudder pedal blank between the form block and the back-up block, as shown in Figure 8, with **5/16"** of the pedal blank protruding above the top of the form block. Place the assembly in a vise (or use large C-clamps to secure it to the edge of a sturdy work bench if your vise isn't big enough) and use a 2 X 4 struck with a hammer to bend the top edge of the pedal around the radius of the form block. Bend the flange to a **45°** angle.

Note The angles of the flanges are not critical. At the top, you need just enough flange to stiffen the pedal; at the sides you need just enough to keep your feet from slipping off. The pedals will look better, however, if you match the angles closely from one pedal to the next.

Next, use similar procedures to bend the side flanges to **70°** angles in the **opposite direction** from the top flange. When clamping the pedal to form the side flanges, let **11/32"** of the sheet protrude beyond the form block before bending.

Repeat these procedures for both pedals.

Completed: [ ]

Step 4: Fabricate the Rudder Pedal Brackets

Fabricate the **rudder pedal pivot brackets** from the **.050" X 3/4" X 1.55" formed steel rudder pedal pivot angle** [45], as shown in Figure 9. Fabricate the **rudder pedal brake actuator brackets** from the **.050" X 3/4" X 3" formed steel rudder pedal brake actuator angle** [46], as shown in Figure 10. Fabricate two of each type of bracket: one **left-flange** bracket and one mirror-image, **right-flange** bracket.

To make the brackets, first cut the brackets to length from the formed angle stock. Then, lay out the trim lines on the wider flanges of the angles; use a hacksaw to cut outside the lines and finish the cuts with a belt sander or a file. Next, use a form block with a **5/32"** radius to bend the flanges of the brackets; bend all the flanges **45°** toward the existing 90° flange of the angle, as shown. (The 45° angle isn't critical; even bending the flanges to just 30° would stiffen them adequately.)

Drill **19/64"**-diameter **pivot holes** in all the brackets and **19/64"**-diameter **brake master cylinder attach holes** in the brake actuator brackets. Then, ream these holes to **5/16"** diameter (.313" maximum, .312" minimum). Finally, lay out and drill the **#40** pilot holes through the mounting flanges of the brackets, as shown in Figures 9 and 10.

Note To drill and ream the 5/16"-diameter **pivot holes**, pair each pivot bracket with an opposite-flange brake actuator bracket. Place each pivot bracket and its paired actuator bracket back-to-back with their mounting flanges resting on a flat surface. Clamp the two brackets together, and drill and ream the pivot holes through both brackets at the same time to ensure that the pivot axis of the pedal assembly is parallel to the pedal. Once the pivot holes have been reamed in each pair, mark the brackets and keep that pair together as a set.

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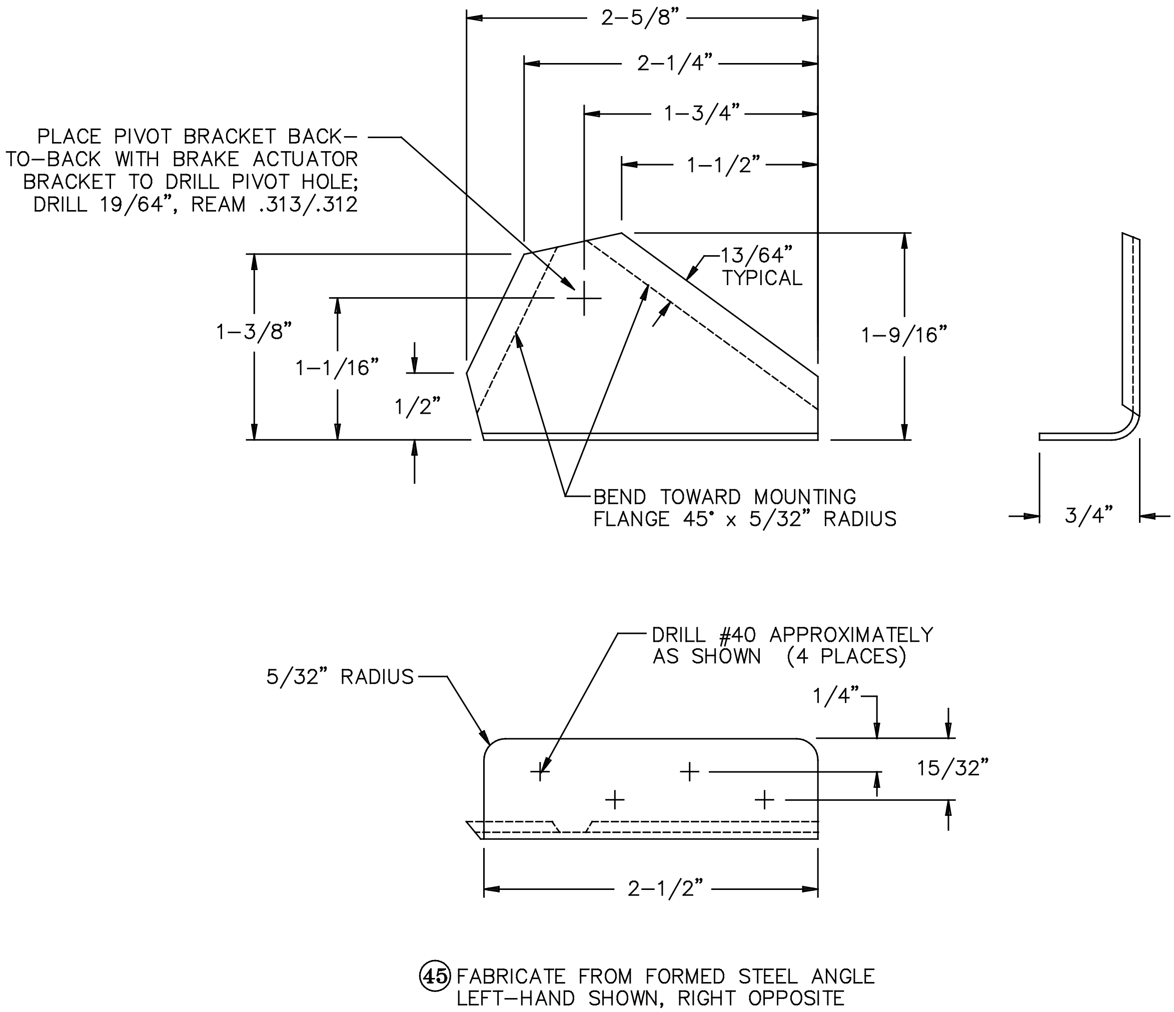

Figure 9: Rudder Pedal Pivot Bracket

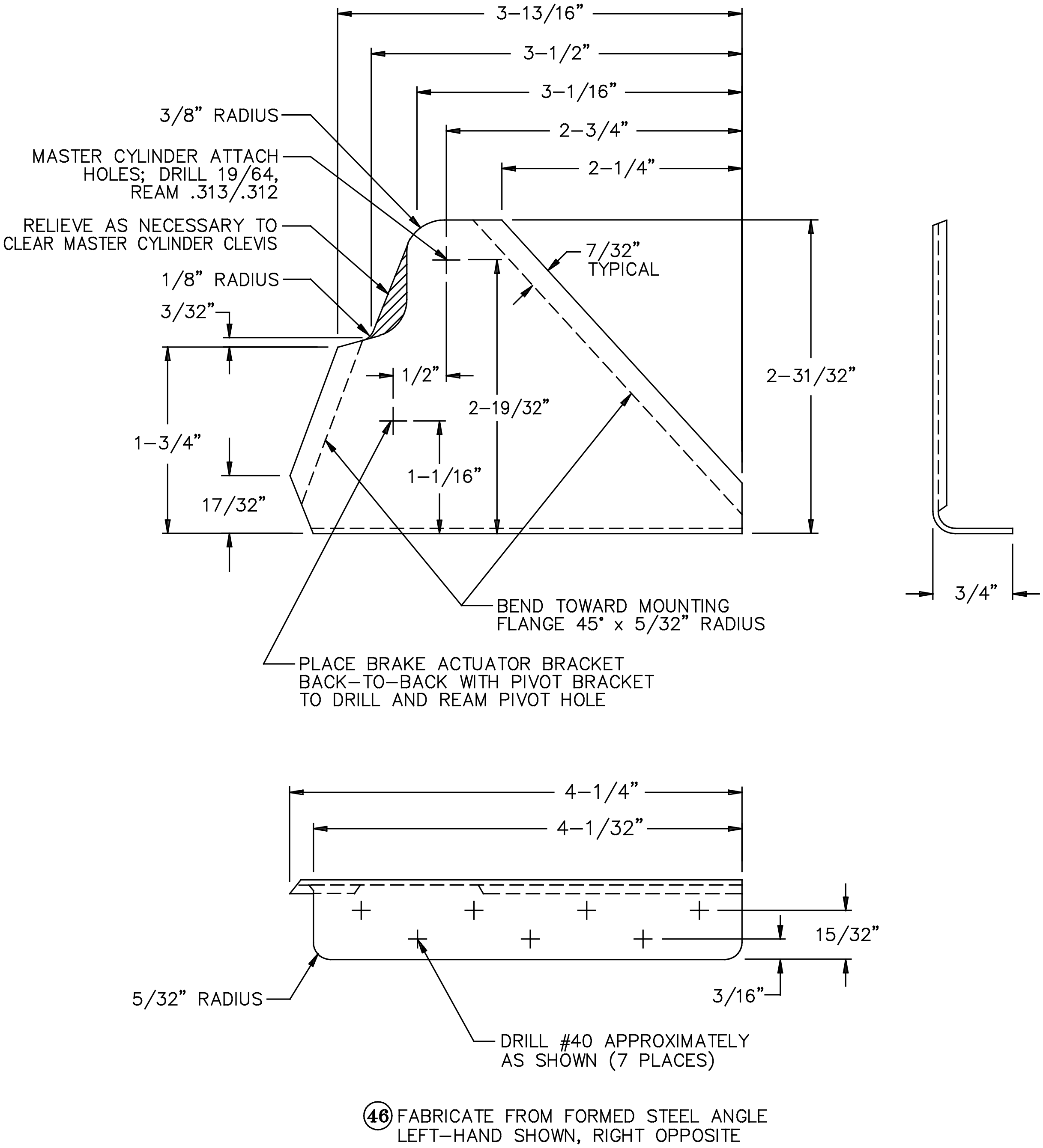

Figure 10: Rudder Pedal Brake Actuator Bracket

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Step 5: Assemble the Rudder Pedals

Position each brake actuator bracket/pivot bracket pair on the forward side of a rudder pedal (the side closest to the airplane's nose), as shown in Figure 11, with the pivot holes in the two brackets **1-5/8"** above the lower edge of the pedal. Position the two brackets **3-5/32"** apart, equidistant from the vertical centerline of the pedal, as shown. Make sure the two brackets are parallel to each other and square to the pedal. Clamp the brackets to the pedal.

> **Note** The pedal assembly shown in Figure 11 is the **right** pedal. The left rudder pedal is a mirror-image of the right. Assembled in this manner, the brake actuator brackets of the left and right rudder pedals are positioned next to each other when the pedals are mounted to the rudder control, as shown in Figure 1.

Use the #40 pilot holes in the bracket flanges as guides to drill **#30** rivet holes through the bracket/pedal assembly.

Disassemble the rudder pedals, deburr the rivet holes and apply corrosion protection to the parts.

> **Note** Because you'll be riveting two dissimilar metals together (steel to aluminum), it's especially important to apply adequate corrosion-protection to the contact surfaces of the parts.

Rivet the rudder pedal brackets to the rudder pedals with 1/8" AN470AD4 universal-head rivets. Place the rivet heads on the pedal sides of the assemblies.

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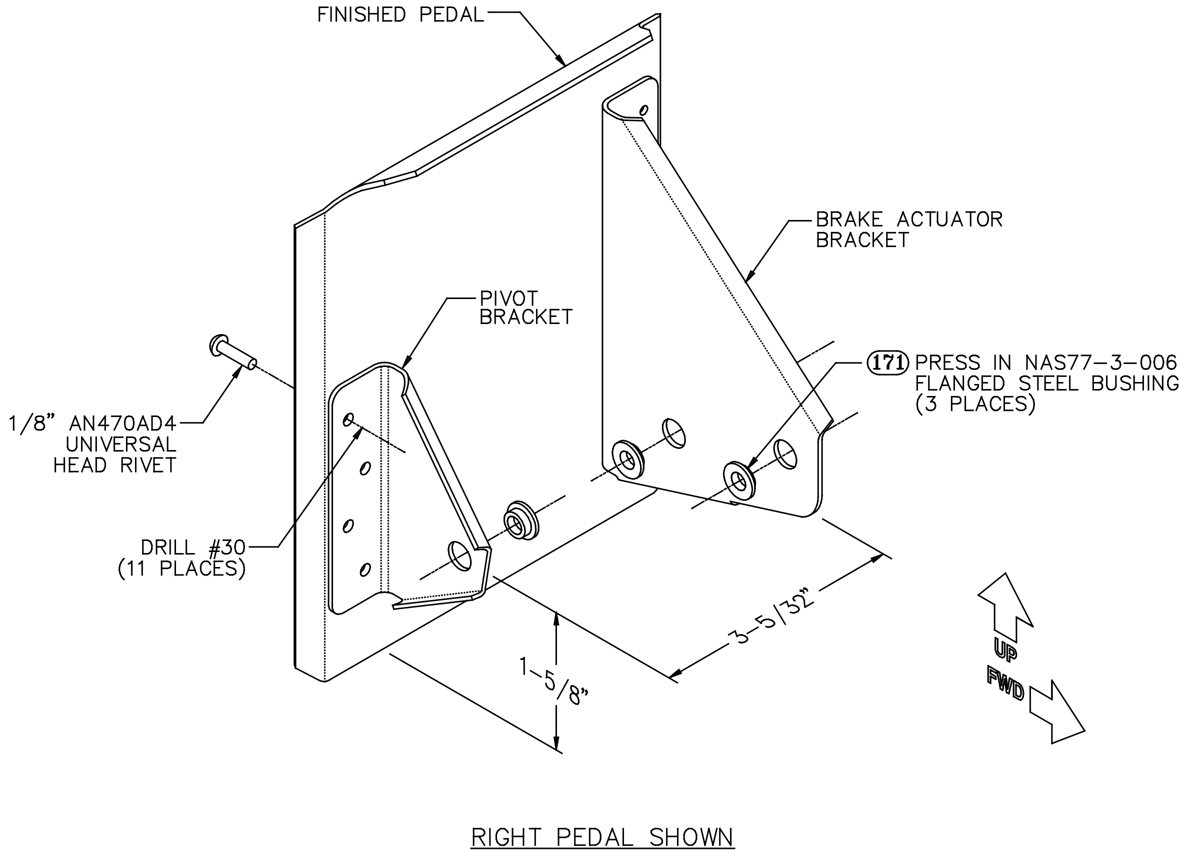

Figure 11: Rudder Pedal Assembly

Step 6: Mount the Rudder Pedals on the Rudder Control Weldments

As shown in Figure 11, press an NAS77-3-006 **flanged-steel bushing** [171] into each of the brake pedal bracket pivot holes with the bushing flanges toward each other. Also, press NAS77-3-006 bushings into the master cylinder mounting holes of the brake actuator brackets. Secure the bushings by applying Loctite bearing mount adhesive before pressing them in, or stake the bushings if they are loose in their holes.

Note The illustrations in this section show the pilot's rudder pedals mounted on the **left** side of the airplane. If you wish to set up the airplane for flight from the right seat (in order to have a left-hand throttle, for example), you may install the pilot's rudder pedals on the **right** side. (If you are installing the Dual Brake Option, of course, the pilot can fly from either seat.) The only other changes needed to fly primarily from the right seat would be in the placement of the instruments on the panel.

Use an AN3-35 **drilled-shank bolt** [93], two AN960-10L **thin washers** [141], an AN310-3 **castle nut** [100] and an AN380-2-2 **cotter pin** [113], as shown in Figure 12, to mount each rudder pedal to its rudder control. Position the brake actuator brackets of the left and right pedals next to each other, as shown in Figure 1.

Hint Cotter pins are specified in many places throughout the control system to secure various fasteners. While the cotter pins certainly should all be properly installed at final assembly before flying your GlaStar, you will save time and trouble at this stage if you leave them out. You will be installing and removing bolts and castle nuts numerous times as you proceed, so for now just thread the nuts on finger-tight without the cotter pins to make removal and reinstallation as easy as possible. One exception is for clevis pins that aren't held in by gravity; use cotter pins with these to keep them from falling out during the initial control system assembly procedures. Bend the ends of these cotter pins just enough to hold them in place; if not bent too far, they can be removed and replaced easily and reused multiple times.

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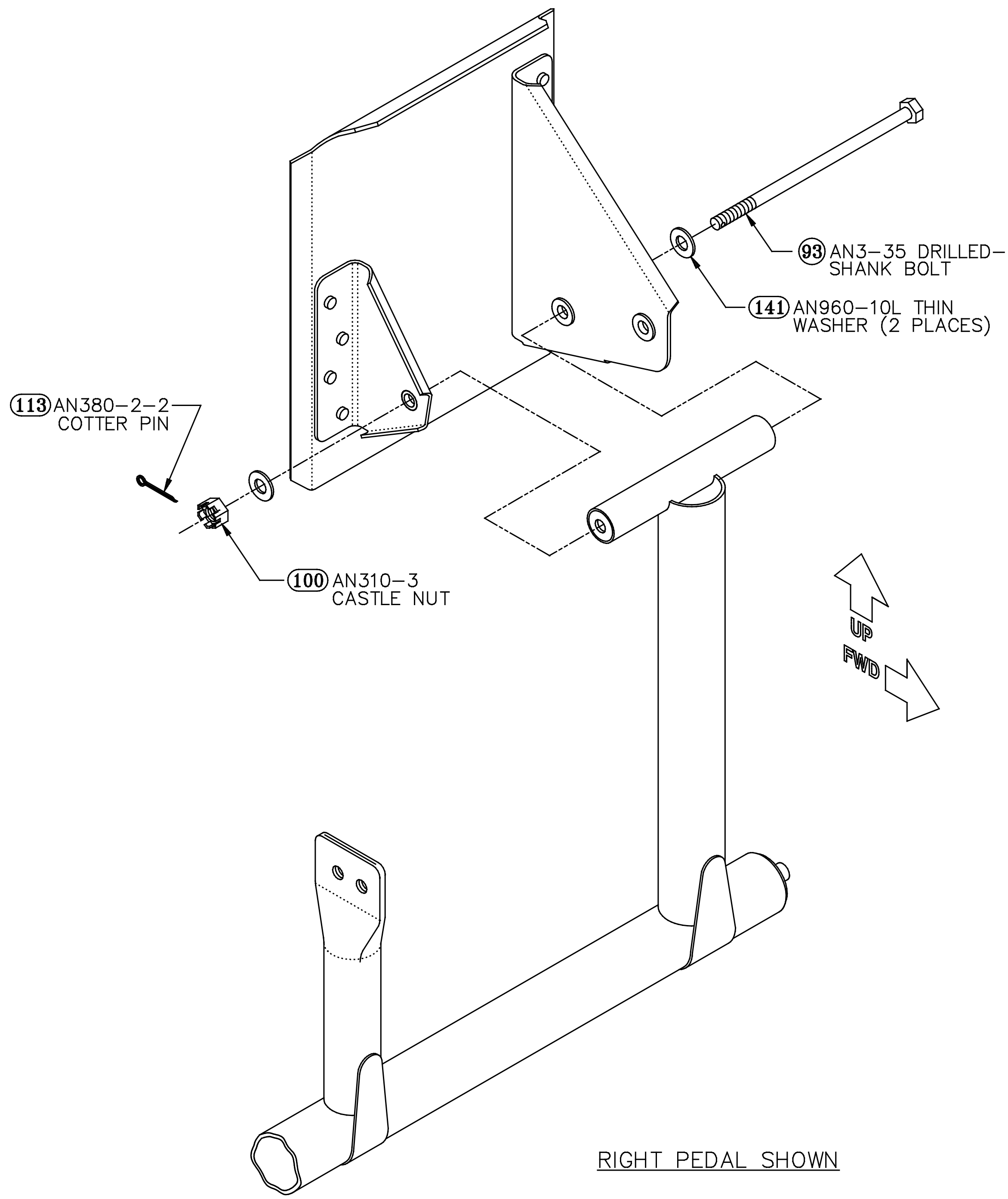

Figure 12: Mounting the Rudder Pedals

Step 7: Fabricate the Brake Master Cylinder Mounting Brackets

Use the supplied **.063" X 1" X 2-3/4" formed aluminum angle** [54] to fabricate four **master cylinder mounting brackets**, as shown in Figure 13. Be sure to make two left-hand brackets and two mirror-image, right-hand brackets. Use a bandsaw or a hacksaw to cut out the brackets, and finish the cuts with a belt sander or a file. Lay out, center punch and drill the two **#10** mounting bolt holes in the narrow flange of each bracket.

Dual Brake Option If you are installing the Dual Brake Option, use the additional material supplied with the option kit to fabricate two extra pairs of master cylinder mounting brackets. Use the same procedures described in this and the following step to mount the two additional master cylinders on the co-pilot's side.

Divide the four brackets into two pairs consisting of one left-hand and one right-hand bracket. The mounting holes for the master cylinders will be drilled in the next step, after which additional trimming of the brackets may be necessary. The brackets will be deburred and corrosion-proofed after any necessary final trimming.

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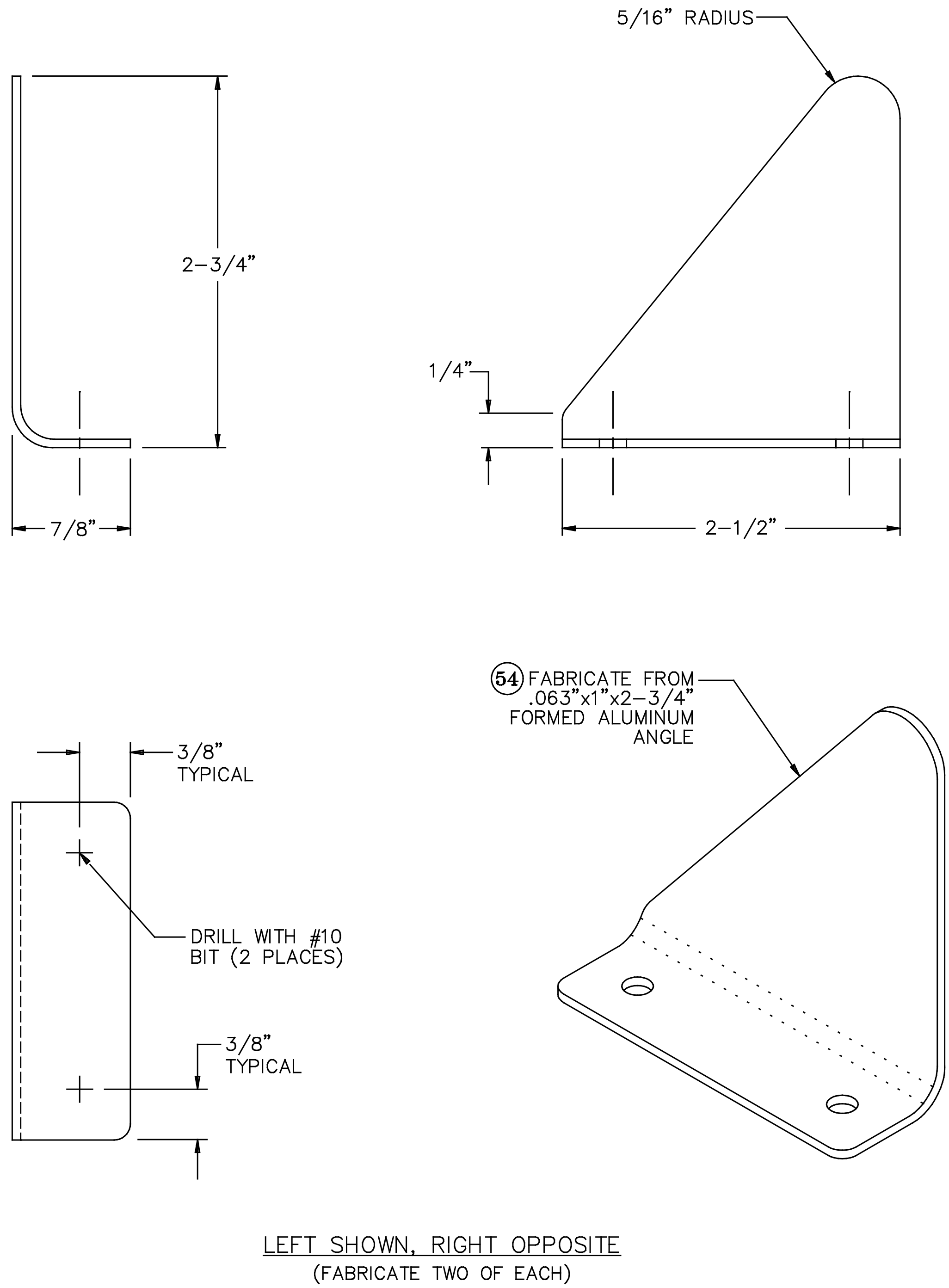


Figure 13: Master Cylinder Mounting Brackets

Step 8: Install the Brake Master Cylinders

In the neutral position, the rudder pedal pivot tubes (the small, horizontal tubes to which the rudder pedals are attached) for the left and right rudder controls are aligned, which means that the right rudder control stem (the upright tube to which the rudder pedal pivot tube is welded) must angle forward slightly and the left rudder pedal stem must angle aft slightly, as shown in Figure 14. The rudder pedals themselves, in the neutral position, are perpendicular to the waterline. Use tape, wire, clamps or any means necessary to securely support the rudder controls and the rudder pedals in the neutral positions.

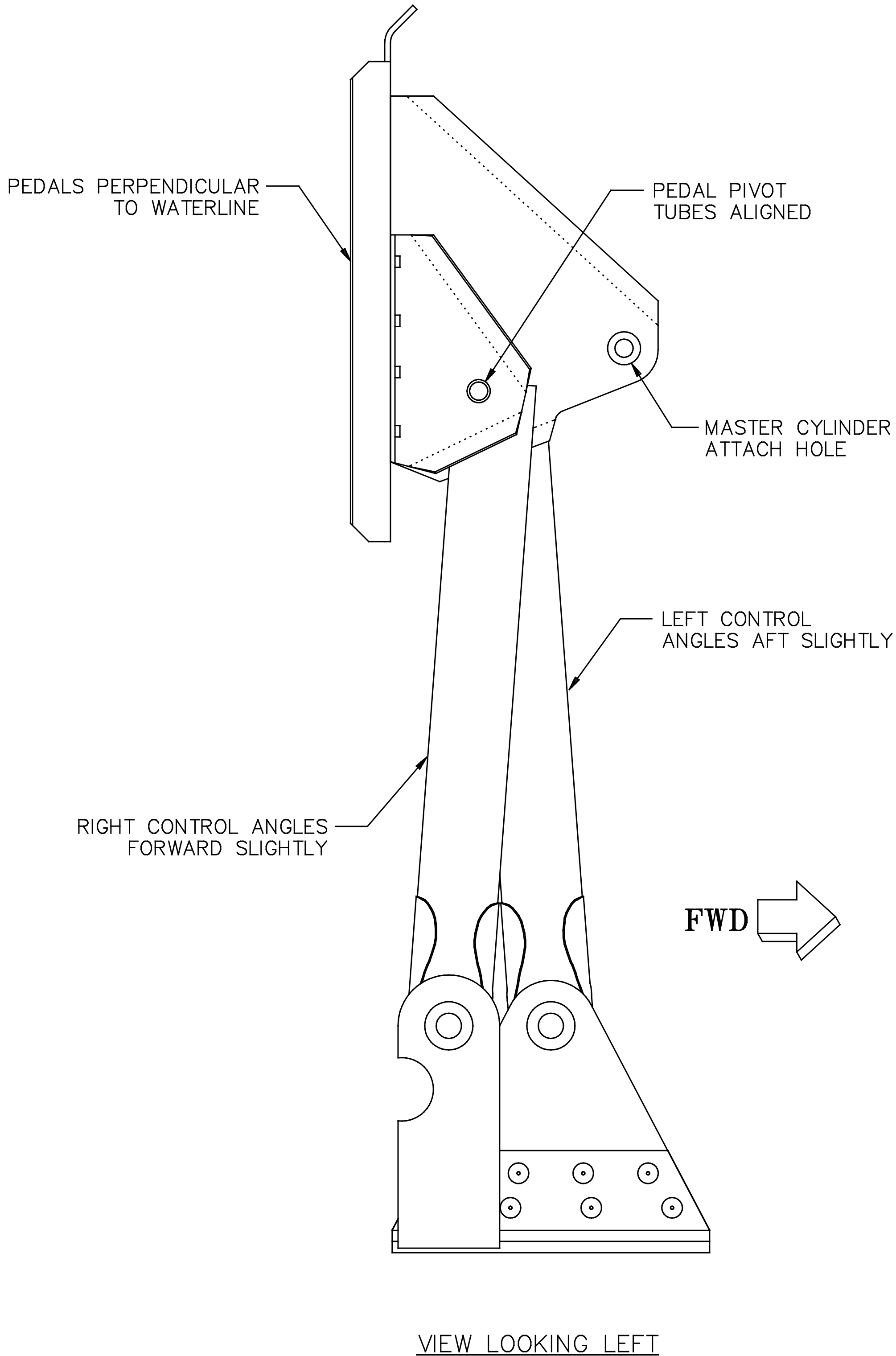
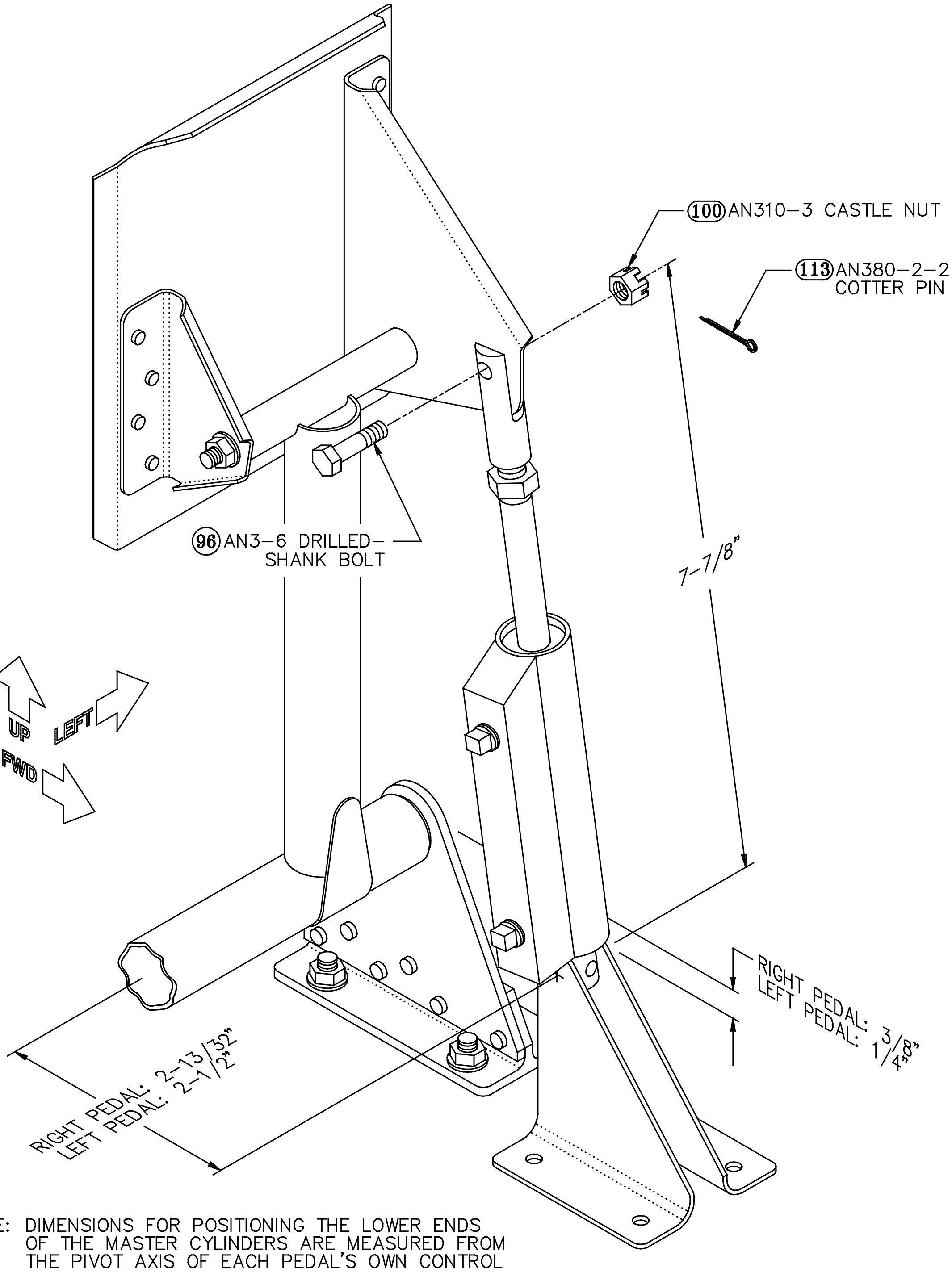


Figure 14: Rudder Pedal Neutral Position



NOTE: DIMENSIONS FOR POSITIONING THE LOWER ENDS OF THE MASTER CYLINDERS ARE MEASURED FROM THE PIVOT AXIS OF EACH PEDAL'S OWN CONTROL

RIGHT PEDAL SHOWN

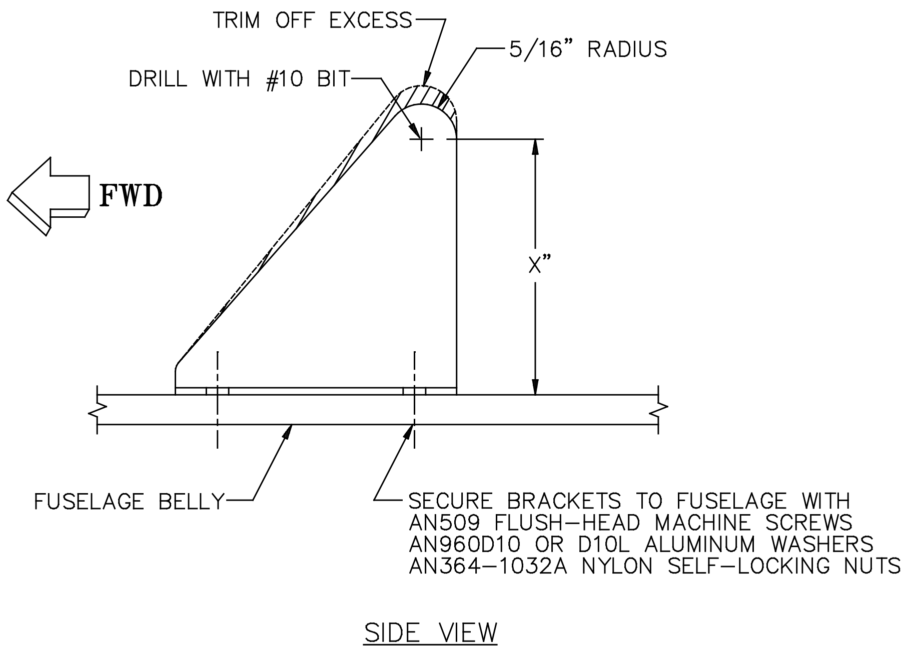
Figure 15: Master Cylinder Installation

With each **brake master cylinder** [18] in the extended (relaxed) position, thread the piston rod fork onto the piston rod until the distance between the hole in the fork and the hole at the base of the master cylinder body is **7-7/8"**, as shown in Figure 15. Lock the fork to the piston rod by tightening the jam nut against it.

Note The master cylinders come with small, plastic plugs in the ports. To prevent the entry of contaminants, leave the plugs in until you are ready to connect the brake lines, which will be described in a later step.

Fasten the piston rod end of the left master cylinder to the brake actuator bracket of the left rudder pedal, using an AN3-6 **drilled-shank bolt** [96], an AN310-3 castle nut and an AN380-2-2 cotter pin.

Position the mounting point at the lower end of the **left** master cylinder **1/4"** below and **2-1/2"** forward of the left rudder control pivot axis, as shown in Figure 15.



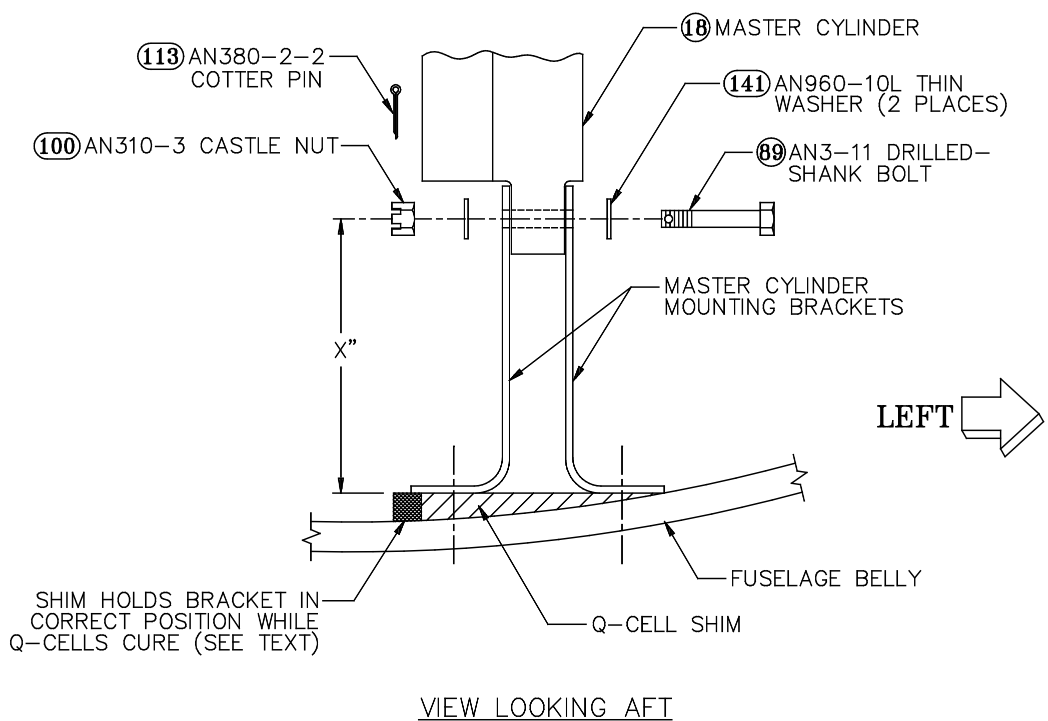


Figure 16: Finishing the Master Cylinder Mounting Brackets

While holding the master cylinder in the position described in the last paragraph, measure the height of the lower master cylinder mounting hole above the highest point of the fuselage belly that will be contacted by the master cylinder mounting brackets, as shown in Figure 16. (The dimension is marked **"X"** in the figure.) Transfer the measurement to one of the master cylinder mounting bracket pairs, as shown, and center punch the mounting hole location onto one angle of the pair.

Note If the X measurement is greater than 2-7/16", mark the hole location 2-7/16" above the base of the bracket. Otherwise, the edge distance from the top of the bracket to the center of the hole will be too small. In this situation, the thickness of the Q-cell shim will be increased as necessary to position the end of the master cylinder at the correct height.

Hold the two angles of the bracket pair back-to-back and drill the **#10** mounting hole through both angles at the same time. Trim the upper ends of the bracket angles to a **5/16"** radius centered on the master cylinder mounting hole, as shown, and trim off excess material. Deburr and corrosion-proof the brackets. Wax the bases of the brackets so they won't stick to the Q-cell shim.

Note For the **outboard** master cylinder brackets, stagger the inboard bracket down about 1/8" relative to the outboard angle while drilling the master cylinder mounting hole. This will reduce the thickness of the Q-cell shim needed under the bracket.

Mount the lower end of the master cylinder between the master cylinder mounting brackets, using an AN3-11 **drilled-shank bolt** [89], AN960-10L thin washers, an AN310-3 castle nut and an AN380-2-2 cotter pin, as shown in Figure 16. When installing the master cylinders, point the ports for the fluid lines **inboard**.

Apply a layer of thick Q-cell mixture to the area of the fuselage belly where the master cylinder support brackets mount. Lower the brackets into the Q-cell mixture until the lower end of the master cylinder is in the position described above: 2-1/2" forward and 1/4" below the left rudder control's pivot axis. Let the Q-cell mixture cure.

Hint It will be easier to do this if you use some kind of shim (a piece of wood under the corner of the support bracket that's farthest from the shell, or a built-up hot-glue shim along one edge) to position the master cylinder the correct distance from the rudder control pivot axis. This will free you from measuring and adjusting the position of the master cylinder after the Q-cell mixture is in place. If you use hot glue for this purpose, it could remain as a permanent part of the Q-cell shim.

Repeat these procedures for the **right** master cylinder and its mounting brackets, except position the mounting point at the lower end of the **right** master cylinder **3/8"** below and **2-13/32"** forward of the **right** rudder control pivot axis.

Note In order for the rudder pedals to maintain the same angle throughout their entire stroke, the master cylinders would have to form perfect parallelograms with the pedal stems. The geometry of the rudder control system does not permit this. Using the specified dimensions for positioning the master cylinders is actually better than a pure parallelogram linkage in that, as the rudder pedal is pushed forward, the top of the pedal rotates aft slightly, making it easier to apply brake with rudder. The position of the left master cylinder relative to the left rudder control weldment is different from the position of the right cylinder relative to the right rudder control weldment because the neutral positions of the two pedals are different.

After the Q-cell shims for both master cylinder brackets have cured, use the holes in the mounting bracket flanges as guides to drill **#10** mounting holes through the fuselage shell. Countersink the outside of the fuselage for the mounting screws, and mount the brackets to the fuselage with AN509 flush-head machine screws and AN364-1032A nylon self-locking nuts. Because of the varying thicknesses of the Q-cell shims, you will need different length screws for each location (there should be an adequate assortment of different lengths left over from the fuselage assembly). Use standard procedures to choose the correct length screws, adjusting their fit with AN960D10 and AN960D10L aluminum washers as necessary.

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Control Stick Assembly Installation

Step 9: Assemble the Elevator/Aileron Control

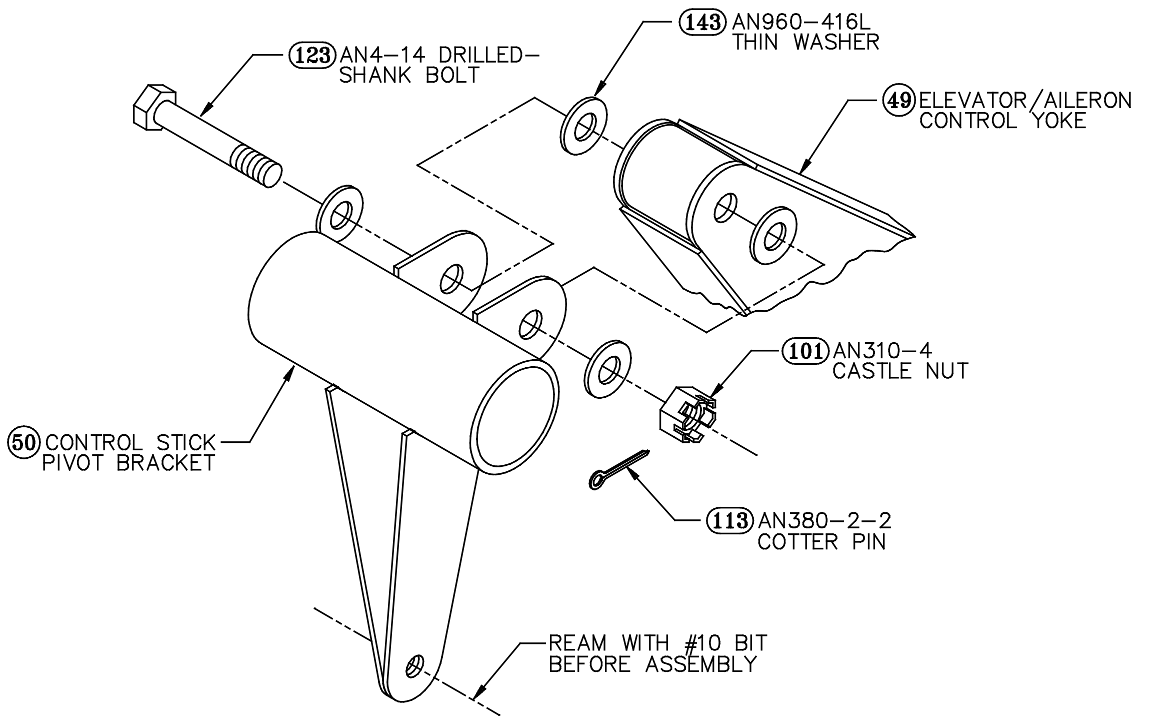
Use a **#10** bit to ream the hole in the long arm of each **control stick pivot bracket** [50], as shown in Figure 17. Use AN4-14 **drilled-shank bolts** [123], AN960-416L **thin washers** [143], AN310-4 **castle nuts** [101] and AN380-2-2 cotter pins to bolt the control stick pivot brackets to the **elevator/aileron control yoke** [49], as shown in Figure 17.

Hint If you have extras of the thin nylon washers from "SECTION VIII: FUSELAGE ASSEMBLY," you can install them instead of the AN960-416L washers between the pivot brackets and the arms of the control yoke. This will help to reduce friction in the system.

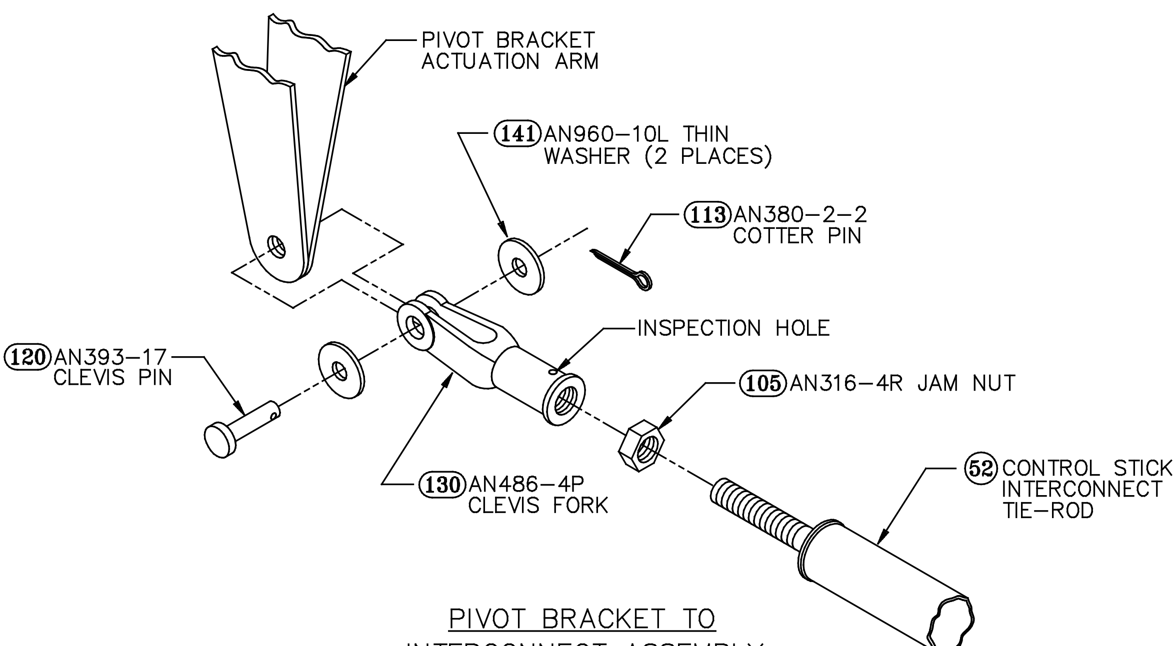
Note Especially for early GlaStar kits, there may be some play between the control stick pivot brackets and their pivot bolts. This is perfectly acceptable and won't affect the controllability of the airplane. The play will seem greater, however, when felt through the control sticks. If you wish, you can reduce the play by drilling the pivot holes through the assembly to 1**9/64"**-diameter, and then reaming them to **5/16"**-diameter (.3125"). Then, use AN5-14 bolts (not supplied), instead of AN4-14s, to bolt the pivot brackets to the yoke.

Thread an AN316-4R **jam nut** [105] and an AN486-4P **clevis fork** [130] onto each end of the **control stick interconnect rod** [52], as shown in Figure 17, until the bolt holes in the ends of the two forks are **18-3/4"** apart, as shown in Figure 18. (The 18-3/4" dimension is a starting point; the length of the linkage may be adjusted later to achieve the specified aileron deflections.)

Warning Each clevis fork must be threaded onto the tie rod stud past the inspection hole in the fork. Use a stiff wire inserted into the inspection hole to feel for the end of the stud. If the wire passes through the inspection hole in the fork without contacting the stud, an unsafe condition exists, and the fork must be readjusted.



PIVOT BRACKET TO TORQUE TUBE ASSEMBLY



PIVOT BRACKET TO INTERCONNECT ASSEMBLY

Figure 17: Elevator/Aileron Control Yoke Assembly

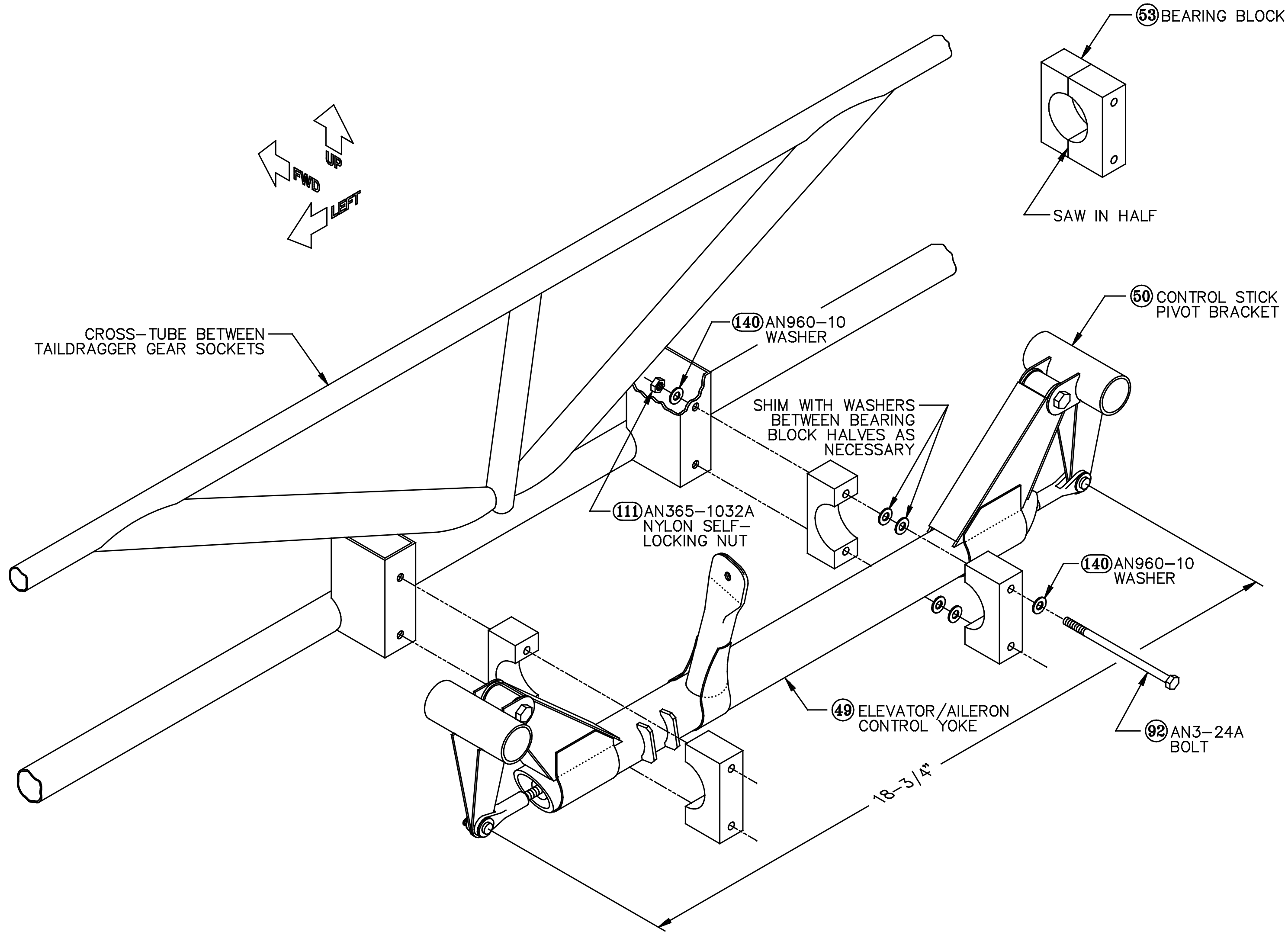


Figure 18: Control Yoke Assembly Installation

Insert the control stick interconnect assembly through the elevator/aileron control yoke torque tube, as shown in Figure 18, and use the AN393-17 **clevis pins** [120], AN960-10L thin washers and AN380-2-2 cotter pins to secure the interconnect rod forks to the control stick pivot bracket actuation arms, as shown in Figure 17.

> **Note** The AN393-17 clevis pin is longer than it needs to be to secure the interconnect rod forks. The extra length will be taken up by the strap shackles on the ends of the control cables, which will be installed in a later step.

Step 10: Install the Control Yoke Assembly

Use a bandsaw or a hacksaw to split the UHMW polyethylene **control yoke bearing blocks** [53] in half perpendicular to the two 3/16"-diameter mounting holes, as shown in Figure 18. (For a neater installation, you can form a 1/16" chamfer on all the corners of the bearing blocks, as shown in Figure 19.)

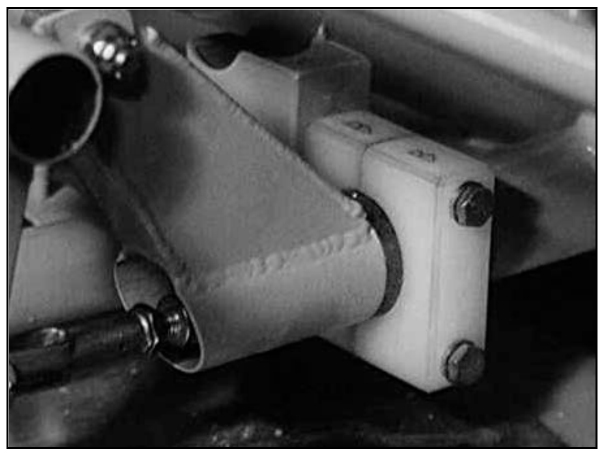


Figure 19: Control Yoke Installation

> **Note** Cutting the control yoke bearing blocks in half removes a saw kerf of material, so you will have to shim between the bearing block halves with washers to regain the circular cross-section of the large bearing hole and to achieve free rotation of the control yoke. The desired result is to have the bearing blocks **firmly** clamped up, but with rotational friction as low as possible. When sawing the blocks in half, stop part way through one of them to determine the washer stack-up needed to fit the width of the kerf.

Use the bearing blocks, AN3-24A **bolts** [92], AN960-10 **washers** [140] and AN365-1032A **nylon self-locking nuts** [111] to mount the control yoke assembly to the fuselage cage.

Note Some early GlaStar kits were shipped with smaller control yoke bearing blocks—**1-3/4"** measured parallel to the mounting bolts, instead of **2"**. If you have the smaller bearing blocks, use **AN3-22A bolts**, instead of the -24As, to mount the control yoke assembly. You will also need AN960-10L washers, instead of -10s, under the bolt heads.

Note A potential problem is weld shrinkage in the fuselage cage that can pull the bearing block mounting pads out of parallel. If the bearing blocks are misaligned when viewed from the **aft** side, use a small, round file to slot the holes in the mounting pads on the cage to bring the blocks into alignment. If the blocks are out of alignment when viewed from **above**, bevel the mounting surfaces of the blocks.

Note Another potential source of friction is weld penetration on the insides of the small tabs that reference the aileron/elevator control yoke to the bearing blocks. If such roughness is found, file it smooth.

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Flap Handle Assembly Installation

Step 11: Assemble the Flap Handle

Press the MS16555-341 **3/16" dowel pin** [157] into the **flap handle plunger** [57], as shown in Figure 20. Insert the other end of the flap handle plunger into the **flap handle plunger extension** [56] and secure the extension to the plunger with super glue. Install the **flap handle thumb button** [75] into the flap handle plunger extension; secure the button with super glue, also.

> **Note** It's OK to use super glue here because all the loads on both glue joints tend to tighten rather than to loosen the assemblies. If you wish, you can drill holes and pin the parts together with 1/16" or 3/32" roll pins (not supplied).

Fabricate a **2-1/8"** long spacer from 3/4" O.D. thick-wall plastic tubing or 3/4" wooden dowel.

> **Note** You can use just about any material you want for the spacer; its only purpose is to occupy space under the spring inside the flap handle. If you use a wooden dowel, varnish it so the moisture in the wood doesn't induce corrosion on the inside of the handle. The 2-1/8" dimension is a good starting length; you can shorten the spacer slightly to soften the action of the spring, if you wish, as long as the spring forces the flap plunger pin solidly into the notches of the ratchet plate.

Insert the spacer and then the **flap handle spring** [78] into the **flap handle** [58]. Then insert the flap plunger assembly into the flap handle, aligning the slot in the plunger with the slot in the handle. Insert the **flap handle ratchet plate** [55] through the slot in the handle, as shown, until one of the notches in the ratchet plate captures the dowel pin in the plunger. Press the 3/16" X 1/2" **roll pin** [42] into the hole at the upper end of the flap handle ratchet plate; this pin serves as a limit stop for the flap handle.

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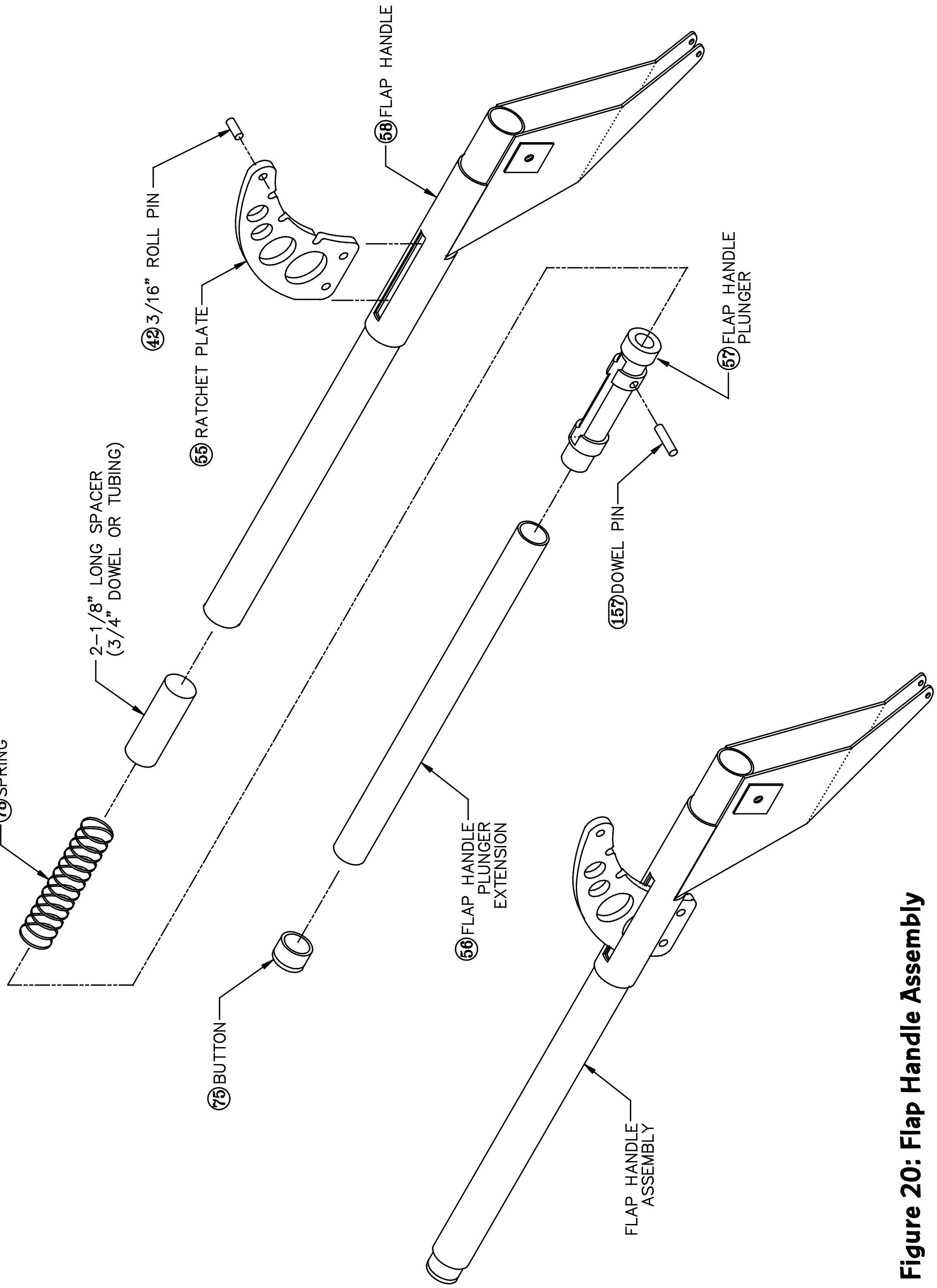

Figure 20: Flap Handle Assembly

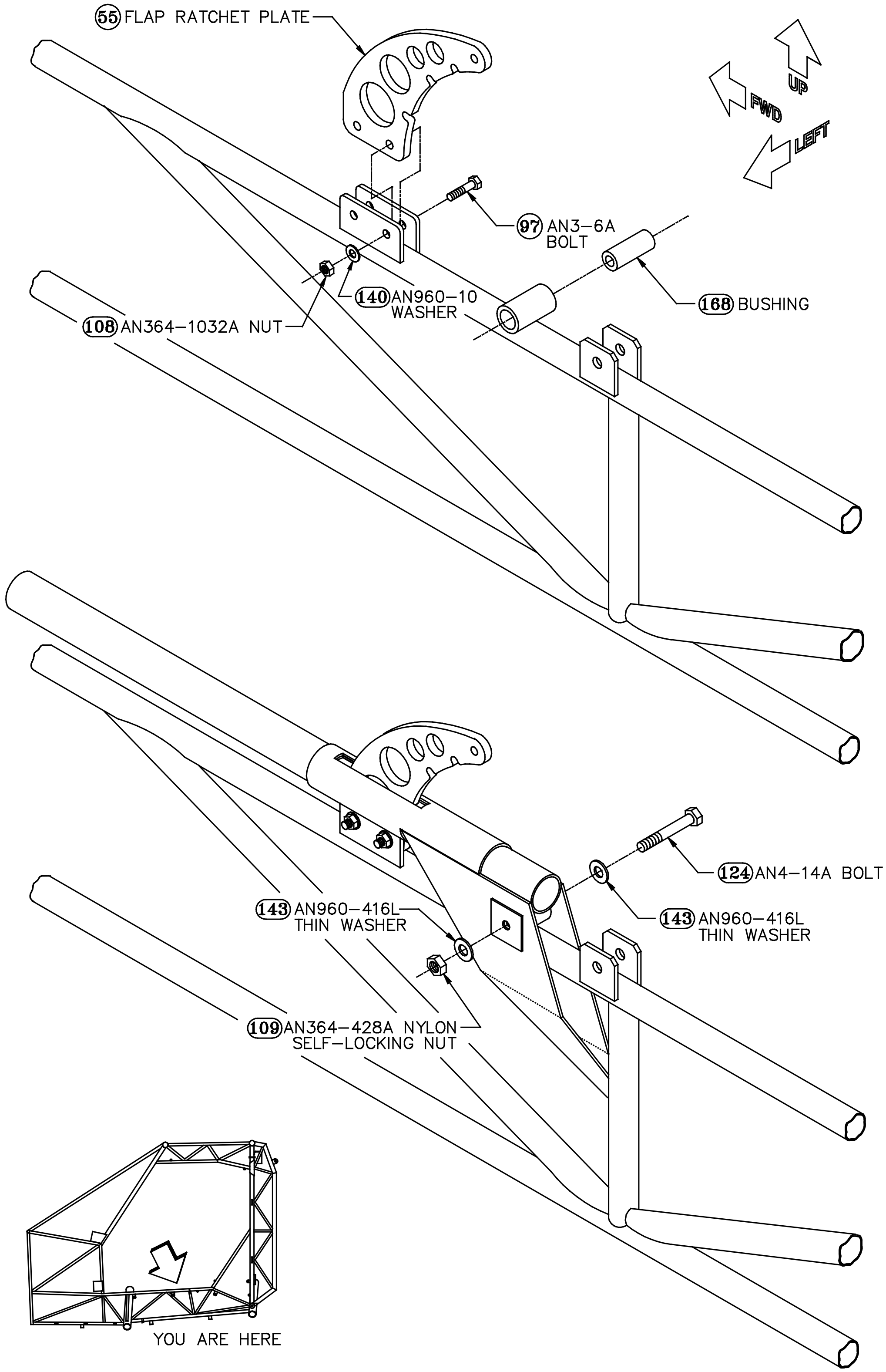

Figure 21: Flap Handle Installation

Step 12: Install the Flap Handle

Coat the NAS73-4-14 **clamp-up bushing** [168] with grease and insert it into the small tube welded to the top of the longitudinal cage tube between the pilot and copilot seats, as shown in Figure 21.

Note If weld penetration inside the cage tube prevents insertion of the clamp-up bushing, ream the tube with a **7/16"** (.4375") straight reamer.

Carefully spread apart the two arms of the flap handle assembly and slip them over the mounting tube on the fuselage cage. Align the flap handle pivot hole with the bushing in the mounting tube, and secure the handle with an AN4-14A **bolt** [124], AN960-416L thin washers and an AN364-428A **nylon self-locking nut** [109]. Tighten the nut securely to clamp the pivot bushing between the flap handle arms; the only rotation is between the pivot bushing and the tube on the fuselage cage.

Secure the ratchet plate to its mount on the cage with AN3-6A **bolts** [97], AN960-10 washers and AN364-1032A nylon self-locking nuts.

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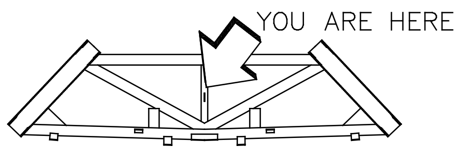
Fuselage Control System Pulleys Installation

Steps 13 through 19 describe procedures for installing control system pulleys in the fuselage. Guard straps and other cable retainers will be left off the pulleys until after the control cables have all been routed. Cable retainers will be described in Step 48.

Step 13: Install the Forward Pulleys



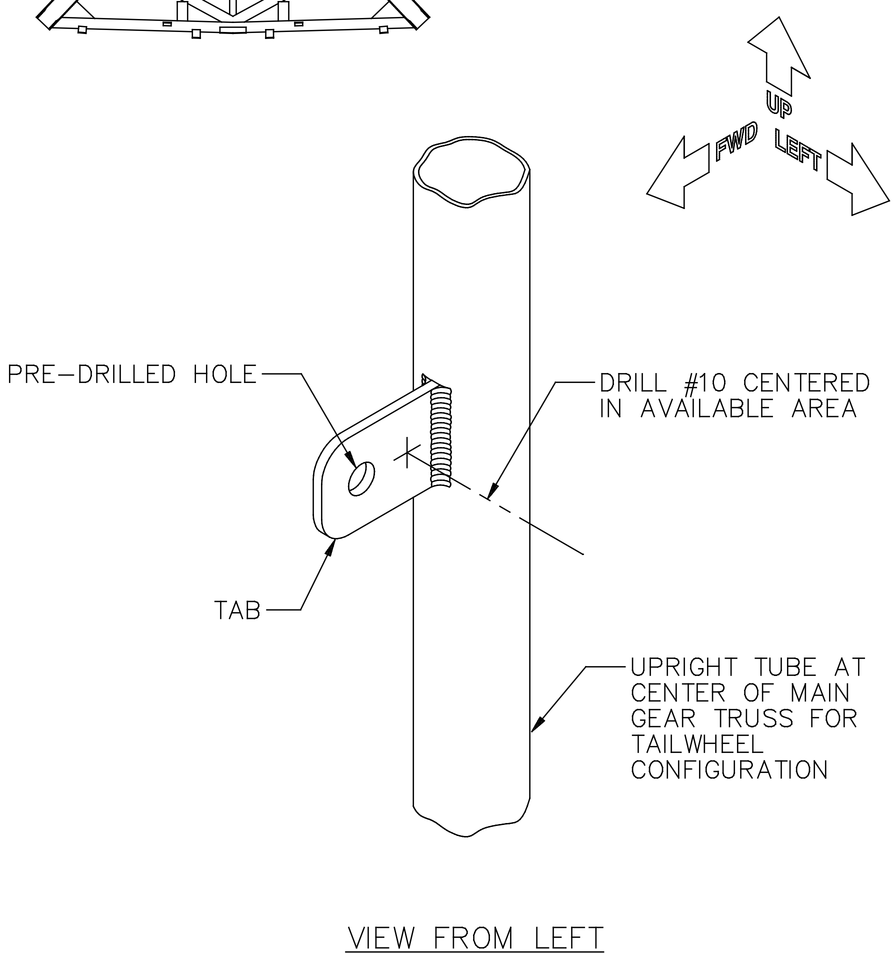


Figure 22: Hole in Tab on Fuselage Cage

Drill a **#10** hole through the single tab on the central, upright tube in the taildragger main landing gear truss, as shown in Figure 22. Center the hole in the available area on the tab between the pre-drilled hole and the weld. Deburr the hole and corrosion-proof the resulting bare metal. An AN3 bolt will be installed through the new hole to anchor the cable guards for the forward pulley group, as described later (see Figure 28). (You can't install the anchor bolt through the pre-drilled hole in the tab, because the bolt would rub on the flap cable reversing pulley. The pre-drilled hole will not be used for any purpose.)

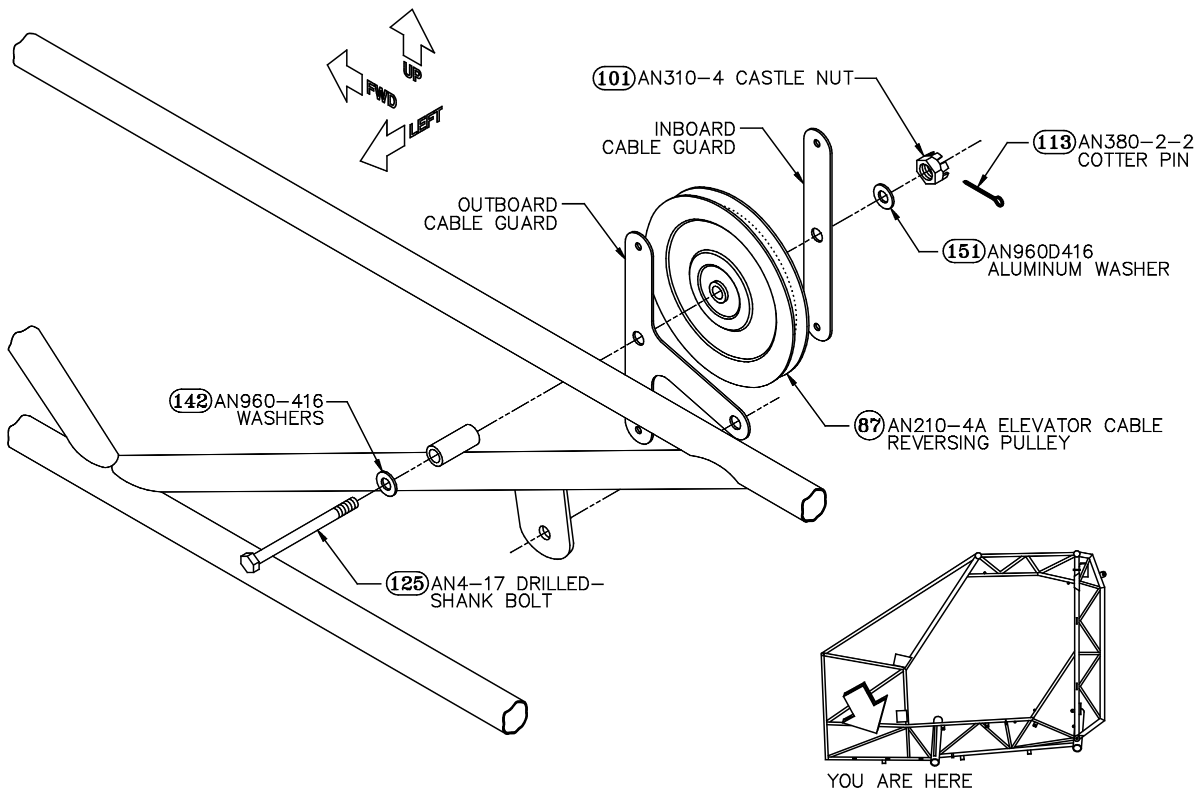


Figure 23: Elevator Cable Reversing Pulley Installation

The elevator cable reversing pulley and its cable guards mount to the bushing on the left-side forward keel beam, about 5" forward of the taildragger main gear truss, as shown in Figure 23. (Procedures for fabricating the guards are described below.) The AN210-4A **pulley** [87] and the guards are secured with an AN4-17 **drilled-shank bolt** [125], an AN960-416 **washer** [142], an AN960D416 **aluminum washer** [151], an AN310-4 castle nut and an AN380-2-2 cotter pin.

Note Instead of the **AN210-4A** pulleys specified in the preceding paragraph and in Figure 72, some GlaStar kits include **MS24566-4B** pulleys. Both types of pulleys are aircraft-grade, 3-1/2" phenolic pulleys and are thus completely interchangeable. Which pulley is supplied simply depends on current pricing and availability from our vendors.

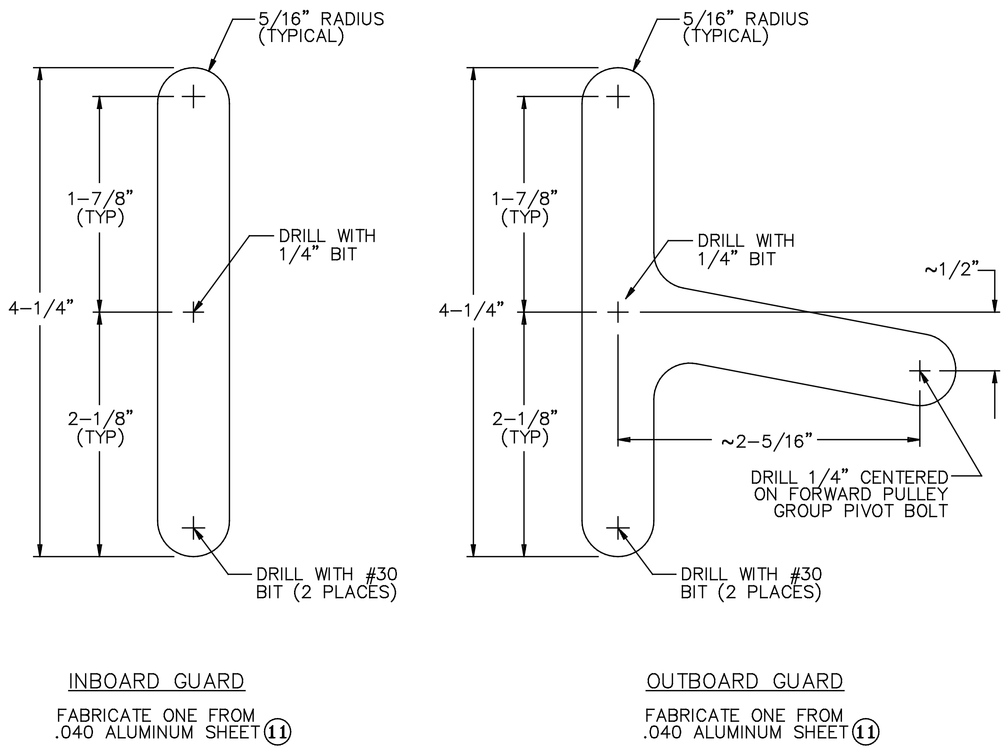


Figure 24: Elevator Cable Reversing Pulley Guards

Fabricate one inboard and one outboard cable guard for the elevator cable reversing pulley from the **.040" X 6" X 6" aluminum sheet** [11], as shown in Figure 24. Use a Unibit (or equivalent) to drill the 5/16" radii for the inside corners of the outboard guard, and then make the rest of the cuts on a bandsaw, finishing with a belt sander, files and sandpaper. Clamp the two guards together to drill the **1/4"** pulley axle hole and the **#30** clevis pin holes.

> **Note** The 5/16" radii shown in Figure 24 at the ends of the guards are **not** centered on the #30 guard pin holes. Also, the dimensions for the 1/4" hole in the angled aft arm of the outboard guard are approximate and should be used for reference only. To drill the hole, install the guard on the elevator cable reversing pulley pivot bolt and use the holes in the mounting tabs for the forward pulley group (described on the next pages) as a guide to locate the hole. Since the only purpose of this hole is to anchor the cable guard, preventing it from rotating, it's not a problem if the hole is a little off; the hole can be elongated slightly to align with the bolt.

Deburr and corrosion proof the guards.

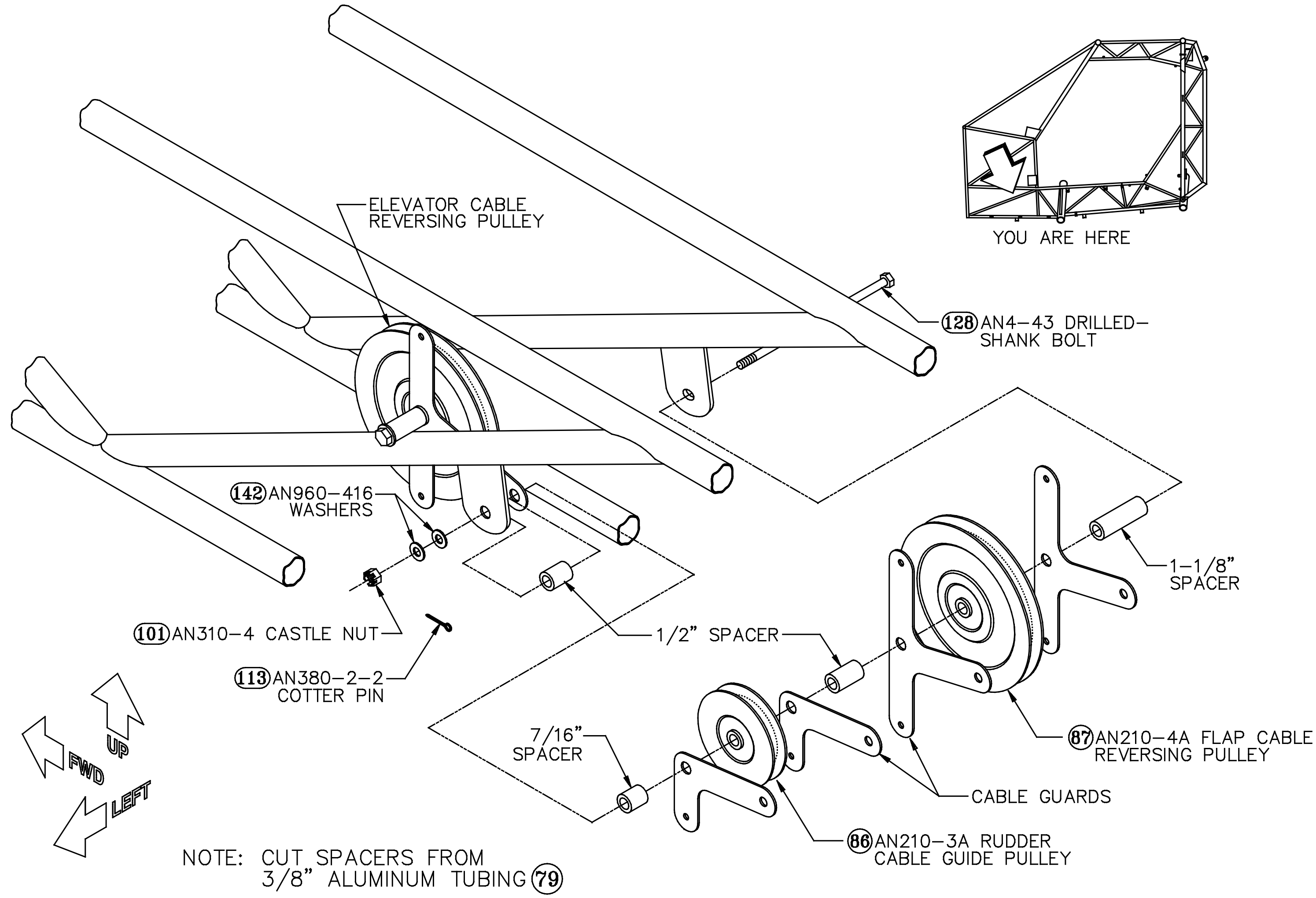


Figure 25: Forward Pulley Group Installation

Use a tubing cutter to cut one **7/16"** length, two **1/2"** lengths and one **1-1/8"** length from the **3/8" aluminum tubing** [79]; these pieces serve as spacers in the forward pulley group.

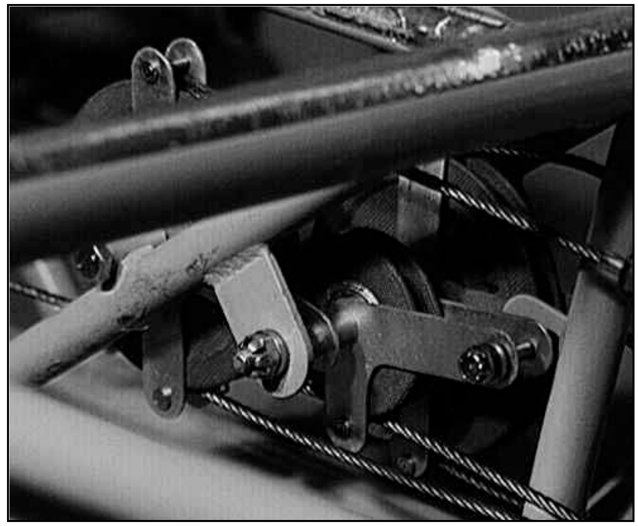
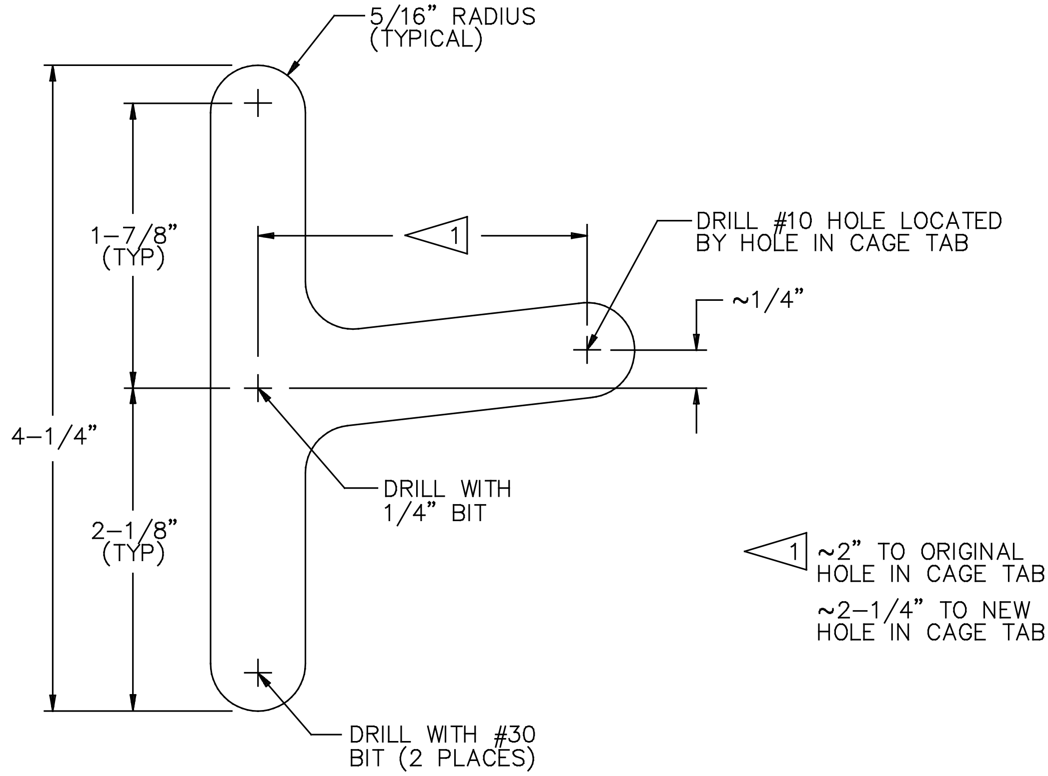


Figure 26: Forward Pulley Group

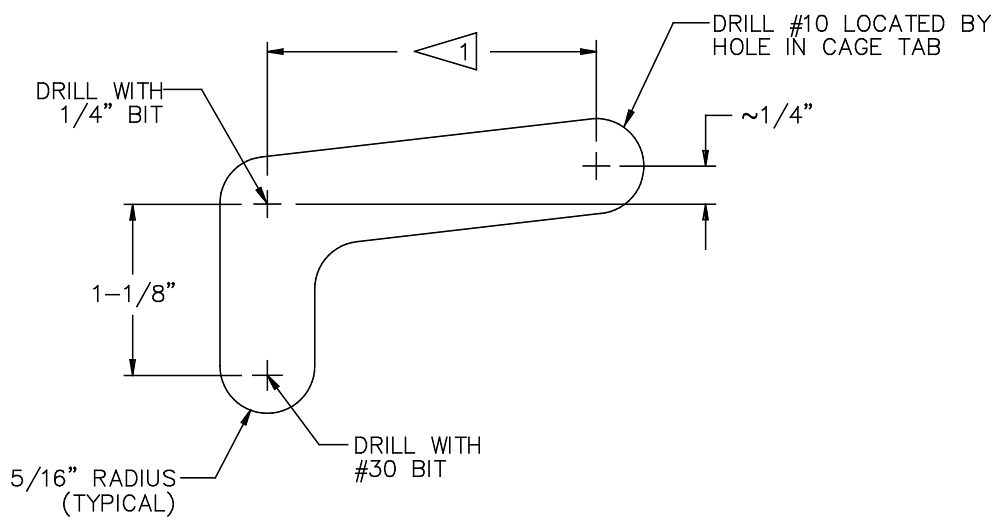
As shown in Figure 25, the spacers, an AN210-3A **pulley** [86], an AN210-4A pulley and cable guards for the pulleys will be installed between the mounting tabs on the left- and right-side forward keel beams about 2-1/2" forward of the taildragger main gear truss. (Fabrication of the cable guards is described below.) The larger, AN210-4A pulley functions as a reversing pulley for the flap cable; the smaller, AN210-3A pulley is a guide for the **left** rudder cable. The spacers, the cable guards and the pulleys will be secured with an AN4-43 **drilled-shank bolt** [128], AN960-416 washers, an AN310-4 castle nut and an AN380-2-2 cotter pin.

Note A guide pulley is not needed for the right rudder cable.



FLAP CABLE REVERSING PULLEY GUARD

FABRICATE TWO FROM .040 ALUMINUM SHEET (11)



RUDDER CABLE GUIDE PULLEY GUARD

FABRICATE TWO FROM .040 ALUMINUM SHEET (11)

Figure 27: Forward Pulley Group Cable Guards

Fabricate cable guards for the flap cable reversing pulley and the left rudder cable guide pulley, as shown in Figure 27, using the same material and similar procedures as described for the elevator cable guards, above: use a Unibit (or equivalent) to drill the large radii for the inside corners of the guards, and then make the rest of the cuts on a bandsaw, finishing with a belt sander, files and sandpaper. Clamp the two guards of each set together to drill the **1/4"** pulley axle hole and the **#30** clevis pin holes. To drill the **#10** holes in the angled, aft arms of the guards, install the guards on the pulley pivot bolt, as shown in Figure 25, and use the **new** hole in the tab on the taildragger main gear truss (shown in Figure 22) as a guide to locate the holes.

Note If the **original** hole in the cage tab is **no closer** than **2"** to the pulley pivot bolt, you can use the original hole to drill the anchor holes in the aft arms of the pulley cable guards. If the original hole is **closer** than **2"** to the pivot bolt, the pulleys are likely to rub on the anchor bolt, so in this case, use the **new** hole to locate the anchor bolt holes.

When all the holes have been drilled, deburr the guards and apply the corrosion-protection of your choice.

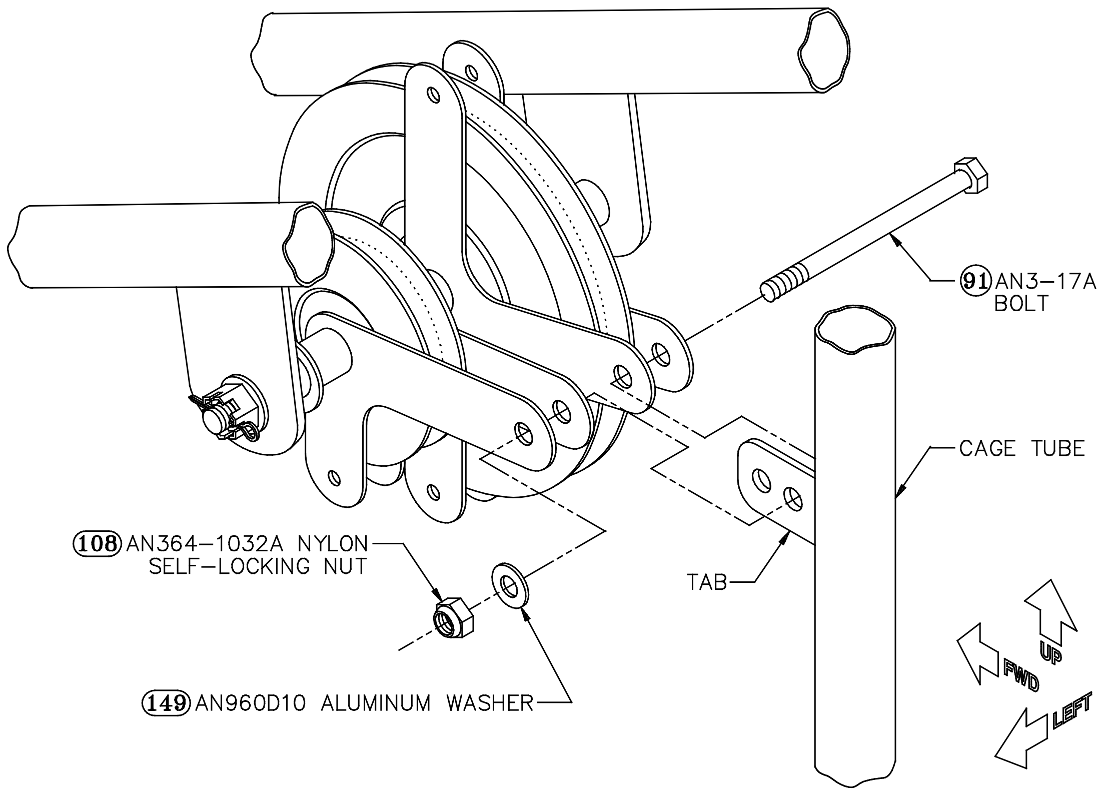


Figure 28: Cable Guard Anchor Bolt

When all of the guards have been fabricated, install them with their pulleys and the tubular spacers on their respective bolts, as shown in Figures 23 and 25. Anchor the aft arms of the guards for the flap cable reversing pulley and the left rudder cable guide pulley with an AN3-17A **bolt** [91] installed through the **new** hole in the cage tab, as shown in Figure 28. Secure the bolt with an AN960D10 aluminum washer and an AN364-1032A nylon self-locking nut. Tighten the nut just enough to keep the bolt from rattling; over-tightening will cause the cable guards to rub on the pulleys.

Note Optionally, you can make spacers from 5/16" O.D. X .035" wall aluminum tubing to fit over the anchor bolt between the pulley guard arms so that the entire assembly can be clamped up.

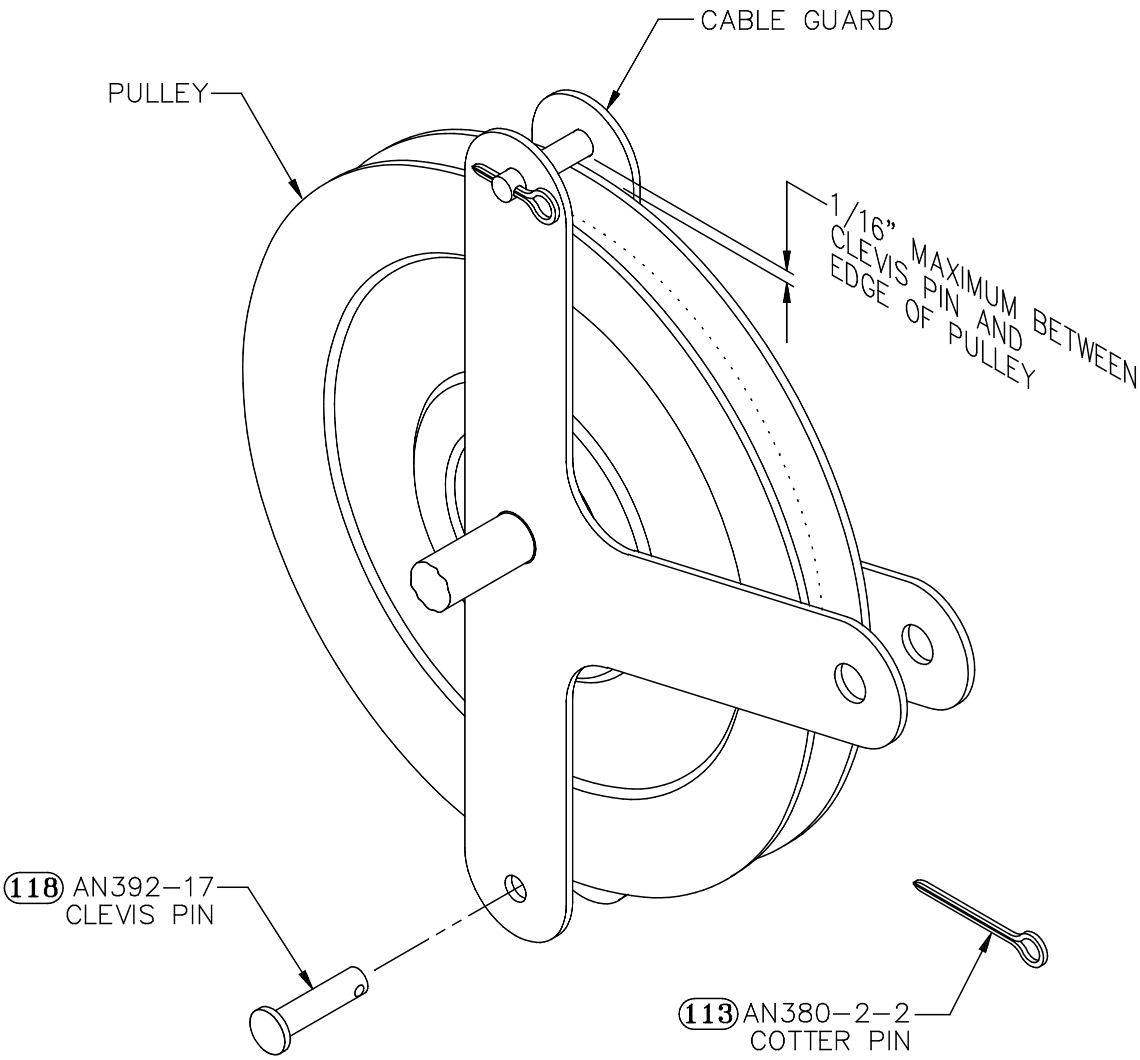


Figure 29: Typical Cable Retainer Installation

After the cables have been routed over the pulleys, use AN392-17 **clevis pins** [118] secured with AN380-2-2 cotter pins to retain the cables in the pulleys, as shown in Figure 29. Verify that the clevis pins are positioned a maximum of **1/16"** from the edges of the pulleys, as shown in Figure 29, to effectively retain the cables.

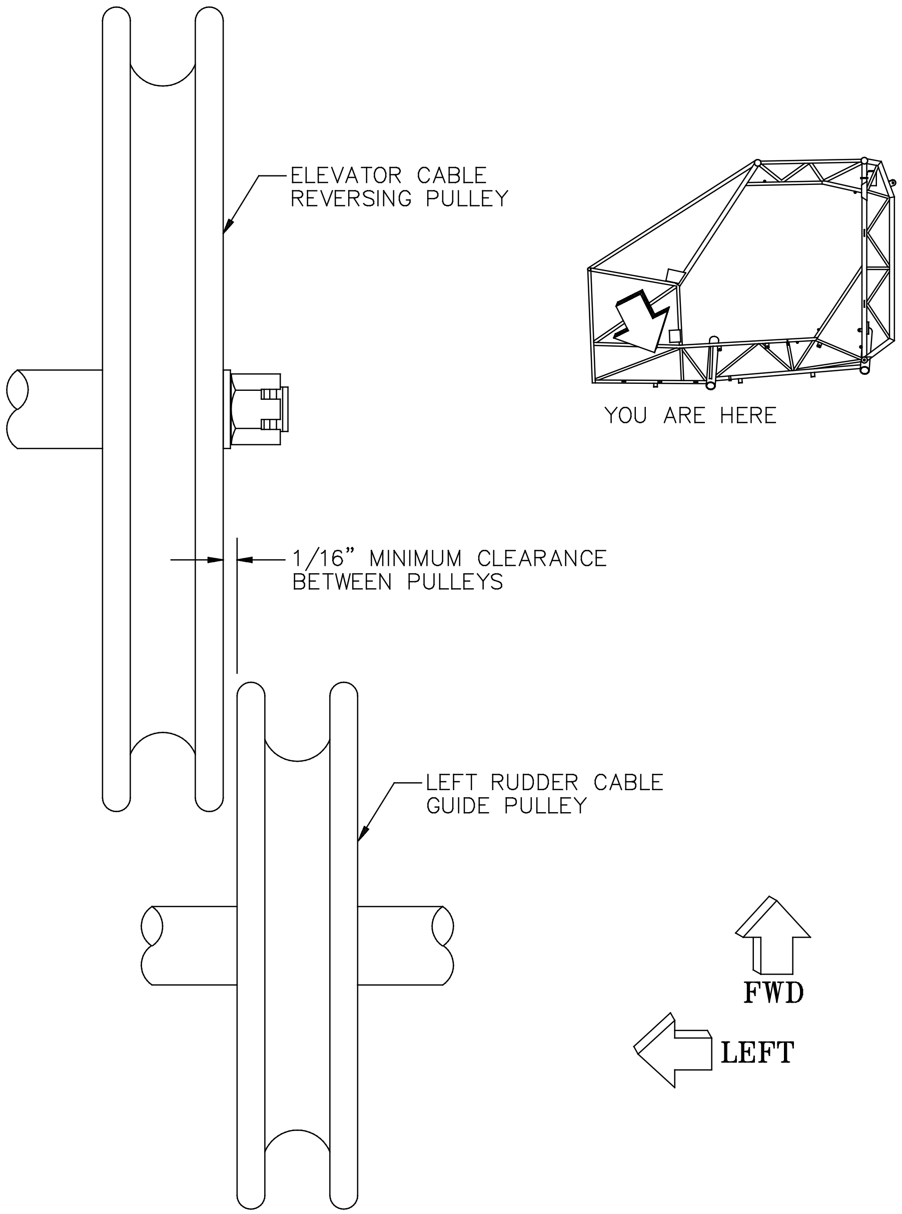


Figure 30: Clearance Between Pulleys

Note Provide a minimum of **1/16"** clearance between the left rudder cable guide pulley and the elevator cable reversing pulley, as shown in Figure 30. Adjust the lengths of the tubular spacers and/or shim with washers, as necessary to achieve this condition.

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Step 14: Install the Lower Forward Aileron Pulleys

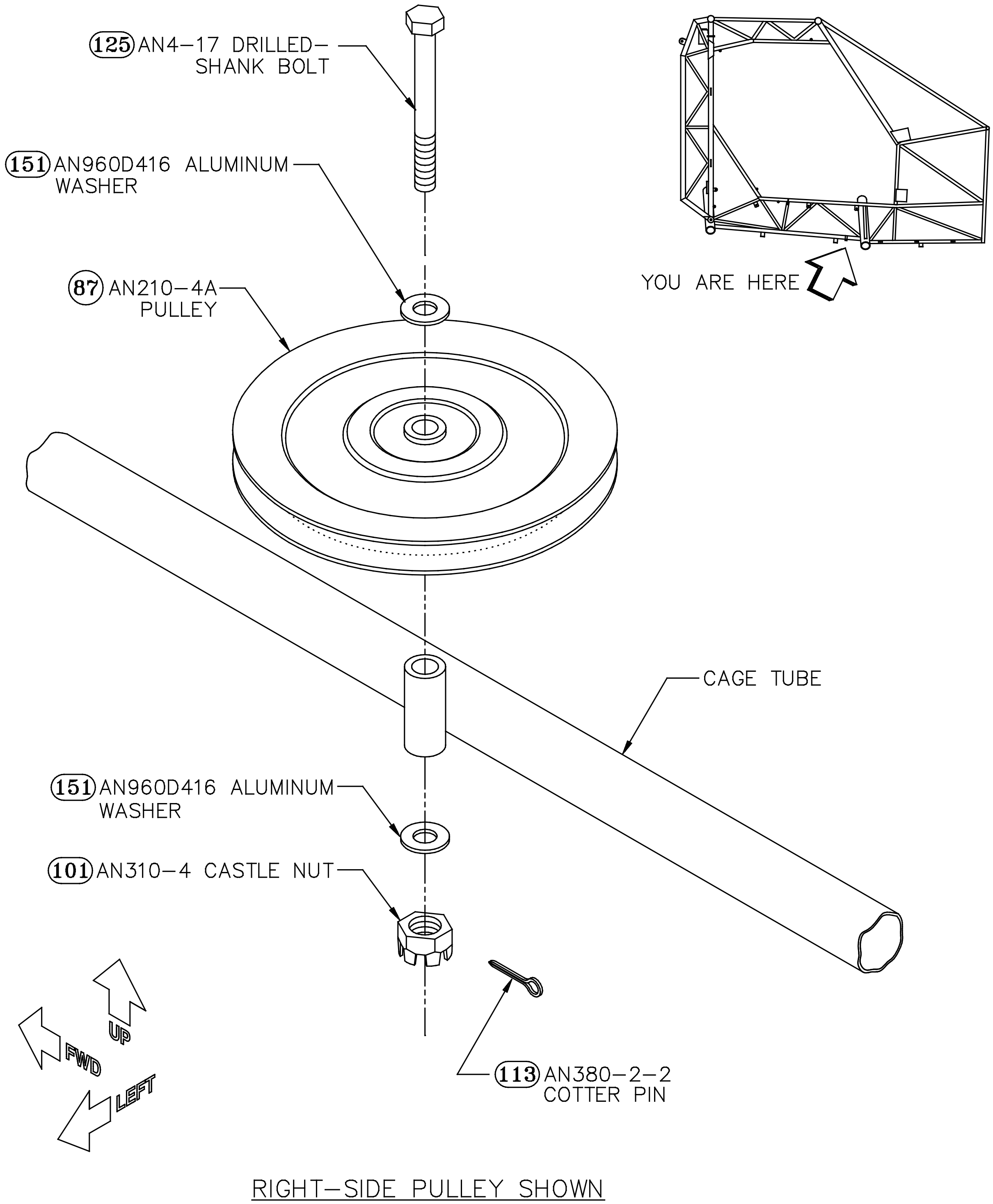

Figure 31: Forward Aileron Pulleys

On each side of the fuselage, mount an AN210-4A pulley to the bushing on the lower outboard fuselage cage longeron about 4-1/4" aft of the taildragger main gear truss. Mount the pulleys with AN4-17 **drilled-shank bolts** [125], AN960D416 aluminum washers, AN310-4 castle nuts and AN380-2-2 cotter pins, as shown in Figure 31. The cable guard shown in Figure 32 will be described later (in Step 48).

Figure 32: Forward Aileron Pulley

Note Early kits included **AN4-20** bolts for this application rather than AN4-17s. These longer bolts will require at least one and perhaps two extra AN960D416 washers in order to keep the cotter pin hole aligned with the castle nut. Add the first extra washer under the bolt head and the second, if required, under the nut.

Note In rare instances, the cage tubes or the fuselage shell can interfere with the pulleys. If necessary, use washers to space the pulleys away from the cage tubes. Interference with the shell can be relieved by grinding away the interior laminates and foam core and then applying a one-layer bi-directional patch laminate.

Completed: [ ]

Step 15: Install the Lower Aft Aileron Pulleys

Mount MS20220-3 **pulleys** [158] to the bushings near the lower end of the aft main cage upright on each side, just outboard of the tricycle main gear sockets. Use AN5-20 **drilled-shank bolts** [133], AN970-5 **large washers** [155], AN960-516L **thin washers** [145], AN310-5 **castle nuts** [102] and AN380-2-2 cotter pins, as shown in Figure 33, to mount the pulleys. (The AN970 washer goes under the bolt head to retain the pulley in the unlikely event the bearing ever disintegrates.)

Note In some cases, the weld bead at the junction of the aft main cage upright tube and the reinforcement gusset for the tricycle main gear socket can interfere with the pulley. If this happens, trim the **inboard** end of the cage bushing to move the pulley outboard, away from the gusset. Then add washers under the bolt head to fill the resulting gap. If this doesn't completely solve the problem, you can bevel a **small** amount off the edge of the pulley.

In other instances, the cage bushing has been welded too far outboard, allowing the pulley mounting bolt to contact the inside of the fuselage shell. In this case, trim material off the outboard side of the bushing and add washers under the bolt head to move the bolt away from the fuselage. Alternatively, relieve the inner laminates and foam core of the fuselage and apply a one-layer bi-directional patch laminate over the relieved area.

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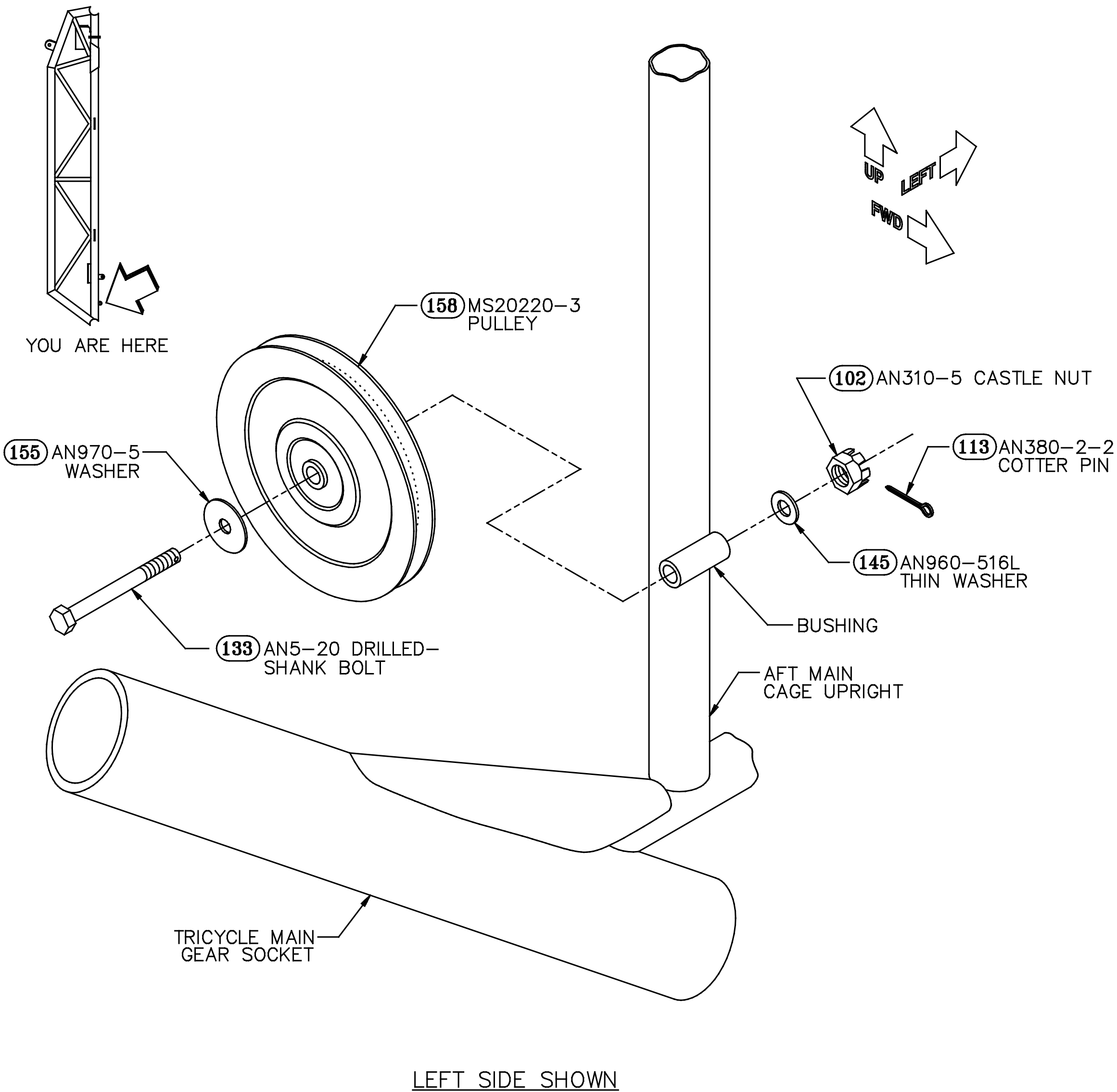

Figure 33: Lower Aft Aileron Pulleys

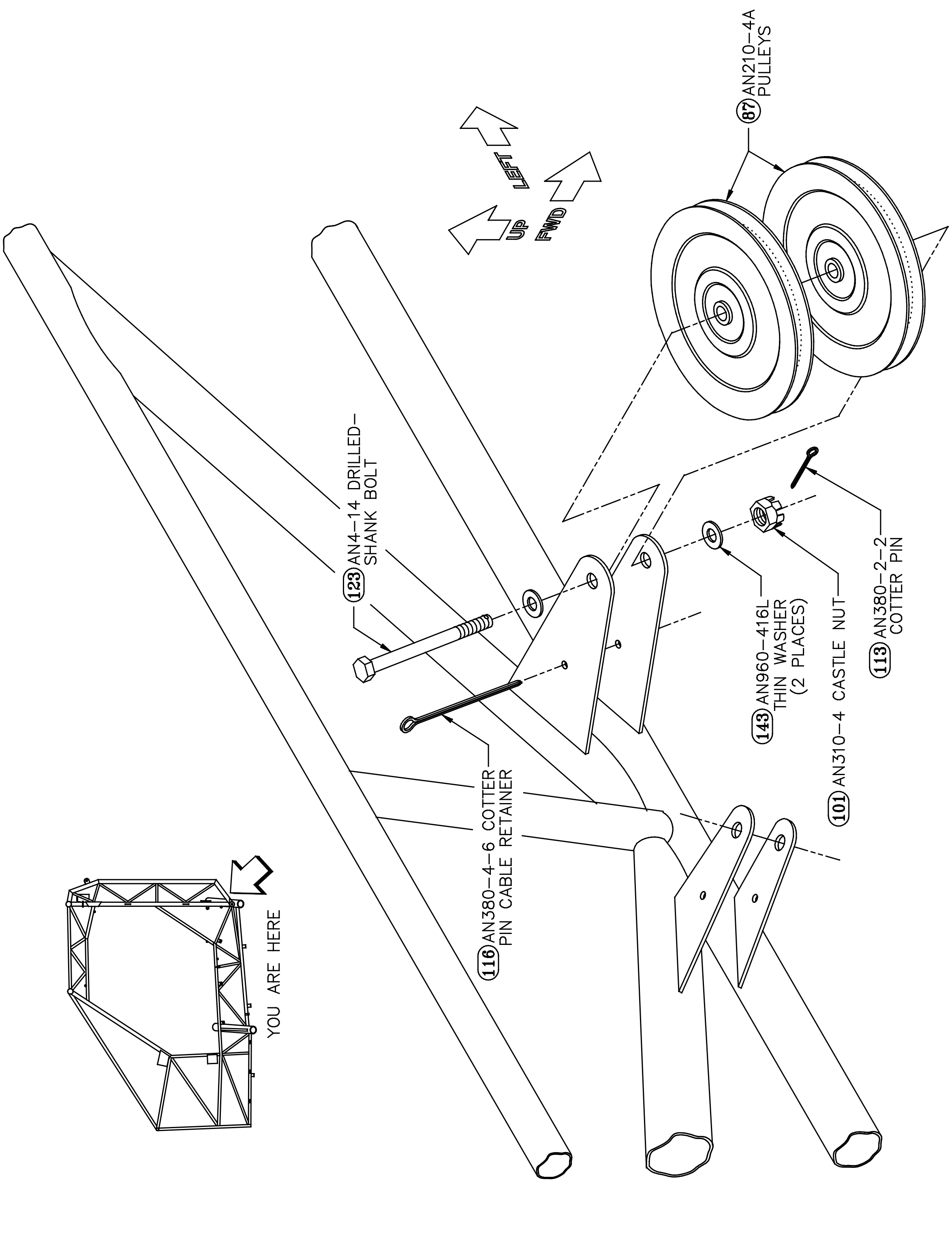

Figure 34: Center Flap Pulleys

Step 16: Install the Center Flap Pulleys

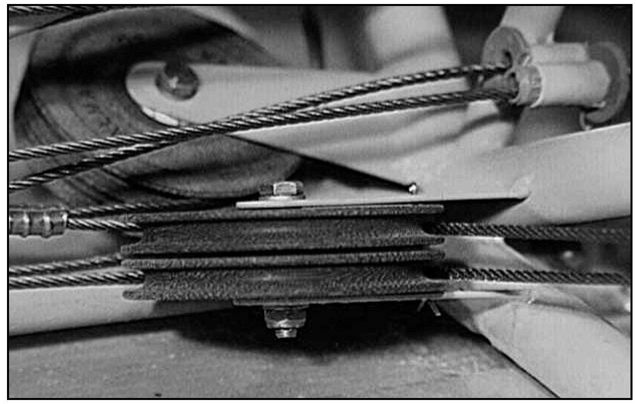

Figure 35: Center Flap Pulleys

Install two AN210-4A pulleys on each side near the fuselage centerline between the arms welded near the bottom of the tricycle main gear truss, as shown in Figure 34. Use AN4-14 drilled-shank bolts, AN960-416L thin washers, AN310-4 castle nuts and AN380-2-2 cotter pins to mount the pulleys, as shown. After the flap cable installation has been completed, install the AN380-4-6 **cotter pin** [116] as a cable retainer (refer to Step 48).

Completed: [ ]

Step 17: Install the Lower Outboard Flap Pulleys

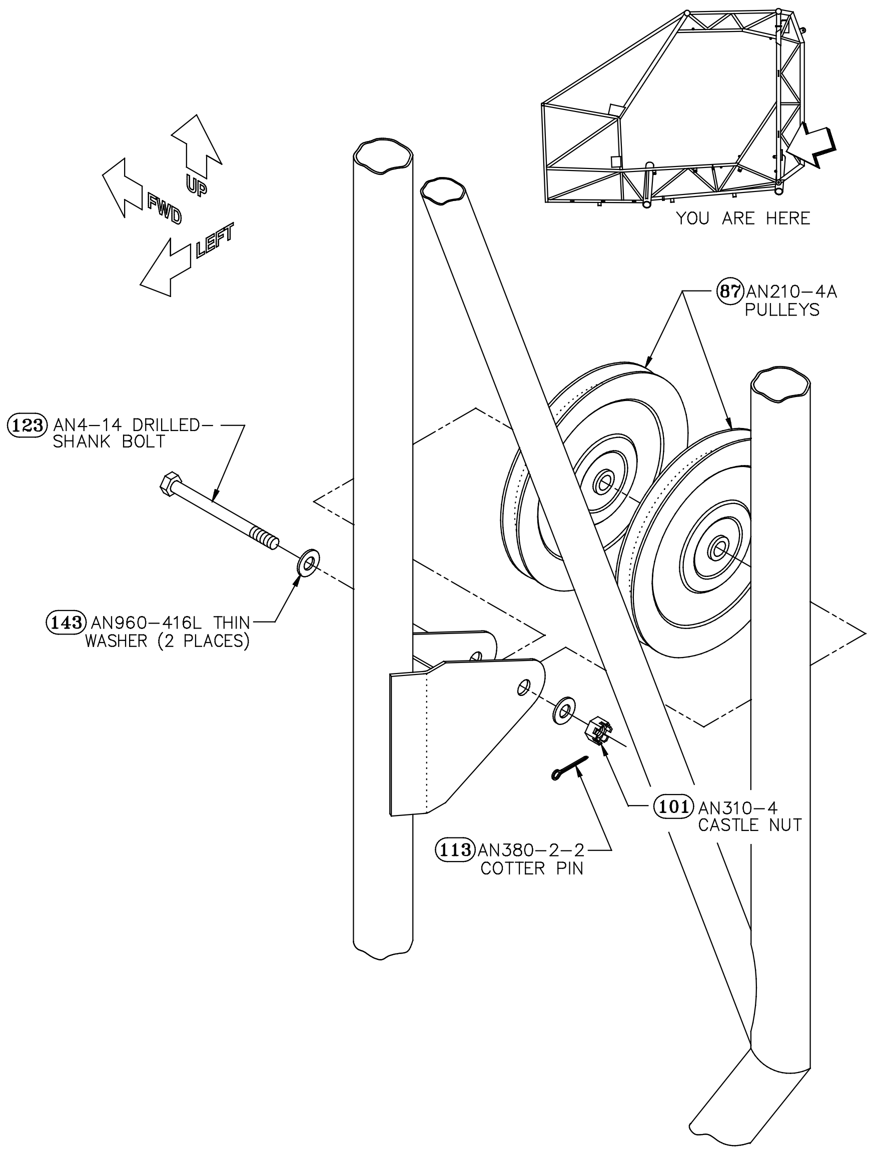

Figure 36: Lower Outboard Flap Pulleys

Mount two AN210-4A pulleys on each side between the arms on the inboard side of the main vertical tube just aft of the cabin door. Use AN4-14 drilled-shank bolts, AN960-416L thin washers, AN310-4 castle nuts and AN380-2-2 cotter pins to mount the pulleys, as shown in Figure 36.

Completed: [ ]

Step 18: Install the Upper Crossover Pulleys

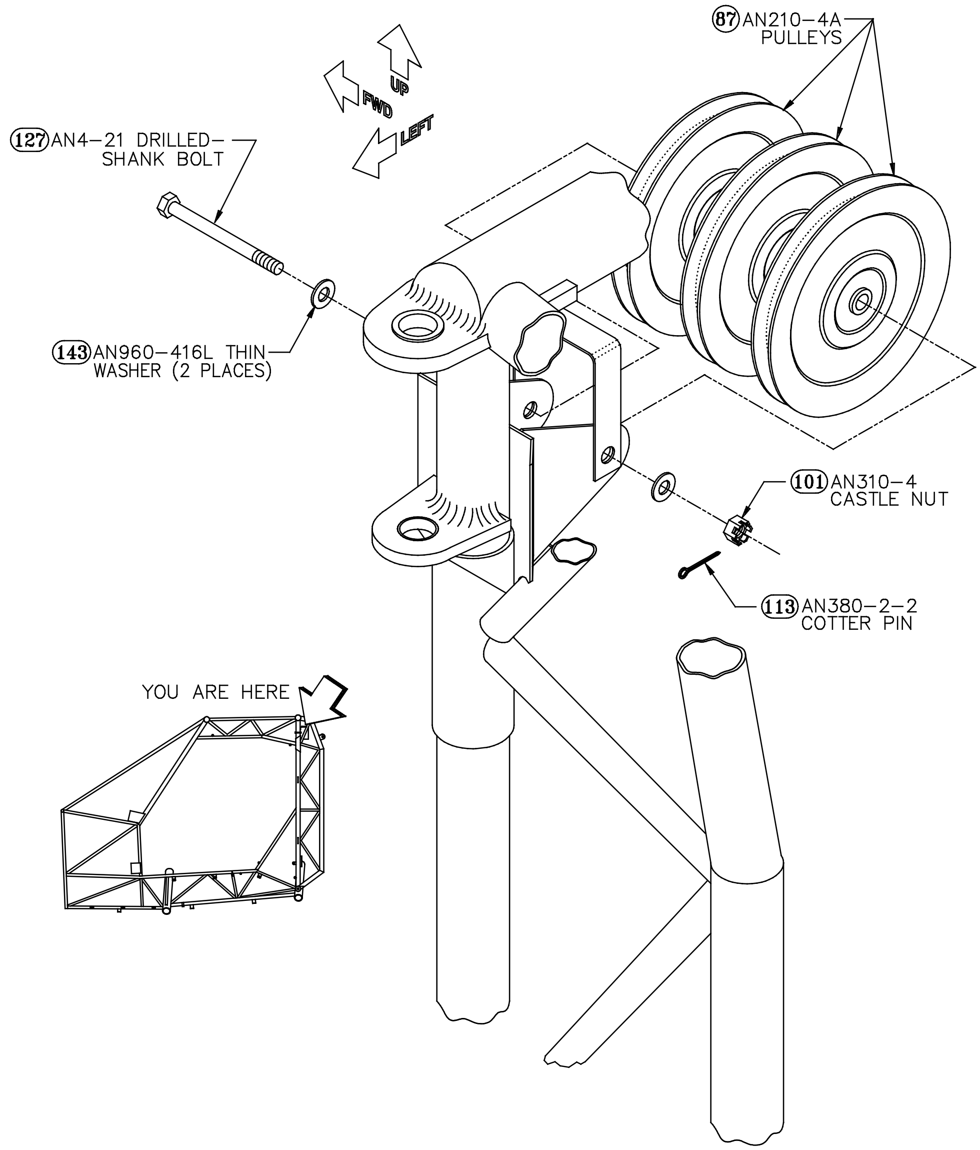

Figure 37: Upper Crossover Pulleys

Mount three AN210-4A pulleys between the arms at the upper aft corners of the fuselage cage on each side near the aft wing spar attach fittings, as shown in Figure 37. Secure the pulleys with AN4-21 **drilled-shank bolts** [127], AN960-416L thin washers, AN310-4 castle nuts and AN380-2-2 cotter pins.

Completed: [ ]

Step 19: Fabricate and Install the Bulkhead A Pulley Brackets

Two pairs of pulleys are installed on the aft side of Bulkhead A. Two of the pulleys guide the rudder control cables; the other two guide the elevator control cables. The pulleys are mounted in brackets fabricated from formed aluminum angle, as shown in Figure 38, and installed on the aft side of Bulkhead A, as shown in Figures 39 and 45.

To fabricate the Bulkhead A pulley brackets, first cut the **four** angles to length from the **.063" X 7/8" X 2-1/2" formed aluminum angle** [60], as shown in Figure 38. Separate the four angles into two pairs, and clamp each pair together with the narrow flanges of the angles nested together, as shown, and with the wide flanges spaced **1"** apart. Drill the two **#10** mounting holes through the base of each bracket pair and use AN3 bolts to bolt the two angles together.

Mark the side profile and the pivot hole and cable retainer hole locations onto the side of one of the angles of each pair. Clamp a 1"-thick wood block between the legs of the angles, and drill the holes all the way through both angles and the wood block from one side, being careful to keep the drill bit perpendicular. Use a hacksaw or a bandsaw to cut the angles to rough shape and then use a belt sander or files to finish the cuts. Also, cut the cable openings in the bases of the brackets, as shown, by first drilling **1/4"** holes in the corners of the openings and then removing the material between the holes. Round all corners, deburr and corrosion-proof the brackets.

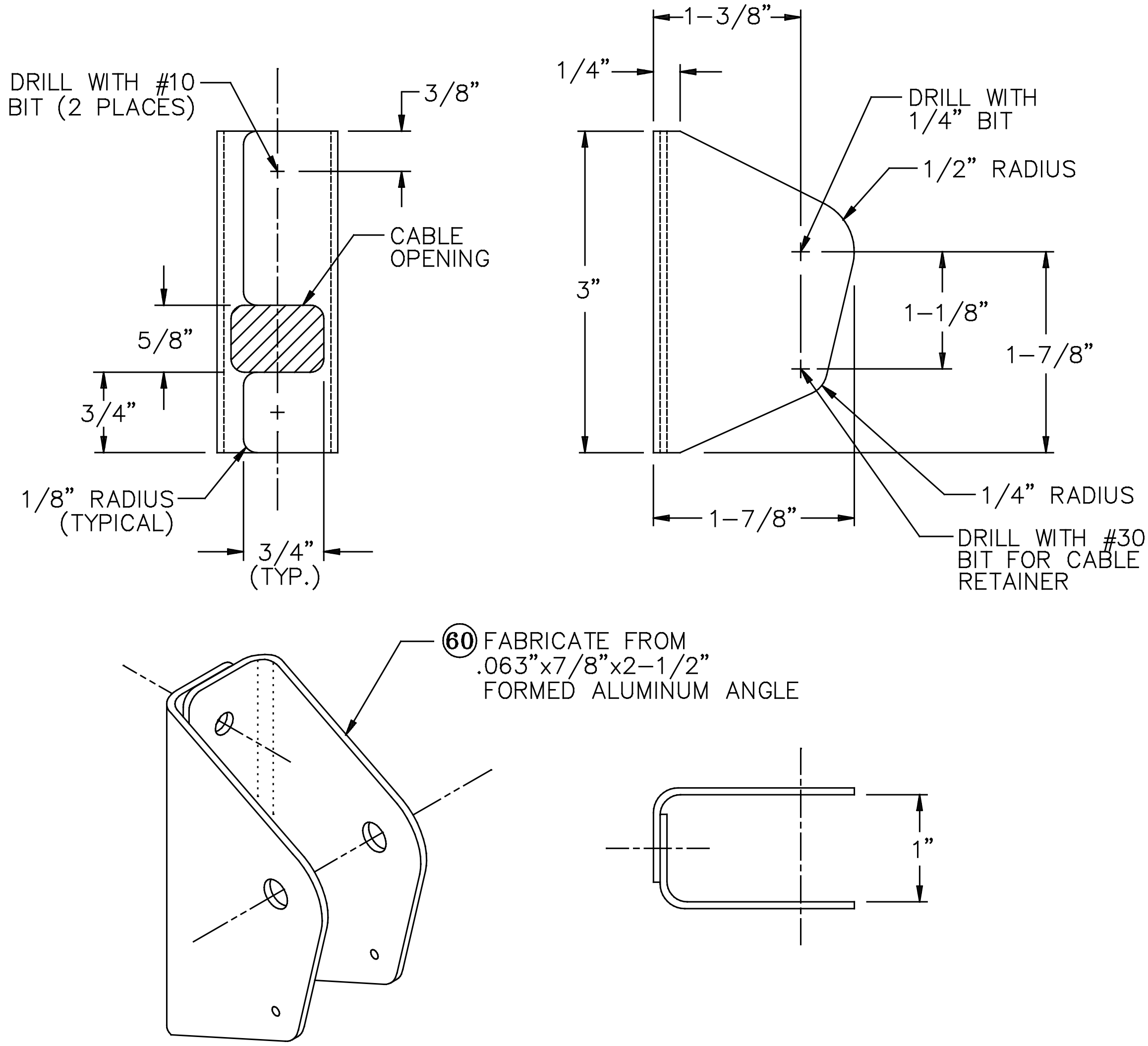

Figure 38: Bulkhead A Pulley Brackets

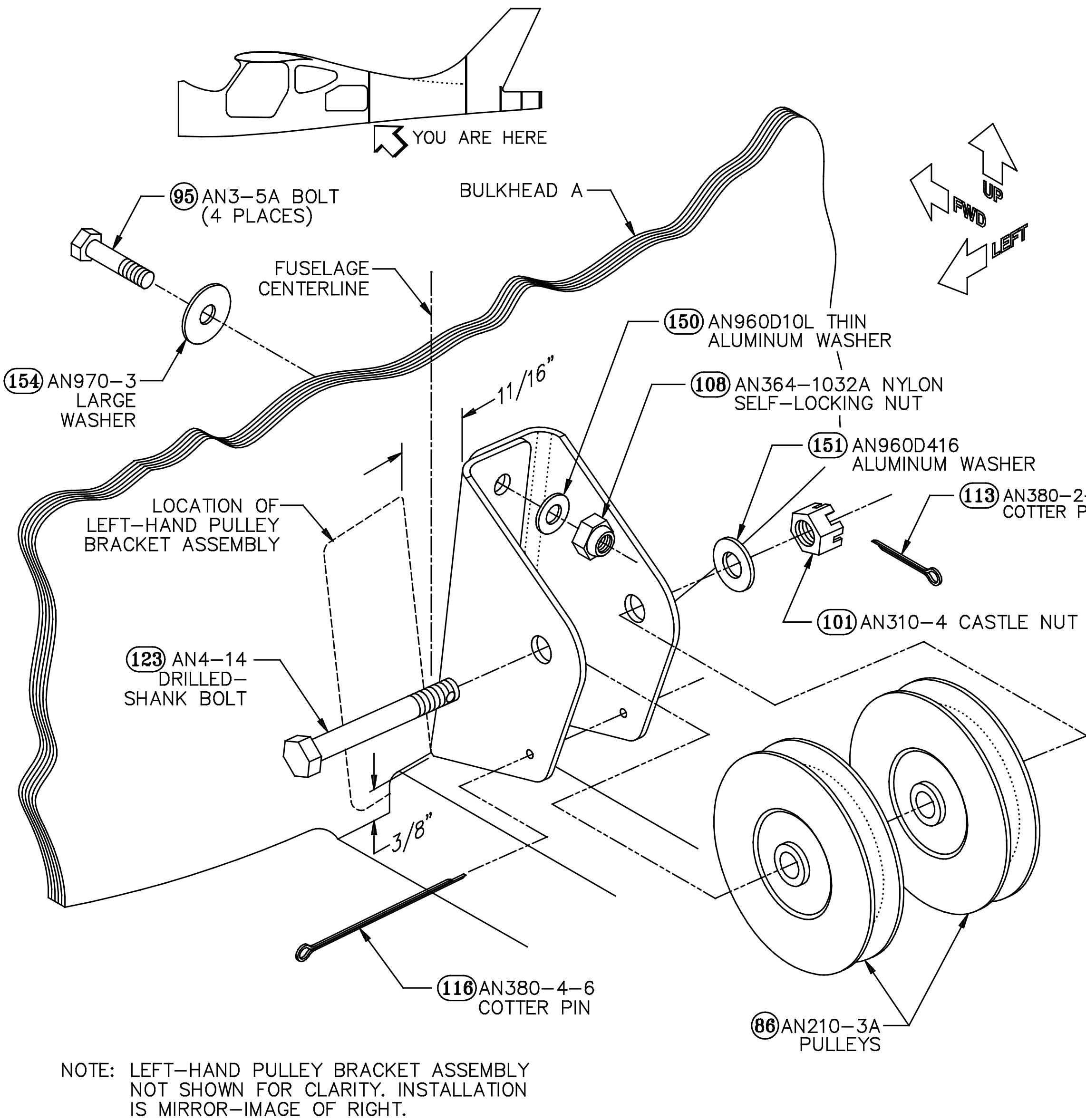

Figure 39: Bulkhead A Pulley Bracket Installation

Hold the two pulley bracket assemblies in position **3/8"** above the fuselage belly on the aft side of Bulkhead A and centered laterally in the fuselage, as shown in Figures 39 and 45. Angle the bracket assemblies with their bottom ends touching each other and their top ends **11/16"** apart (the top end of each bracket assembly is 11/32" outboard of the fuselage centerline). Use the mounting bolt holes in the brackets as guides to drill **#10** mounting holes through Bulkhead A.

Mark around the insides of the cable openings in the brackets onto Bulkhead A. Remove the brackets and cut away the bulkhead inside the marked areas so the cables can pass through.

Mount two AN210-3A pulleys between the legs of each pair of bracket angles, using an AN4-14 drilled-shank bolt, an AN960D416 **aluminum washer** [151], an AN310-4 castle nut and an AN380-2-2 cotter pin; place the heads of the bolts on the **inboard** sides of the brackets. Install AN380-4-6 **cotter pins** [116] as cable retainers with the heads on the **inboard** sides of the brackets; you'll probably have to flatten the heads of the cotter pins to eliminate interference between them when the brackets are installed.

Secure the brackets to the bulkhead with AN3-5A **bolts** [95], AN970-3 **large washers** [154], AN960D10L thin aluminum washers and AN364-1032A nylon self-locking nuts.

Completed: [ ]

Step 20: Install the Cable Fairleads

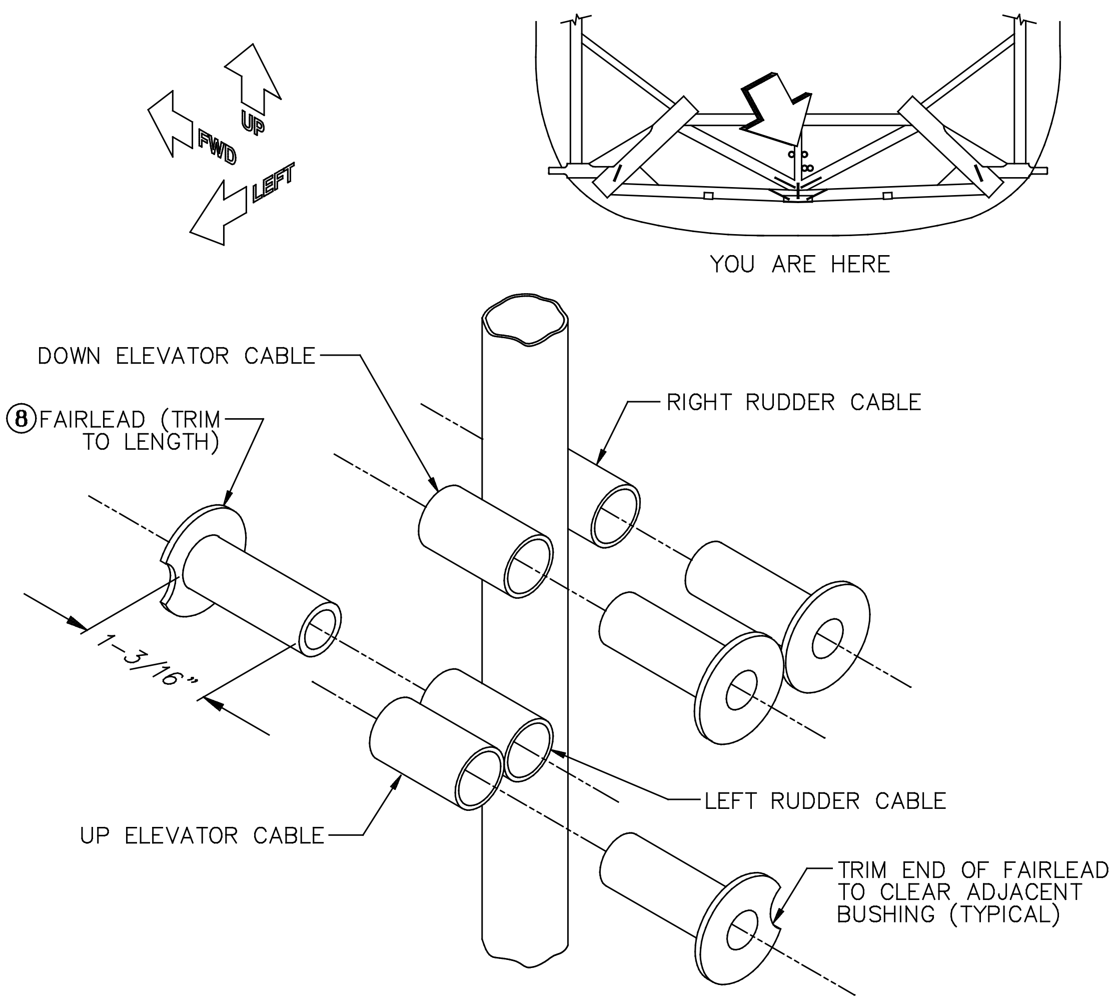

Figure 40: Cable Fairlead Installation

Four plastic **fairleads** [8] are installed in bushings welded to the aft end of the fuselage cage, as shown in Figure 40. The fairleads guide the rudder and elevator cables to provide proper clearance from the flap handle and control stick assemblies. Figure 40 also shows which fairlead guides each cable.

Cut the fairleads **1-3/16"** long, as shown. Relieve the "heads" of the left rudder cable and up elevator cable fairleads to clear the adjacent bushings in the fuselage cage.

Use a hammer to tap the fairleads into the bushings on the cage. Install the left rudder cable and up elevator fairleads from opposite ends of the cage bushings, as shown.

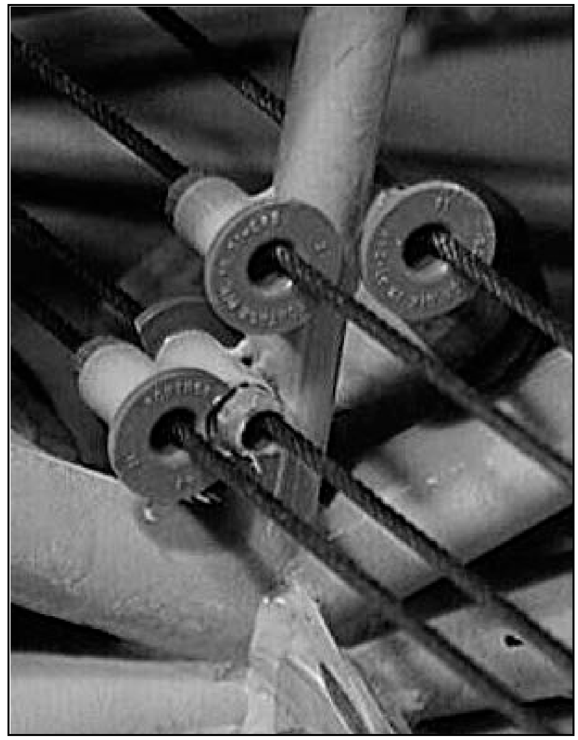

Figure 41: Cable Fairleads

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RUDDER CONTROL CABLES INSTALLATION

Figure 42 is a schematic of the rudder control cable system. The left rudder cable is routed aft from the actuator arm on the rudder control, under the small guide pulley in the forward pulley group (mounted in Step 13) and then through a fairlead at the aft end of the fuselage cage. The right cable is routed from the rudder control directly to its fairlead. From the fairleads, the cables run aft under the Bulkhead A pulleys to the horns on the rudder yoke. A turnbuckle is incorporated in the middle of each cable run (in the area just aft of the fuselage cage) for easy adjustment. Springs between the rudder controls and the fuselage cage maintain tension on the cables.

Note Before beginning installation of the rudder and other control cables, we recommend reviewing the general procedures described in "CONTROL CABLES" in "SECTION II: TOOLS AND TECHNIQUES."

Note Figure 42 shows the rudder spring installation for **early** GlaStar fuselage cages: the springs are attached to straight tabs on the cage by means of shackles and clevis pins. Later cages have bent tabs for attaching the springs; for these cages the springs are hooked directly to the tabs. Refer to Figure 46 in Step 22 for clarification.

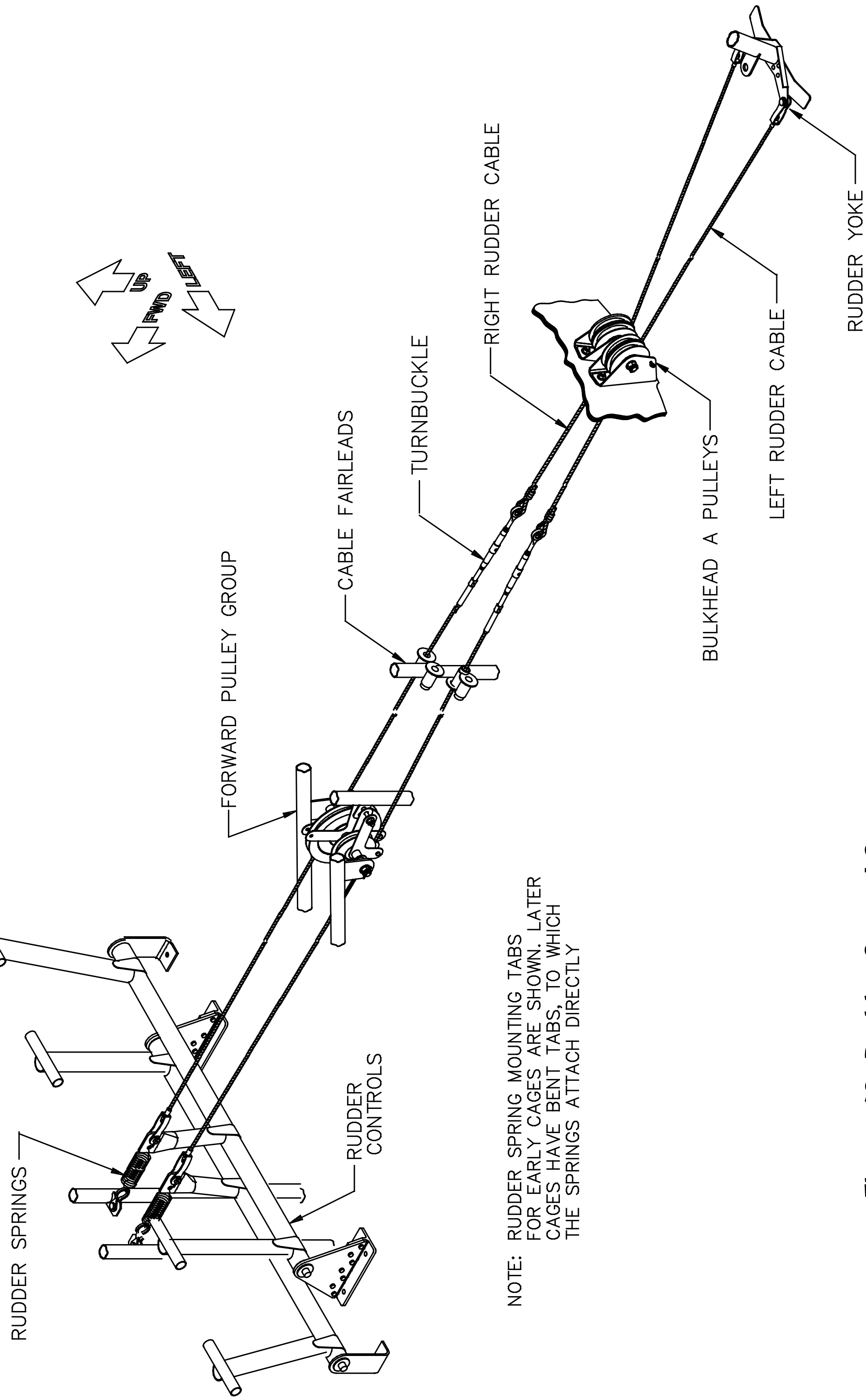

Figure 42: Rudder Control System

Step 21: Install the Forward Rudder Cables

Fasten the strap shackles at the ball ends of the **forward rudder cables** [63] to the **aft** holes in the rudder control uprights with AN393-13 **clevis pins** [119.1], AN960-10L thin washers and AN380-2-2 cotter pins, as shown in Figure 43. (To identify the forward rudder cables, they are about 69-1/2" long, measured from the attach holes in the strap shackles to the ends of the swaged turnbuckle ends.)

Note The space between the arms of the strap shackles can be increased or decreased by bending the arms apart with pliers or squeezing them together in a vise to more closely fit their attach points.

Route the left cable aft, under the small, AN210-3A guide pulley in the forward pulley group and then through the fairlead at the aft end of the fuselage cage. Route the right cable aft from the pedal stem directly to the fairlead. See Figure 40 to choose the correct fairlead for each cable.

Hint The swaged ends of the cables are a tight fit through the fairleads; you can use a 21/64" or 11/32" drill bit to ream the fairleads, if you wish, to make the cable installation easier.

Thread the swaged turnbuckle ends of the forward rudder cables into MS21251-B5S **turnbarrels** [159], as shown in Figure 43. Thread MS21255-5LS **cable eyes** [160] into the other ends of the turnbarrels. Adjust each turnbuckle so that all of the threads on both ends just disappear into the turnbarrel and both ends of each turnbuckle are threaded on an equal amount.

Note The swaged turnbuckle ends of the forward rudder cables have right-hand threads. The MS21255-5LS cable eyes have left-hand threads. The **externally-grooved** end of the turnbarrel is the end with the **left-hand** threads.

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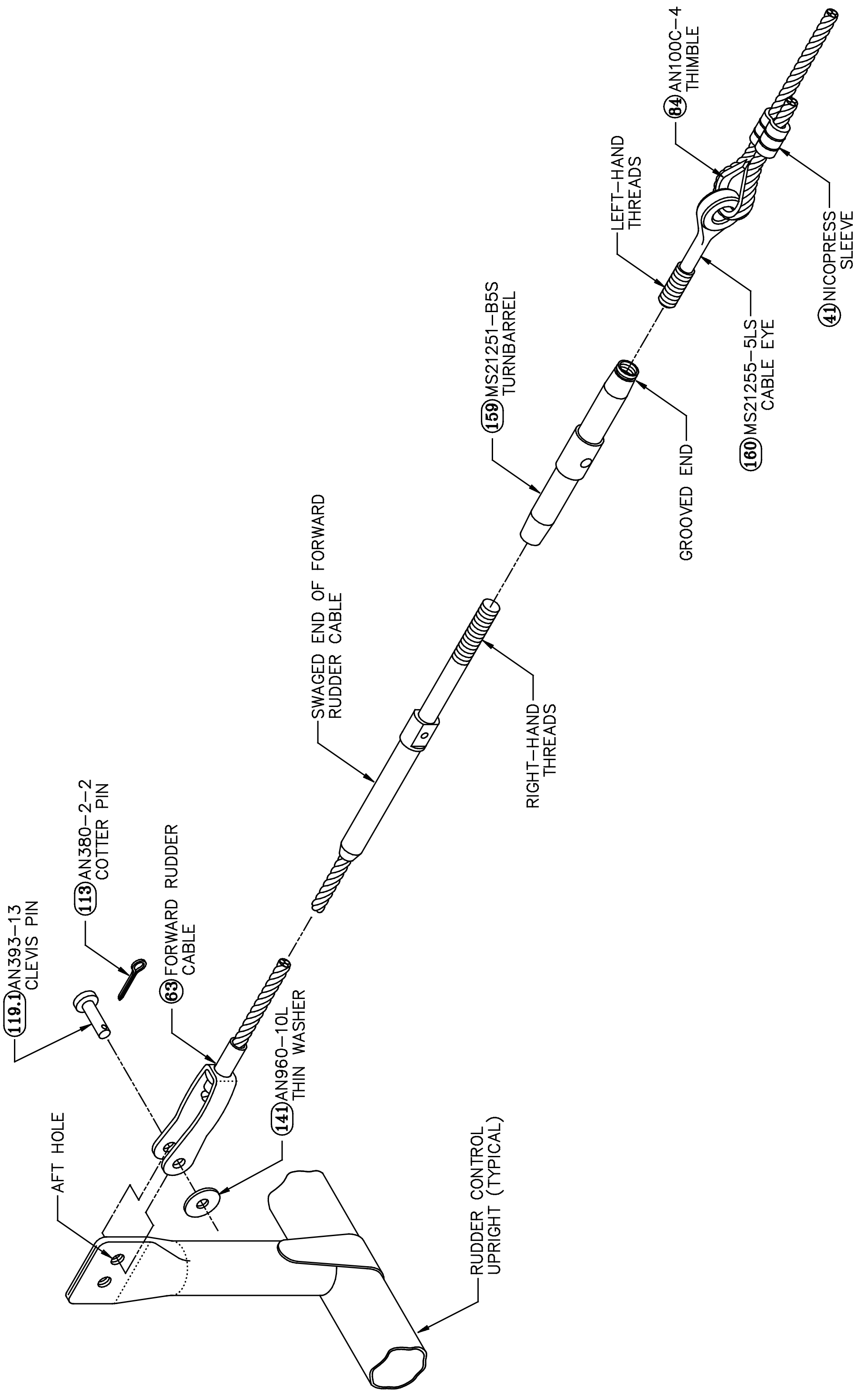

Figure 43: Forward Rudder Cable Installation

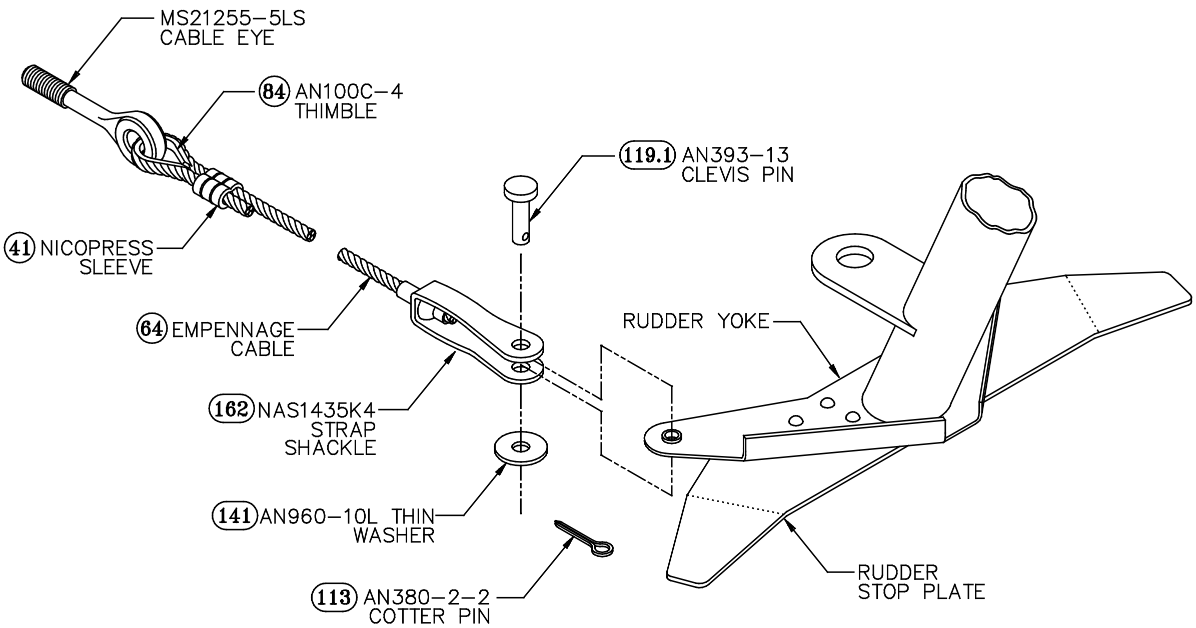

Figure 44: Aft Rudder Cable Attachment to Rudder Yoke

Step 22: Complete the Rudder Cable Installation

Slide NAS1435K4 **strap shackles** [162] onto two **empennage cables** [64], as shown in Figure 44, until the ball ends of the cables settle in the recesses of the shackles. (The empennage cables are about 10' long, with a swaged ball on one end and nothing on the other.) Use an AN393-13 clevis pin, an AN960-10L thin washer and an AN380-2-2 cotter pin to fasten the strap shackle end of an empennage cable to each arm of the rudder yoke weldment.

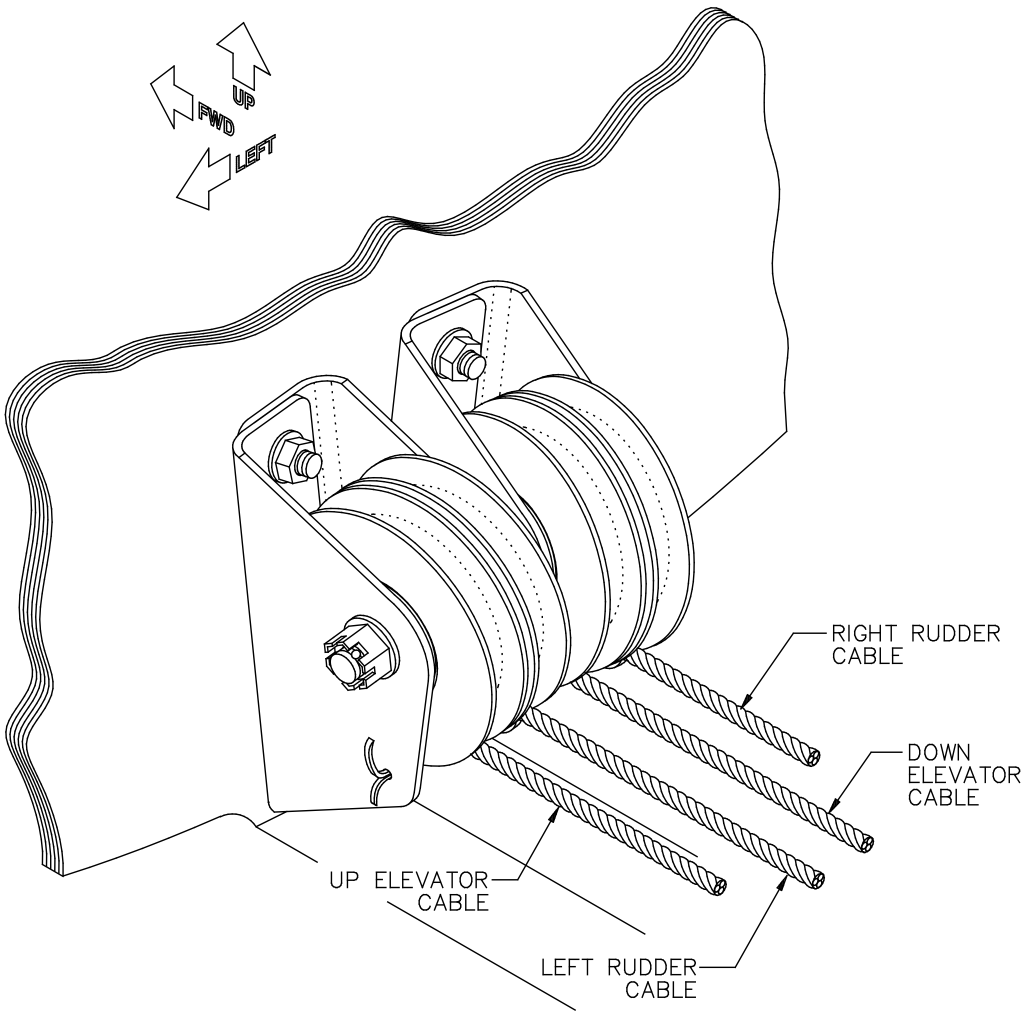

Figure 45: Cable Routing over Bulkhead A Pulleys

Route the two empennage cables forward to the Bulkhead A guide pulleys. Route the right cable under the **right** pulley in the **right-hand** pair of guide pulleys, as shown in Figure 45; route the left cable under the **right** pulley in the **left-hand** pair of guide pulleys.

Secure the rudder and the rudder pedals in the neutral positions.

> **Note** Refer back to Step 8 of this section for a description of the rudder pedal-neutral position.

Hint For the purposes of this step, you can assume that, when the rudder is in the neutral position, the forward rudder skin is aligned with the leading edge of the vertical fin; use tape to secure the rudder to the fin. (The true rudder-neutral position won't be known until the airplane has flown and any necessary rudder trim tab installed and adjusted.) Refer to Figure 14 for the rudder-pedal-neutral positions.

Pull the empennage cables forward from the Bulkhead A pulleys to the cable eyes in the aft ends of the forward rudder cable turnbuckle assemblies, being careful to properly match up the cables, right to right and left to left. Insert an AN100C-4 **thimble** [84] into each of the cable eyes in the forward cable turnbuckles. Slip a **NicoPress sleeve** [41] over the end of each empennage cable, thread the end of the cable around the thimble in the cable eye and back through the sleeve. Pull each cable taut and complete the NicoPress splice as described in "SECTION II: TOOLS AND TECHNIQUES."

Hint We recommend using 1/8" cable clamps (available at any hardware store) to temporarily secure the control cables during initial fit-up. The clamps make it easy to adjust the lengths of the cables and to keep the adjustment from slipping. (Don't tighten the clamps too much, however; light pressure is all that's needed. Over-tightening could kink the cable, which would ruin it.) Once the proper lengths of the cables have been determined, compress the NicoPress sleeves to finalize the cable installation, and then remove the temporary cable clamps

Remove whatever temporary fixtures you used to secure the rudder and rudder pedals in the neutral positions.

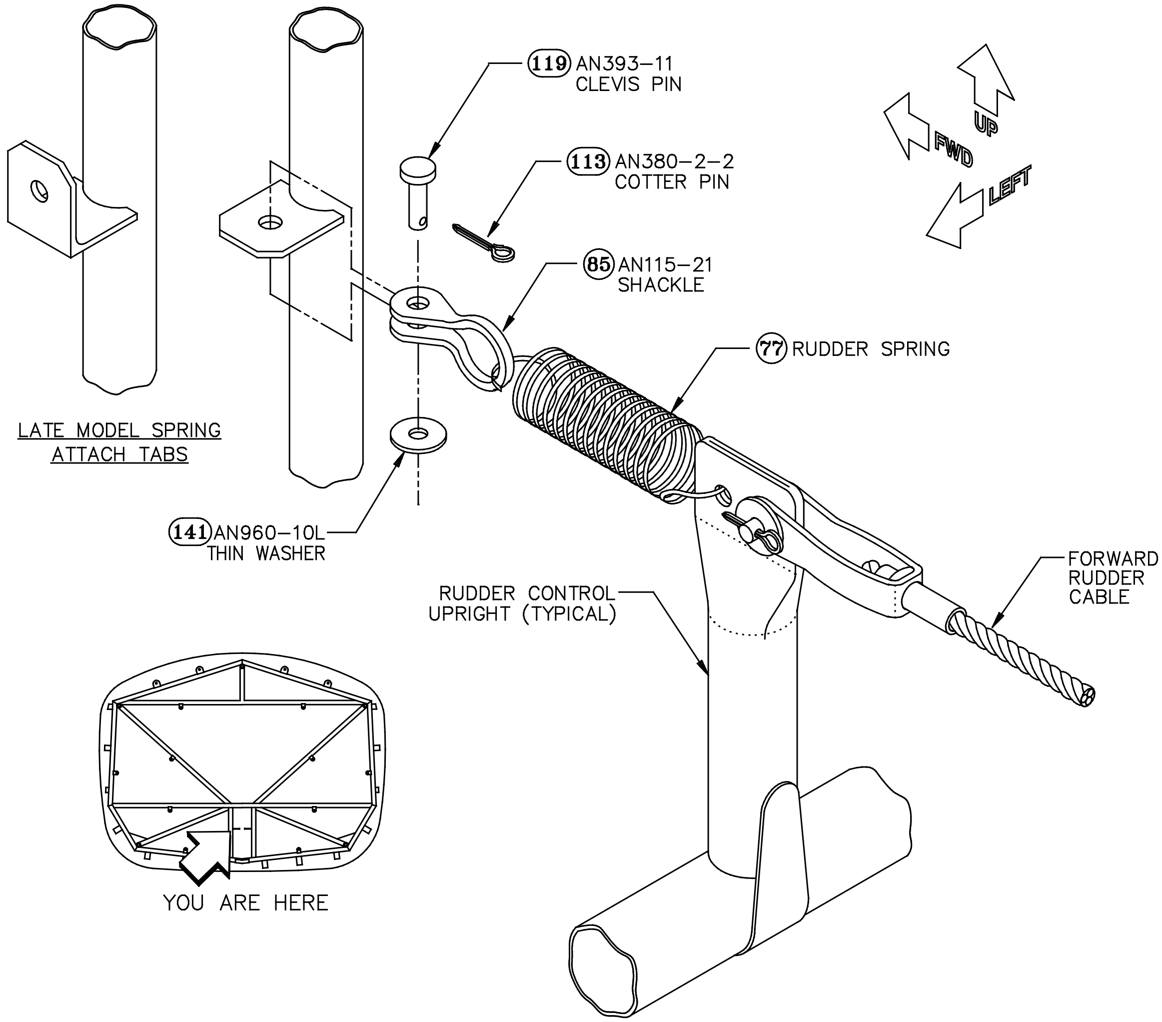

Figure 46: Rudder Control Spring Installation

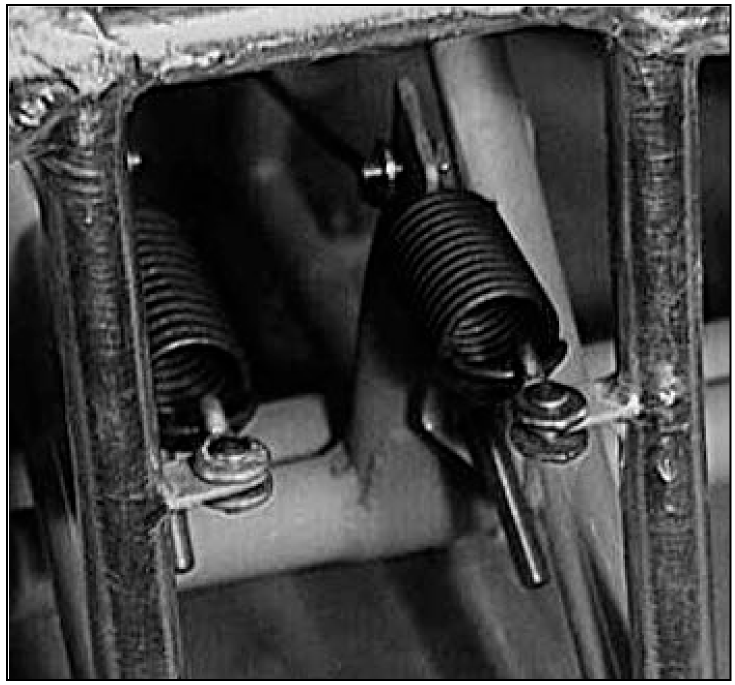

Figure 47: Rudder Control Springs

Install the **rudder control springs** [77] between the forward holes in the rudder control uprights and the fixed tabs on the fuselage cage, as shown in Figure 46. If the tabs on your fuselage cage are straight (early GlaStar fuselage cages), secure the springs to the cage with AN115-21 **shackles** [85], AN393-11 clevis pins, AN960-10L thin washers and AN380-2-2 cotter pins. If the tabs on the fuselage cage are bent like the attach tabs that secure the shell to the cage, just hook the springs directly to the tabs.

Adjust the cable turnbuckles so that the rudder pedals are neutral and the rudder is centered when there is no force on either pedal.

Note If you encounter difficulty stretching the springs to the cage tabs on later kits, make **extension links** from .063" thick 4130 steel sheet to fit between the springs and the cage tabs. Drill **3/16"** holes in both ends of the links and fasten them to the cage tabs with AN3-4 bolts. By making the extension links extra long and drilling a series of mounting bolt holes, the links can also provide an additional adjustment point in the system besides the turnbuckles. (The forward ends of the links will eventually have to be trimmed off, however, to provide clearance for the firewall.)

Note The turnbuckles will be safetied during final assembly, when the aircraft is being prepared for the first flight.

Completed: [ ]

ELEVATOR PUSHROD AND CONTROL CABLES INSTALLATION

The elevator bellcrank (mounted on Bulkhead C) is actuated by cables routed from the actuation stem on the elevator/aileron control yoke; a pushrod mounted between the bellcrank and the elevator horns completes the elevator control system (see Figure 48). The **up** elevator cable runs forward from the actuation stem to the elevator cable reversing pulley described in Step 13; the up cable then runs aft through a fairlead to the Bulkhead A pulleys and then to the **left** side of the elevator bellcrank. The **down** elevator cable routes directly aft from the actuation stem through a fairlead and the Bulkhead A pulleys to the **right** side of the elevator bellcrank.

Note When you have finished the procedures in this section, you will be ready to mount the wings to the fuselage, after which your first task will be to drill the outboard ends of the wing struts for attachment to the strut attach arms in the wing. To accomplish this task, you will need the Wing Strut Drill Jig Kit (P/N 981-03000-01), which is available on a rental basis from Stoddard-Hamilton. If you have not yet ordered the drill jig kit, do so now so that you will have it on hand when you need it.

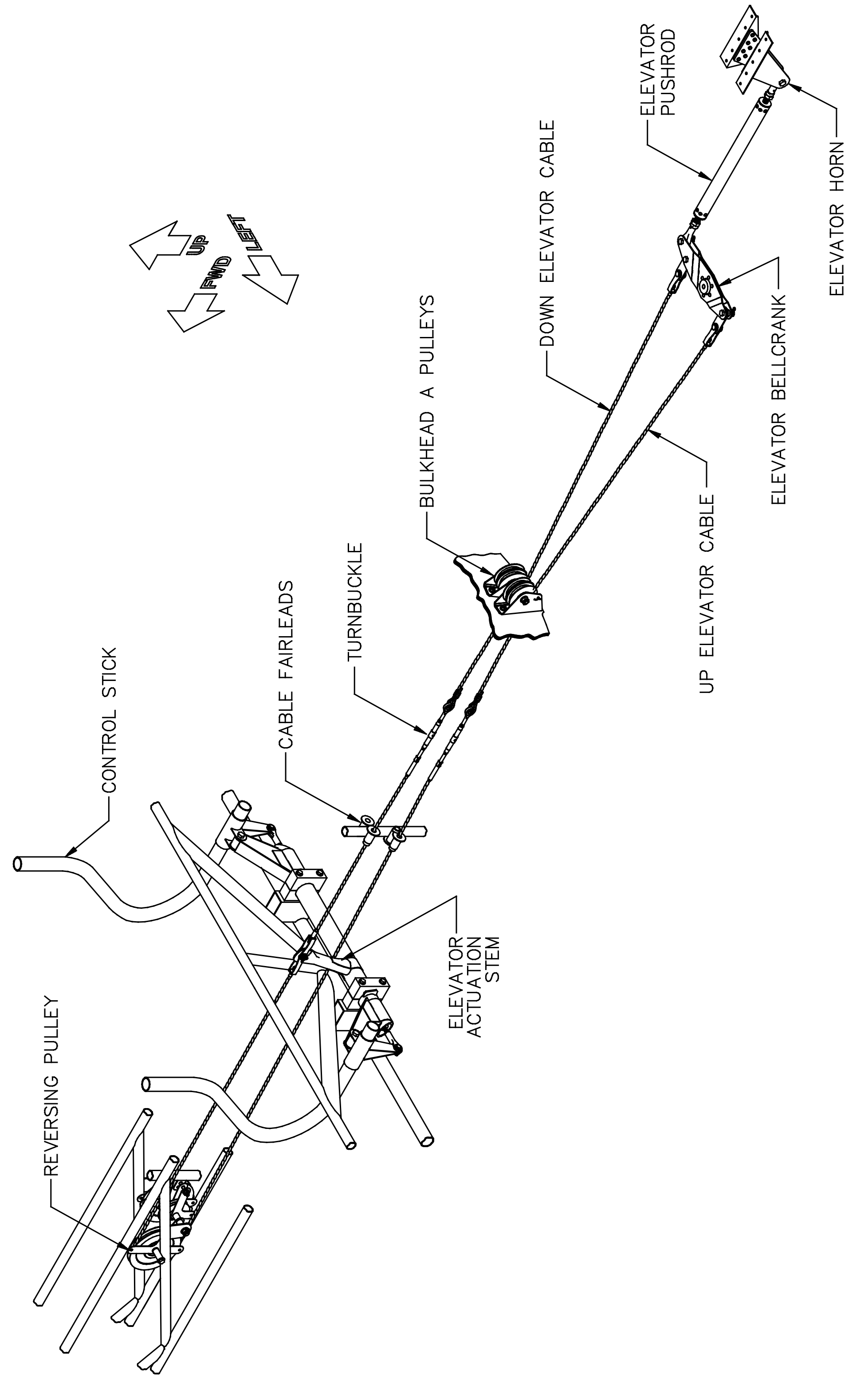

Figure 48: Elevator Control System

Step 23: Fabricate the Elevator Pushrod

The elevator pushrod is fabricated from **3/4" aluminum tubing** [80], as shown in Figure 51 (the tubing is 6061-T6 with a .058" wall thickness). Six **monel blind rivets** [76] are used at each end of the elevator pushrod to secure a **3/4" rod end insert** [43] in place.

In order to fabricate and install the elevator pushrod, holes must be drilled through Bulkheads D and E. To provide access for drilling the holes (and for the rest of the procedures in this step), remove the horizontal stabilizer and elevator (if installed) and the inter-bulkhead shearweb between Bulkheads C and D.

Drill a **1"**-diameter hole through **Bulkhead E**, **4"** above the bottom of the fuselage shell and **3/8"** to the **right** of centerline. This is the approximate location of the pushrod. Similarly, drill a **1"**-diameter hole through **Bulkhead D**, **4-1/2"** above the bottom of the shell and **1-1/2"** to the right of centerline. The two holes will be enlarged later, as necessary, to permit installation of the pushrod and to allow for its free movement.

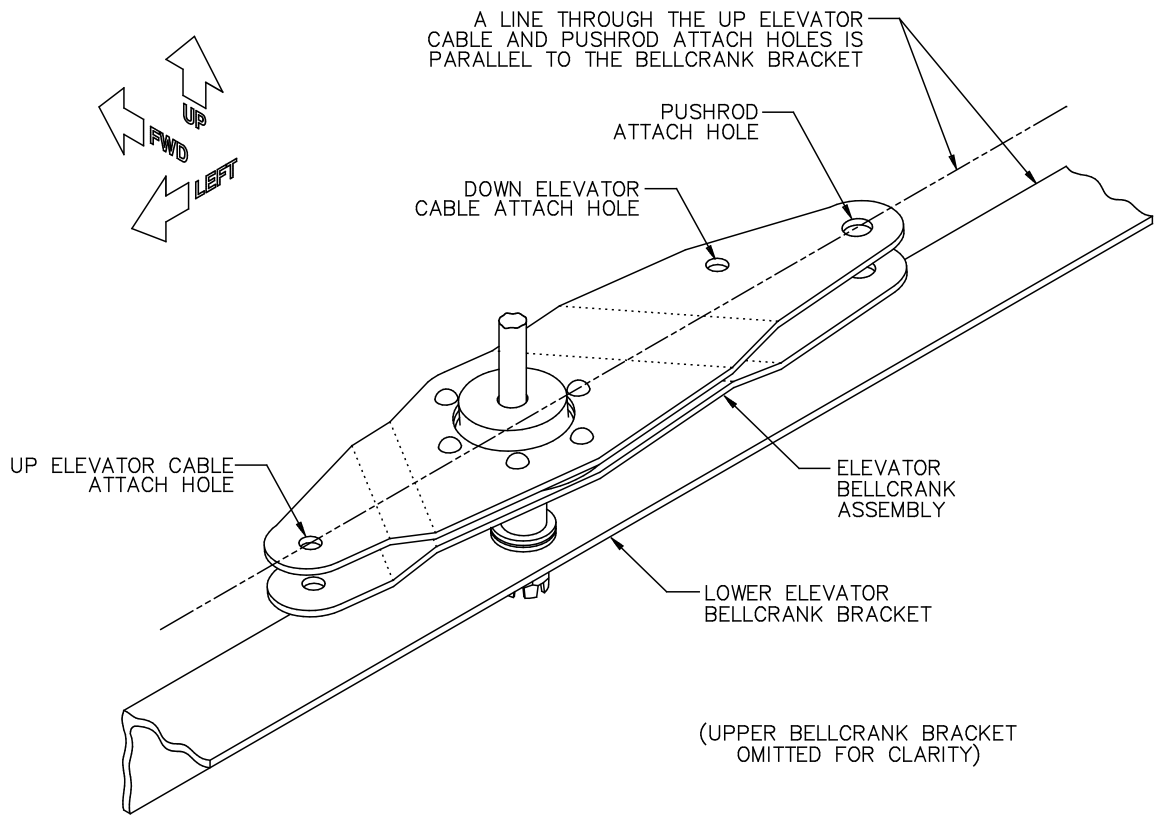

Figure 49: Elevator Bellcrank Neutral Position

Secure the elevator bellcrank in the neutral position. In the neutral position, a line through the attachment holes for the **up** elevator cable at the **left** end of the bellcrank and for the elevator **pushrod** at the **right** end is aligned parallel to the bellcrank brackets, as shown in Figure 49. (Use duct tape, safety wire, string, clamps or whatever works best for you to secure the bellcrank.)

> **Note** The **left** arm of the bellcrank has a single hole for attaching the **up** elevator cable. The **right** arm of the bellcrank has two holes: the inboard, 3/16"-diameter hole is for attaching the **down** elevator cable; the outboard, 1/4"-diameter hole is for attaching the pushrod.

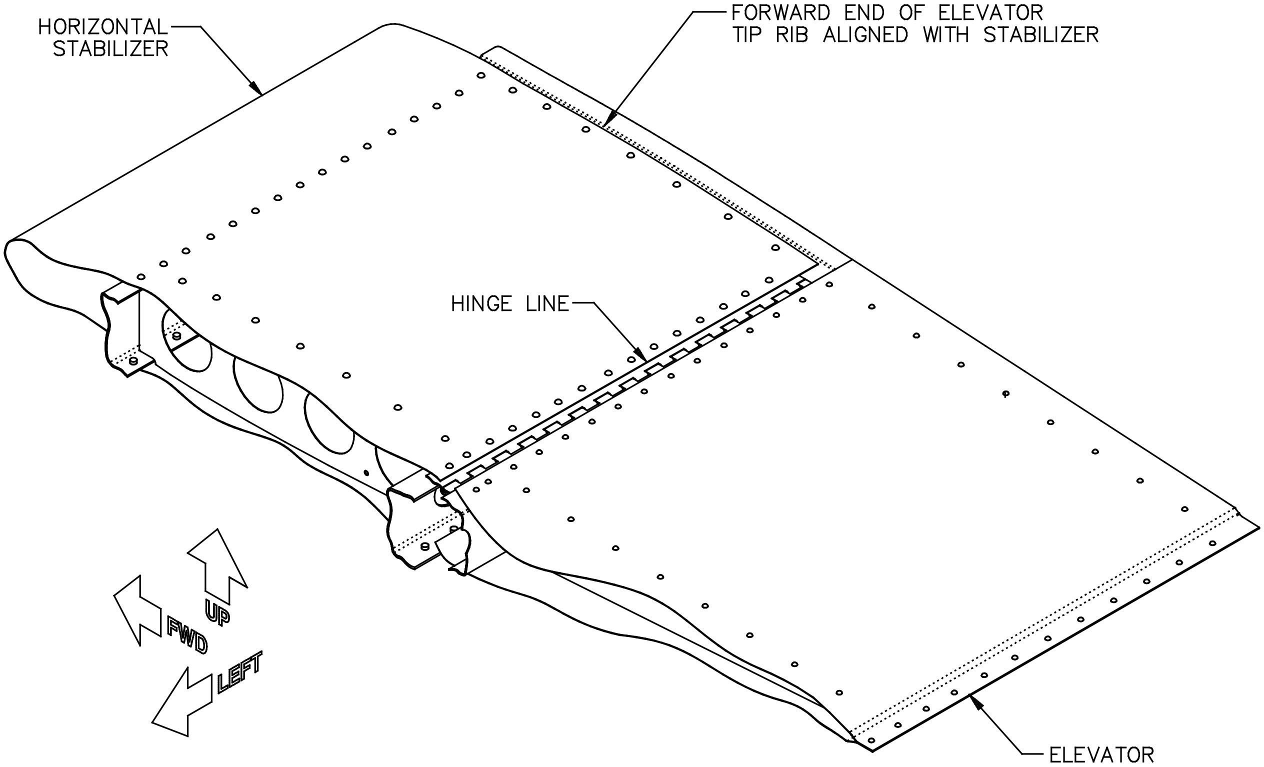

Figure 50: Elevator Neutral Position

Install the horizontal stabilizer/elevator assembly by sliding the alignment pins on the stabilizer forward spar into the bushings in the forward attach bracket bolted to Bulkhead D. Use AN4-10A **bolts** [121.1] to secure the stabilizer aft attach bracket to the nutplates installed on Bulkhead E.

Secure the elevator in the neutral position. (In the elevator-neutral position, the elevator tip ribs are aligned with the stabilizer, as shown in Figure 50.)

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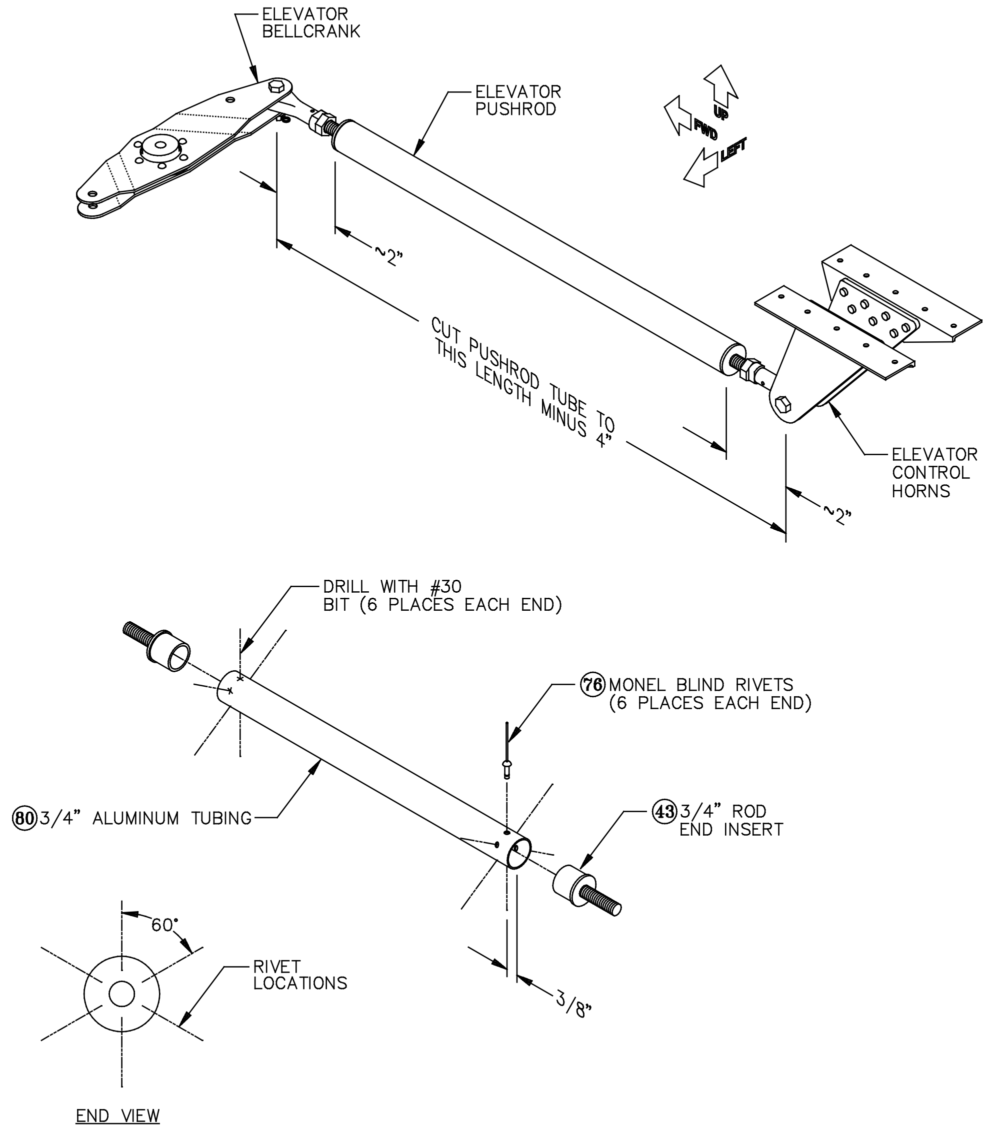

Figure 51: Elevator Pushrod Assembly

With the elevator and bellcrank in the neutral positions, measure the distance from the centers of the attach bolt holes in the elevator control horns to the center of the pushrod attach hole in the elevator bellcrank.

Hint Enlarge the holes in Bulkheads D and E, if necessary, to get a straight shot with your tape measure from the attach holes in the elevator horns to the pushrod mounting hole in the bellcrank. Insert a bolt into the hole in the bellcrank to provide a place to hook your tape measure.

Subtract **4"** from the measured distance and use a roller-type tubing cutter to cut the 3/4" aluminum tubing to the reduced length. (The 4" reduced length results from the fact that the rod end inserts and rod end bearings add about 2" to the length of the linkage at each end.) If you don't have a tubing cutter, you can use a bandsaw or a hacksaw to cut the tubing, but you will then have to carefully square the ends with a file while removing saw marks. No matter how you cut the tubing, deburr the ends after cutting.

Note If you use a tubing cutter, make sure the roller is smooth and turns freely. Inspect the end of the tube, after cutting, to make sure the roller hasn't indented it. A tube with a visible indent should not be used for the elevator pushrod.

At both ends of the tube, mark the locations of six rivet holes **3/8"** from the end, spaced equidistantly around the circumference of the tube, as shown in Figure 51. The holes are spaced **60°** apart from each other (or just over **3/8"** measured around the circumference of the tube).

Insert a 3/4" rod end insert into each end of the tube and center punch the six rivet hole locations at each end with the inserts in place. Drill the six holes at each end with a **#30** bit, preferably using a drill press. Remove the inserts and deburr the holes in the parts. Corrosion-proof the tube and the inserts.

Note It is especially important to corrosion-proof the tube and the inserts where they contact each other. The parts are made from dissimilar metals (aluminum and steel), which increases the opportunity for corrosion when moisture is present.

Rivet the rod ends to the tube with six monel blind rivets at each end.

Warning Be absolutely certain that you use the correct rivets. Do not substitute aluminum blind rivets for this application. The monel rivets provide greater shear strength to this flight-critical junction.

Completed: [ ]

Step 24: Install the Elevator Pushrod

Thread an AN316-5R **jam nut** [106] and a **rod end bearing** [23] onto each end of the elevator pushrod, as shown in Figure 52, and adjust the rod ends so that the pushrod will bolt between the attach holes in the bellcrank and the elevator horn when the bellcrank and elevator are in the neutral positions. Lock the rod end bearings in place by tightening the jam nuts against them.

> **Warning** Each rod end bearing must be threaded onto the rod end insert's stud past the inspection hole in the bearing. Use a stiff wire inserted into the inspection hole to feel for the end of the stud. If the wire passes through the inspection hole in the bearing without contacting the rod end insert, an unsafe condition exists and the bearing must be threaded on farther.

Remove the horizontal stabilizer and elevator, once again, to provide access for connecting the pushrod to the bellcrank. Use files or a drum sander on a die grinder to enlarge the holes in Bulkheads D and E, as necessary, to permit installation of the pushrod.

At the forward end, fasten the pushrod to the bellcrank with an AN4-12 **drilled-shank bolt** [122], an AN960D416 aluminum washer, an AN310-4 castle nut and an AN380-2-2 cotter pin, as shown in Figure 52.

> **Note** The AN4-12 bolt is longer than it needs to be to secure the elevator pushrod; the extra length accommodates the thickness of the elevator control stop plate, which will be fastened to the bottom of the bellcrank in "SECTION X: FINAL ASSEMBLY." For now, use extra washers as necessary to tighten the bolt.

After the elevator control cables have been completed, as described in the next step, reinstall the inter-bulkhead shearweb and the horizontal stabilizer/elevator assembly. Fasten the pushrod to the elevator control horns with an AN4-17 drilled-shank bolt, two NAS42DD8-19 **aluminum spacers** [164] (one on each side of the rod-end bearing), an AN960D416 aluminum washer, an AN310-4 castle nut and an AN380-2-2 cotter pin.

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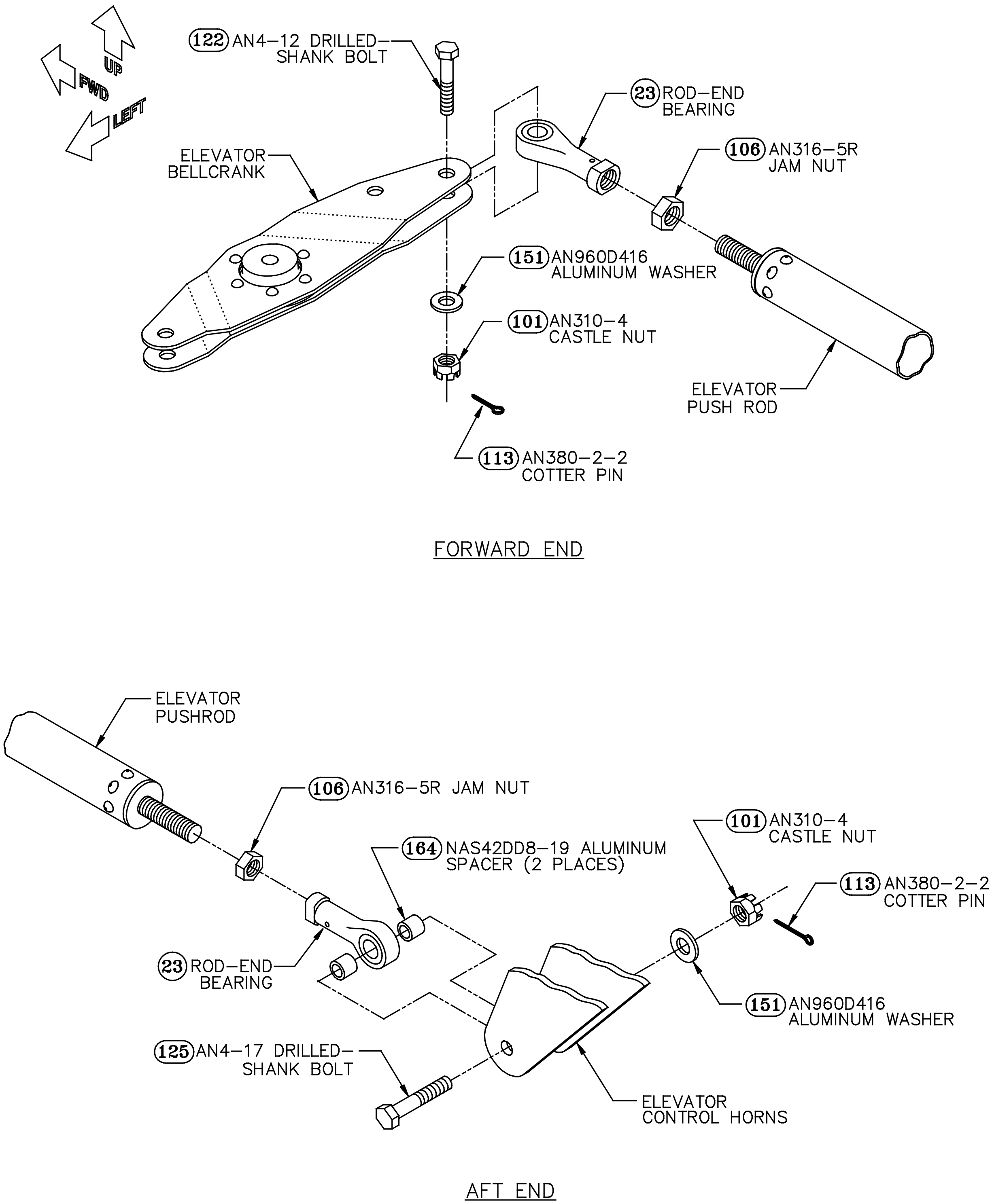


Figure 52: Elevator Control Pushrod Installation

Step 25: Install the Elevator Control Cables

As shown in Figure 53, fasten the strap shackle ends of the **elevator up cable** [66] and the **elevator down cable** [65] to the actuation stem of the elevator/aileron control yoke, using an AN393-19 **clevis pin** [121], an AN960-10 washer and an AN380-2-2 cotter pin. (The elevator **up** cable is about 60" long, measured from the attach holes in the strap shackle to the end of the turnbuckle end; be careful not to confuse this cable with the **aileron primary actuation cables** [71], which are about 66" long. The elevator **down** cable is about 40" long from the hole in the strap shackle to the end of the turnbuckle end. The turnbuckle ends on both elevator cables are right-hand threaded.)

Run the elevator **up** cable forward from the actuation stem, **over** the elevator cable reversing pulley (shown in Figures 23 and 25), and then aft through the fairlead at the aft end of the cage, as shown in Figure 48. Run the elevator **down** cable aft through the fairlead. (Use the proper fairleads shown in Figure 40 for the two cables.)

Thread the aft ends of the elevator up and down cables into MS21251-B5S turnbarrels, just like the aft ends of the forward rudder cables shown in Figure 43. Thread MS21255-5LS cable eyes an equal distance into the other ends of the turnbarrels. Adjust the turnbuckles so the threads on both ends just disappear into the turnbarrels.

Note The initial turnbarrel adjustment is critical. If the ends are threaded in too far initially, there won't be enough adjustment range available later for tensioning the cables. (The cables will be tensioned during final assembly.)

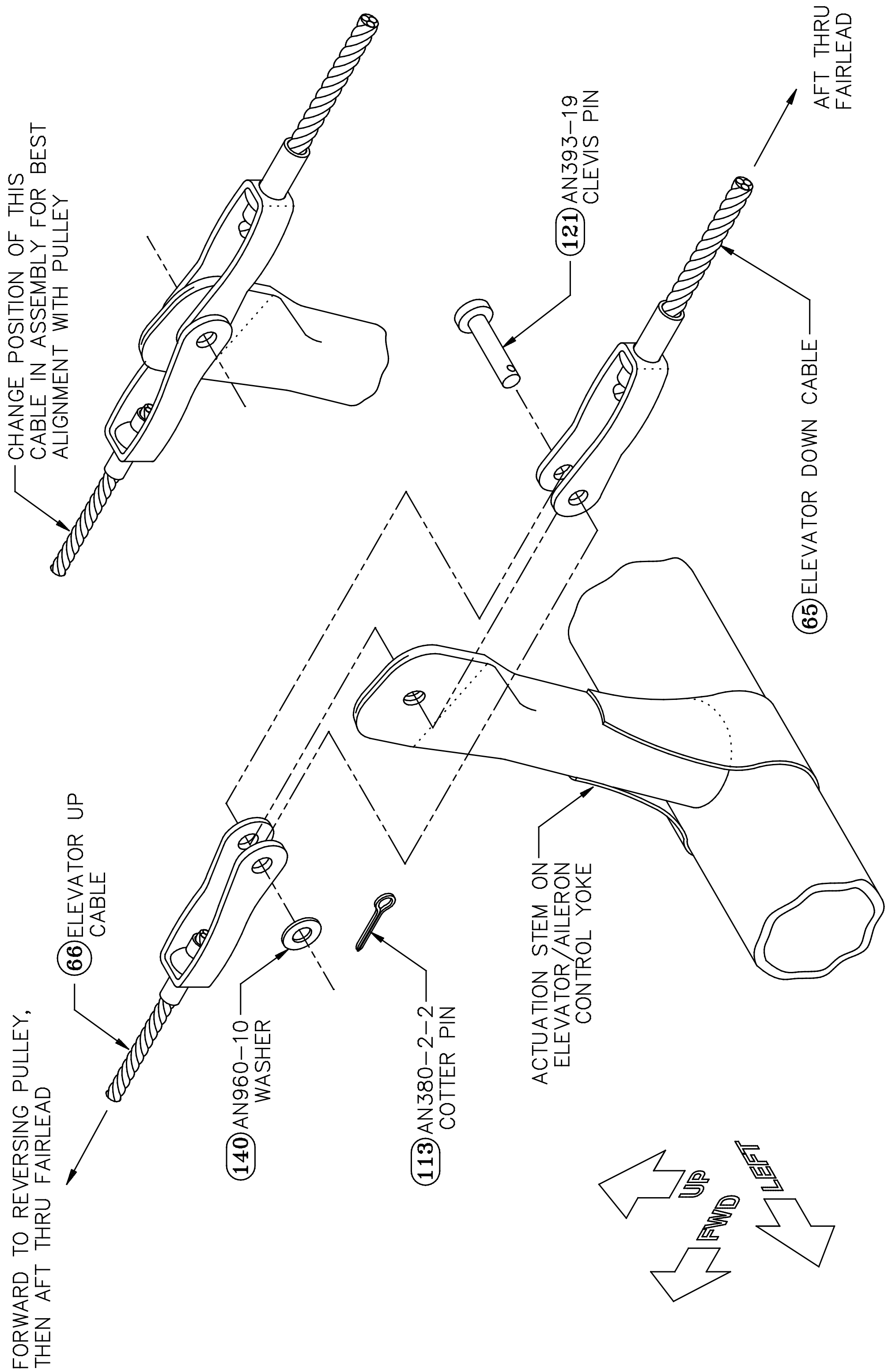
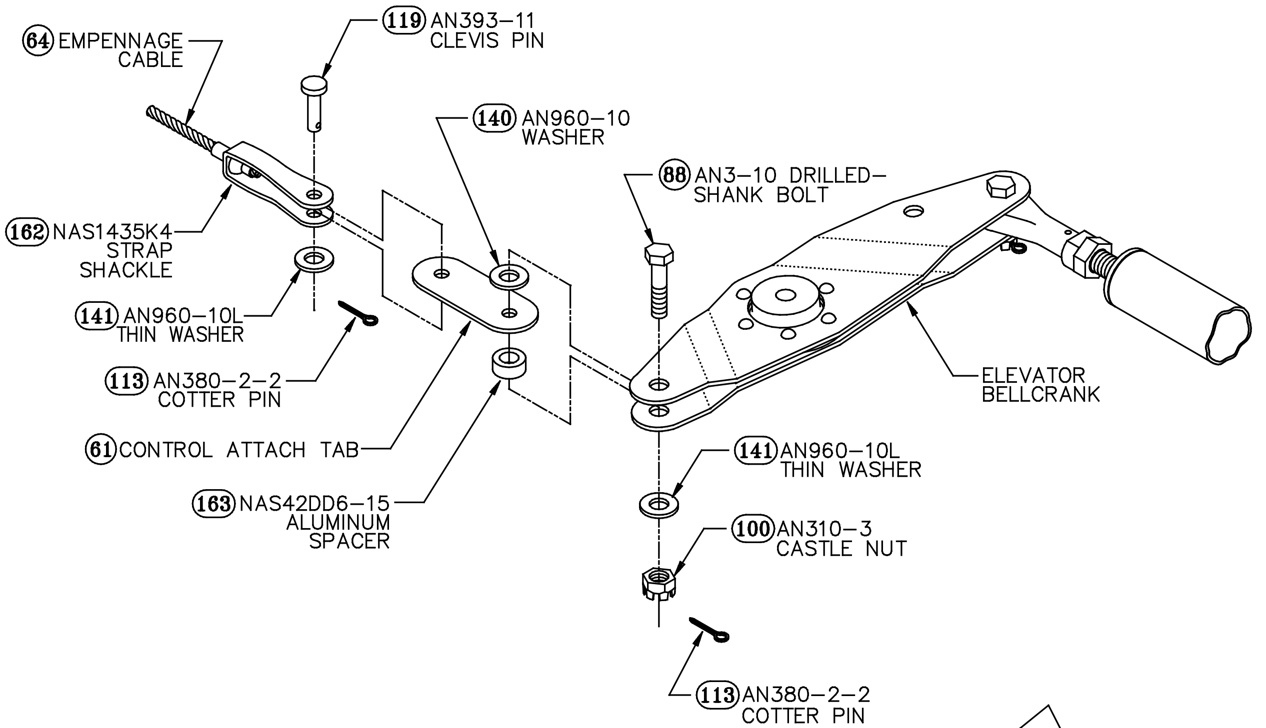


Figure 53: Forward Elevator Cable Assemblies



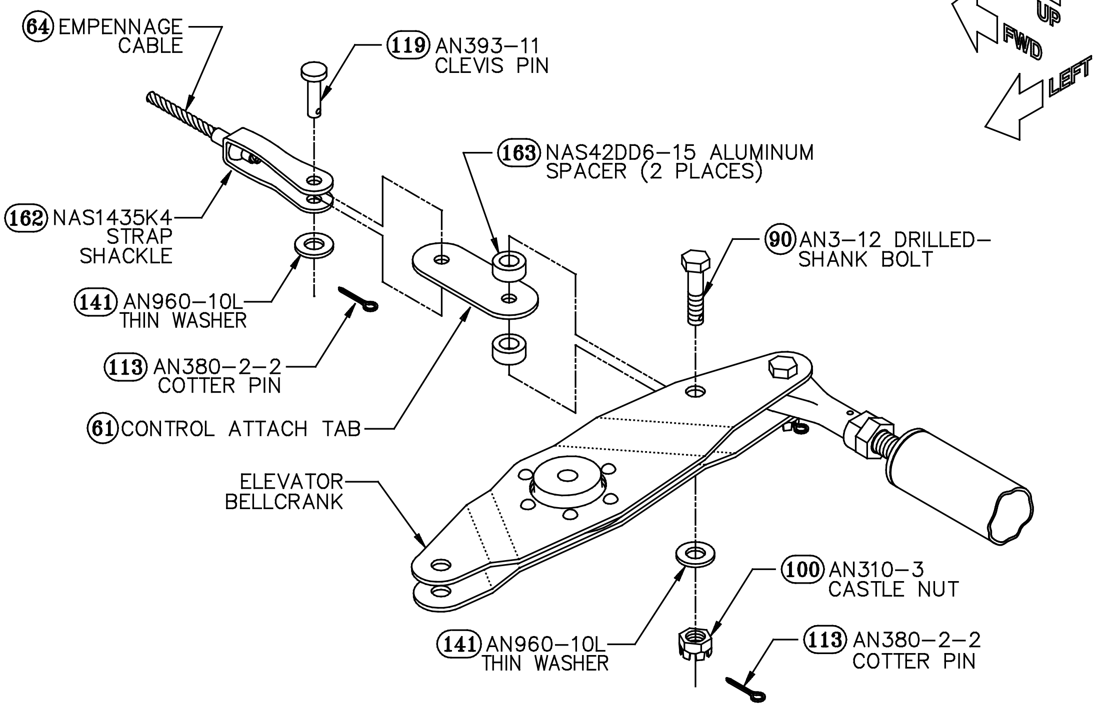


Figure 54: Aft Elevator Cable Attachment

Use an AN3-10 **drilled-shank bolt** [88], one NAS42DD6-15 **aluminum spacer** [163], an AN960-10 washer, an AN960-10L thin washer, an AN310-3 castle nut and an AN380-2-2 cotter pin to secure a **control cable attach tab** [61] to the **left** arm of the elevator bellcrank, as shown in Figure 54. Similarly, use an AN3-12 **drilled-shank bolt** [90], two NAS42DD6-15 aluminum spacers, an AN960-10L thin washer, an AN310-3 castle nut and an AN380-2-2 cotter pin to secure a control cable attach tab to the **right** arm of the elevator bellcrank.

Note The AN3-10 and AN3-12 bolts are longer than they need to be to secure the cable-attach hardware; the extra length accommodates the thickness of the elevator control stop plate, which will be fastened to the bottom of the bellcrank in "SECTION X: FINAL ASSEMBLY." For now, use extra washers as necessary to tighten the bolts.

Slide an NAS1435K4 strap shackle onto each of the two remaining empennage cables until the swaged ball nestles in the recess in the shackle, as shown in Figure 54. Use an AN393-11 **clevis pin** [119], an AN960-10L thin washer and an AN380-2-2 cotter pin to fasten the strap shackle end of an empennage cable to each of the cable attach tabs on the elevator bellcrank.

Hint You will probably find it easier to make all the connections described in the last two paragraphs if you remove the bellcrank from the fuselage.

Stretch the empennage cables forward toward Bulkhead A. Route the **down** elevator cable (the cable fastened to the **right** side of the elevator bellcrank) under the **left** pulley in the **right-hand** pair of Bulkhead A pulleys, as shown in Figure 45. Route the **up** elevator cable under the **left** pulley in the **left-hand** pair of Bulkhead A pulleys.

Pull the empennage cables forward from the Bulkhead A pulleys to the cable eyes in the aft ends of the up and down elevator cable turnbuckle assemblies. Insert an AN100C-4 thimble into each of the cable eyes in the turnbuckles.

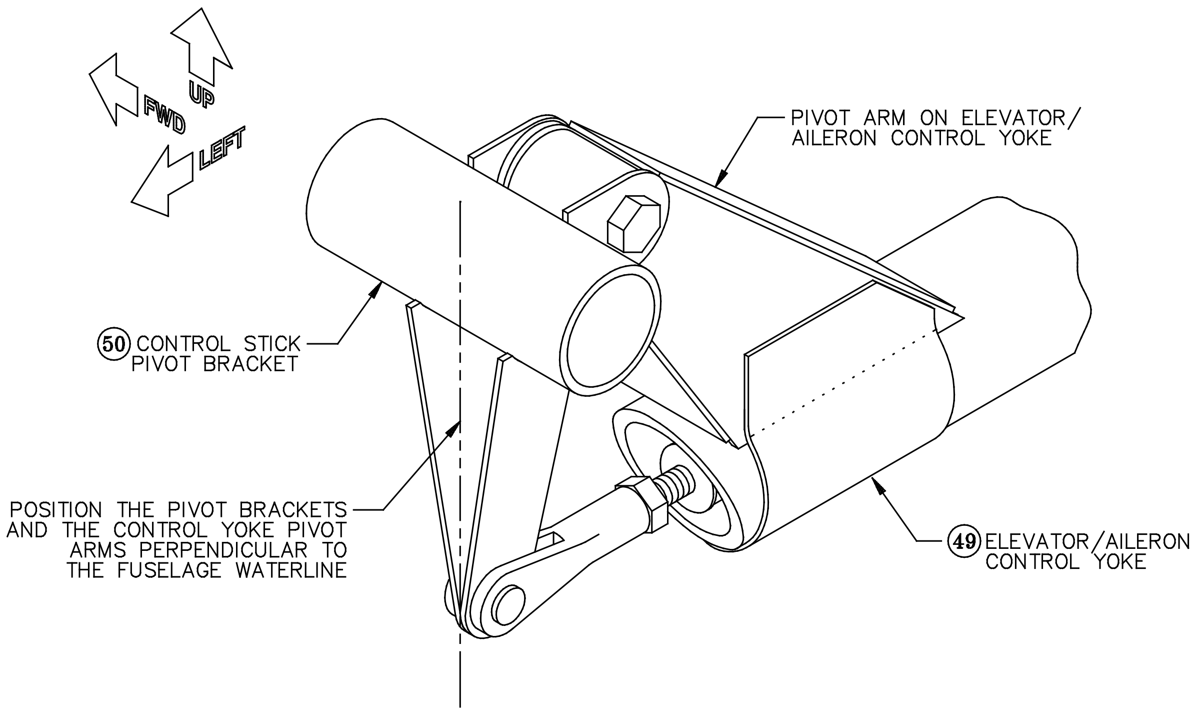


Figure 55: Control Yoke Neutral Position

Before the elevator control cables can be completed, the elevator and the elevator/aileron control yoke must be secured in their neutral positions.

In the control yoke neutral position, the control stick pivot brackets and the pivot arms of the control yoke are perpendicular to the fuselage waterline, as shown in Figure 55. Level the fuselage longitudinally using the waterline marks on the fuselage shell (refer to Step 33 in "SECTION VIII: FUSELAGE ASSEMBLY"), and then use a spirit level or a plumb bob to set the pivot arms and the pivot brackets in the vertical position.

Reinstall the horizontal stabilizer/elevator assembly, and then attach the aft end of the elevator pushrod to the elevator horns, using the hardware shown in Figure 52. Secure the elevator in its neutral position by aligning the elevator tip ribs with the stabilizer and taping or clamping them in this position.

Slip a NicoPress sleeve over the forward end of each empennage cable, thread the end of the cable around the thimble in the cable eye and back through the sleeve, and pull the cable taut. Verify that the aft empennage cables have been connected to the correct turnbuckles, as shown in Figure 48, and complete the NicoPress splices as described in "SECTION II: TOOLS AND TECHNIQUES."

Note The elevator control system will be checked for the specified control surface travel during final assembly when the airplane is being prepared for first flight. At the same time, the elevator cables will be adjusted to the proper tension and safetied.

Completed: [ ]

Mounting the Wings to the Fuselage

At this time, the wings are mounted to the fuselage temporarily so that the aileron and flap control cables can be routed and installed.

Note In order to complete the procedures in this section, you will need the Wing Strut Drill Jig Kit (P/N 981-03000-01) available for rent from Stoddard-Hamilton. The drill jig and its use is described in detail in Step 33, below.

Hint We recommend resting the fuselage on its belly (adequately supported with pads to prevent damage, of course) to install the wings; this positions the wings at a more accessible height for drilling the wing struts and working on the control systems.

Step 26: Install the Inboard Wing Strut Fittings

If you don't have an arbor press, use a large C-clamp or a bench vise to press two NAS75-8-016 **plain steel bushings** [169] into a **fuselage wing strut attach fitting** [27], as shown in Figure 56.

Hint Apply corrosion-proofing primer to the outsides of the bushings and press them in while still wet; besides helping prevent corrosion on the contact surfaces between the bushings and the fitting, this will lubricate the bushings for insertion.

Insert the strut fitting into the end of the **wing strut** [26] with the pre-drilled holes, as shown. Use an AN6-24A **bolt** [135] inserted through the 3/8"-diameter hole (the hole closest to the end of the strut tube) to pin the two parts together. Insert the end of a 23/64" drill bit into the second hole to align the parts. Run a .3745" reamer through the second hole from the other side, pushing the 23/64" drill bit out as you go. (A .3745" reamer is supplied with the Wing Strut Drill Jig Kit.) Be careful to keep the reamer perpendicular to the strut; have a helper assist you with alignment.

Remove the fuselage wing strut attach fitting from the wing strut and deburr the newly reamed holes in both parts.

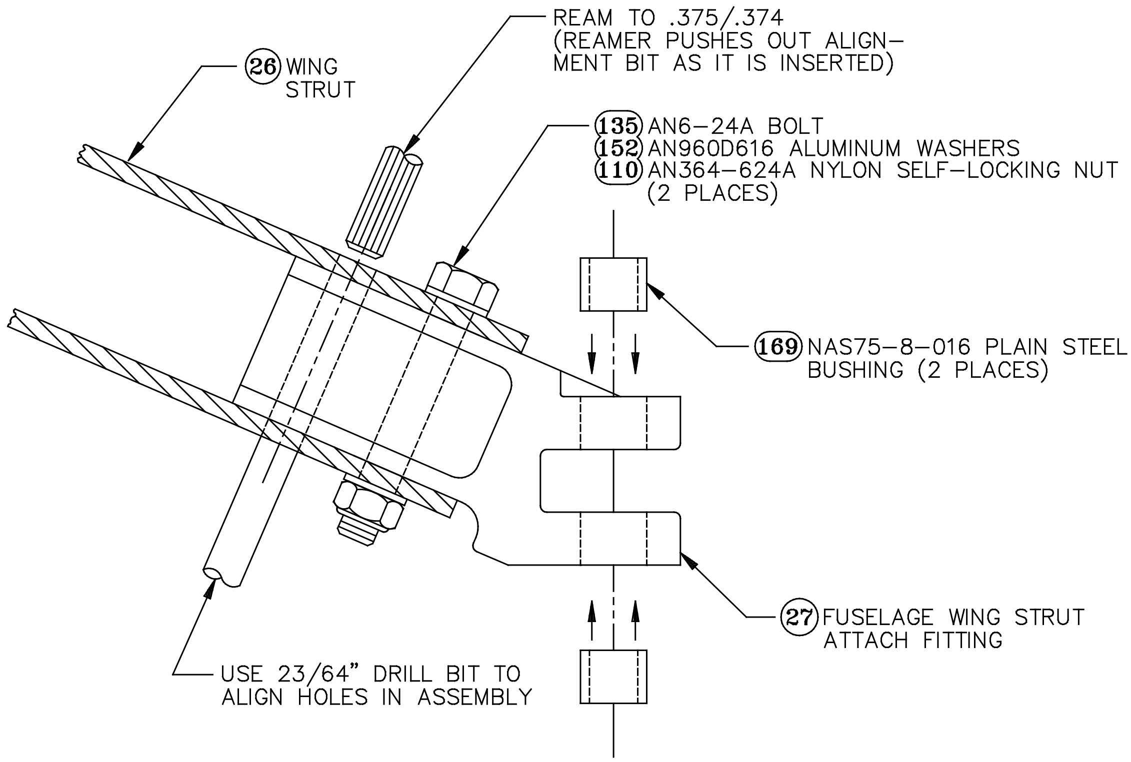


Figure 56: Fuselage Wing Strut Fitting Installation

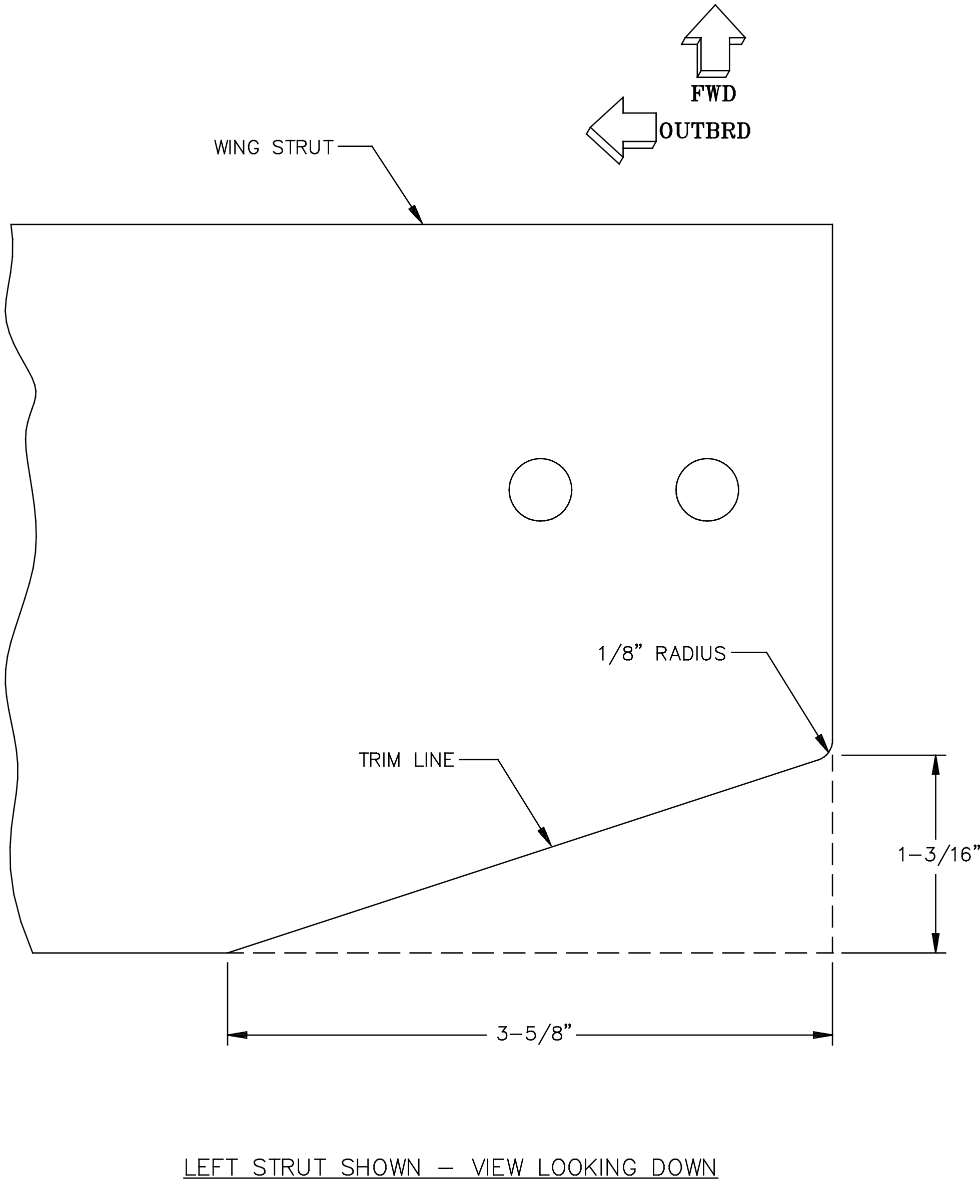


Figure 57: Trimming the Inboard End of the Wing Strut

Mark the inboard, aft corner of the wing strut for trimming, as shown in Figure 57. Use a hacksaw or a bandsaw to trim the struts outside the marked lines and then finish with a belt sander or a file. Use fine sandpaper to remove any remaining roughness. Round the angles of the finished cut to a 1/8" radius, as shown.

Note Trimming the wing struts is unnecessary if you plan never to fold the wings of your GlaStar.

Apply the corrosion protection of your choice to the wing strut and to the fuselage wing strut fitting. Then, bolt the strut fitting to the strut with AN6-24A bolts, AN960D616 **aluminum washers** [152] and AN364-624A **nylon self-locking nuts** [110], as shown in Figure 56.

Note The fuselage wing strut fittings have been anodized for corrosion resistance, so only the bolt holes that you reamed require additional protection. Do **not** use an alodine treatment on the strut fittings as this can damage the anodized finish.

If you plan to use your GlaStar as a float plane on salt water, we recommend also corrosion-proofing the **inside** of the strut. This is accomplished by pouring the corrosion-protection liquid through the strut and sloshing it around, and then discarding any excess out the end.

Repeat this step for the other wing strut, being careful to make the second strut a mirror-image of the first so that the struts will fit correctly on opposite sides of the airplane. Mark the struts "left" and "right" to help prevent confusion.

Completed: Left [ ] Right [ ]

Step 27: Mark the Bolt Centerlines on the Strut Attach Arm and the Wing Strut

The outboard end of the wing strut must be positioned correctly in the fore and aft direction relative to the strut attach arm in the wing, so that the strut can be accurately marked for drilling the attach arm bolt holes. (The strut attach arm is the fitting bolted between the strut beams in the wing. Refer to Steps 21 and 22 in "SECTION VI: WING ASSEMBLY.") In this step, you will mark the wing strut and the strut attach arm with reference lines that will be used as a guide for alignment.

Use a felt-tip pen to mark the bolt hole centerline on the **upper**, **outboard** end of the strut **1-3/4"** aft of the strut leading edge, as shown in Figure 58. Also, mark the centerline on the angled, **upper** surface of the strut attach arm in the wing. When you install the strut, you will align the centerline marked on the strut with the centerline marked on the strut attach arm.

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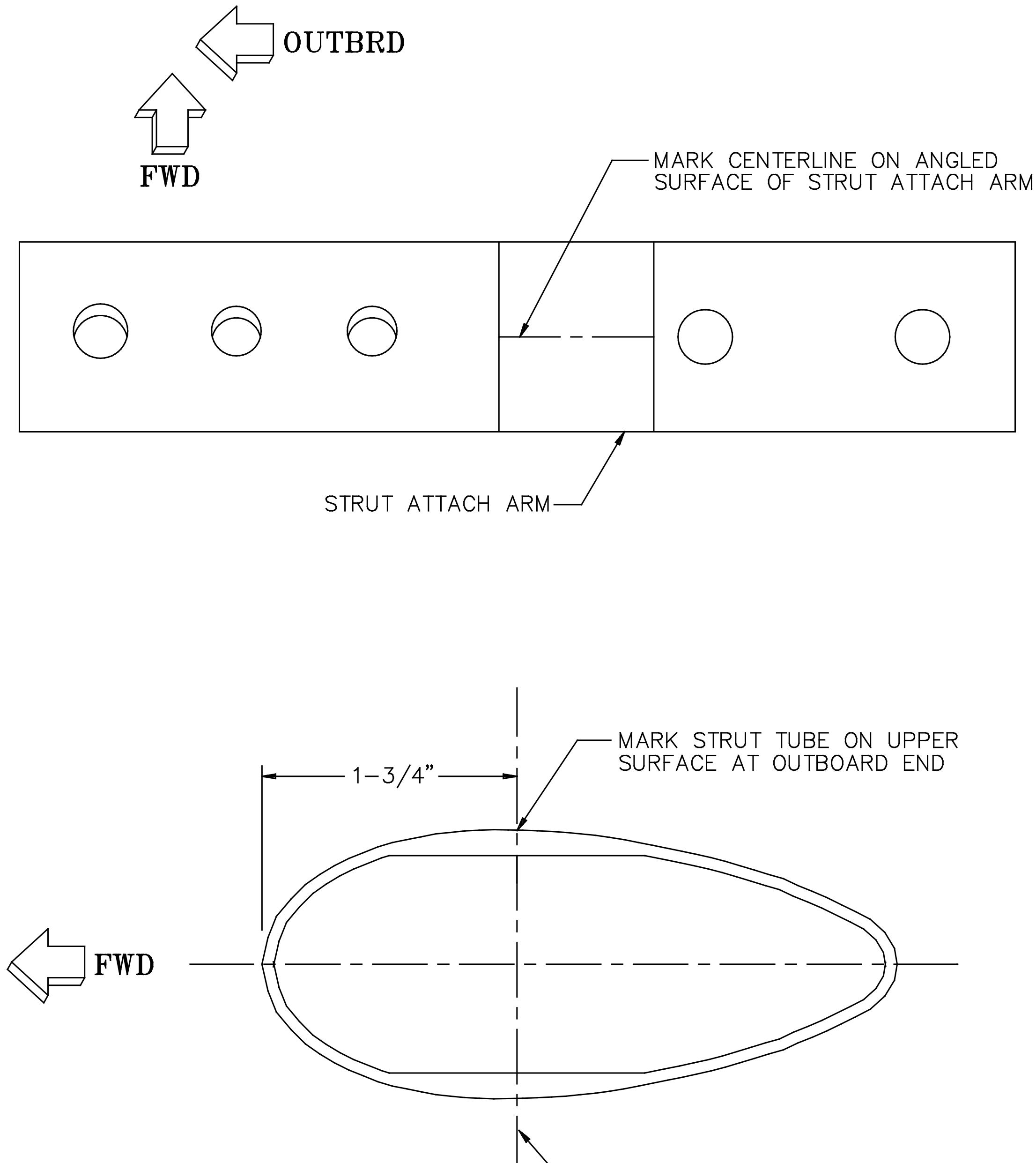

Figure 58: Marking Bolt Centerlines on the Strut Attach Arm and the Wing Strut

Step 28: Trim the Openings in the Wing Root Areas of the Fuselage Shell

When the fiberglass fuselage shells were mated to the cage, slots were cut in the wing root areas of the shells to accommodate the alignment jigs. These slots must be enlarged at this time so that the wing spars can be inserted through them for attachment to the cage.

Continue the slots cut in Step 15 of "SECTION VIII: FUSELAGE ASSEMBLY" down to the inside surface of the lower skin in the airfoil-shaped wing root area of the shell on each side, as shown in Figure 59. Also, increase the width of the slots as necessary to accommodate the full thicknesses of the spar webs, and cut slots in the chordwise direction to accommodate the spar flanges and portions of the root rib doublers.

Completed: Left [ ] Right [ ]

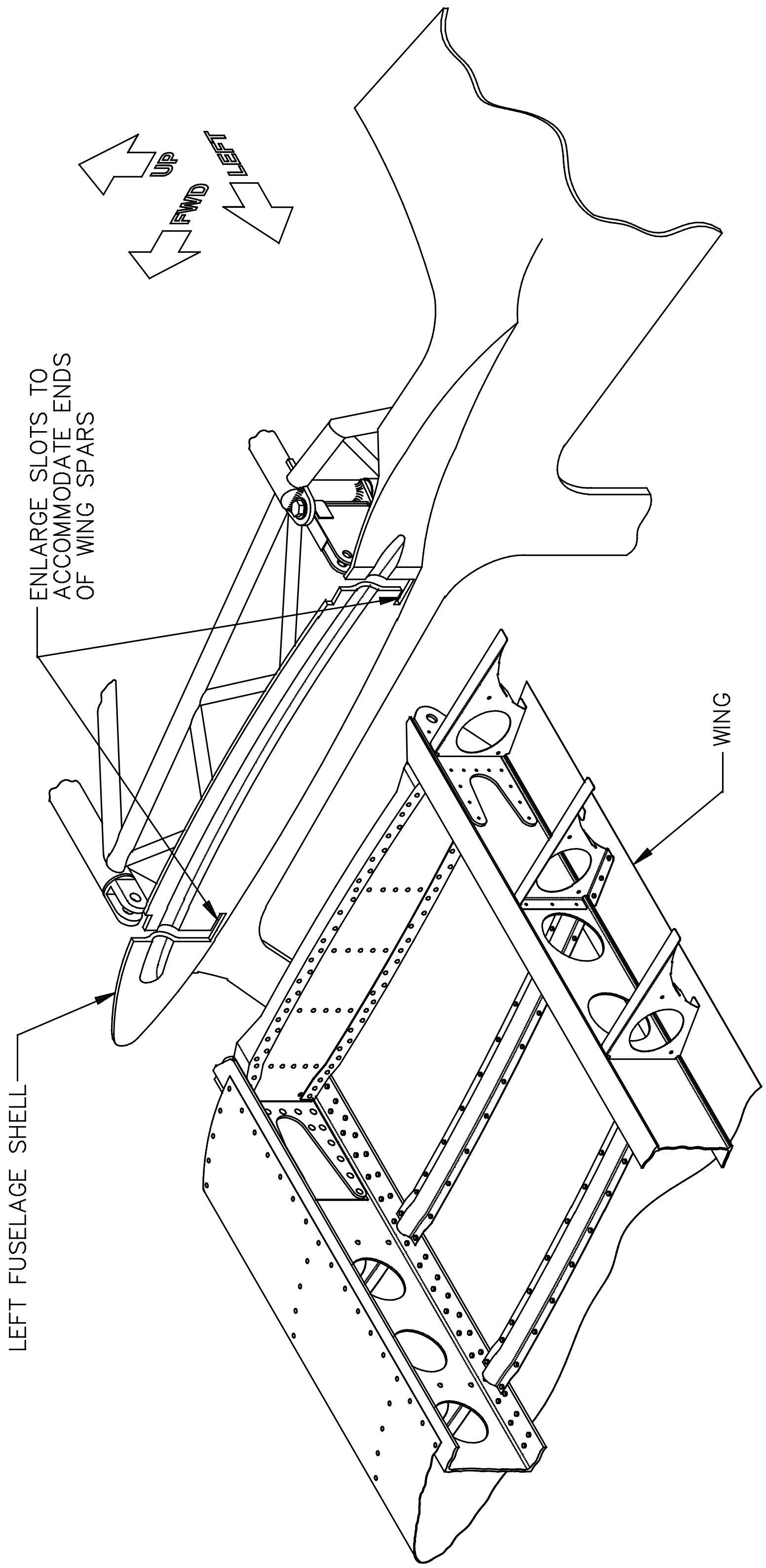

Figure 59: Enlarging the Spar Slots in the Fuselage Shell

Step 29: Mount the Wings to the Fuselage

Caution Be sure you have plenty of help to mount the wings. Trying to accomplish this without adequate assistance can result in damage to the airframe or injury to you or your helpers. Fabricate or procure stands of some sort (tall, padded sawhorses or step ladders of the correct height, for example) to support the wings while setting the wing dihedral and fitting the wing struts (procedures that will be described in the following steps).

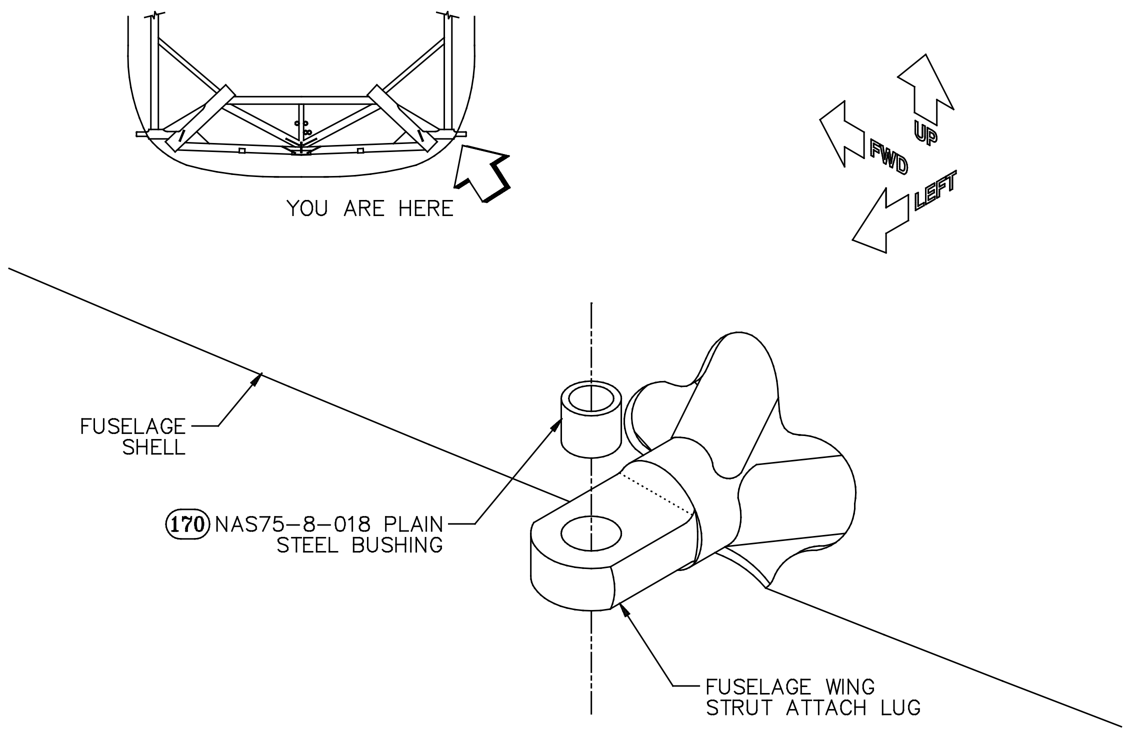

Figure 60: Pressing the Bushing into the Fuselage Wing Strut Attach Lug

Use a 1/2" bolt and nut (hardware-store quality is fine) with a stack of washers on either side to press an NAS75-8-018 **plain steel bushing** [170] into the fuselage wing strut attach lug on each side of the fuselage cage.

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Have your helpers lift the wing into position while you carefully guide the ends of the forward and aft spars into their mounting lugs on the fuselage cage, as shown in Figures 61 and 62. Enlarge the slots in the wing root area of the fuselage shell as necessary.

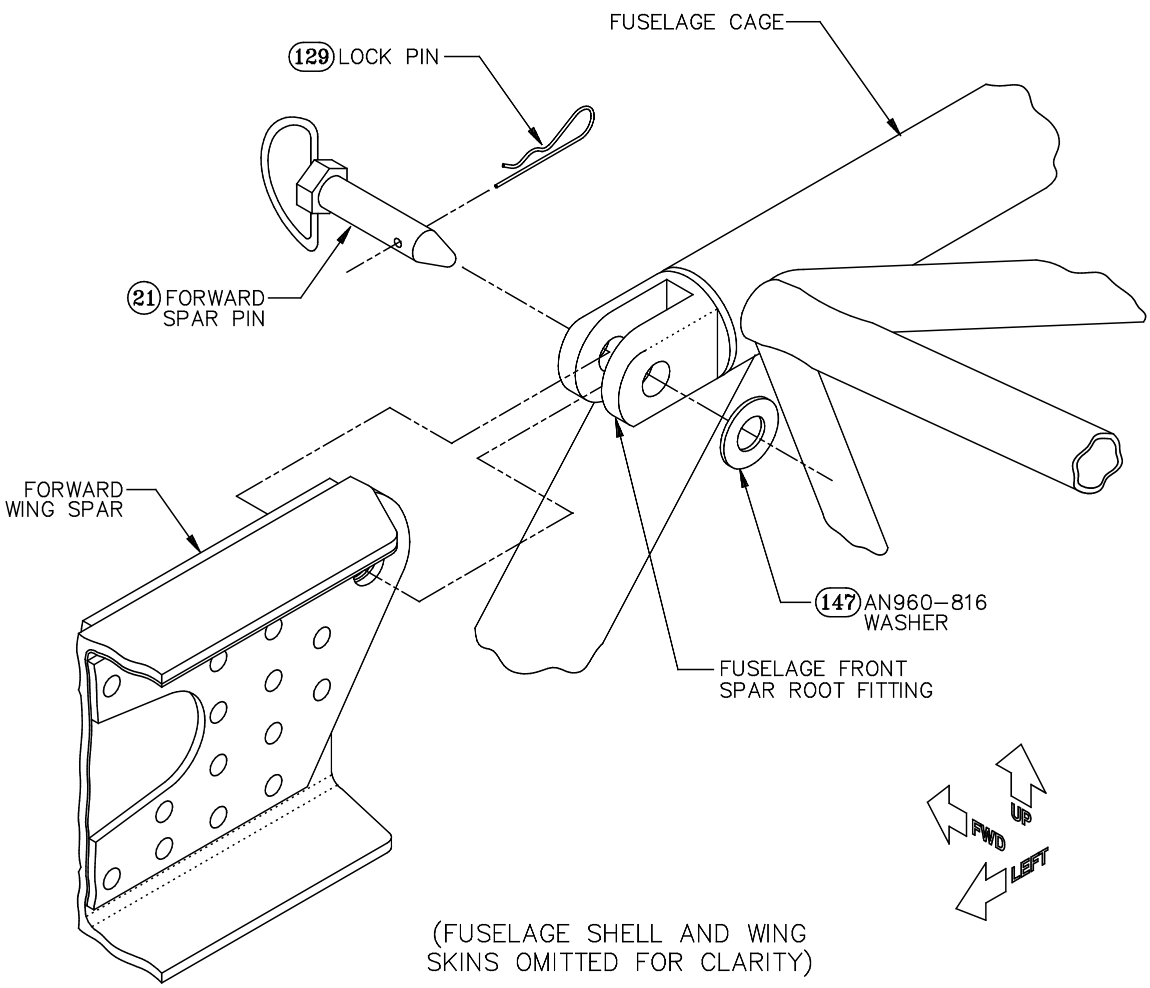

Figure 61: Forward Spar Attachment to Fuselage Cage

Pin the forward spar to the fuselage cage with the **forward spar attach pin** [21], as shown in Figure 61; pin the aft spar to the wing pivot on the fuselage cage with an AN7-12 **drilled-shank bolt** [136], as shown in Figure 62. Install both the pin and the bolt from the **forward** sides of their respective fittings.

Note A light coat of grease will ease insertion of the spar attach pins and bolts.

At this time, there is no need to install the washers, nuts and cotter pins shown in Figures 61–63. The weight of the wing is sufficient to retain the mounting pins and bolts for this temporary wing installation. All the necessary washers, nuts and safety pins will be installed during final assembly.

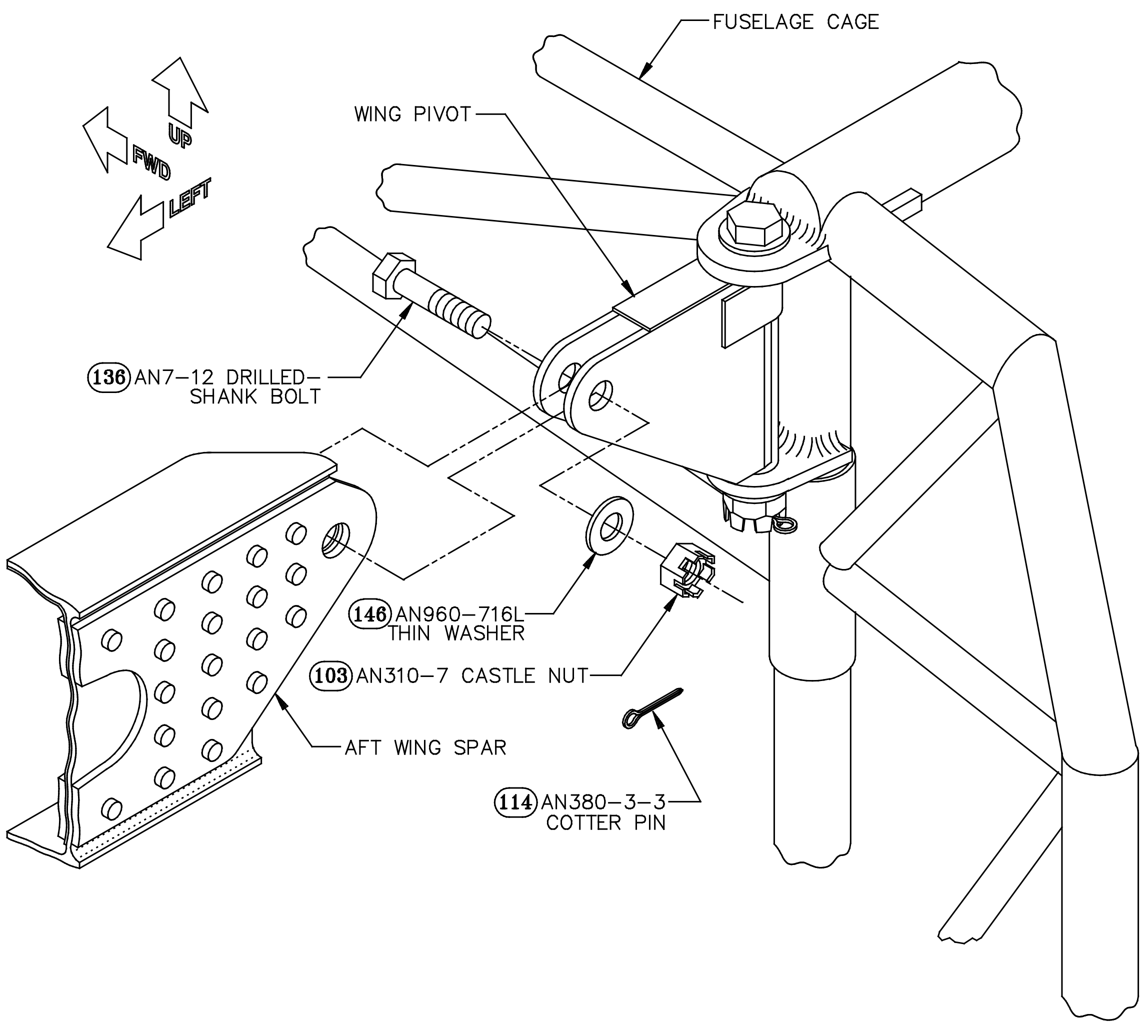

Figure 62: Aft Spar Attachment to Fuselage Cage

With your helpers supporting the wing, slip the outboard end of the wing strut over the inboard end of the strut attach arm, which is bolted between the two halves of the strut beam in the wing. Then, align the fitting on the inboard end of the strut with the attach lug on the fuselage cage, and pin the fitting to the lug with an AN8-22 **drilled-shank bolt** [137], as shown in Figure 63. The washers, nut and cotter pin shown in the figure can be installed or omitted for now at your option.

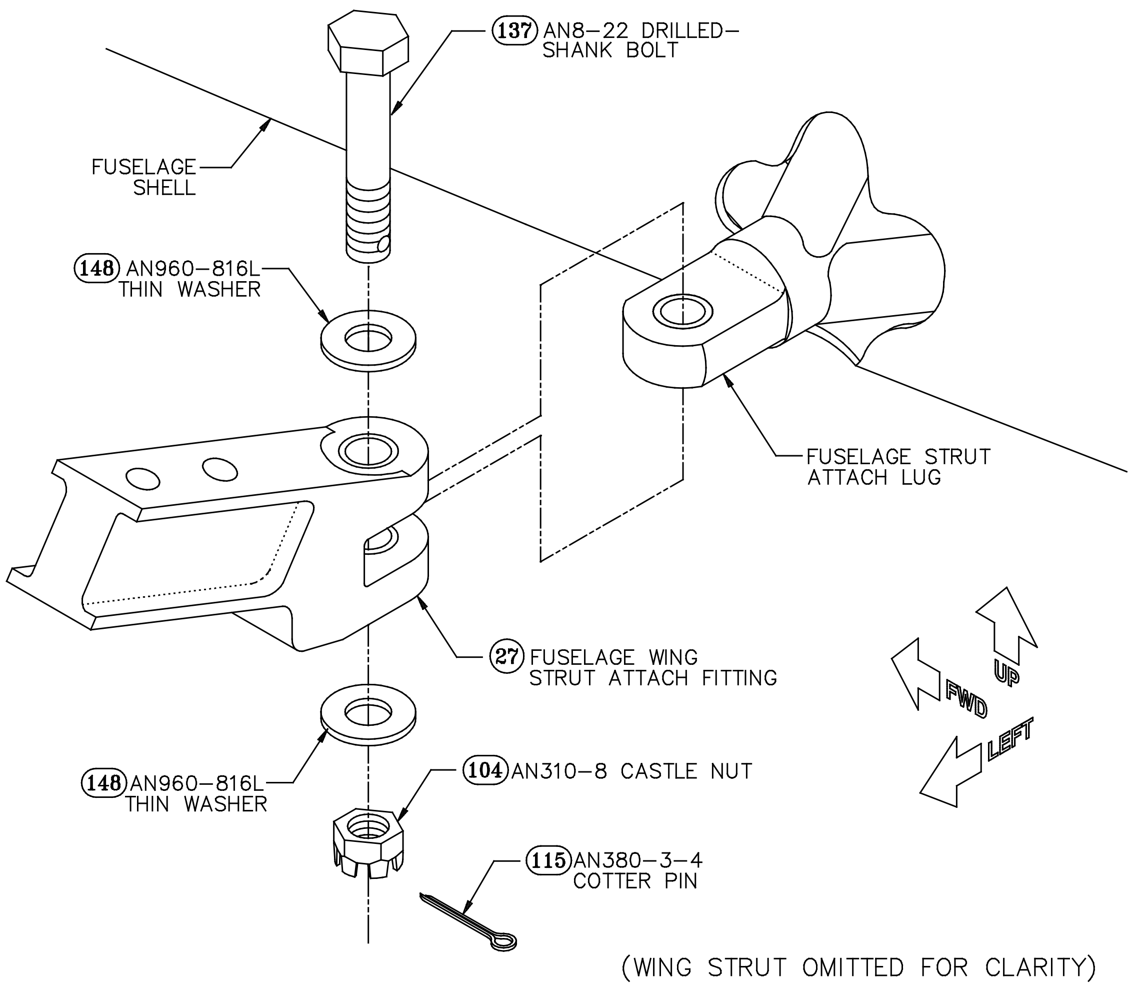

Figure 63: Wing Strut Attachment to Fuseluge Lug

Note Moderate force may be required to install the bolt that secures the wing strut to the fuselage. As with the other wing attach pins, a light coat of grease will help. Also, sight through the holes in the two parts to make sure they are in close alignment before trying to insert the bolt. You can use a rubber mallet or a lead-filled plastic hammer to tap the bolt into place; heavy hammer blows should not be necessary. If the wing strut attach fitting seems to be grossly out of alignment with the fuselage attach lug, verify that the correct strut attach arm was installed between the strut beams in each wing. Refer to Step 21 in "SECTION VI: WING ASSEMBLY" for procedures to identify the left and right strut attach arms.

Support the first wing securely with a tall, padded stand, and repeat for the other wing.

Caution Since the outboard ends of the wing struts are not secured to the attach arms in the strut beams, the wings **must** be supported to prevent damage to the strut attach arms or the ends of the struts. Place your supports directly under the front spar and a rib to prevent deformation of the wing skins.

Completed: Left [ ] Right [ ]

Step 30: Set the Dihedral Angle of the Wings

Level the fuselage laterally, using a level on the horizontal stabilizer.

> **Note** Although the stabilizer is theoretically parallel to the main cross tubes in the cage, it's more important here that the flying surfaces be properly arranged relative to one another. So use the stabilizer, rather than the cage cross tubes, to level the fuselage.

Use a digital level to set each wing at a **1.5°** dihedral angle, as shown in Figure 64. (If you have a transit, you can set the wing dihedral by positioning the wing tips **4-21/32"** higher than the wing roots. Or stretch a string from wing tip to wing tip, and measure down from the string **4-21/32"** at the wing roots.) Support each wing securely at this angle.

> **Note** It may be necessary to trim the outboard end of the wing strut so that the wing can be lowered to the correct dihedral angle without the strut contacting the strut beam assembly in the wing. If necessary, disassemble and trim just enough from the end of the wing strut to achieve the specified dihedral. If trimming is necessary, be careful to make the cut square to the length of the strut tube. A chop saw with a sharp wood-cutting blade is a quick way to shorten the wing struts. Use light oil or wax on the blade to reduce galling and then thoroughly deburr the finished cut. To remove the wing strut, undo the lower fitting first, and then pull the strut off the upper fitting.

Completed: Left [ ] Right [ ]

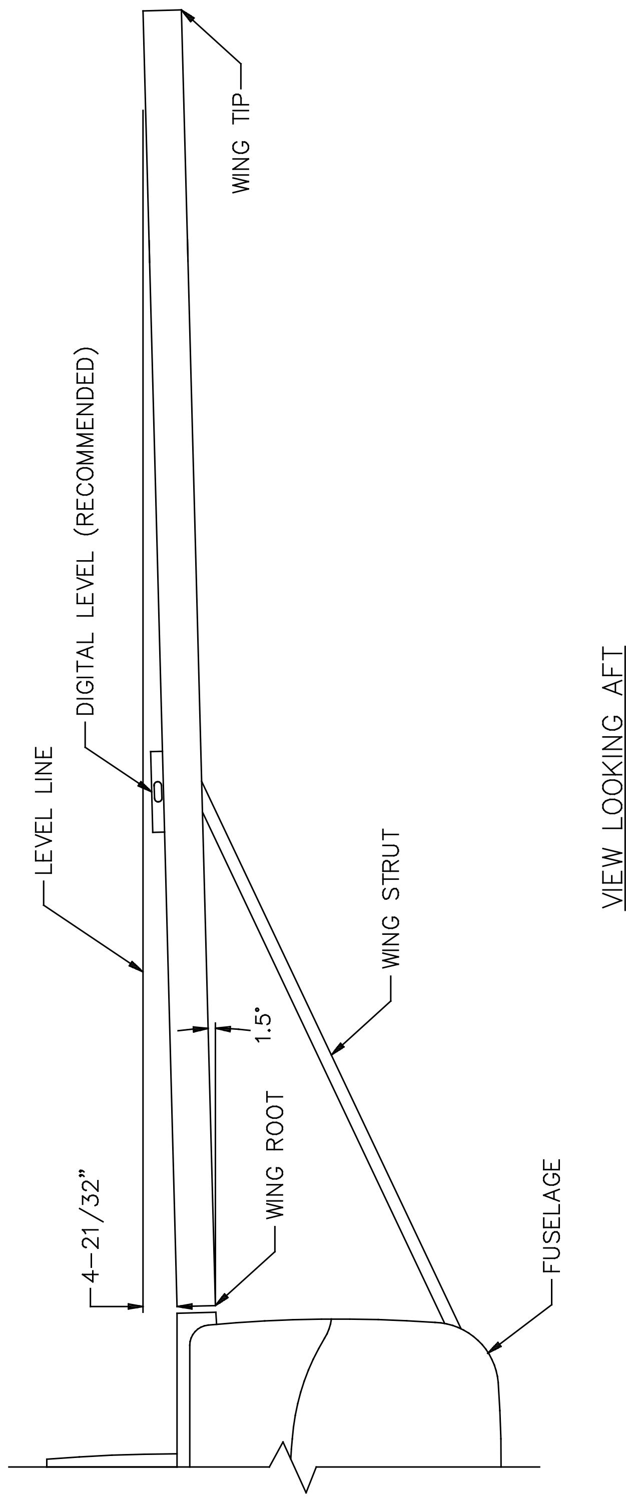

Figure 64: Setting the Wing Dihedral

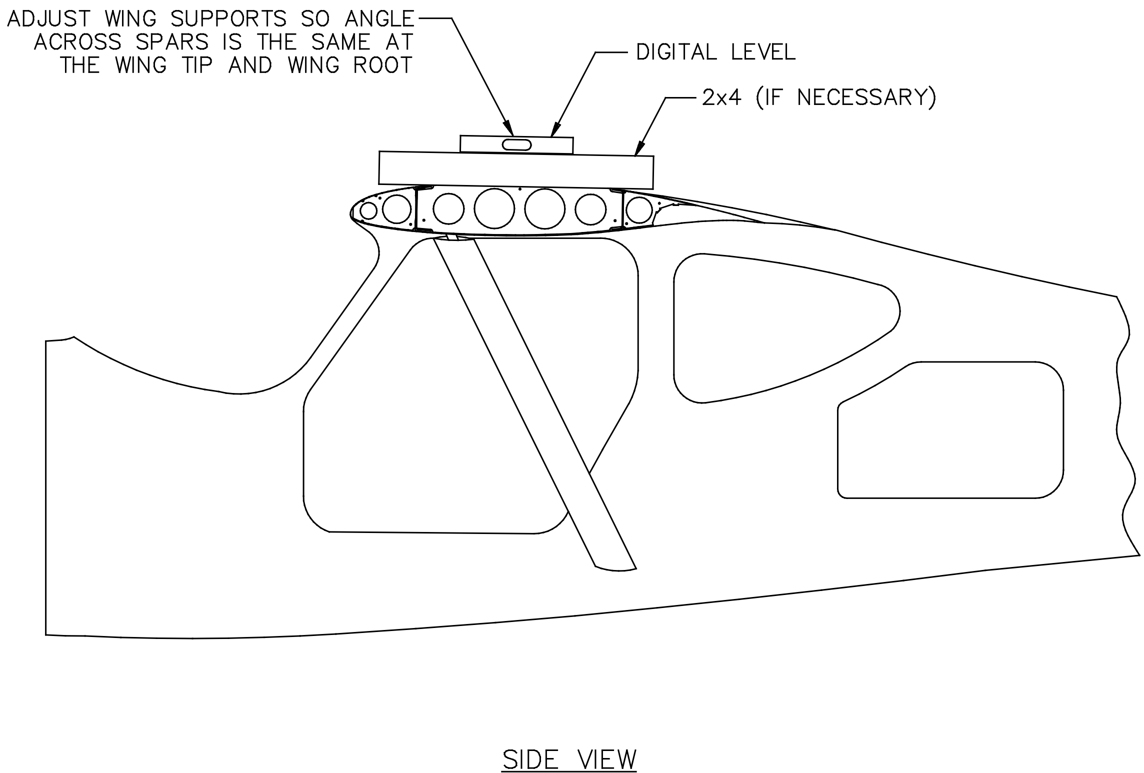

Figure 65: Checking for Wing Twist

Step 31: Remove Twist from the Wings

Without the upper wing skins riveted on, the wings are free to twist slightly. Any twist present in the wings must be removed at this time because wing twist can affect the accuracy of the measurements you will be making in the next step.

To check for wing twist, use a digital level or a protractor level to measure the angle of the aft spar relative to the forward spar **just outboard of the root rib** (Main Rib 1), as shown in Figure 65. (If your level is not long enough to span the distance between the two spars, rest it on a scrap length of 2 X 4.) Then repeat the angle measurement **just inboard of the tip rib** (Main Rib 6). Adjust the wing supports as necessary, moving them forward or aft, **until the angle at the tip is the same as the angle at the root**. Repeat for the other wing.

Obviously, any adjustment you make to the wing supports can change the dihedral angle that you set in the previous step, so go back and repeat that step if necessary. When you are satisfied that both wings are set to the proper dihedral angle (1.5°) and that neither wing is twisted, proceed to the next step.

Completed: Left [ ] Right [ ]

Step 32: Mark the Wing Struts for Drilling

With the wing dihedral angle set at 1.5°, you now must drill two bolt holes through the outboard end of the wing strut that are exactly aligned with the existing bolt holes through the strut attach arm in the wing. The wing strut drill jig will be used to drill the bolt holes, as described in the next step, but, to position the jig for drilling, you first need to transfer the location of the outboard bolt hole in the strut attach arm to the outside surface of the strut. Since the hole in the strut attach arm is hidden by the strut, transferring its location must be done by indirect measurement of the distance X, as described below.

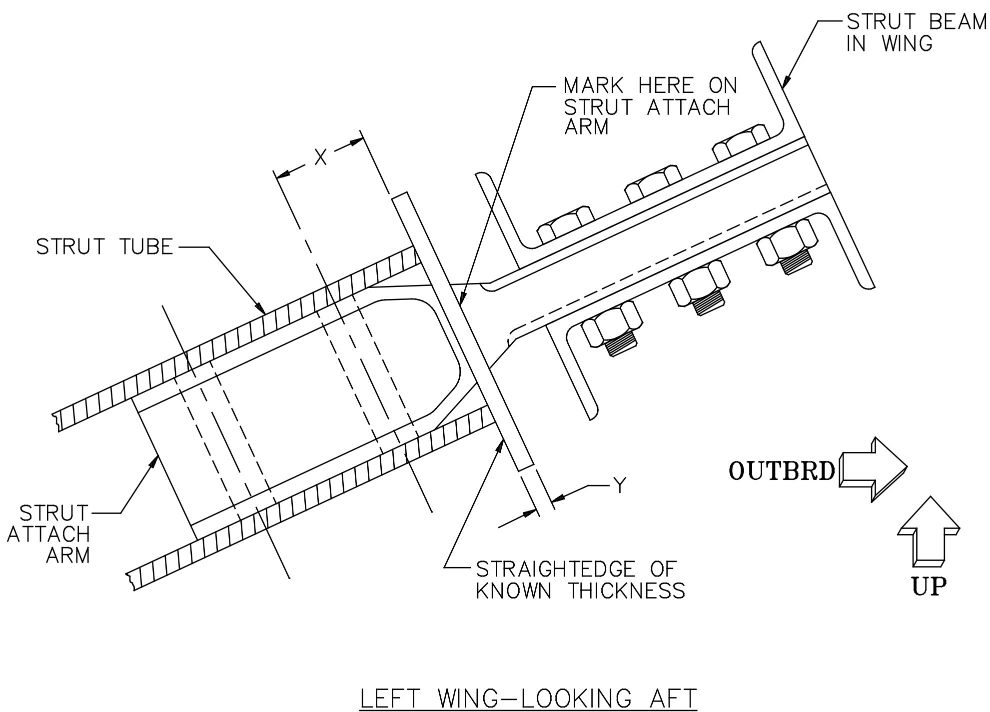

Figure 66: Marking Strut Attach Arm at End of Wing Strut Tube

A) Move the outboard end of the strut fore and aft as necessary until the bolt hole centerlines marked on the strut and the strut attach arm in Step 27 are aligned. Then mark the end of the wing strut tube onto the **forward** side of the wing strut attach arm, as shown in Figure 66. To do this, hold a rigid straightedge of known thickness, Y, against the end of the strut tube and, using a **very fine-point** felt-tip pen (like the Pilot "Razor Point II"), mark along the outboard side of the straightedge onto the strut attach arm.

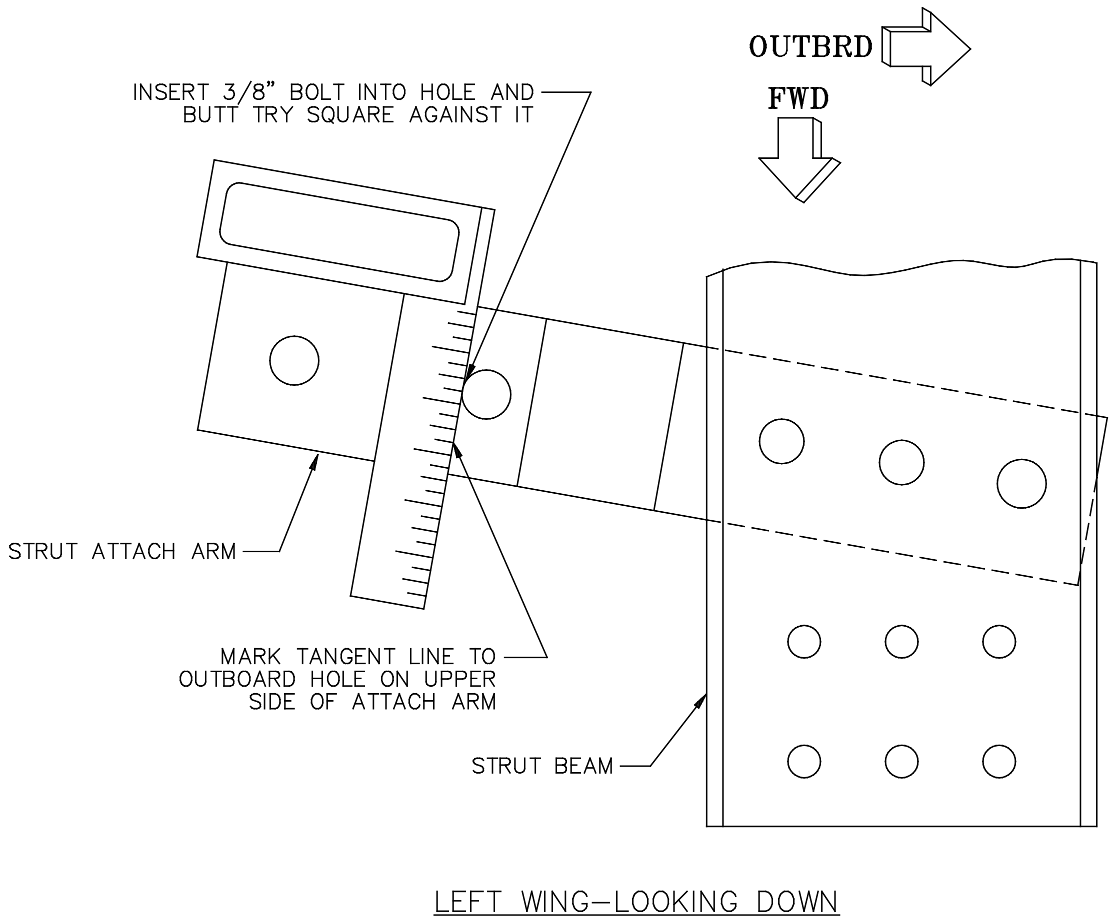

Figure 67: Marking Edge of Hole on Attach Arm

B) Remove the wing strut. Using a small try square, make a mark across the **upper** surface of the strut attach arm tangent to the **inboard** side of the **outboard** wing strut attach hole, as shown in Figure 67. To make the mark, insert an AN6 (3/8") bolt into the hole and then butt the try square up against the shank of the bolt. Use a fine-point felt-tip pen to mark the tangent line on the **outboard** side of the try square blade, as shown.

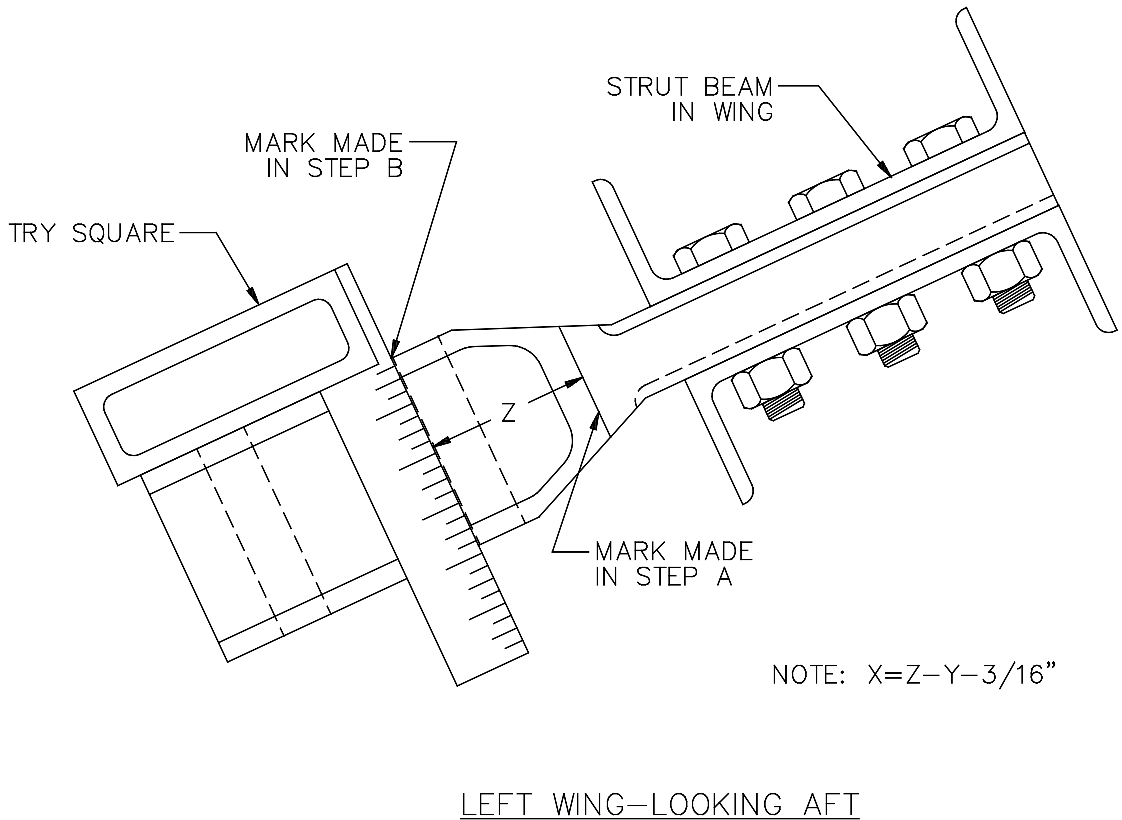

Figure 68: Measuring Between Marks Made in Steps A and B

C) Hold your try square on the **forward** side of the strut attach arm (where the mark in Step A was made), with the edge of the blade on the mark made in Step B, as shown in Figure 68. Measure the distance, Z in Figure 68, from the mark made in Step A to the edge of the blade, being careful to measure **parallel** to the length of the strut attach arm, as shown. **Subtract** from Z the thickness, Y, of the straightedge used to make the mark in Step A, and then **subtract 3/16"** (.187", half the hole diameter) from the result. The final result, X, is the distance from the end of the strut tube to the **center** of the outboard strut attach hole in the strut attach arm.

Hint Although this measurement can be made in place, it may be worthwhile to remove the strut attach arm from the wing. Use your own judgment.

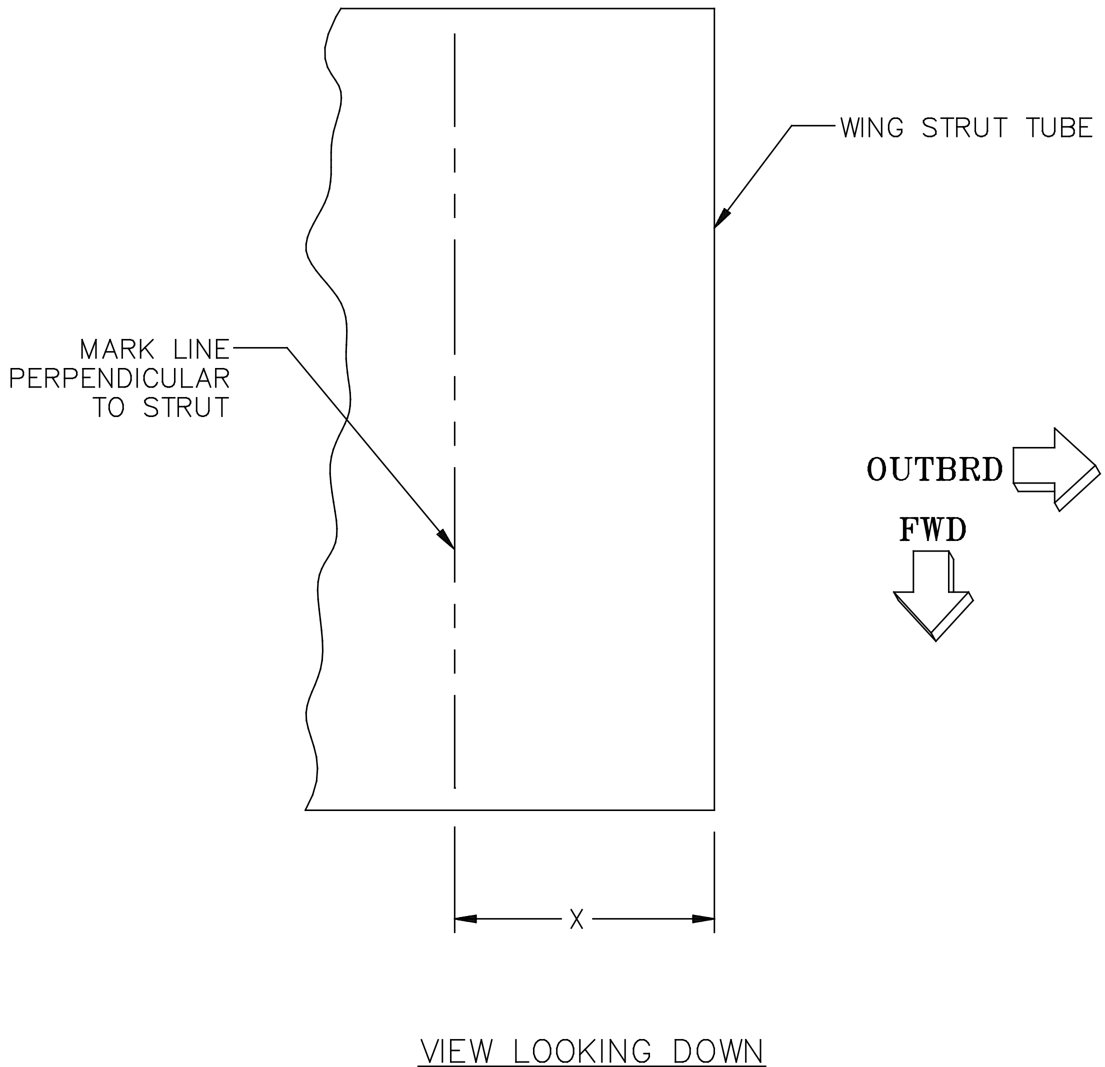

Figure 69: Marking the Distance Determined in Step C onto the Wing Strut

D) Measure from the **outboard** end of the wing strut the distance X determined in Step C, and mark a line onto the **upper** surface of the strut perpendicular to the length of the strut, as shown in Figure 69. Use a fine-point felt-tip pen to make the mark.

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Step 33: Drill the Outboard Ends of the Wing Struts

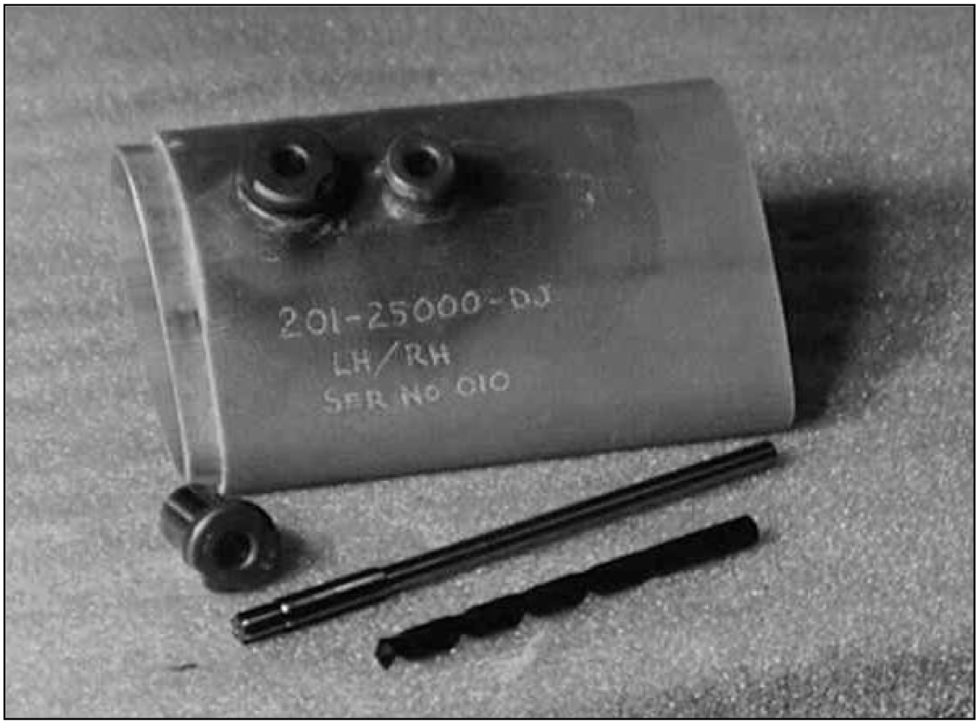

Figure 70: Wing Strut Drill Jig

Drilling the outboard ends of the wing struts requires the use of a **wing strut drill jig** (available on a rental basis from Stoddard-Hamilton). Without the drill jig, it would be nearly impossible for the average homebuilder (and difficult even for an experienced machinist) to locate the holes correctly and to drill them straight and in proper alignment with the center of the strut attach arm. The jig consists of a fiberglass sleeve molded to slip over the end of the wing strut, with a pair of drill bushings on each side of the sleeve. The inboard drill bushings are 11/32" in diameter and are permanently bonded into the jig. The outboard drill bushings are removable; an 11/32"-diameter and a 3/8"-diameter insert are supplied for the outboard bushings. Also supplied with the jig are an 11/32" drill bit, a 3/8" (.3745") step reamer, and a length of 11/32" drill rod (not shown in Figure 70).

Note The drill jig is shipped with a short section of wing strut inside it. Remove this before using the jig, but replace it when you are finished. Keep the short section of wing strut inside the jig during shipment and storage to help the jig retain its shape.

Caution Before installing the jig, deburr the end of the strut and make sure the strut and the drill jig are free of drill chips, shavings and other debris. To help slide the drill jig onto the strut, you can lubricate it or try squeezing the jig in the chordwise direction (applying force to the leading and trailing edges of the jig sleeve). You can also use a block of wood and a hammer to tap the **end** of the drill jig sleeve, as shown in Figure 71, but **DO NOT hammer on the drill bushings or their receptacles.**

Slip the drill jig over the end of the strut and position it so that the line marked in Step 32d is centered as closely as possible under the **outboard** hole in the drill jig. As Figure 71 shows, the end of the jig **without** the bushings goes **inboard**.

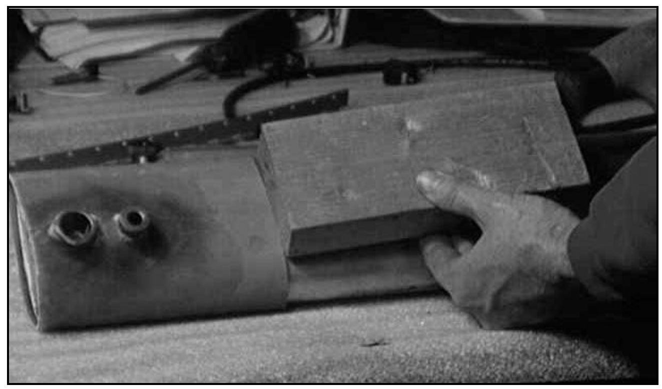

Figure 71: Adjusting the Position of the Drill Jig

Figure 72: Marking the Hole Center

Mount the removable **11/32"** drill bushing into the receptacle for the **outboard** hole in the wing strut drill jig. Then insert the 11/32" drill bit into the drill bushing until the drill point contacts the strut, as shown in Figure 72, and twist the drill bit with your fingers to make a small mark.

Remove the drill bit and the bushing and note the distance, if any, between the line marked in Step 32d and the drill bit mark just made; this is the distance you need to move the drill jig on the strut to bring the center of the drill bushing into alignment with your mark. Shift the position of the drill jig as necessary and repeat the drill bit test. Continue in this manner until the drill bit mark is centered on the line marked in Step 32d. When satisfied, clamp the fiberglass portion of the drill jig securely to the strut. A suggested clamping method, using vise-grip pliers, is shown in Figure 73 (pad the vise-grip jaws with small blocks of wood to prevent damage to the jig or the strut).

Figure 73: Drilling the Inboard Holes

With the jig now clamped in position, the **inboard** holes will be drilled first. Use the supplied 11/32" drill bit guided by the **inboard** drill bushing (the permanent bushing) to drill through **one side** of the wing strut.

Note Do not attempt to drill all the way through both sides of the strut from one side. Use some light oil (preferably cutting oil) on the drill bit, both to help the bit cut into the strut's metal and to lubricate the bit's rotation in the bushing.

Insert the 11/32" drill rod into the first hole to maintain alignment, as shown in Figure 73, and drill the **inboard** hole on the other side of the strut using the permanent drill bushing on the other side.

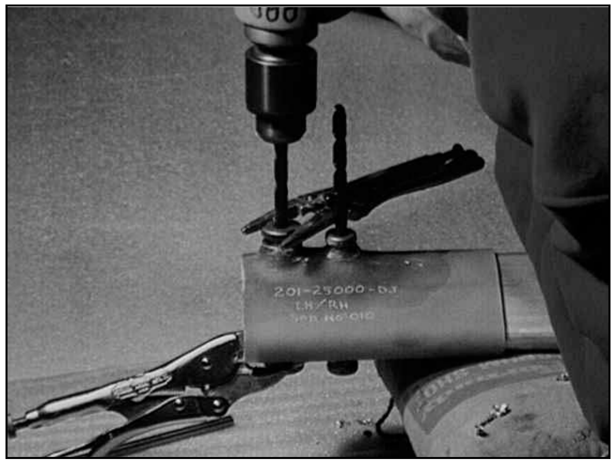

Figure 74: Drilling the Outboard Holes

Now you can drill the **outboard** holes. Insert the **11/32"** drill bushing into the receptacle for the **outboard** hole and clamp it to keep it from rotating (one way to do this is shown in Figure 74: lightly lock a pair of vise-grip pliers onto the bushing and let the pliers rest against the 11/32" drill rod that is holding the jig's alignment with the inboard holes). Drill the outboard holes, one side at a time; you will have to shift the 11/32" drill bushing to the receptacle on the other side to drill the second outboard hole.

Replace the 11/32" drill bushing in the outboard receptacle with the **3/8"** bushing, and use the 3/8" (.3745") step reamer to enlarge the outboard holes through the strut. As you did when drilling, ream each side of the strut using the bushing on that side; don't ream all the way through both sides at the same time. Be careful to hold the reamer perpendicular to the strut while reaming. Have a helper assist you by sighting the alignment of the reamer.

Note Leave the **inboard** holes at 11/32"-diameter; these will be reamed to final size (.3745") after the strut is reattached to the strut attach arm in the wing.

Remove the drill jig from the wing strut.

With the strut attach arm bolted between the strut beams in the wing, slide the outboard end of the wing strut over the strut attach arm and pin the inboard end of the strut to the fuselage strut attach lug using the AN8-22 bolt. Secure the outboard end of the strut to the strut attach arm using an AN6-24A bolt inserted through the **outboard** hole in the assembly. Insert the 11/32" drill rod through the inboard hole in the assembly from the **lower** side to properly align the parts for reaming. Run the 3/8" (.3745") step reamer through the inboard hole from the **upper** side, pushing the 11/32" drill rod out as you go. Since you are now reaming all the way through both the wing strut and the strut attach arm, be especially careful to keep the reamer perpendicular to the strut.

Remove the wing strut and deburr the holes in the strut and the strut attach arm. Apply the corrosion protection of your choice to the attach arm and the inside of the strut.

Note The wing strut attach arms have been anodized for corrosion resistance, so only the bolt holes that you reamed require additional protection. Do **not** use an alodine treatment on the strut attach arms as this can damage the anodized finish.

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Step 34: Trim the Outboard End of the Strut *(Optional)*

Note As long as the end of the wing strut does not contact the strut beam assembly in the wing, there is no real need to trim the strut as described here. Especially if the length to be trimmed off the strut is just a small fraction of an inch, the weight saved may not be worth the trouble of trimming. Use your own judgment to decide whether or not to trim the wing strut.

Mark a line around the entire circumference of the strut **3/4" outboard** of the line marked in Step 32d (the center of the outboard attach hole), being careful to make the mark square to the length of the strut.

Caution The 3/4" dimension is a **minimum**. The end of the strut must not be trimmed closer than 3/4" from the **center** of the outboard hole.

Trim the strut at the mark, as shown in Figure 75. Trim outboard of the line first, using a hacksaw or bandsaw, and then file and sand back to the line to remove saw marks. Make sure the finished edge is smooth and thoroughly deburred.

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Step 35: Bolt the Wing Strut to the Wing

Reinstall the wing strut. Pin the outboard end of the strut to the strut attach arm in the wing, using two AN6-24A bolts as shown in Figure 75. (This is still a temporary installation, so there's no need to install the washers and nuts at this time.) Pin the inboard end to the fuselage fitting with an AN8-22 bolt.

Note If the AN6 bolts feel loose in their holes, substitute NAS close-tolerance bolts (not supplied).

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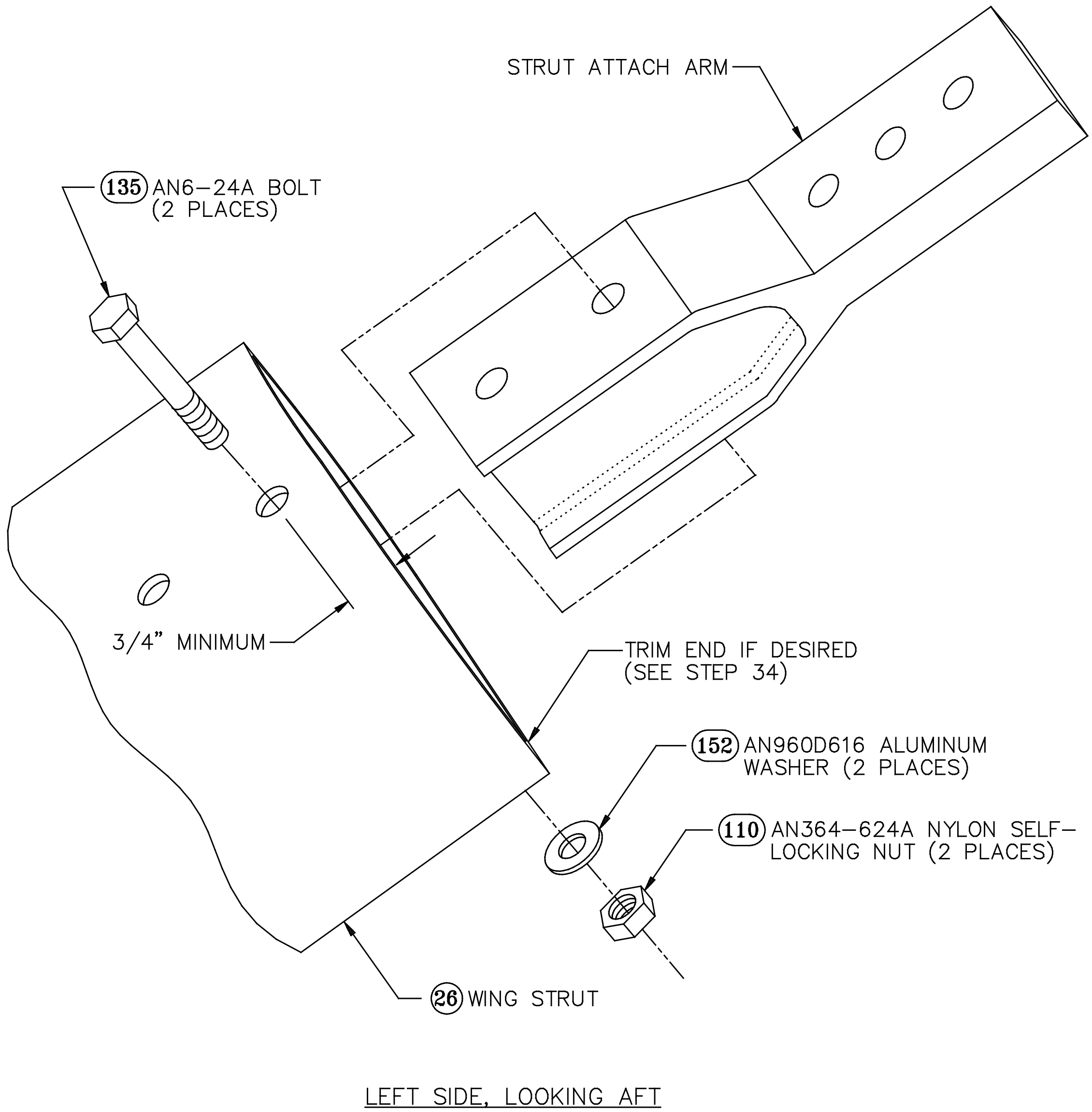

Figure 75: Wing Strut Attachment to Strut Attach Arm

MOUNTING THE FLAPS TO THE WING

Step 36: Mount the Flap to the Flap Tracks

For each flap, pack four flap track **roller bearings** [1] with a light grease, using just enough to coat all the rollers. Avoid using too much, because excess grease acts as a magnet for dirt. Insert a **clamp-up bushing** [25] into each roller bearing.

Have a helper support the flap in position, with the centers of the mounting holes in the flap-track guide arms aligned with the slots in the flap tracks. Place a roller bearing/clamp-up bushing assembly into each slot in each flap track and then place a **thin nylon washer** [16] and a **thick nylon washer** [17] over the clamp-up bushing on each side of the bearing, as shown in Figure 76. Insert an AN3-12 drilled-shank bolt through the guide arms and the clamp-up bushing. Adjust the grip of the bolt with AN960D10 aluminum washers, as necessary, and secure the bolt with an AN310-3 castle nut. Tighten the nut firmly to clamp the clamp-up bushing so that the only movement is between the bearing and the bushing. At final assembly, the nut will be secured with an AN380-2-2 cotter pin, but leave the cotter pin out for now as the flaps will be removed again after the cables have been installed. Install two bearing assemblies at each flap track, one in each slot.

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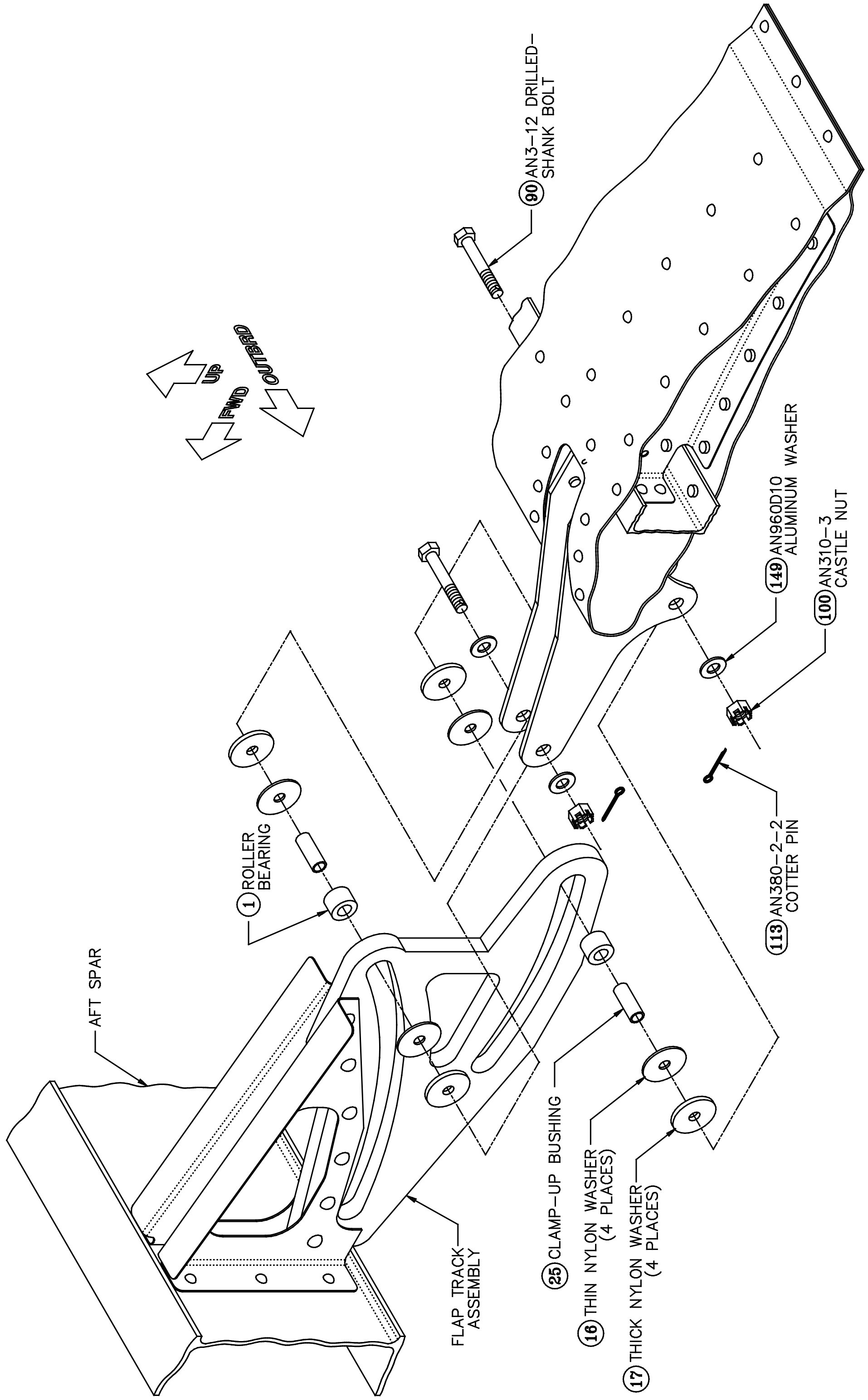

Figure 76: Flap Track Bearing Assemblies

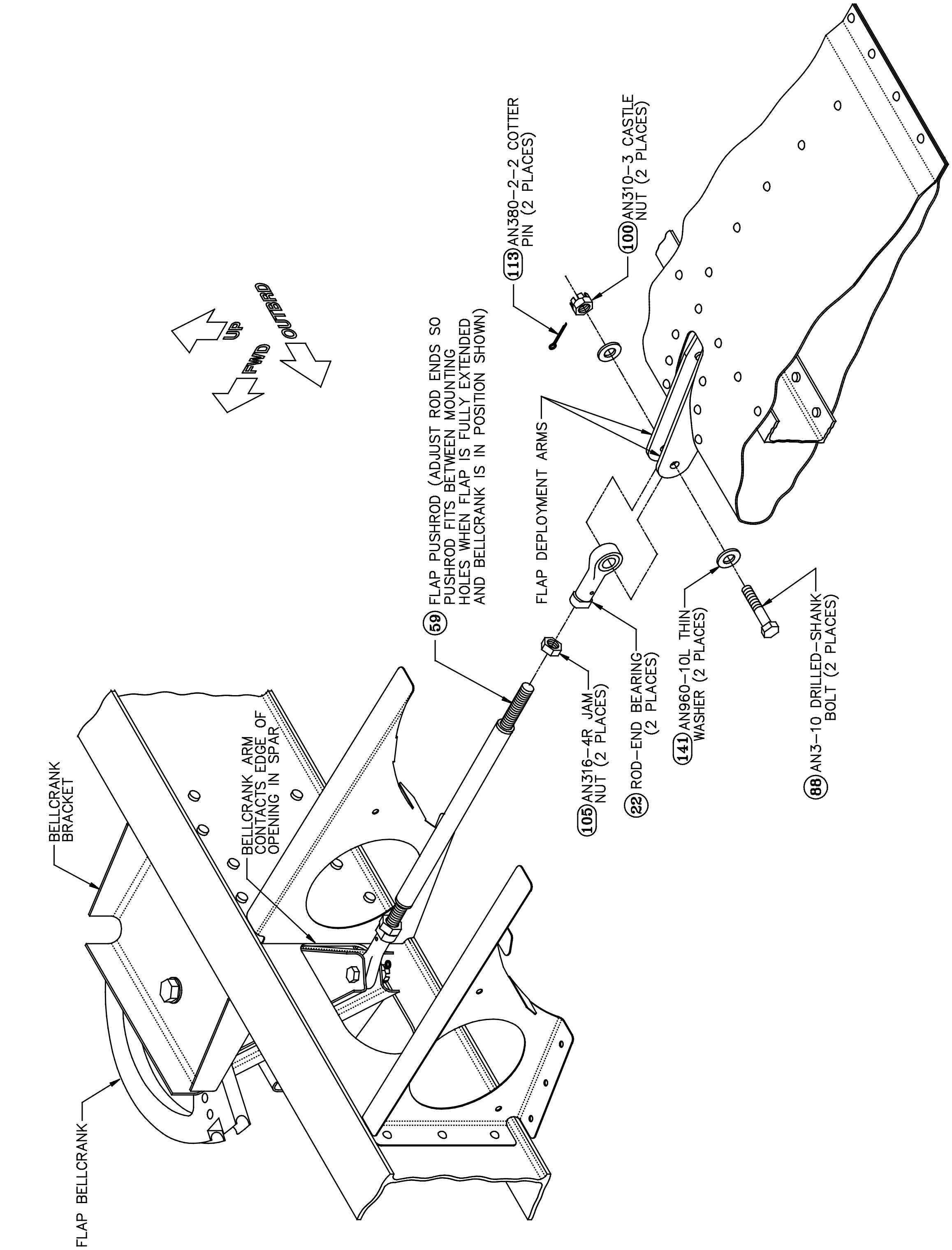

Figure 77: Flap Pushrod Installation

Step 37: Install the Flap Pushrod

Thread an AN316-4R jam nut and a **rod end** [22] onto each end of the **flap pushrod** [59], as shown in Figure 77.

Move the flap to the fully extended position with the roller bearings at the aft ends of the slots in the flap tracks. Also, move the flap bellcrank arm as far aft as possible so that it contacts the edge of the cutout in the spar. Adjust the length of the pushrod by threading the rod ends in or out until they will fit between the attach holes in the bellcrank arm and the flap deployment arms. Secure the rod ends by tightening the jam nuts firmly against them.

Warning Verify that the rod end bearings are threaded onto the pushrod past the inspection holes in the rod ends. As was done for the elevator linkage, insert a piece of safety wire into the inspection holes to check that the rod ends are threaded on far enough.

Bolt the pushrod assembly between the end of the bellcrank arm and the deployment arms, using an AN3-10 drilled-shank bolt, AN960-10L thin washers, an AN310-3 castle nut and (at final assembly) an AN380-2-2 cotter pin at each end of the pushrod. Insert washers (not shown in Figure 77) between the rod ends and the insides of the mounting arms at both ends, as needed, to eliminate axial play.

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MOUNTING THE AILERONS TO THE WINGS

Step 38: Mount the Aileron to the Aileron Hinges

Use a **9/32"** drill bit to enlarge the holes in eight AN970-3 large washers (four for each wing). These washers will be used as hinge bearing retainers for the aileron hinges.

Mount the ailerons to the aileron hinge arms, as shown in Figure 78. The AN960-416L thin washers and then the modified AN970-3 large washers go right next to the hinge arms on each side; the thin washers keep the large washers from rubbing on the hinge arm when the pivot bolt is tightened. At the **outboard** hinge, use an AN4H14A **drilled-head bolt** [131] and an AN960D416 aluminum washer to secure the aileron. Install an NAS42DD8-27 **aluminum spacer** [165] on the outboard side of the hinge arm and AN960-416 washers on the inboard side, as needed, to prevent lateral movement of the aileron. At the **inboard** hinge, use an AN4H20A **drilled-head bolt** [132] and an AN960D416 aluminum washer to mount the aileron, with an NAS42DD8-58 **aluminum spacer** [167] on the outboard side of the hinge arm and AN960-416 washers as shims. The inspection openings in the lower surface of the aileron provide access for inserting the hinge bolts.

Note If the inboard end of the aileron interferes with the outboard end of the flap, or if the aileron hinge arms interfere with the interiors of the slots in the aileron, adjust the lengths of the spacers and the positions of shim washers, as needed, to move the aileron in the spanwise direction to achieve free movement.

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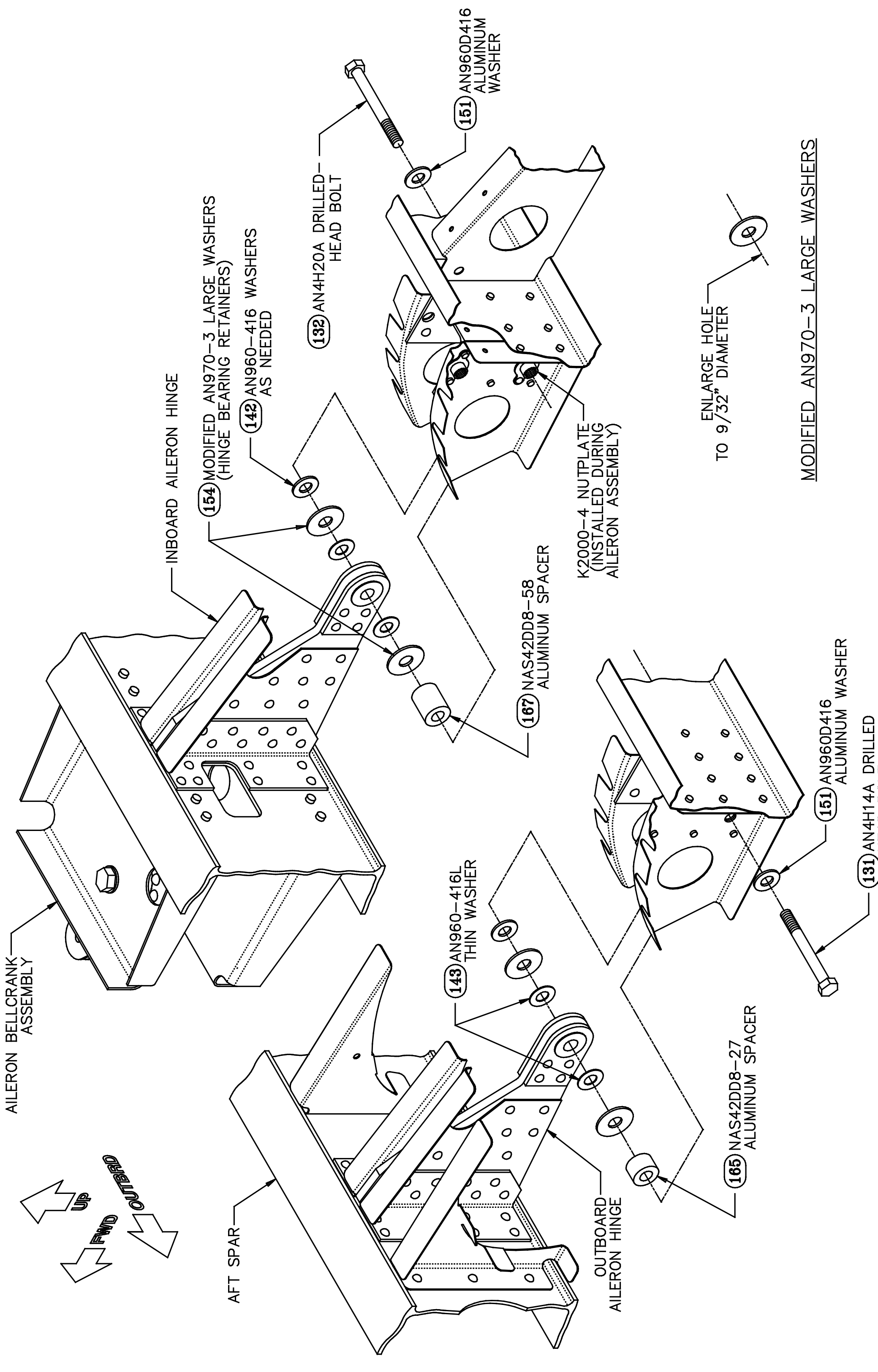

Figure 78: Mounting the Aileron to the Hinges

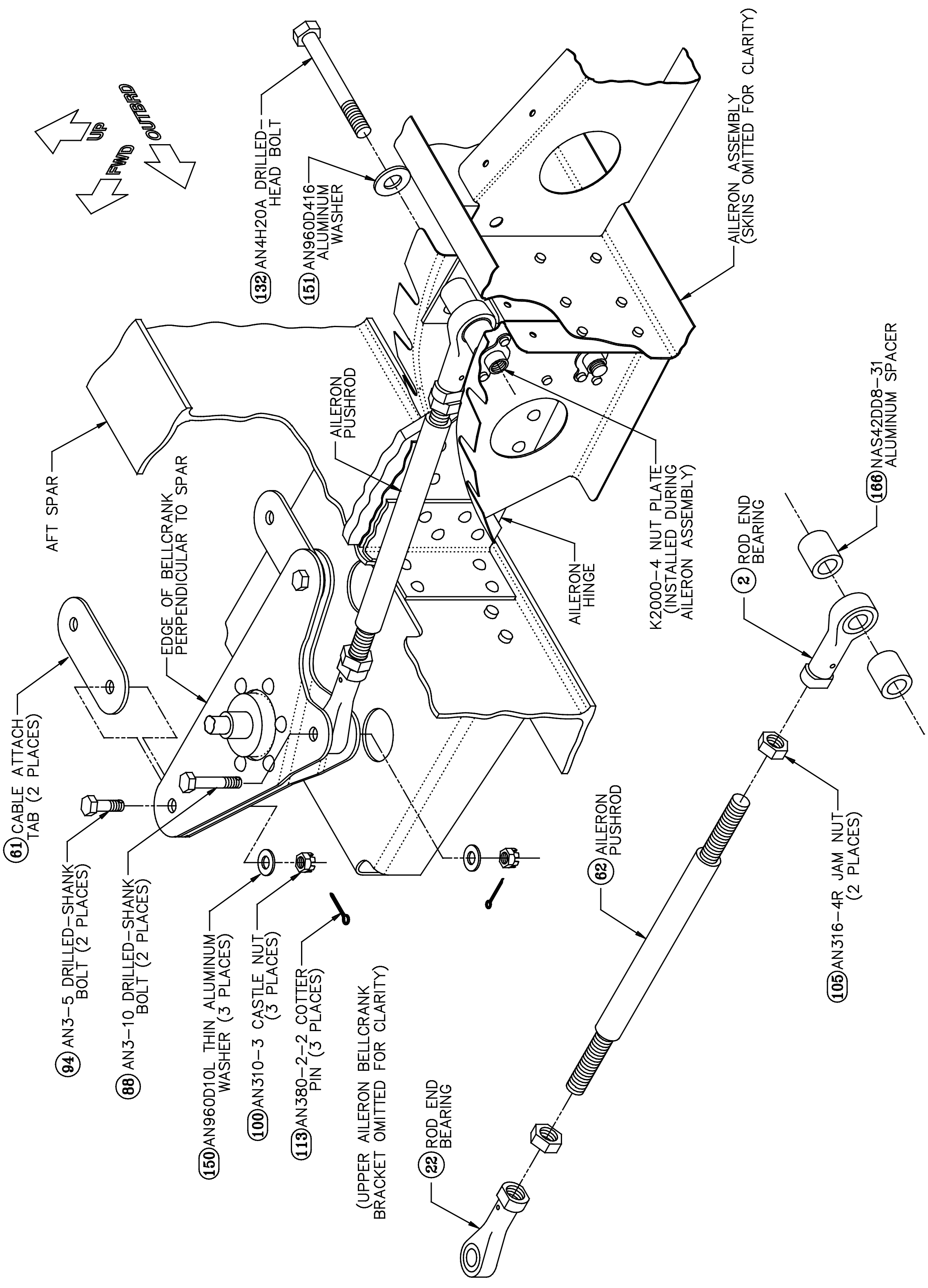

Figure 79: Aileron Pushrod and Cable Attach Tab Installation

Step 39: Install the Aileron Pushrod and Cable Attach Tabs

Thread an AN316-4R jam nut onto each end of the **aileron pushrod** [62]. Thread a 1/4" bolt-diameter **rod end** [2] onto the aft end of the pushrod; thread a 3/16" bolt-diameter rod end onto the forward end of the pushrod, as shown in Figure 79.

Support the aileron in the neutral position—even with the flap when the flap is fully retracted (you can use tongue depressors and small C-clamps to clamp the aileron trailing edge to the flap trailing edge). Then, move the aileron bellcrank to the neutral position—with the inboard edge of the bellcrank perpendicular to the spar. Adjust the length of the pushrod by threading the rod ends in or out until they will fit between the attach holes in the bellcrank and the aileron. Verify that each rod end is threaded onto the pushrod past the inspection hole, and adjust as necessary. When satisfied, secure the rod ends by firmly tightening the jam nuts against them.

Bolt the forward end of the pushrod between the bellcrank arms, using an AN3-10 drilled-shank bolt, an AN960D10 aluminum washer and an AN310-3 castle nut. (At final assembly, the nut will be secured with an AN380-2-2 cotter pin.) Bolt the aft end to the aileron with an AN4H20A drilled-head bolt, two NAS42DD8-31 **aluminum spacers** [166] and an AN960D416 aluminum washer, as shown.

> **Note** As with the aileron hinges, adjust the sizes and positions of the spacers and insert shim washers, as needed, to eliminate any interference between the pushrod and the sides of the slot in the aileron.

Secure a control cable attach tab to each end of the aileron bellcrank with an AN3-5 **drilled-shank bolt** [94], an AN960D10L thin aluminum washer, an AN310-3 castle nut and an AN380-2-2 cotter pin, as shown in Figure 79. The attach tabs fit **between** the two halves of the bellcrank. As usual, apply a light coat of grease to all moving parts.

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FLAP CONTROL CABLES INSTALLATION

Step 40: Fabricate the Inboard Cable Guide

The aileron and flap cables pass through the inboard flap track attach ribs. A plastic guide is needed in this location to keep the cables from wearing the ribs. Cut a **4"** length of the 5/16" X 1" **polyethylene block** [9] to form the inboard cable guide. Trim one end at a **72°** angle, as shown in Figure 80, so that the piece can rest between the ribs on the upper side of the inboard flap track with the angled end against the aft spar.

> **Note** The polyethylene block supplied with early GlaStar kits is **3/8"** rather than 5/16" thick. For these early kits, use a belt sander or a coarse file to shave the cable guide down to a 5/16" thickness to fit between the flap track ribs. Also, early kits were supplied only a **24"** length of the polyethylene block from which **six 4"-long** cable guides are cut (the four additional guides are described in Step 44, below). Consequently, each of the six guides will actually be 4" long **minus the width of the saw kerf**, which is acceptable.

Place the cable guide in position and mark the outline of the cutout in the flap track rib onto the guide. Drill **#30** holes through the flap track ribs and the cable guide in the two positions shown. Remove the guide and trim it **1/4"** above and inside the marked rib cutout line. Deburr the holes in the flap track ribs.

Reinstall the cable guide and secure it in place with 1/8" aluminum **blind rivets** [10].

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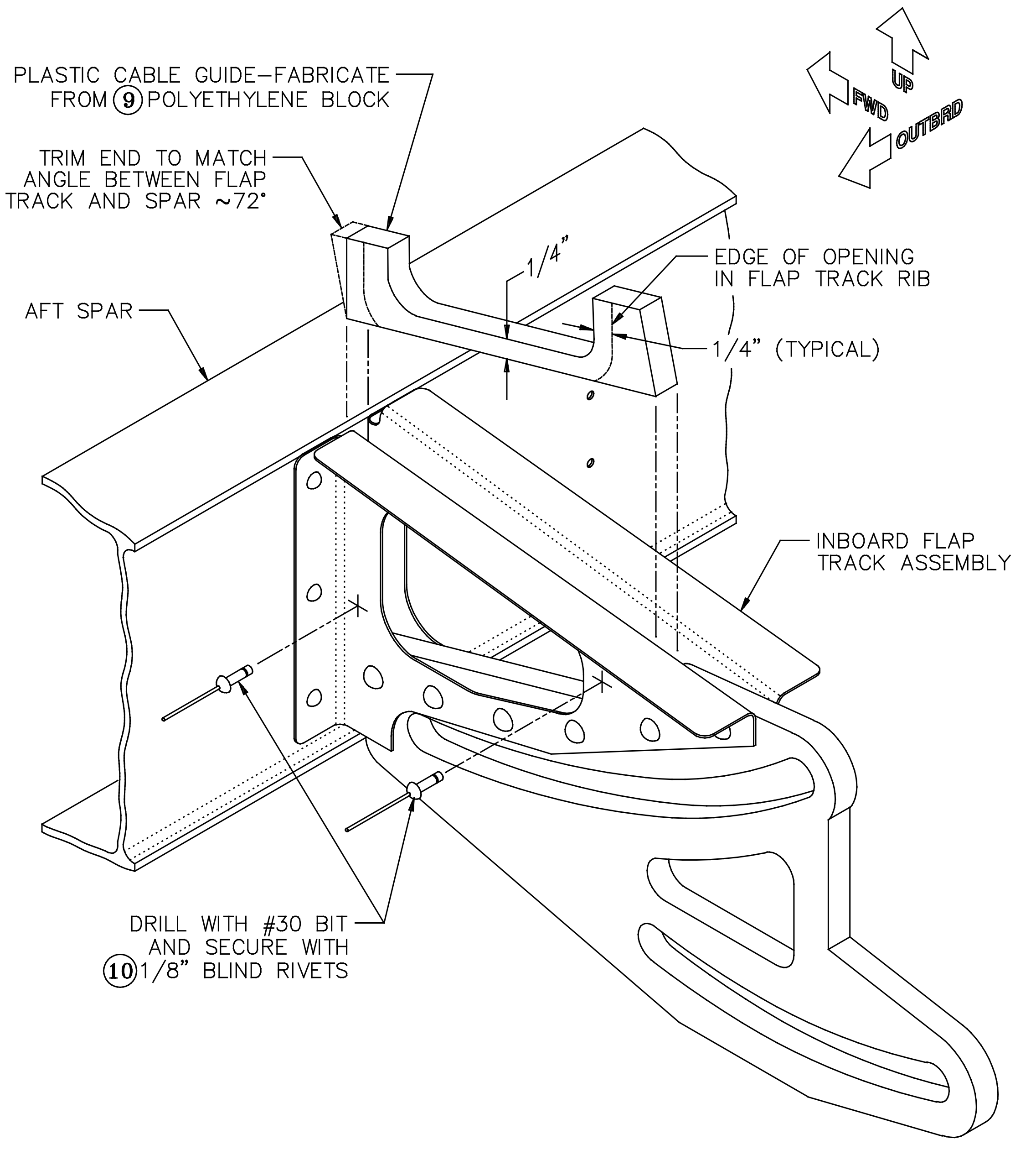

Figure 80: Inboard Cable Guide

Step 41: Route the Flap Deployment Cable

Insert the ball end of a **flap final deployment cable** [69] into the notch in the **left** flap bellcrank located between the flap bellcrank arms, as shown in Figure 81. (The flap final deployment cable has a swaged ball on one end and a left-hand-threaded turnbuckle end on the other; it is 107" long from the swaged ball to the end of the turnbuckle stud.) Secure the ball end in the bellcrank notch with a **cable retainer clip** [24] fastened with AN3-7A **bolts** [99], AN960D10L thin aluminum washers and AN364-1032A nylon self-locking nuts. The washers and nuts fit into the cutout made in the lower bellcrank arm when the bellcrank was assembled. (See the flap cable schematic, Figure 82, for cable nomenclature and an overview of flap cable routing.)

Route the final deployment cable from the bellcrank through the **outboard** cable hole in the aft spar, over the **lower** flap cable guide pulley, through the cutout in the inboard flap track ribs, across the fuselage centerline, over the **forward** pulley in the **right-side** crossover pulley cluster in the fuselage (you'll have to remove the crossover pulley from its mounting bolt temporarily to fit the swaged end of the cable over the pulley) and down toward the lower, outboard flap pulleys on the **right** side of the fuselage cage (these are the pulleys shown in Figure 36). Connect a **flap primary cable** [67] to the final deployment cable by threading the swaged turnbuckle ends of both cables equal distances into an MS21251-B5S turnbarrel. (The flap primary cable is 60" long; one end has a right-hand-threaded turnbuckle end and the other end is bare. Of the three flap primary cables supplied, two will be used as the left and right primary deployment cables and the third will be used as the right wing primary retraction cable.) Route the bare end of the flap primary cable over the **forward** pulley in the lower, outboard flap pulley cluster and then over the **top** pulley in the center, right-side cluster. Finally route the cable forward toward the actuator arm on the flap handle.

Repeat for the **right** wing flap deployment cable, which is a mirror-image of the left. The right flap deployment cable routes from the bellcrank across the fuselage centerline to the crossover pulleys on the **left** side of the fuselage. In a later step, the primary deployment cables from both sides will be spliced together between the flap handle and the center flap pulleys, and one of the cables will be secured to the flap actuator arm.

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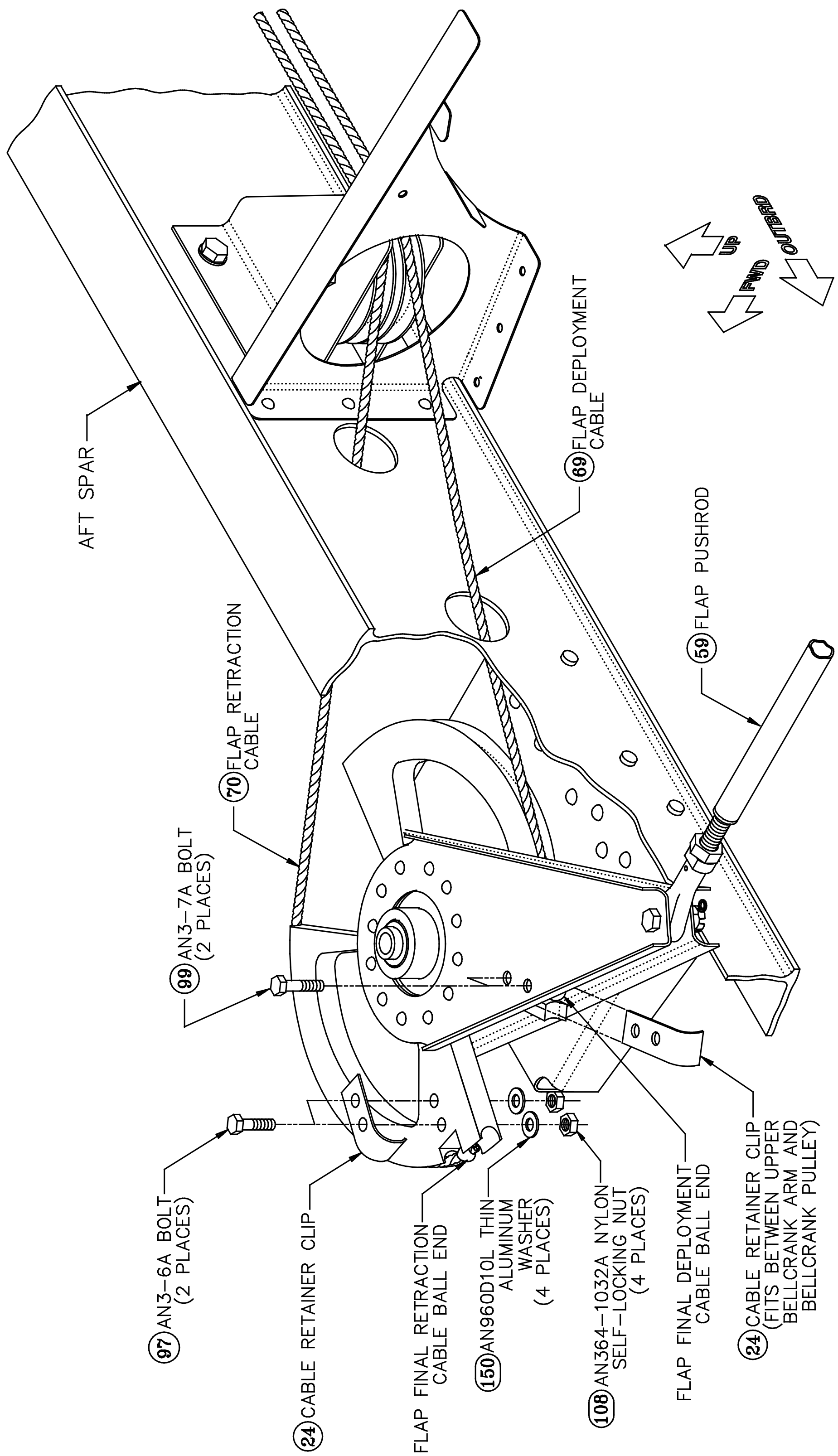

Figure 81: Flap Cable Attachment to the Flap Bellcrank

Step 42: Route the Flap Retraction Cable

Insert the ball end of the **flap final retraction cable** [70] into the remaining notch in the left flap bellcrank, as shown in Figure 81. Secure the cable end in the bellcrank notch with a cable retainer clip fastened with AN3-6A bolts, AN960D10L thin washers and AN364-1032A nuts. (The flap final retraction cable is 116" long from the swaged ball to the end of the turnbuckle end; the turnbuckle end has left-hand threads.)

Route the final retraction cable through the **inboard** cable hole in the aft spar, over the **upper** flap cable guide pulley, through the cutout in the inboard flap track ribs, across the fuselage centerline, over the **center** pulley in the **right-side** crossover pulley cluster in the fuselage and down toward the lower, outboard flap pulleys on the **right** side of the fuselage cage. Connect the **flap primary retraction cable** [68] to the final retraction cable by threading the swaged stud ends of both cables equal amounts into an MS21251-B5S turnbarrel. (The flap primary retraction cable is 90" long; one end has a right-hand-threaded turnbuckle end and the other end is bare.) Route the bare end of the primary retraction cable over the **aft** pulley in the lower, outboard flap pulley cluster and then around the **lower** pulley in the center, right-side cluster. Slide a NicoPress sleeve over the flap primary retraction cable, route the cable forward to the underside of the flap cable reversing pulley in the forward pulley group, and then up and over the pulley and back to the forward side of the actuator arm on the flap handle. Slide a second NicoPress sleeve over the end of the cable.

Repeat a mirror-image installation for the right wing, with one exception. For the right wing, you will fasten a **flap primary cable**, instead of a **flap primary retraction cable**, to the flap final retraction cable. (The flap primary cable is the same as used for the primary deployment cables. We will hereafter refer to this flap primary cable as the "right wing primary retraction cable.") The right wing primary retraction cable will fasten to the left wing primary retraction cable with a NicoPress splice between the flap cable reversing pulley and the lower center pulley cluster. Refer to the schematic, Figure 82, for clarification.

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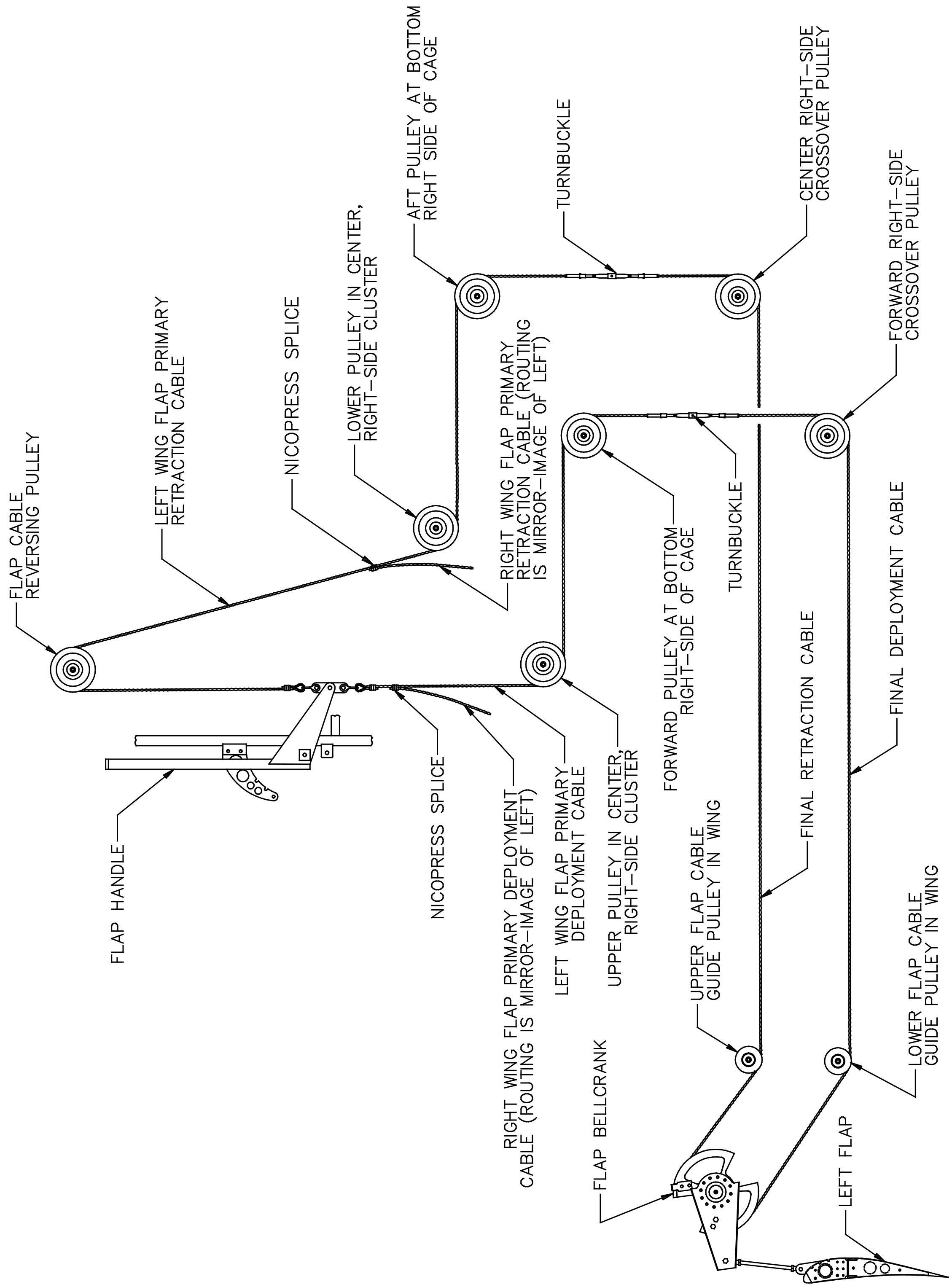

Figure 82: Flap Cable Schematic

Step 43: Complete the Flap Cables

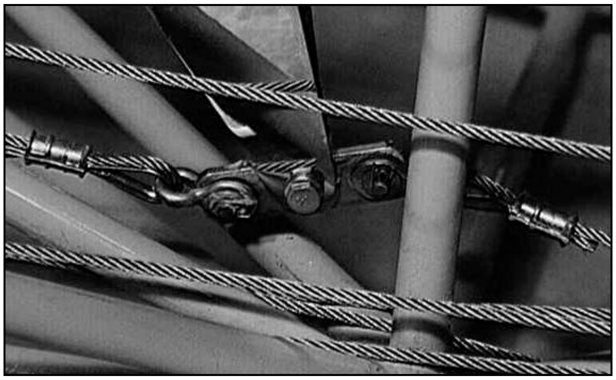

Figure 83: Cable Attachment to Flap Actuator Arm

Fabricate the flap cable attach tab from the **.090" X 3/4" X 6" steel sheet** [14], as shown in Figure 84. Since the flap handle actuator arms are angled slightly, form a slight S-bend in the cable attach tab to align the ends of the tab parallel to the fuselage centerline. Form the S-bend by clamping each end of the tab in a vise (one end at a time) and striking the tab with a hammer. Deburr the tab, as usual, and apply corrosion-proofing.

Bolt the cable attach tab between the two sides of the flap actuator arm, using an AN3-5 drilled-shank bolt, an AN960-10L thin washer, an AN310-3 castle nut and an AN380-2-2 cotter pin.

Insert an AN100C-4 cable thimble into each of two AN115-21 shackles and secure one of the shackles to each end of the cable attach tab with an AN393-11 clevis pin, an AN960-10L thin washer and an AN380-2-2 cotter pin, as shown in Figure 84.

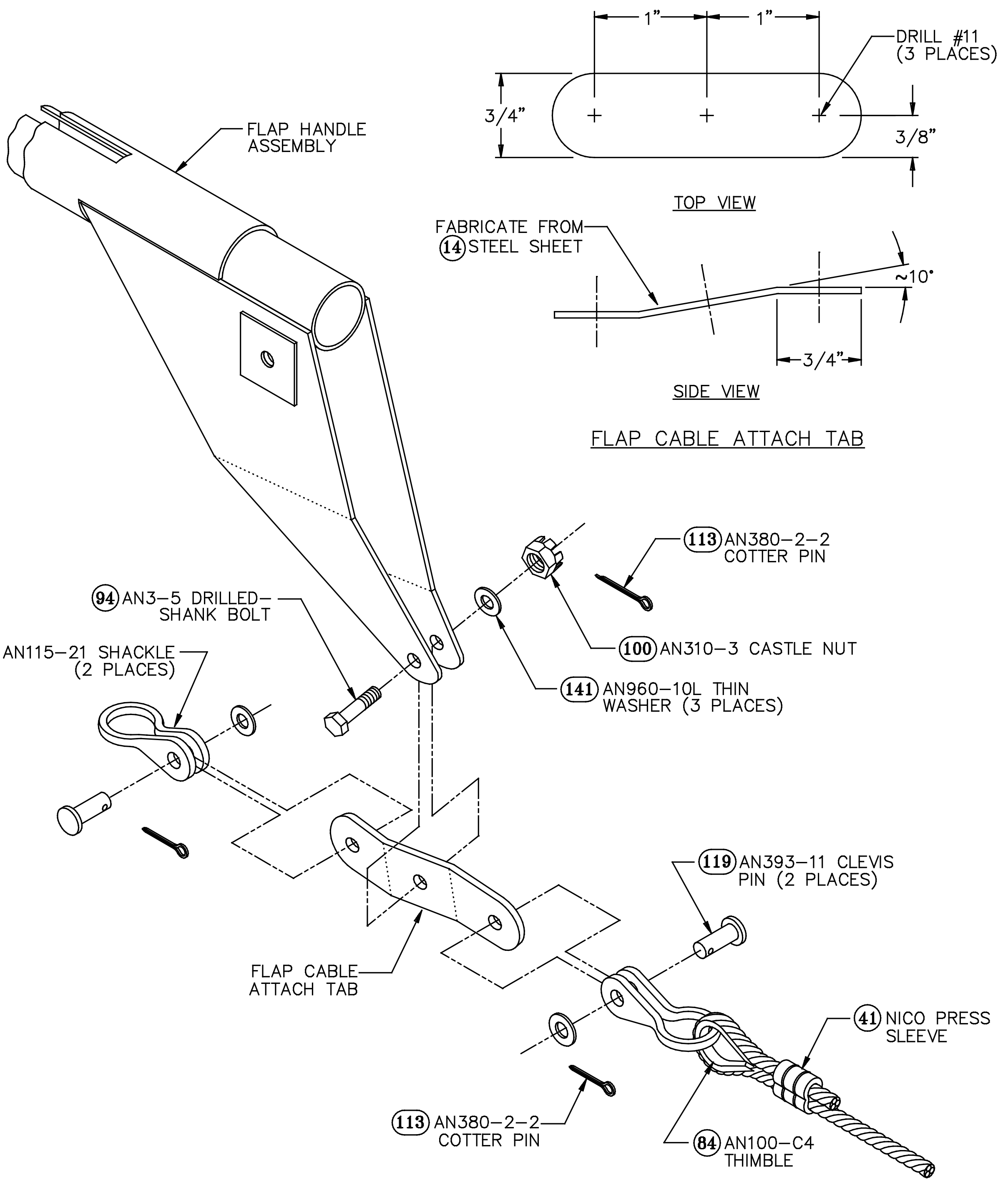

Figure 84: Flap Cable Attachment to Flap Handle

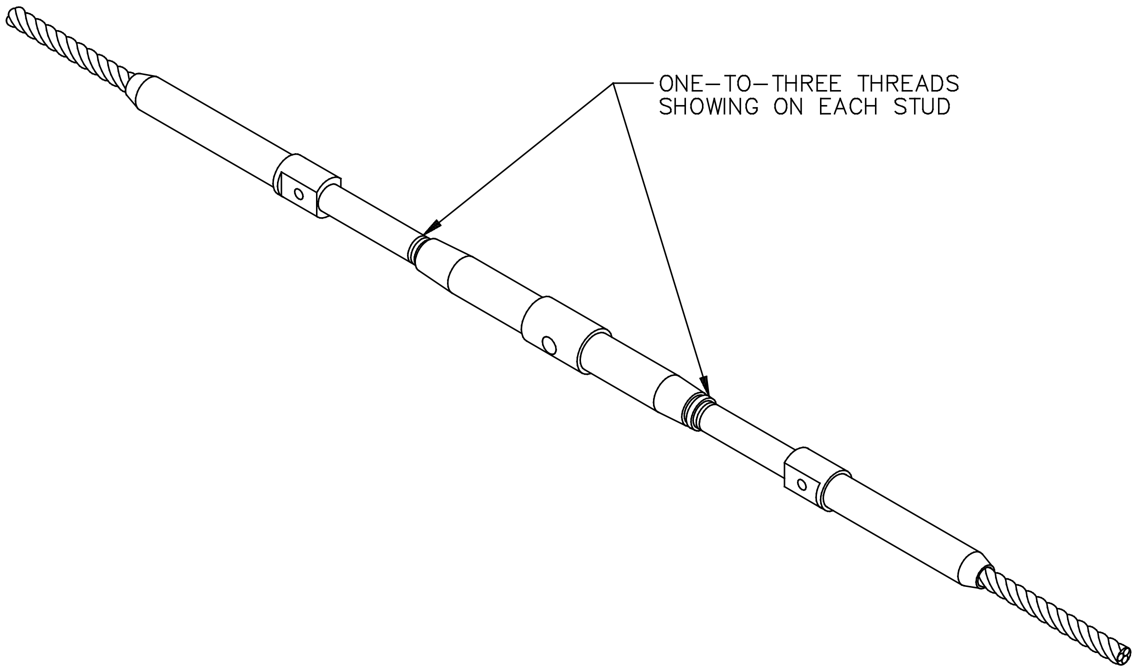

Figure 85: Initial Turnbuckle Adjustment

Adjust the turnbuckles in all four flap cables so that one-to-three threads of the turnbuckle end of each cable are showing past the end of the turnbarrel.

Move both flaps to the fully **retracted** position (all roller bearings at the forward ends of the slots in the flap tracks) and hold them there with lengths of duct tape between the flaps and the wings. Move the flap handle to the flaps fully retracted position, pushing the handle down until the pin in the plunger locks into the lowest notch in the ratchet plate.

Loop the left wing primary retraction cable over the thimble in the forward end of the flap cable attach tab and then back through the NicoPress sleeve, as shown in Figures 82 and 86. Pull the cable tight, making sure that it is properly seated in all of the pulleys, and secure the free end to itself with a 1/8" cable clamp placed close to the NicoPress sleeve.

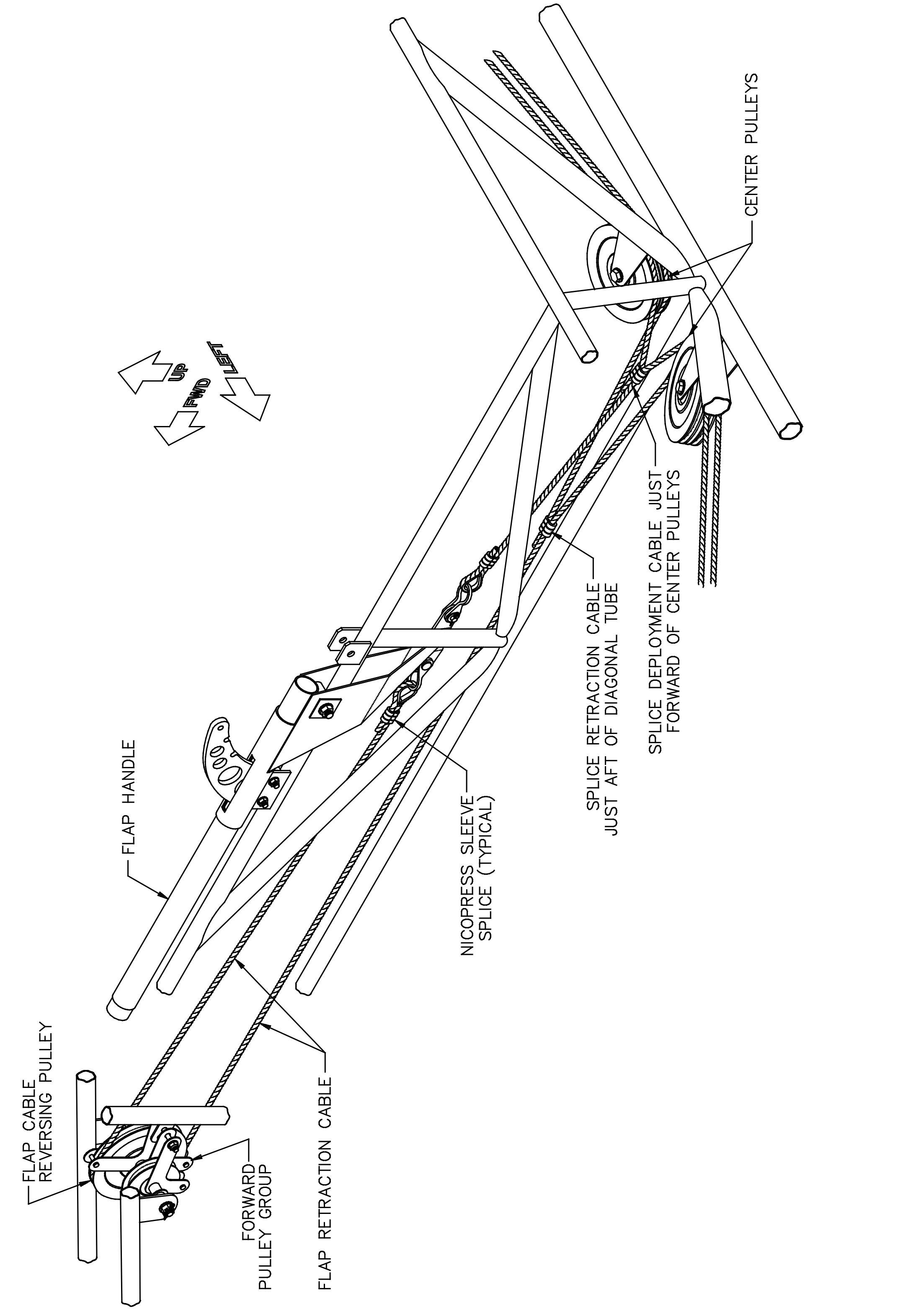

Figure 86: Flap Cable Completion

Insert the end of the right wing primary flap retraction cable through the other NicoPress sleeve installed on the left wing primary retraction cable. Pull the right wing cable tight and use a second 1/8" cable clamp to secure the cable to the left wing primary cable close to the diagonal tube in the fuselage keel, as shown in Figure 86 (this splice is also shown directly above the fuselage cage attach tab at the lower edge of Figure 87).

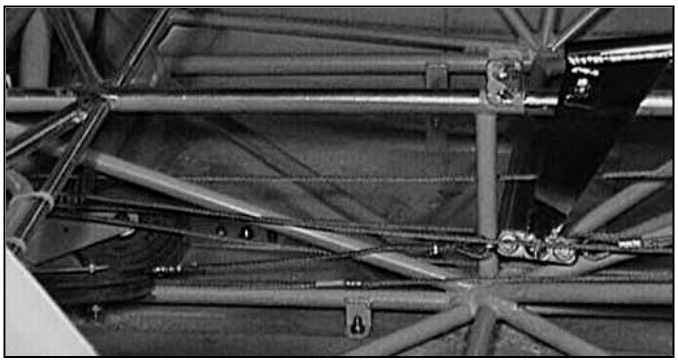

Figure 87: Flap Cable Installation in Fuselage

Slide **two** NicoPress sleeves over the left wing primary flap **deployment** cable. Loop the cable over the thimble in the **aft** end of the flap cable attach tab, and then back through the forward NicoPress sleeve. Pull the cable tight and secure its free end to itself with a 1/8" cable clamp placed close to the NicoPress sleeve. Insert the end of the right wing primary flap deployment cable through the other NicoPress sleeve on the left wing deployment cable, and slide the NicoPress sleeve aft to a position just forward of the lower center pulleys, as shown in Figures 86 and 87. Pull the right wing primary cable tight and use a second 1/8" cable clamp to secure it to the primary flap deployment cable just forward of the NicoPress sleeve.

Un-tape the flaps from the wing, and test the flap actuation by moving the flap handle up and down. Adjust the position of the NicoPress splice where the left and right **deployment cables** join so that it is as far from the lower center pulleys as possible when the flaps are retracted, yet doesn't contact the diagonal cage tube aft of the flap handle when the flaps are fully extended. Adjust the position of the NicoPress splice where the left and right **retraction cables** join so that it is as close as possible to the diagonal cage tube, without contacting it, when the flaps are retracted. (Both splices could actually be slightly farther forward than shown in Figures 86 and 87).

Note It is normal for the cables to rub on the fuselage cage in several locations. This will be rectified during final control system rigging in "SECTION X: FINAL ASSEMBLY."

When satisfied with the cable routing, use the procedures described in "SECTION II: TOOLS AND TECHNIQUES" to complete the NicoPress splices and to cut the free ends of the cables to final length, both at the thimbles where the cables attach to the flap handle tab and where the cables from the two wings splice together.

Final rigging of the flap cables and adjustment of cable tension will be accomplished in "SECTION X: FINAL ASSEMBLY" after the wings are installed for the final time.

Completed: [ ]

Aileron Control Cables Installation

Step 44: Fabricate the Aileron Cable Guides

Cut two **4"** lengths of the supplied 5/16" X 1" polyethylene block, as shown in Figure 88, to make the inboard and outboard aileron cable guides. Drill the two **11/32"** diameter holes through the guides at the locations shown.

The inboard cable guide installs above the flap cable guide pulley bracket, as shown in Figure 90; the outboard cable guide fits between the outboard flap track ribs, as shown in Figure 89.

Note The polyethylene block supplied with early GlaStar kits is **3/8"** rather than 5/16" thick. For these early kits, use a belt sander or a coarse file to shave the **outboard** cable guide down to a 5/16" thickness to fit between the flap track ribs. Also, for the early kits, each of the cable guides will actually be 4" long **minus the width of the saw kerf**, which is acceptable.

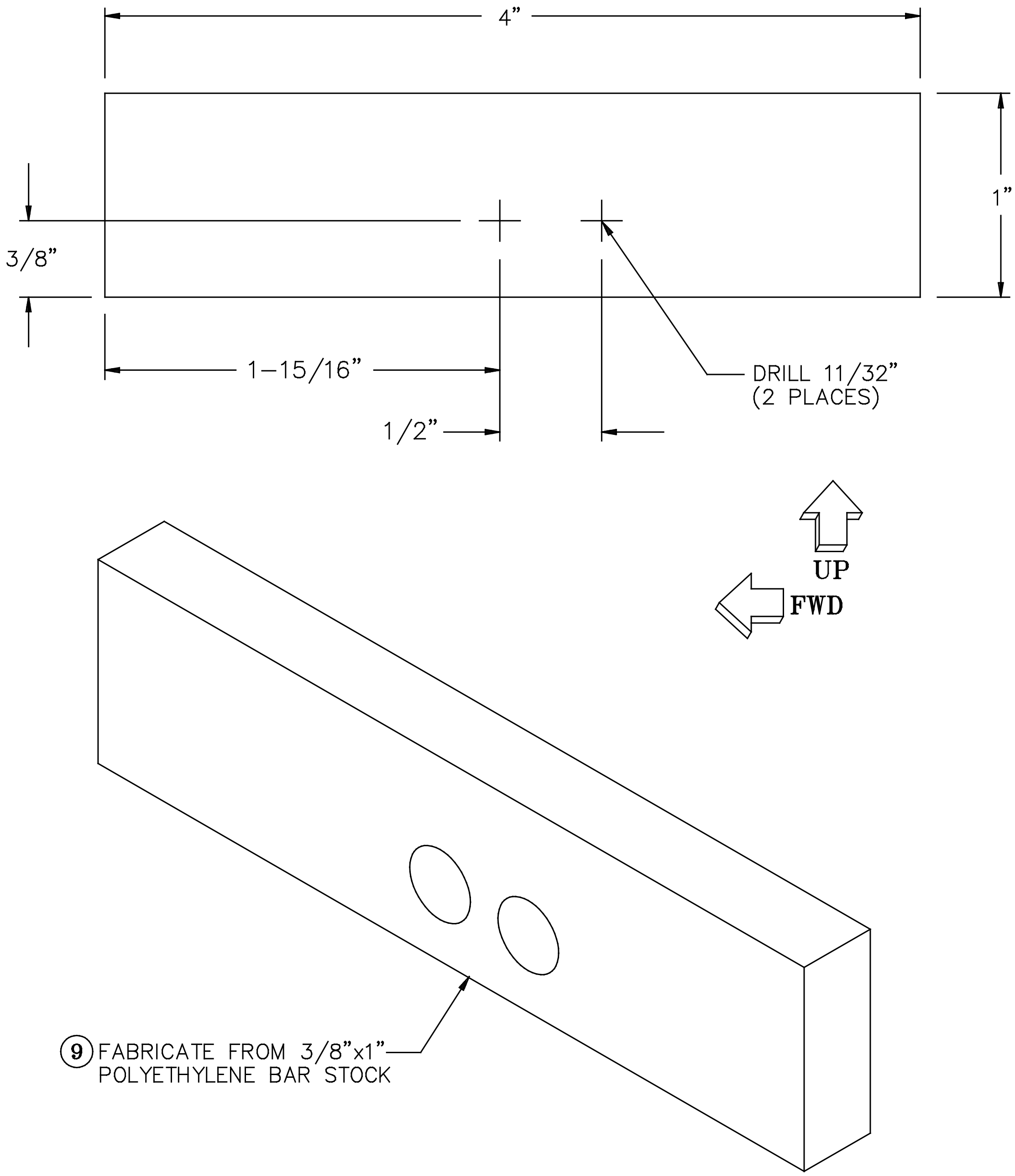

Figure 88: Aileron Cable Guides

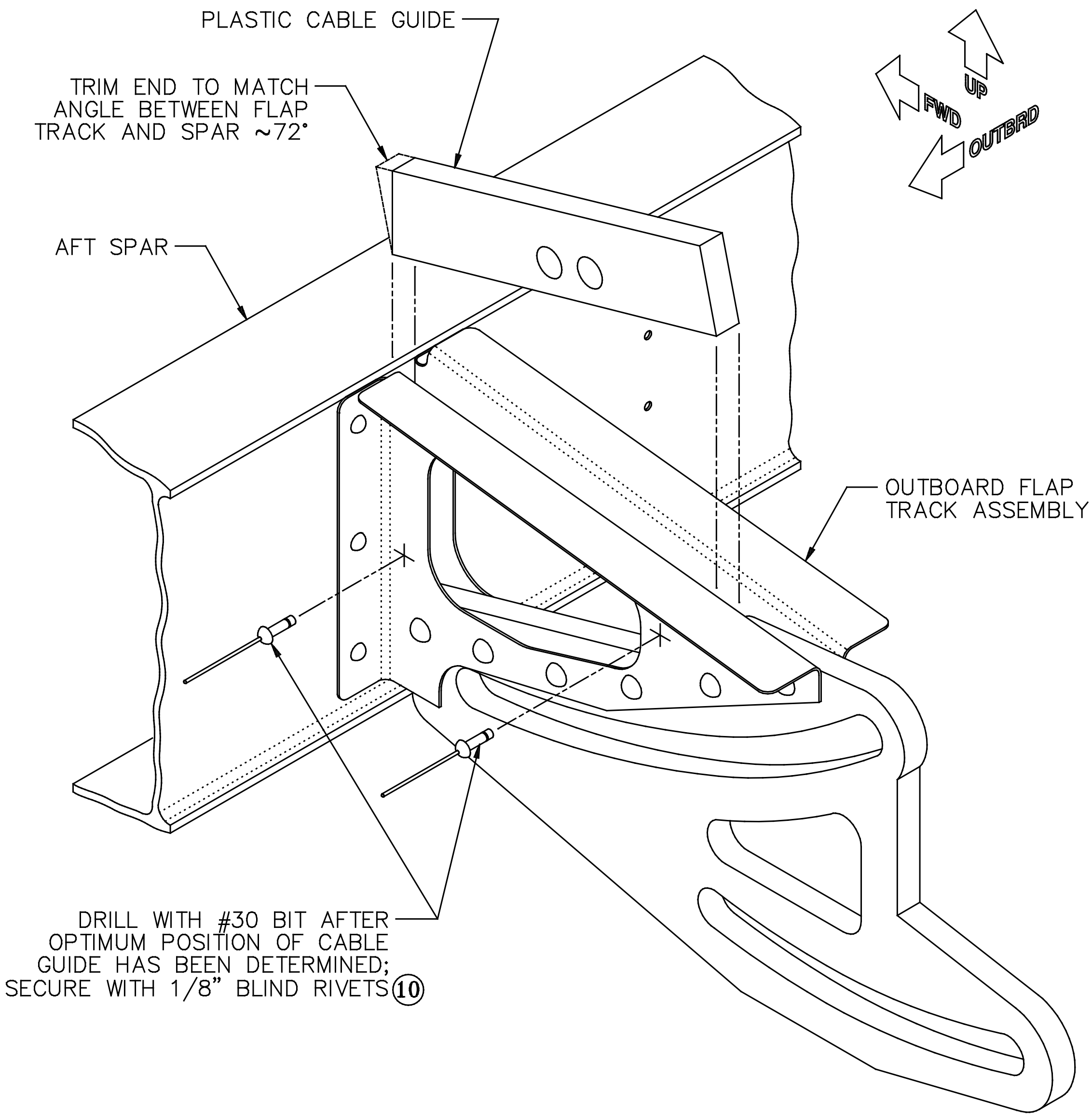

Figure 89: Outboard Aileron Cable Guide Installation

Trim the forward end (the end with the greater distance to the first hole, as shown in Figure 88) of the **outboard** aileron cable guide at a **72°** angle to fit between the upper side of the flap track and the aft side of the aft spar. Slide the outboard guide between the ribs of the outboard flap track assembly, as shown in Figure 89.

Note Do not drill the mounting holes through the cable guides at this time. The mounting holes will be drilled and the guides will be secured with blind rivets after the optimum positions of the guides have been determined.

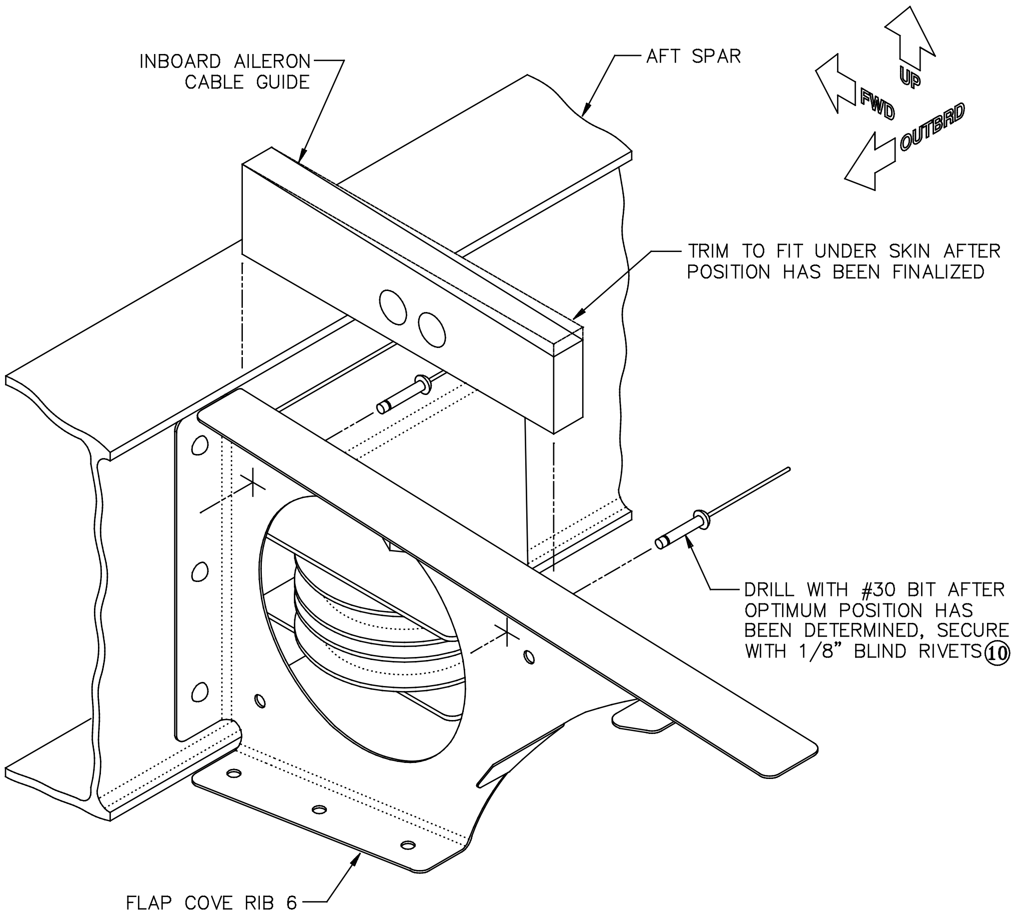

Figure 90: Inboard Aileron Cable Guide Installation

Position the inboard aileron cable guide above the flap cable guide pulley assembly, as shown in Figure 90, and tape it in place temporarily. Again, wait to drill the mounting holes until after the cables have been routed and the optimum positions of the guides have been determined.

Repeat this step for both wings.

Completed: Left [ ] Right [ ]

Step 45: Route the Aileron Control Cables

Note Refer to the aileron cable schematic, Figure 93, for cable nomenclature and a general overview of cable routing.

For each of the four cable attach tabs on the aileron bellcranks, slide an AN100C-4 cable thimble over an AN115-21 shackle and secure the shackle to the tab with an AN393-11 clevis pin, an AN960-10L thin washer and an AN380-2-2 cotter pin.

Secure the ailerons, the aileron bellcranks and the control stick pivot brackets in their neutral positions.

Hint The ailerons are in the neutral position when their trailing edges are aligned with the flap trailing edges (flaps fully retracted). Use wide masking tape or duct tape to secure the flaps in the fully retracted positions and then clamp the aileron trailing edges to the flaps with tongue depressors and spring clamps. Since you adjusted each aileron pushrod to fit between the bellcrank and the aileron when both were in the neutral position, securing the aileron in the neutral position should automatically place the bellcrank in the neutral position, also. If the bellcranks are not in the neutral positions (inboard edges perpendicular to the aft spar web), adjust the lengths of the **aileron pushrods** to achieve this condition. To center the control stick pivot brackets, move the control stick interconnect rod until the clevis pin holes in the fork ends are equal distances from the ends of the elevator/aileron control yoke. Secure the interconnect rod with a pair of vise-grip pliers (padded with tongue depressors) clamped onto the rod at each end of the elevator/aileron control yoke.

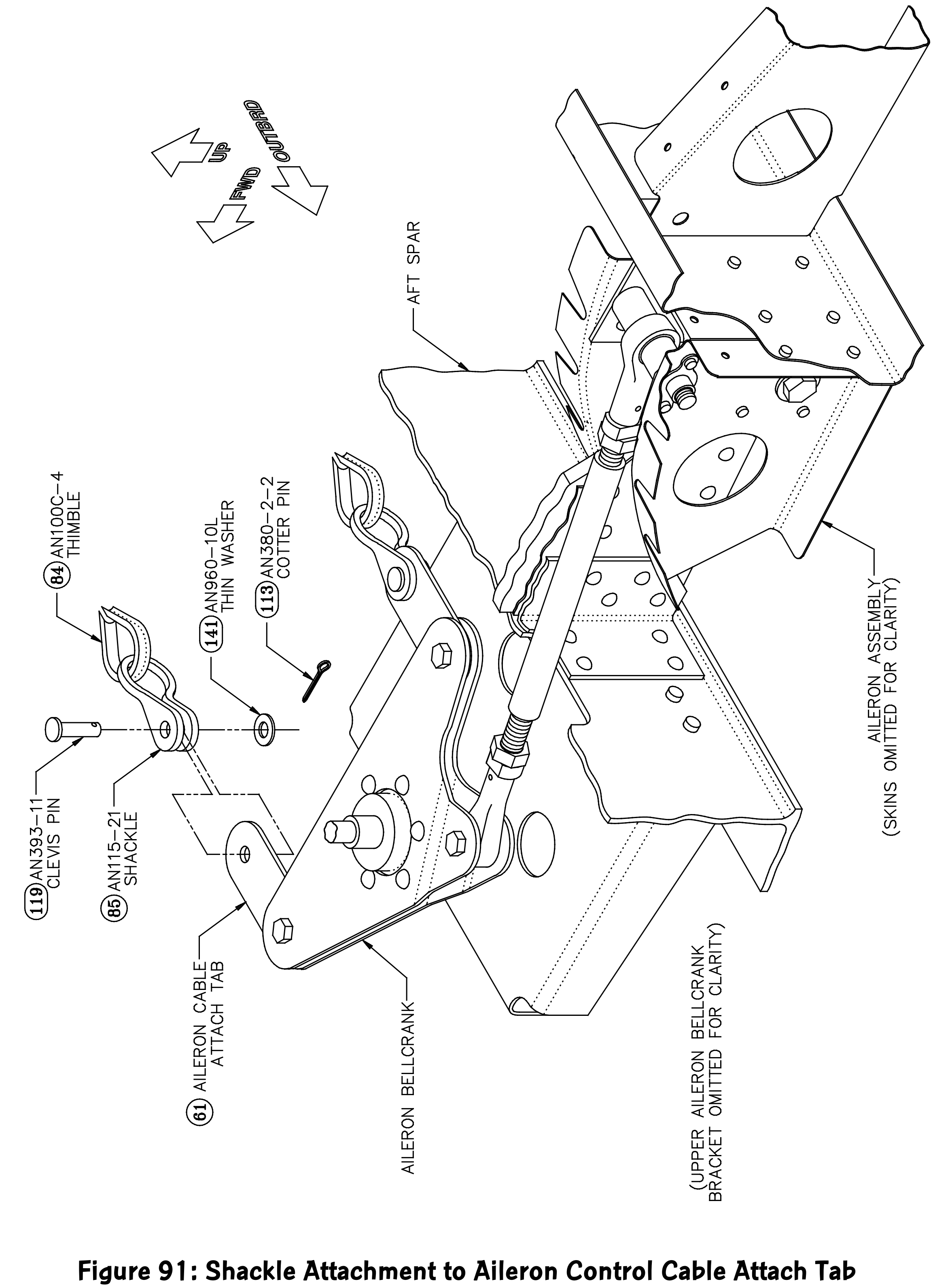

Figure 91: Shackle Attachment to Aileron Control Cable Attach Tab

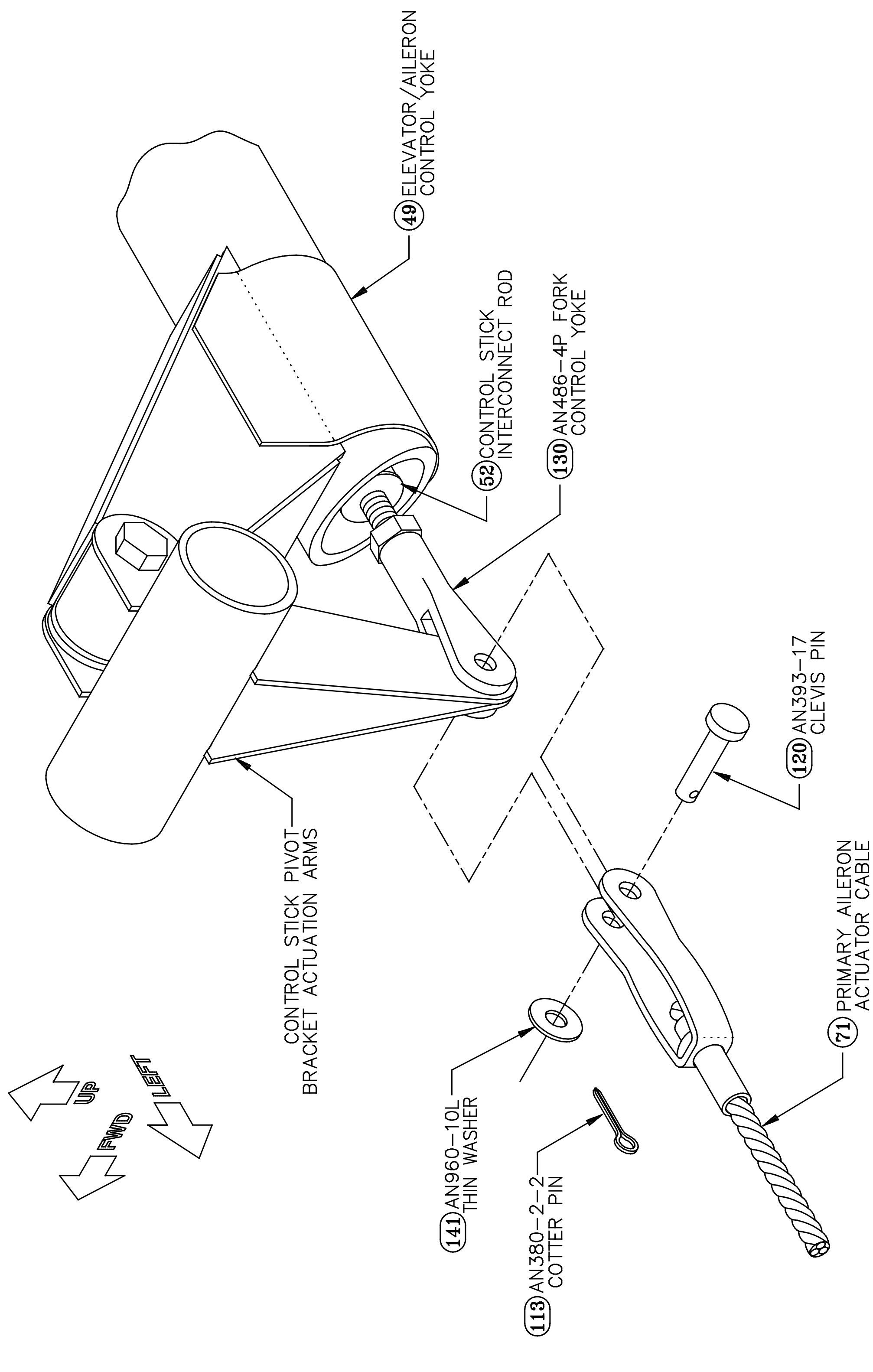

Figure 92: Aileron Control Cable Attachment to Control Stick Assembly

Fasten the shackle end of a **primary aileron actuation cable** [71] to each end of the control stick interconnect rod, as shown in Figure 92, using the same AN393-17 clevis pin that secures the interconnect rod to the control stick pivot bracket. (The primary aileron actuation cable is 66" long from the attach hole in the strap shackle to the end of the swaged turnbuckle end, which has right-hand threads. You will have to spread the arms of the strap shackle on the cable slightly so the shackle will fit over the end of the fork on the interconnect rod.) Secure the clevis pin with an AN960-10L thin washer and an AN380-2-2 cotter pin. Route each cable outboard, around the forward side of the lower forward aileron pulley, aft to the underside of the lower aft aileron pulley and up toward the upper crossover pulleys.

Fasten a **secondary aileron actuation cable** [72] to each primary actuation cable by threading the swaged ends of the two cables into an MS21251-B5S turnbarrel. (The secondary aileron actuation cable is 186" long; one end has a left-hand-threaded turnbuckle end and the other end is bare.) Adjust the turnbuckle so that one-to-three threads show beyond the end of the turnbarrel on each side, as shown in Figure 85.

Route each secondary aileron actuation cable up to the outboard side of the **aft** pulley in the upper crossover pulley cluster. From the upper crossover pulley cluster, each cable travels inboard across the fuselage centerline to the opposite wing. Route the cables through the openings in the inboard flap track ribs and through the **forward** holes in both the inboard and the outboard aileron cable guides. Route each cable over the **lower** inboard aileron guide pulley, through the spar to the **lower** outboard guide pulley and from there to the **aft** arm of the aileron bellcrank. Refer to the aileron cable schematic, Figure 93.

Slide a NicoPress sleeve over the end of the cable. Loop the cable over the thimble in the shackle in the cable attach tab and back through the NicoPress sleeve. Pull the cable tight and slide the sleeve up tight against the thimble. Use a 1/8" cable clamp to clamp the free end of the cable to itself.

Connect the **left aileron crossover cable** [73] to the **right aileron crossover cable** [74] by threading the swaged ends of the two cables into an MS21251-B5S turnbarrel until one-to-three threads of the studs are showing at each end of the turnbarrel. (The left aileron crossover cable is 152" long with one bare end and one right-hand threaded turnbuckle end; the right crossover cable is 168" long with one bare end and one left-hand threaded turnbuckle end.)

Route both crossover cables from the fuselage centerline outboard through the openings in the inboard flap track ribs and through the **aft** holes in both the inboard and the outboard aileron cable guides to the inboard aileron cable guide pulleys in their respective wings. Route each cable over the **upper** inboard guide pulley, through the spar to the **upper** outboard guide pulley and from there to the **forward** arm of the aileron bellcrank. Position the turnbarrel halfway between the fuselage centerline and the **left** side of the fuselage.

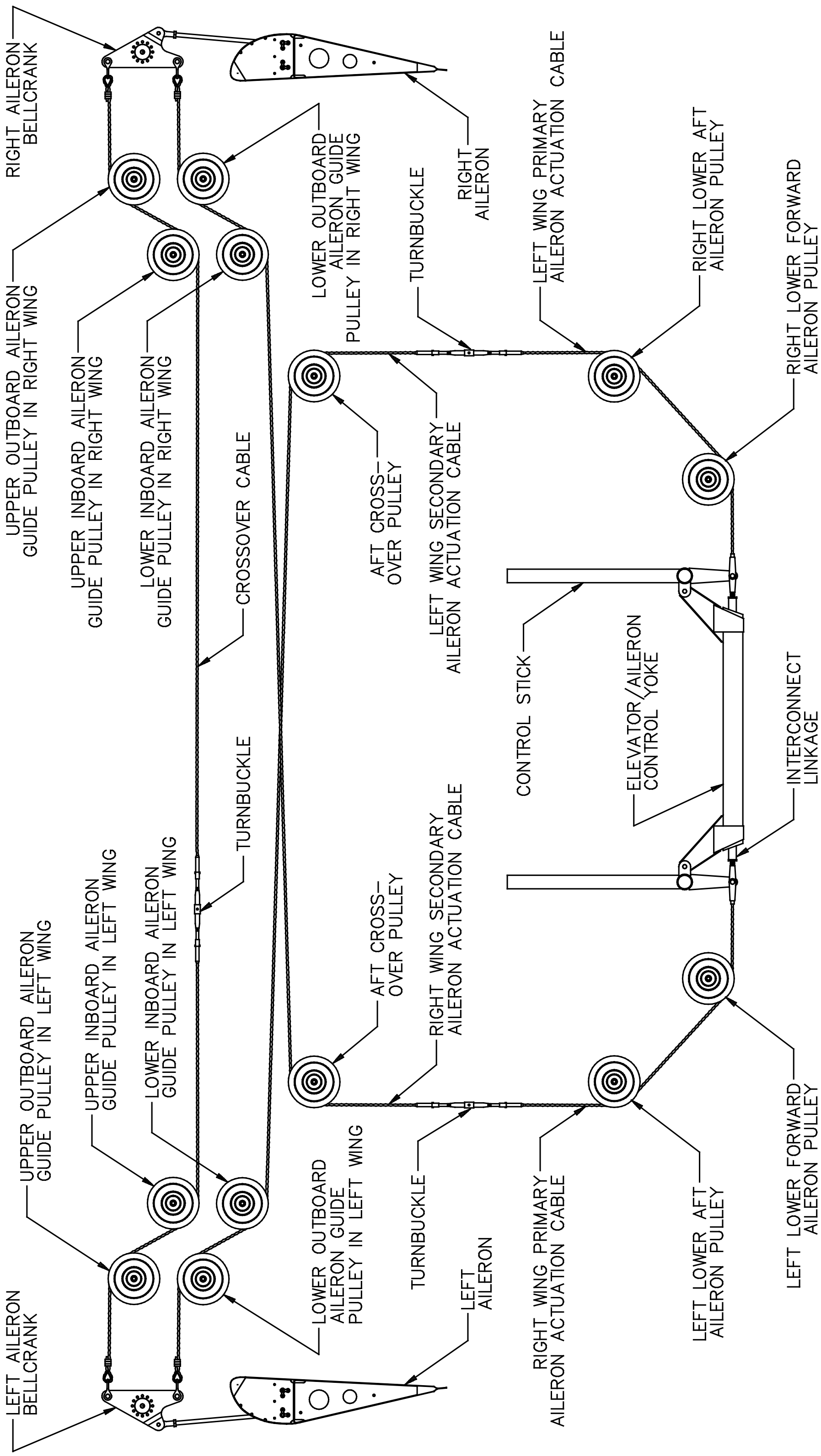

Figure 93: Aileron Cable Schematic

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Note The turnbarrel is positioned off-center so that it will not interfere with the center fuselage cable guide, which will be installed later, during final assembly. The turnbarrel's off-center position is the reason that the left cable is shorter than the right.

Secure each crossover cable to the cable attach tab in the forward aileron bellcrank arm using the same hardware and procedures as for the secondary actuation cables, which were secured to the aft bellcrank arm.

Make sure that the ailerons and the aileron bellcranks are still in the neutral positions and that the turnbarrel for the crossover cable is positioned halfway between the fuselage centerline and the left side of the fuselage. Verify that, with the ailerons in the neutral positions, the aileron interconnect tie rod is centered with respect to the elevator/aileron control yoke so that the control stick pivot brackets are both at the same angle relative to vertical. If necessary, adjust the left and right aileron actuation cables to produce this condition (shorten one cable and lengthen the other the same amount).

Note Adjust the actuation cables by changing the positions of the temporary cable clamps where the cables connect to the aft arms of the bellcranks. **Do not** change the cable length by adjusting the turnbuckles. After the cables are tensioned, there must be no more than three threads of each cable end showing beyond the end of the turnbarrel. Threading the turnbuckle out to lengthen a cable at this time could prevent meeting this requirement later. Leave the turnbuckles with one-to-three threads showing at each end. The number of threads showing will be reduced when the cables are tensioned.

Finally, check that the cables are properly seated in all the pulleys in the system, and make sure that there is no excessive slack.

Completed [ ]

Step 45.1: Adjust the Aileron Travel and Set the Control Stops

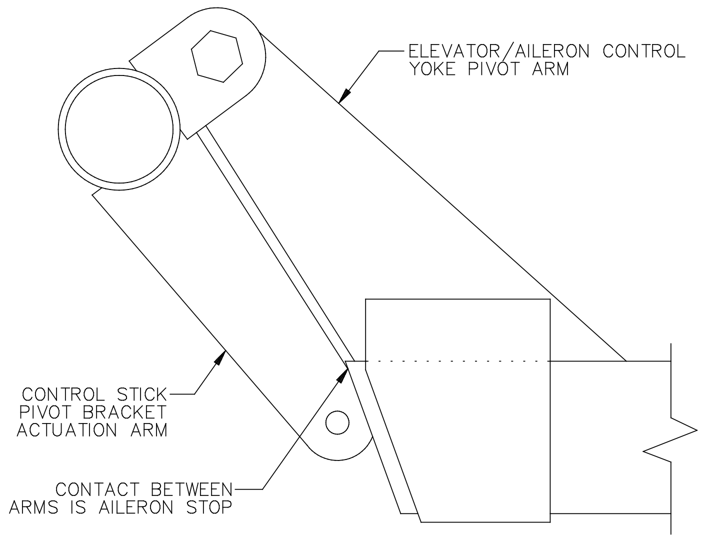


Figure 93.1: Aileron Control Limit Stops

The control stick pivot bracket actuation arms contacting the sides of the elevator/aileron control yoke pivot arms serve as the limit stops for the aileron control system, as shown in Figure 93.1. The actuation arm contacting the pivot arm on the **right** side of the control yoke limits the **down** travel of the **left** aileron; the actuation arm contacting the pivot arm on the **left** side of the control yoke limits the **down** travel of the **right** aileron. Since the aileron linkage is a closed loop and the left and right ailerons move in opposite directions, the down limit stop for the left side serves as the up stop for the right side, and vice versa.

The required travel for the ailerons is **22.5° up** and **17.5° down** with a tolerance of **±1°** in either direction. Because of the aileron hinge configuration, you can't use the bevel gauge method for checking travel that you used for the rudder in Step 60 of "SECTION VIII: FUSELAGE ASSEMBLY." Instead, make two aileron travel gauges (one for the left wing and one for the right), as shown in Figure 93.2, to check the travel.

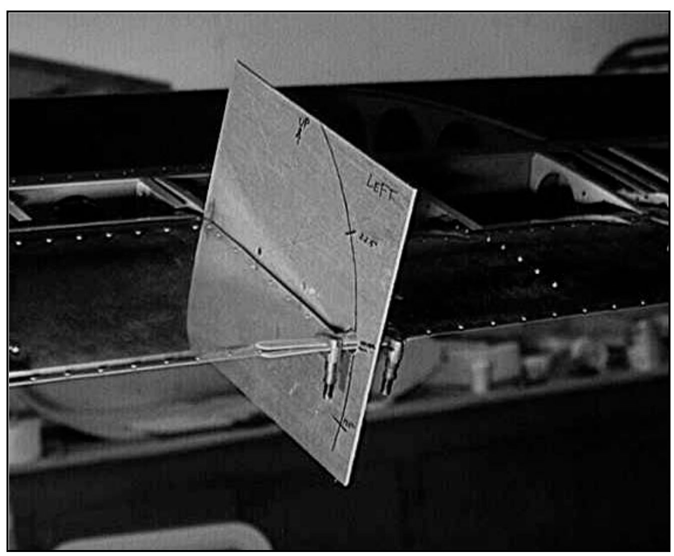


Figure 93.2: Aileron Travel Gauge

To make each gauge, cut a foot-square piece of thin plywood (or any other thin, stiff material) and use drywall screws to fasten the edge of a 6" length of 1 X 2 lumber to the back side of the plywood; position the 1 X 2 parallel to the top edge of the plywood and approximately centered in both directions. In the Figure 93.2, you can see the two screws securing the 1 X 2 just above the surface of the aileron.

With the flap secured in the fully retracted position, tape the 1 X 2 on the travel gauge to the upper surface of the flap with the plywood positioned in the gap between the flap and the aileron, as shown in Figure 93.2. Hold a felt-tip pen against the aileron trailing edge with the pen point resting on the plywood, and swing the aileron up and down, letting the pen mark the arc described by the aileron trailing edge. Also mark the aileron trailing edge neutral position (even with the flap trailing edge) onto the plywood. Remove the travel gauge from the wing and use compass-and-straightedge techniques from high school geometry to find the center of the trailing edge arc (the aileron hinge point) and mark it on the gauge. (To find the center of a circle or an arc remember that the perpendicular bisectors of two different chord lines cross at the center.) Now that the center of the arc is located, you can use a protractor to mark the travel limits (22.5° up and 17.5° down, measured from the neutral position) on the trailing edge arc.

It's handy to drill a 1"-diameter hole through the gauge at the neutral position so that the aileron trailing edge can be secured to the flap trailing edge with tongue depressors and small clamps, as shown in Figure 93.2. Make the gauge for the right wing a mirror-image of the gauge for the left wing. Tape the finished aileron travel gauges to the flaps.

Move the aileron interconnect tie rod from side-to-side to check the aileron travel with the travel gauges. It's most likely that you'll have more than enough travel in both directions. If the ailerons don't have full travel, check for obstructions in the control system. (If the pushrods contact the holes in the spar, for example, enlarge the holes to permit free movement.)

When adequate aileron travel has been achieved, you must shorten the interconnect tie rod by threading the fork ends further onto the rod until each control stick pivot bracket actuation arm contacts the control yoke pivot arm just as the opposite aileron reaches its down travel limit.

Shortening the interconnect tie rod increases the tension in the aileron actuation cables, of course, so at the same time you must lengthen the cables to relieve the tension. The interconnect tie rod and the cables must be adjusted symmetrically so that the tie rod remains centered relative to the control yoke when the ailerons are in their neutral positions. (As mentioned in the previous **Note**, adjust the cables by changing the positions of the temporary cable clamps at the aileron bellcranks, instead of by adjusting the turnbuckles.) Refer to the aileron cable schematic in Figure 93 to help visualize what's going on. Notice that the aileron interconnect tie rod is really just like another turnbuckle joining the left and right actuation cables together.

Here is a systematic method to accomplish the desired results:

1) Support the **left** aileron at its **down** travel limit as measured by the gauge. Because of the geometry of the control system, the right aileron should be very close to its upper travel limit. Also, the interconnect tie rod will be off-center, to the left.

2) While holding the **left** aileron at its down limit, loosen the cable clamp where the left wing actuation cable connects to the **aft** arm of the **left** aileron bellcrank to introduce some slack in the cable. Thread the fork on the **right** side of the interconnect tie rod in until the pivot bracket actuation arm contacts the control yoke pivot arm (you will have to temporarily disconnect the fork from the actuation arm to do this, of course).

3) While continuing to hold the left aileron at its down travel limit and while holding the right pivot bracket actuation arm in solid contact with the control yoke pivot arm, pull the left aileron actuation cable tight and tighten the temporary clamp to hold the adjustment.

4) Repeat a mirror-image of the procedures in Steps 1–3 for the right aileron, and you're finished.

After the control stops have been adjusted, make a final check of the control travel in both directions and make fine adjustments as necessary. Also make a final check that the bellcranks are square to the spar and the interconnect tie rod is centered when the ailerons are neutral. When satisfied, crimp the NicoPress sleeves and trim off excess cable.

Note Since the wings will be removed to complete the rest of the procedures in "SECTION IX: SYSTEMS INSTALLATION" and the initial work in "SECTION X: FINAL ASSEMBLY," there is no point in tensioning the aileron control cables at this time. The cables will be tensioned after the wings are installed for the final time.

Completed: [ ]

Step 46: Secure the Aileron Cable Guides to the Wing Structure

Now that the aileron cables are installed and relatively tight you can finish the aileron cable guide installation that was begun in Step 44.

Determine the optimum chordwise position of each cable guide by sliding it forward and aft until the guide deflects the cables the **minimum** amount. When the optimum position of each guide has been determined, drill two **#30** holes through both the guide and the rib(s) to which it mounts, as shown in Figures 89 and 90. Trim the guides, as necessary, so that they don't protrude above the flap cove and flap track ribs. Secure each guide with two 1/8" aluminum blind rivets. For the cable guides that mount above the flap cable guide pulleys, place the rivet heads against the cable guide.

Completed: [ ]

CONTROL CABLE RETAINERS FABRICATION AND INSTALLATION

Guards or retainers must be installed on all of the control system pulleys to keep the cables from slipping off or jamming. This is especially important if you plan to fold the wings, since the aileron and flap cables go slack when the wings are folded. Guards are essential to ensure that these cables seat properly in their pulleys when the wings are re-extended.

Separate guards or retainers are not needed, however, in instances where the cables are retained in some other manner. Separate cable retainers are **not** needed for the following pulleys: the **lower outboard flap pulleys**, which are mounted in such a way that the pulley bracket itself serves as a guard, and the **crossover pulley clusters** in the fuselage cage, which have cable guards welded in place as part of the cage structure. In addition, by completing the procedures described in Step 13, you have already fabricated cable guards for the **left rudder cable guide pulley** and for the **elevator** and **flap cable reversing pulleys**; if you have not already done so, install the clevis pins and cotter pins to complete the cable guards for these pulleys, as shown in Figure 29.

Note Each cable guard must be positioned no more than **1/16"** from the edge of the pulley to effectively retain the cable.

Step 47: Install Cotter Pin Cable Retainers

The **flap cable guide pulleys** in the wings, the **lower inboard flap pulleys** in the fuselage and the **Bulkhead A pulleys** in the aft fuselage all use 1/8"-diameter, AN380-4-6 cotter pins to retain the cables. Installing these is a simple matter of inserting the cotter pin through the holes provided in the pulley mounting bracket, and spreading the legs of the pin.

Install the cotter pin cable retainers for the above-mentioned pulleys on both sides of the airplane, a total of six places. If you completed the procedures described in Step 19, you installed cotter pin retainers for the Bulkhead A pulleys before you bolted the pulley brackets in place.

Completed: [ ]

Step 48: Fabricate and Install the Control Cable Pulley Guard Straps

The remaining control system pulleys (the **inboard** and **outboard aileron cable guide pulleys** in the wings and the **lower forward** and **lower aft aileron pulleys** in the fuselage) all use cable retainers made from thin aluminum strips.

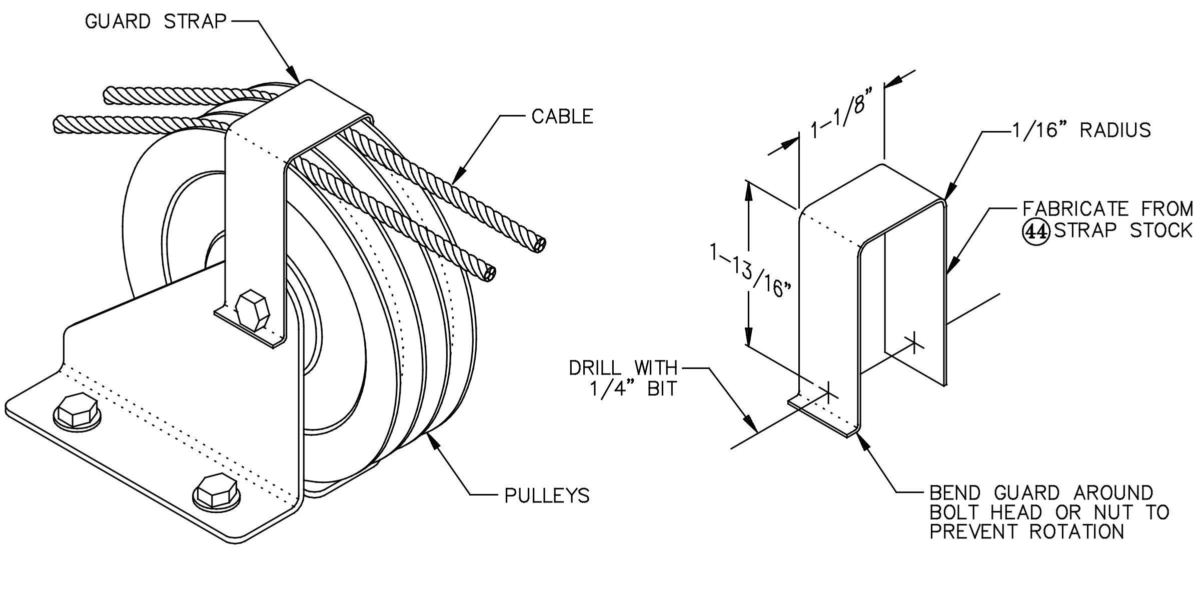
Fabricate guard straps for the remaining pulleys from the supplied **cable retainer strap stock** [44], as shown in Figure 94. Bend the guards over a wooden or metal form block with a minimum radius of **1/16"**. For guards that fit over a single pulley, bend the legs of the strap **1/2"** apart; for guards that fit a double pulley, bend the legs **1-1/8"** apart. To drill the holes for the mounting bolt, clamp the strap over a wooden block, and use a drill press to drill through both legs of the strap and the block all at once. Deburr and corrosion-proof the finished straps.

The straps are fastened in place with the same bolts that the pulleys pivot on. Position the straps so that they are centered over the bend in the cable. To keep the strap from rotating, tighten the pivot bolt firmly and then bend the end of the strap up around either the bolt head or the nut. After installation, check the guards to verify that they retain the cables securely when the cables are slack. Adjust or re-fabricate inadequate guards.

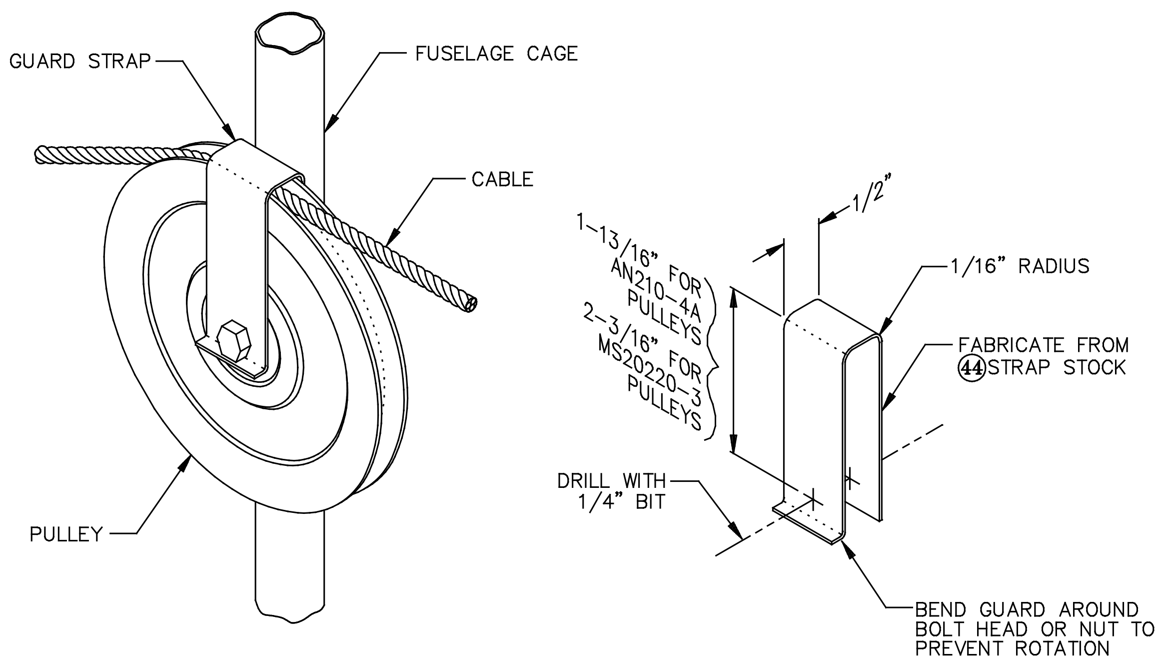
> **Note** Installing the guard straps for the **lower aft aileron pulleys** moves the pulleys inboard slightly, which may cause the pulleys to rub on the cage. To eliminate this interference, file the inboard ends of the small welded bushings to which the pulleys mount. Add washers under the bolt head, if necessary, to compensate for the material removed.

Completed: [ ]

> **Note** The control systems are now complete except for final rigging, tensioning and safetying, which will be done after the wings are installed for the final time. You may now remove the control surfaces from the wings and the wings from the fuselage in preparation for fitting the fuel tanks and completing the remaining systems installations in both the wings and the fuselage.



DOUBLE PULLEY



SINGLE PULLEY

Figure 94: Pulley Guard Straps

> **Note** The text and illustrations in the next two sub-sections of the *Assembly Manual* follow the convention established earlier of referring to and depicting the left-wing parts and procedures only, unless otherwise specified. The right-side procedures are identical.

Preliminary Fuel Tank Installation

Step 49: Apply Anti-Chafe Tape to the Hat Section Stiffeners in the Fuel Tank Bays

The welded aluminum **fuel tanks** [31 and 32] in the GlaStar are not mounted rigidly to the wing structure. Instead, they simply nest between the root rib and the first main rib outboard of the root, supported by the lower-surface hat section stiffeners. As Figure 95 shows, the tanks slide in from the inboard end of each wing before the root rib is riveted in place. There are two important advantages to this system of tank installation. First, if necessary, the tanks can be relatively easily removed from the wings for maintenance, and second, they are isolated to a degree from loads imposed by the normal in-flight flexing of the wing structure. Rigidly mounted tanks would be more subject to cracking from fatigue.

However, because the tanks are free to move relative to the wing structure, it's extremely important to provide protection at potential chafe points. The hat section stiffeners—both upper and lower—are clearly such points. We recommend the application of a durable plastic tape to all the hat section stiffeners between Main Ribs 1 and 2. Carefully wipe each hat section with acetone prior to applying the tape to get the best possible adhesion.

> **Anti-Chafe Tape Option** Special, 3/4"-wide, adhesive-backed ultra-high molecular weight (UHMW) plastic anti-chafe tape is available from Stoddard-Hamilton; order P/N 033-01001-01. The tape comes in an 18' roll, which is sufficient to protect both standard fuel tanks; if you're installing auxiliary tanks, two rolls are required.

Completed: Left [ ] Right [ ]

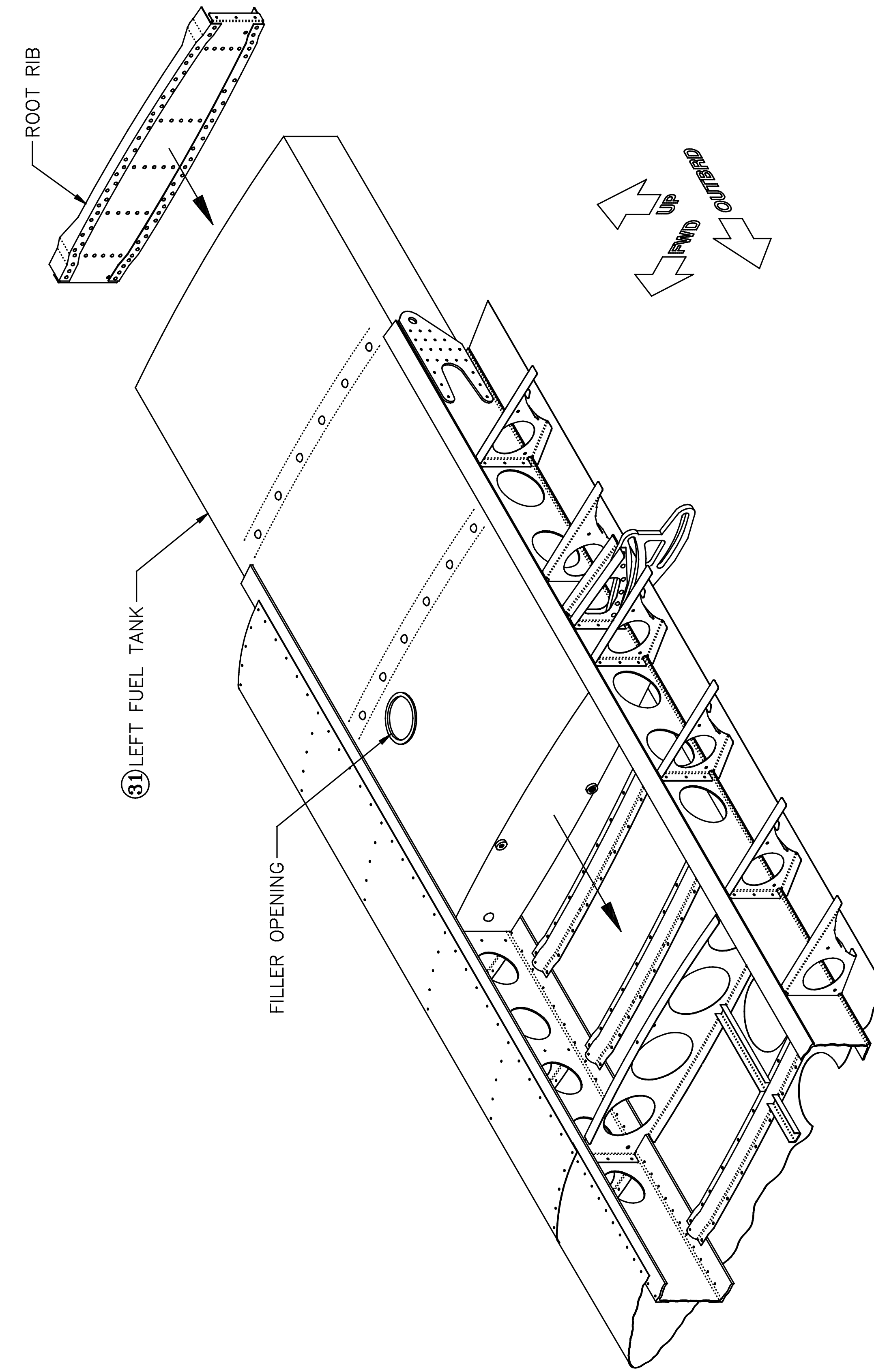


Figure 95: Standard Fuel Tank Installation

Step 50: Test Fit the Fuel Tank

Warning The orifices in your fuel tanks are sealed at the factory with plastic plugs and/or aluminum tape. To minimize the possibility of introducing foreign matter into the tanks, keep these seals in place until specifically instructed to remove them or until the fuel system fittings are installed.

Try sliding the fuel tank into the wing. Ideally, it will slide in between the flanges of the forward and aft spars and over the lower-surface hat sections with minimal interference. However, it's quite possible that the tank initially won't seem to fit.

Hint The left and right tanks can be distinguished by the position of the filler opening: as Figure 95 shows, the opening should be in the forward, outboard corner of the tank when the tank is properly installed.

The reason the tank may not fit is that the thin aluminum sheet from which it's fabricated tends to bulge outward between the ribs as a result of the pressure testing the tanks undergo. Because the tanks are made of soft, non-heat treated aluminum, such bulging is unavoidable, but it is easily dealt with if necessary. Place your tank flat and right-side up on a well padded workbench, with the sump area of the tank hanging over the edge. (The sump is the projection from the bottom of the tank at the inboard end.) As shown in Figure 96, place a **5" X 12"** piece of scrap wood on the upper surface of the tank and use a rubber mallet to tap the bulged areas down. It goes without saying that you don't want to whack the tank **too** hard, but with the piece of wood to distribute the force, you can apply moderately forceful blows without danger of damaging it. Start with the wood block at the forward, inboard corner of the tank and move aft. Then shift the block to the center section of the tank between the two internal ribs and again tap forward to aft. Finally, tap the outboard section. Repeat the process on the bottom side of the tank.

Figure 96: Tapping the Bulges Out of the Fuel Tank

Note Before beginning, remove a plastic plug from any one of the orifices in the tank to relieve internal pressure during the pounding; be sure to replace it when you're done.

After tapping both the top and bottom of the tank, try once again to slide it into the wing. If it still won't fit easily, repeat the tapping process concentrating particularly on the forward and aft edges of the tank. Pounding there will tighten the bend radii of the edges a bit, providing the necessary clearance.

Completed: Left [ ] Right [ ]

Step 51: Drill a Hole in the Lower Wing Skin for the Sump Drain Boss

As you may have noticed when you slid your tanks into the wing, the sump drain boss—that is, the threaded fitting welded into the bottom of the sump—protrudes downward almost half an inch below the bottom of the sump. In this step you will drill holes in the lower inboard wing skin and doubler to allow clearance for this boss and the sump drain valve that you will install in the boss in a later step.

As shown in Figure 97, mark a hole location **1-11/16" outboard** of the inboard edge of the lower skins and **16-1/8" aft** of the trailing edge of the forward spar's lower flange. Use a Unibit or hole saw to drill a **7/8"**-diameter hole through the skins at this location.

At 7/8", the hole will be too small to allow the sump boss to protrude through the skins, but before enlarging it, it's a good idea to slide the tank into the wings and check from underneath to see how well the boss lines up. Note any misalignment.

Finally, use a half-round file or a die grinder with a rotary file to enlarge the hole to provide approximately **1/16"** of clearance all the way around the boss and its welds, taking into account any eccentricity you observed when you checked the alignment. Leave a smooth, deburred finish.

Completed: Left [ ] Right [ ]

Step 52: Test Fit the Upper-Surface Hat Sections

Once the tank will slide easily into the wing with the sump drain boss protruding through the skins, then you need to perform one more test of fit. Take one of the upper-surface hat sections that you applied anti-chafe tape to and try to slide it in place between the forward and aft spar flanges and the fuel tank, as shown in Figure 98. You should be able to start at the inboard end and slide the hat section all the way across the top of the tank to the first main rib. The fit should be snug, but not so tight that you can't move the hat section easily by hand. If necessary, remove the tank and take up your mallet once again until the hat fits.

Completed: Left [ ] Right [ ]

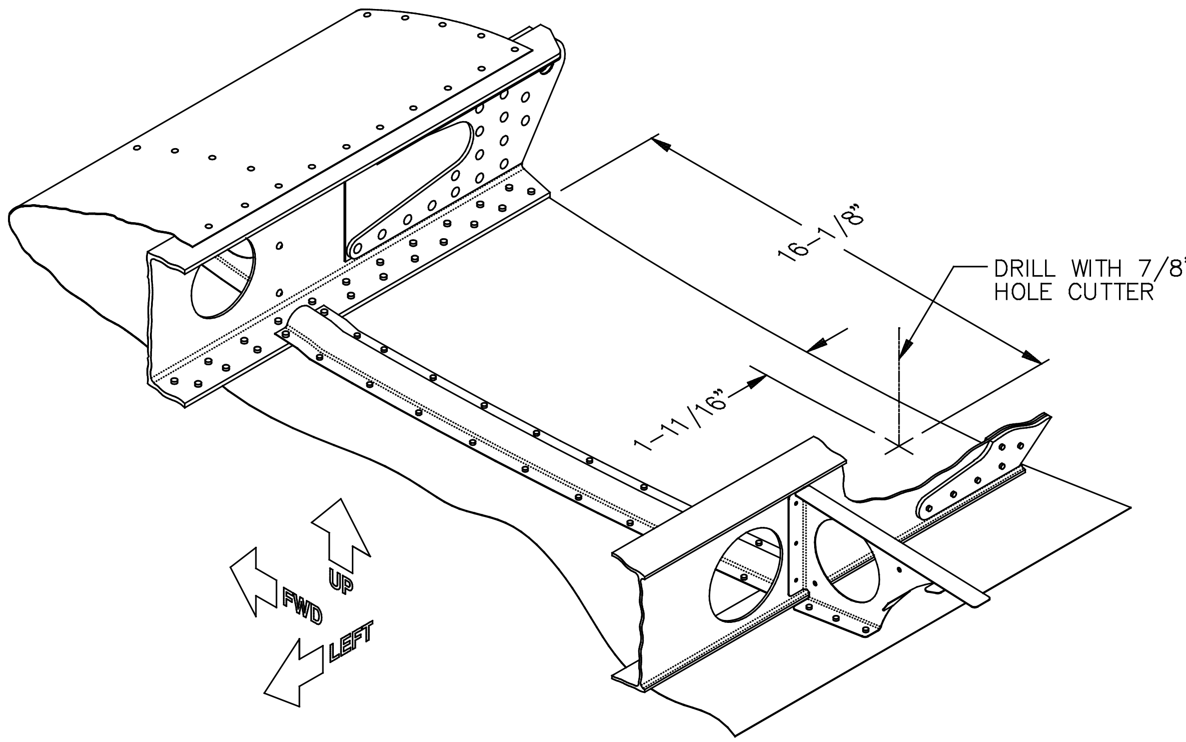


Figure 97: Marking and Drilling a Hole for the Sump Drain Boss

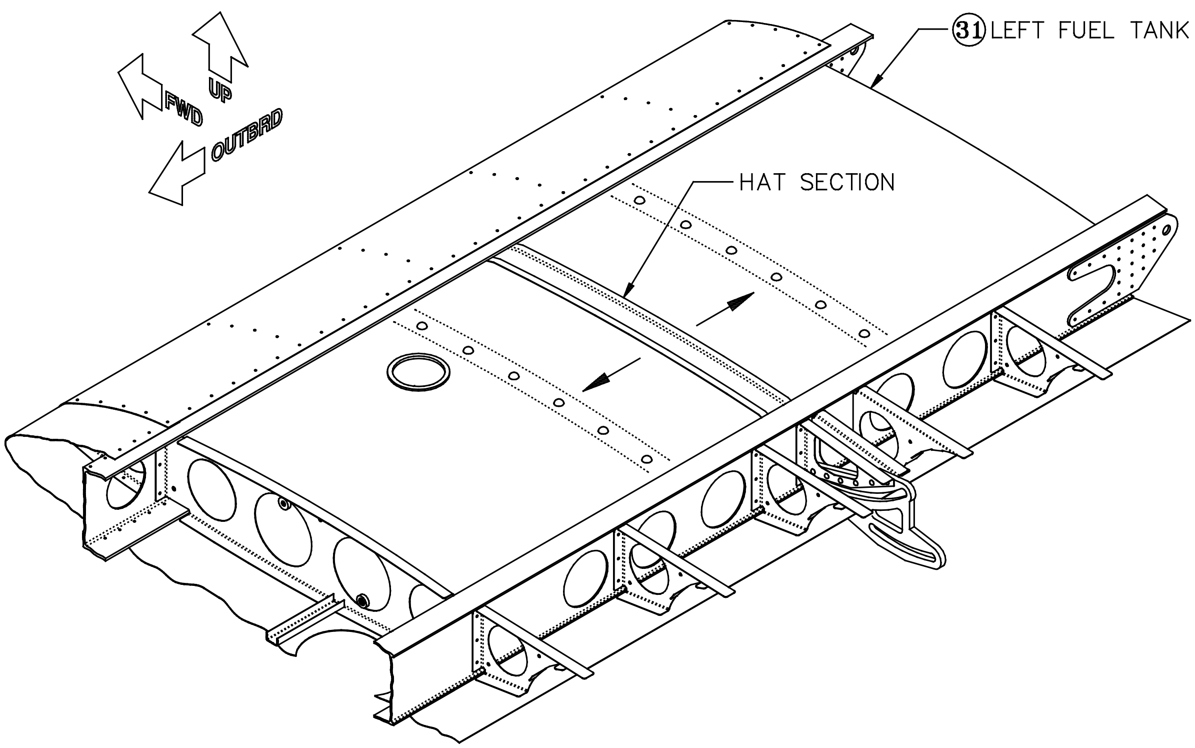


Figure 98: Test Fitting an Upper-Surface Hat Section

Step 53: Install "Bumpers" Around the Perimeter of the Tank

As you've already seen, installing the tank consists of nothing more than sliding it into the wing. However, to prevent it from rattling around in there, it's a good idea to provide some "bumpers" around the perimeter of the tank for cushioning. The best material from which to make these is 1/4"-thick neoprene rubber glued to the ends of the tank with contact cement. The recommended locations and sizes of these bumpers are indicated by the shaded areas in Figure 99.

In the event that you have trouble locating suitable rubber material, an alternative (which we have used with great success in our prototype) is to apply roughly 1/4"-thick layers of rubber caulking compound. We have been unable to find a caulk that is absolutely impervious to gasoline, but both RTV silicone sealer and polyurethane marine sealant appear to be reasonably resistant: when soaked in gasoline, they lose some of their adhesive qualities, but they do not break down. Since the bumpers will be held firmly in place between the tank and the ribs, the loss of adhesion is not serious, and in any case, the bumpers will never be soaked in fuel for long periods like our test samples were; at most, they will be briefly wetted with gasoline if you overfill your tanks.

If you do use rubber caulking, apply vinyl tape over it so that it doesn't adhere to the ribs when the tank is installed.

Completed: Left [ ] Right [ ]

Step 54: Make a Cutout in the Root Rib for the Fuel Gauge Mounting Flange

When the fuel tank is finally installed, three fittings will protrude inboard through the root rib: the fuel gauge mounting flange, the main fuel line boss and the fuel return line boss. (The return line boss is used only in Continental engine installations, but a clearance holes must be made for it regardless of the engine you're using.) Figure 100 shows the placement of these fittings on the inboard end of the tank. Because the fuel gauge flange sticks out furthest from the tank, the clearance cutout for it must be made first.

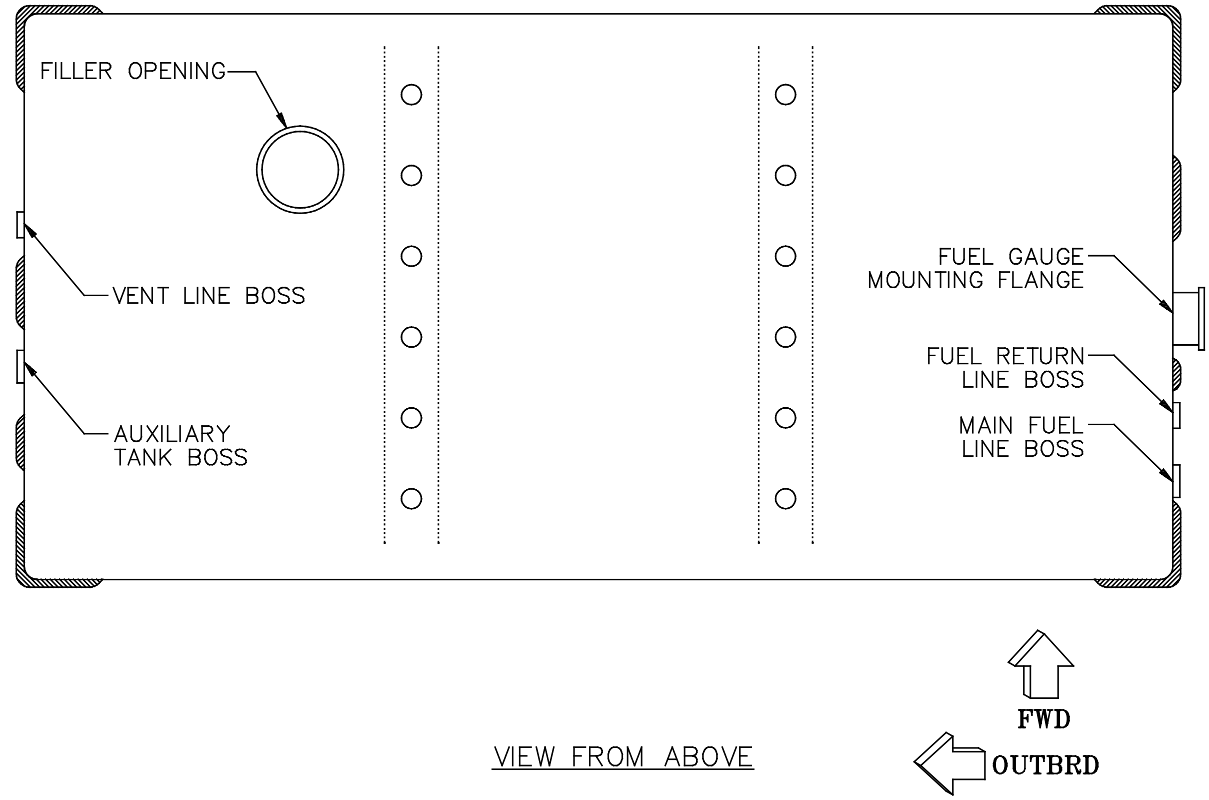


Figure 99: Bumpers Around the Fuel Tank

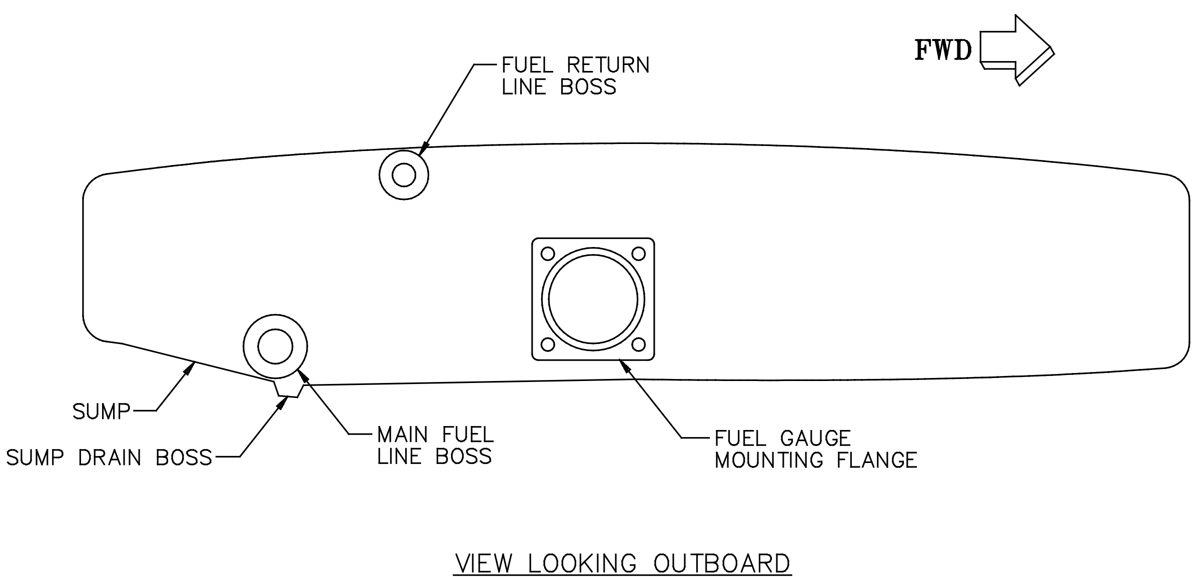


Figure 100: Inboard End of the Fuel Tank

Begin by sliding the tank into the wing all the way to the outboard rib, making sure that the sump drain boss falls into its hole in the lower skins. To mark where the fuel gauge flange falls on the root rib, apply a thin (about 1/16"-thick) layer of modeling clay to the outboard face of the root rib web. As shown in Figure 101, the flange falls between the third and fourth root rib doubler angles (counting fore-to-aft), so you only need to apply the clay to that portion of the rib.

The clay will allow you to take an impression of the flange when the rib is moved into position. Slide the rib in between the forward and aft spars until it contacts the gauge mounting flange. Press the rib against the flange to make a good, solid imprint in the clay, and then remove the rib.

Note You don't want the clay to actually contact the surface of the mounting flange, as it's residue can be difficult to remove. If your tanks came to you with aluminum tape over the mounting flange, then just leave that in place while performing this operation. If your flange is exposed, apply a light coating of grease to it before pressing it into the clay.

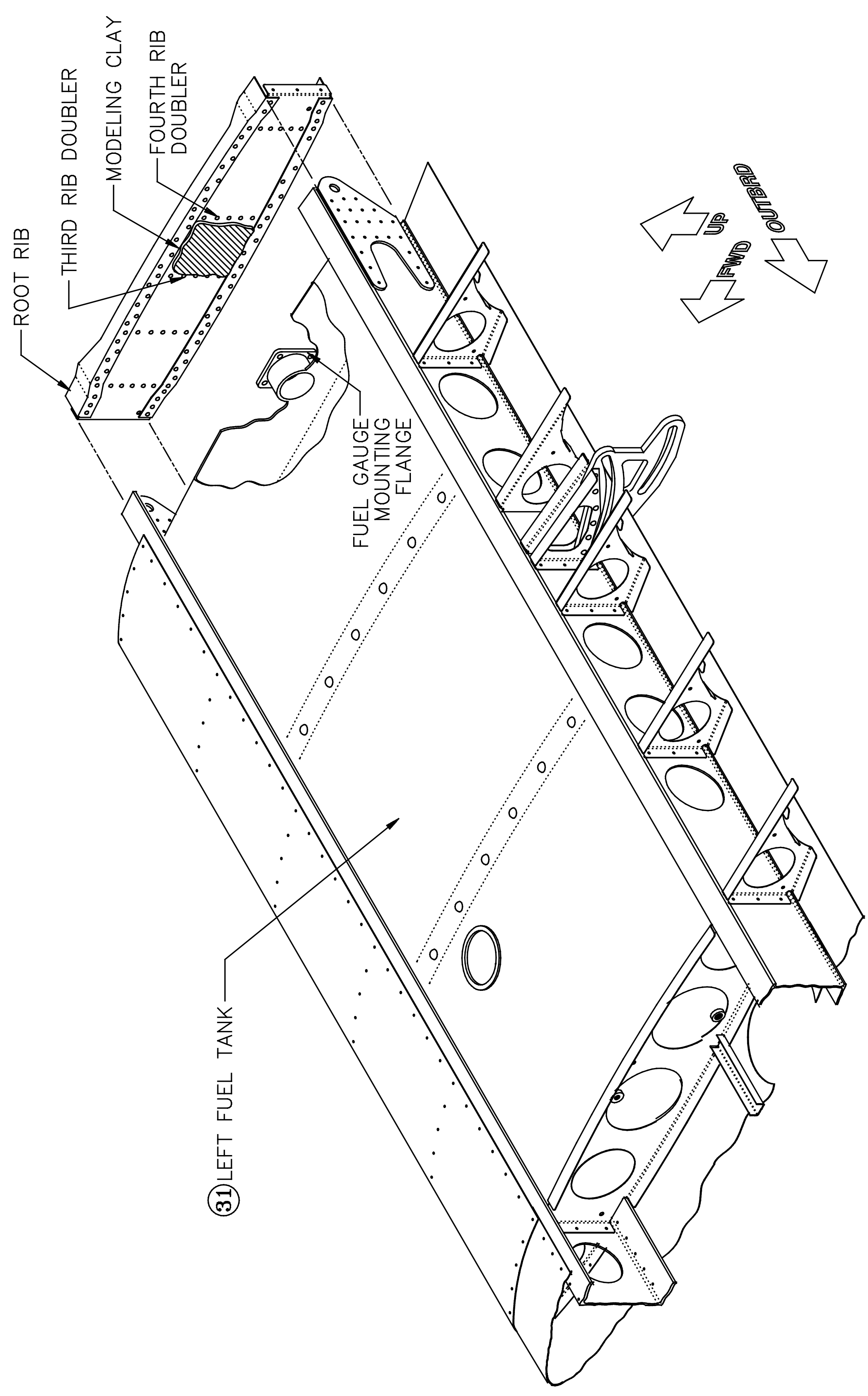


Figure 101: Taking an Impression of the Fuel Gauge Mounting Flange on the Root Rib

Next, as shown in Figure 102a, use a sharp scriber or awl through the clay to make a mark on the rib web at the **outermost** point on each rounded corner of the flange imprint. Remove the clay and mark lines connecting the opposite corner points (Figure 102b), and then mark hole locations on these lines **1/4"** in from each corner point (Figure 102c). Use a Unibit or hole cutter to drill a **1/2"**-diameter hole at each of these locations.

Mark tangent lines connecting the four holes and use a single-bladed hacksaw or a rotary cutting tool to remove the material between them. The resulting cutout will be exactly the same size as the gauge flange. Use fine-toothed files to enlarge the cutout just enough to allow the flange to pass cleanly through the rib web. Leave a smooth, deburred finish, and avoid sharpening the corner radii of the cutout.

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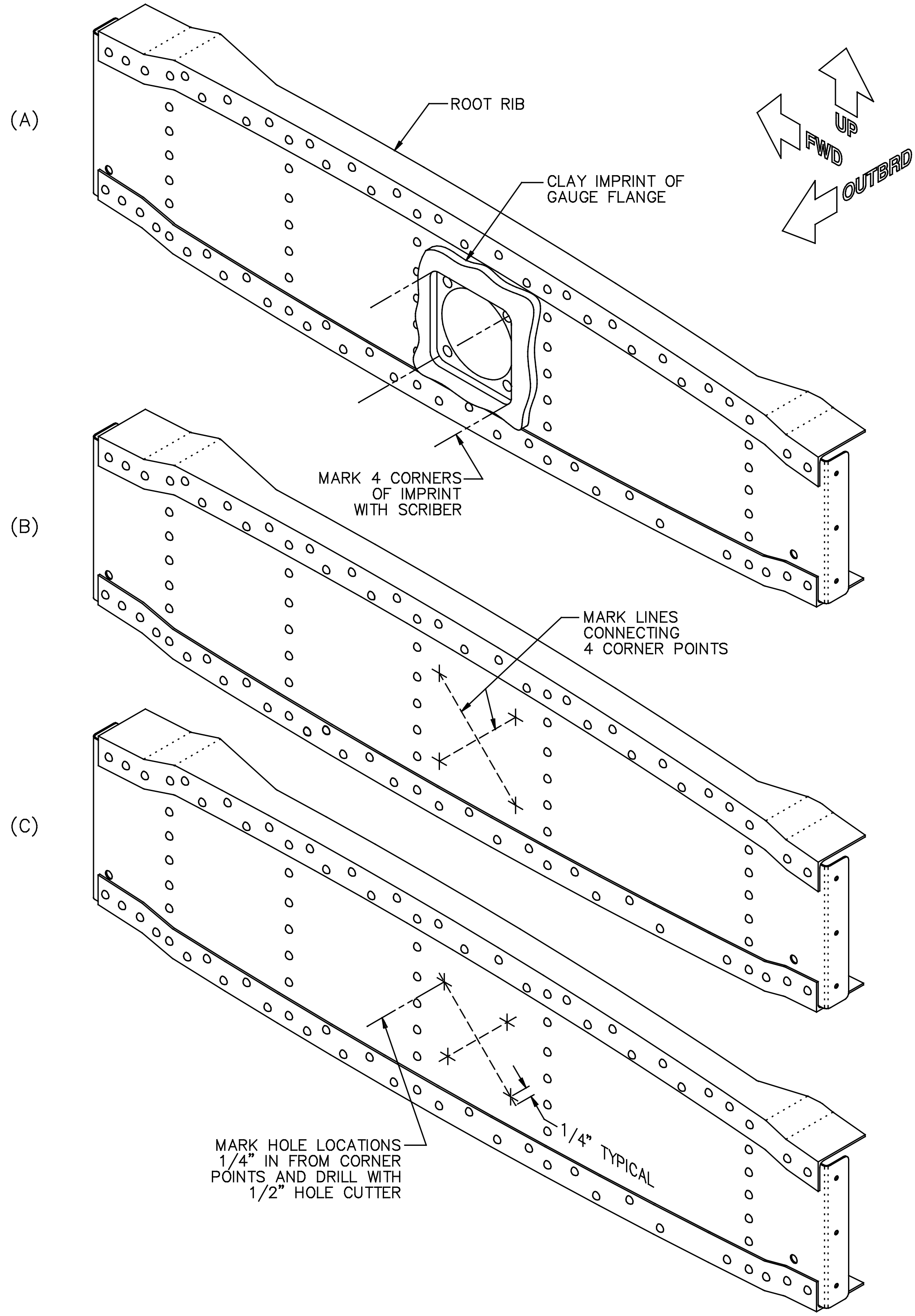

Figure 102: Marking and Drilling the Corner Holes for the Fuel Gauge Mounting Flange Cutout

Step 55: Drill Holes in the Root Rib for the Main and Return Fuel Line Bosses

With a cutout made for the fuel gauge mounting flange, you can now move the root rib closer to its final position. However, holes must still be provided for the bosses for the main fuel line and the fuel return line (see Figure 100).

Use the modeling clay method once again: apply a thin layer of clay to the areas of the rib web where the bosses will make contact, slide the rib into position between the spars (and over the gauge mounting flange), and take imprints of the two bosses. Mark the center of each hole through the clay with a scriber or awl, and then remove the clay.

As shown in Figure 103, drill the hole for the fuel return line boss with a **7/8"** hole cutter and the hole for the main fuel line boss with a **1"** hole cutter. Then use a half-round or rotary file to enlarge the holes as necessary until you can Cleco the root rib to the forward and aft spars through the appropriate holes. Ultimately, there should be about **1/16"** of clearance between the rib web and each tank boss.

> **Note** Both of these holes will overlap from the root rib web onto the upper or lower root rib doublers. This is **not** a problem; simply drill the holes where the bosses fall.

Leave the root rib Clecoed between the spars after you have it fit to your satisfaction.

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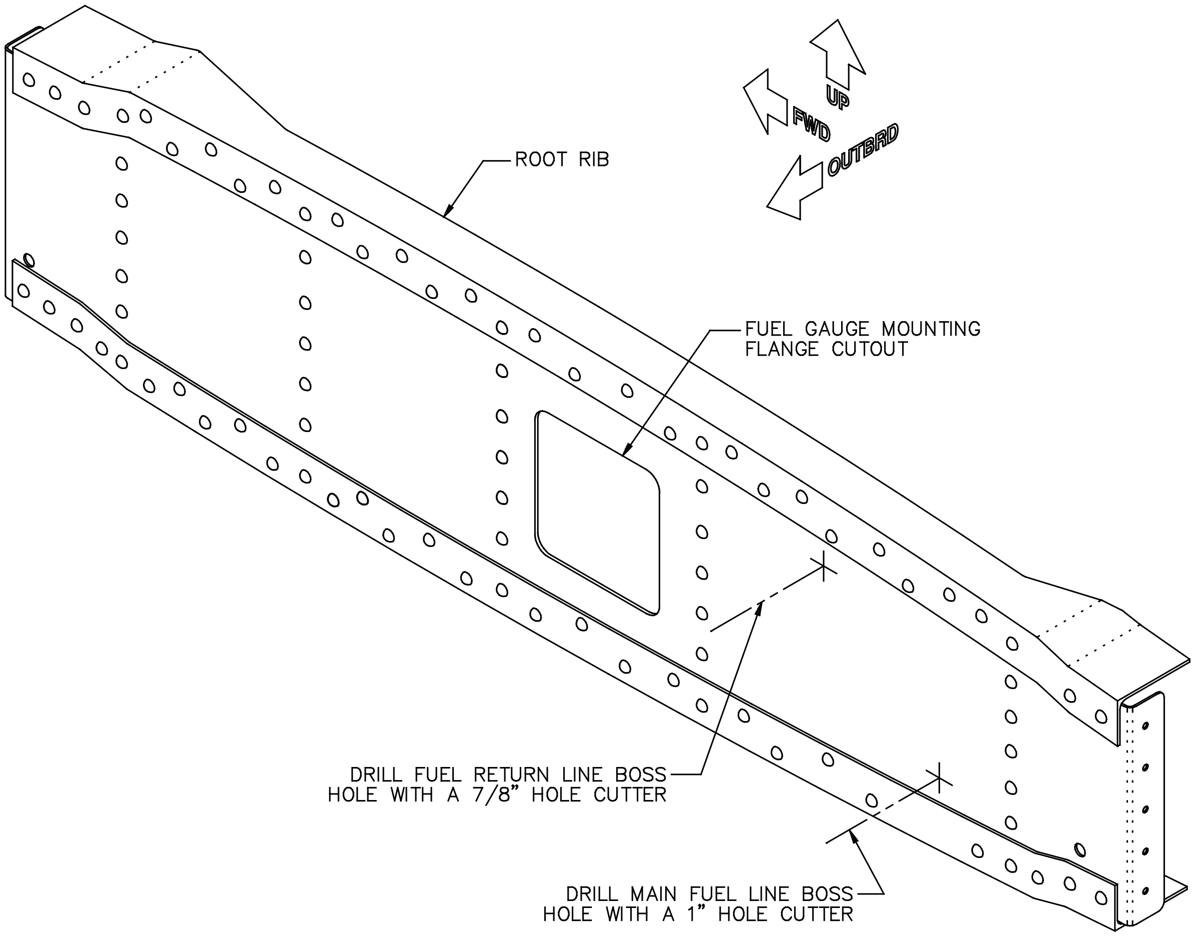

Figure 103: Drilling Holes for the Main and Return Fuel Line Bosses

Step 56: Cut a Hole in the Upper Wing Skin for the Filler Neck

When the upper inboard wing skin is riveted in place in "SECTION X: FINAL ASSEMBLY," the **fuel tank filler neck** [33] will protrude through it, and this will go easier if you provide a hole in advance!

First you have to figure out where the hole belongs. With the tank in place and the root rib Clecoed between the spars, thread the filler neck into the filler opening in the tank. Don't tighten it down; just get it started. Then measure and record the two dimensions labeled "X" and "Y" in Figure 104; "X" is the chordwise distance from the trailing edge of the inboard leading edge skin to the filler neck, and "Y" is the spanwise distance from the inboard edge of the inboard leading edge skin to the filler neck.

> **Note** The reason for measuring these distances is that there will likely be some variation among GlaStars in the precise locations of both the filler openings in the tanks and the upper inboard wing skins themselves. Thus, to make sure the filler neck hole ends up properly positioned, it's necessary to use the actual dimensions from your GlaStar.

With that fairly important gas tank sitting in the wing under the skin, we recommend cutting the hole with the skin **off the wing**! Lay the skin **right-side up** on a bench and mark an initial hole location according to the dimensions given in Figure 105: **"X" + 1-1/8" aft of the leading edge** and **"Y" + 1-1/8" outboard of the inboard edge**. (The additional 1-1/8" increments place the hole location in the center of the 2-1/4"-diameter filler neck.) Drill a **2-1/4"** hole at this location with a hole cutter.

Check the size of the hole by trying to slide the skin over the neck. You'll probably have to enlarge the hole a bit with a round, fine-toothed file. Enlarge the hole until you can Cleco the skin in place on the wing structure with about **1/16"** of clearance around the neck. Be sure to leave a smoothly filed finish on the edges of the hole. When you're done, remove the filler neck and tape over the filler opening. You will install the filler neck permanently later.

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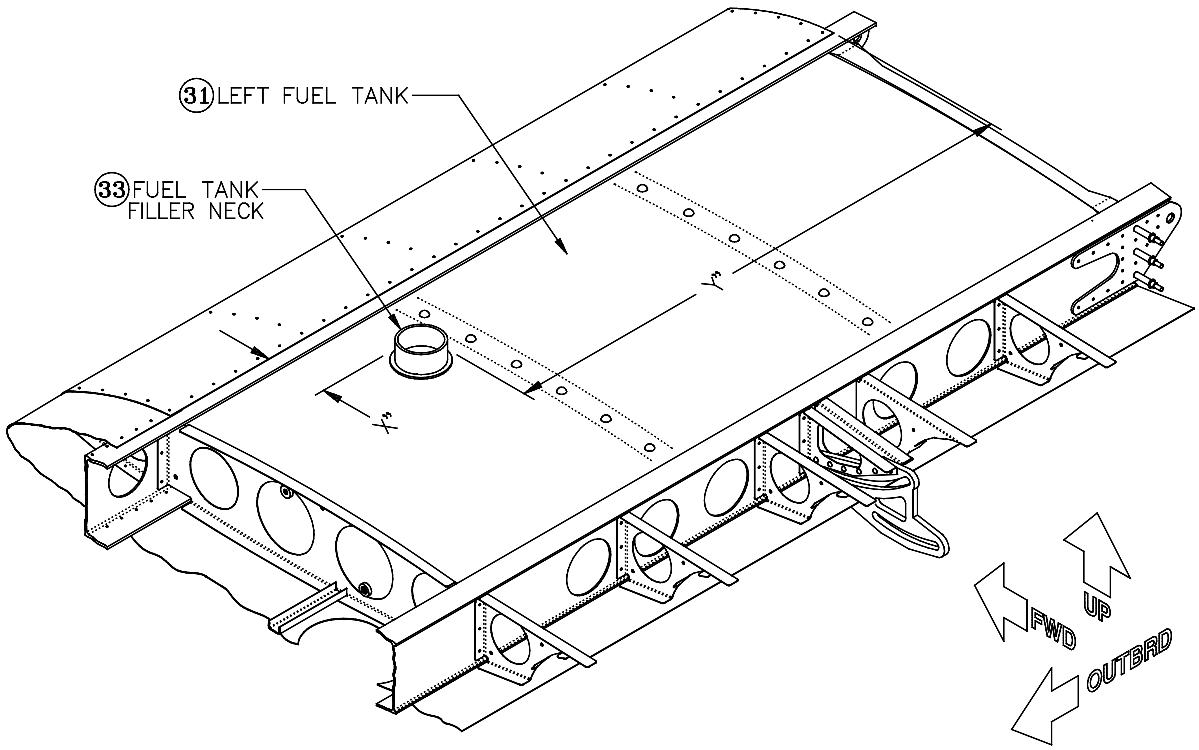

Figure 104: Measuring the Location of the Filler Neck

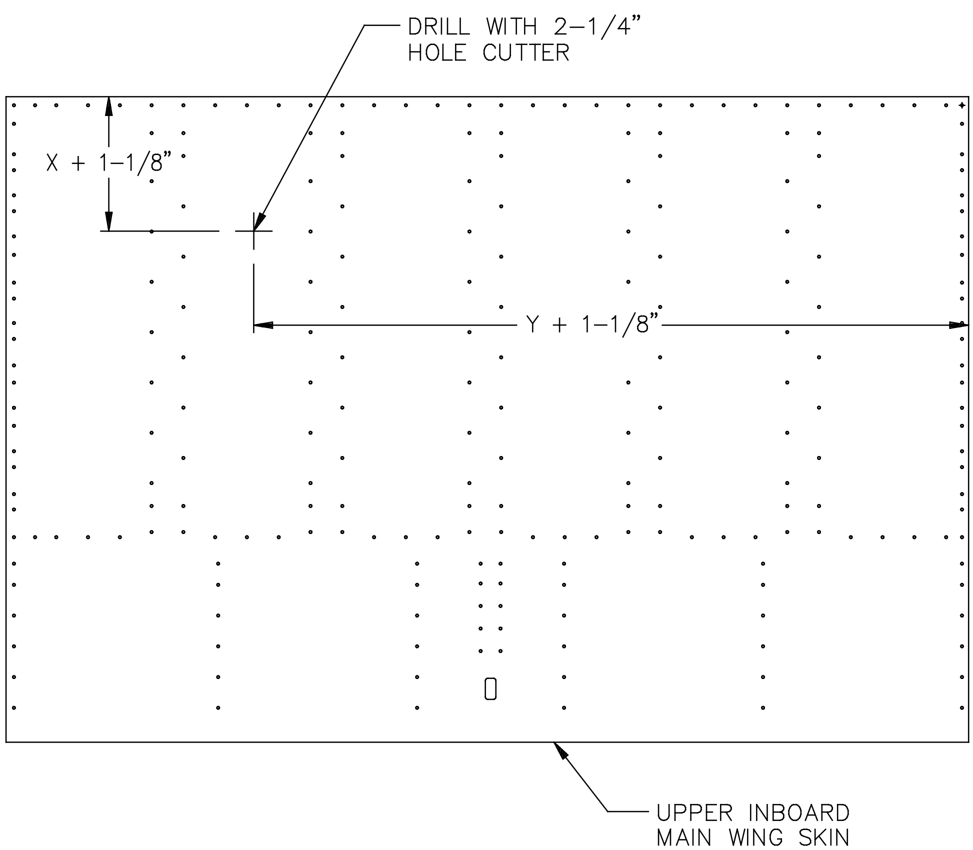

Figure 105: Marking and Drilling the Filler Neck Hole

Step 57: Install a Plug in the Auxiliary Fuel Tank Boss (Standard Fuel Tanks Only)

Auxiliary Fuel Tank Option If you are installing auxiliary fuel tanks, **skip this step and turn to the *Option Instructions* now.** Return to Step 59 of this *Assembly Manual* when the specified option steps have been completed.

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Figure 106 shows the fitting bosses on the outboard end of the tank. The auxiliary fuel tank boss is not used in the standard tank installation, so thread an AN913-2D **plug** [139] into the boss, as shown in Figure 107. Tighten this firmly with a wrench.

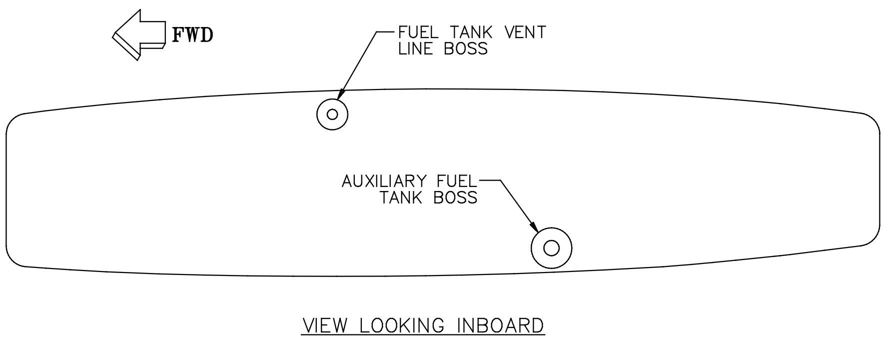

Figure 106: Outboard End of the Fuel Tank

Warning Use a thread lubricant/sealant on all metal-to-metal connections in the fuel system to prevent galling the threads; we used Permatex High Tack Adhesive Sealant on our prototype. Teflon tape is **not** recommended, since small particles of it can get into the fuel system and cause serious problems.

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Step 58: Install the Fuel Tank Vent Line Fittings (Standard Fuel Tanks Only)

The fuel tanks must be vented to the outside air to ensure proper fuel flow. Each vent line runs from the vent line boss near the top of each tank to the wingtip. Begin, therefore, by cutting the supplied 25' length of **1/4" nylon tubing** [83] in **half**. Make the cut with a utility knife, taking care to keep it perpendicular to the tubing.

The tubing is secured to the vent line boss, as shown in Figure 107, with a **nylon male connector** [35] and **nylon connector insert** [36]. The connector has three parts—the body, nut and sleeve. Unscrew the nut from the body; the sleeve will come off with the nut. Thread the body into the vent line boss, as shown in Figure 107. The end of the body with the **finer** threads goes into the boss.

Note The use of thread sealant is **not** recommended with nylon fittings.

Slide the nut and sleeve over the square-cut end of the tubing and push the tapered end of the tubing connector insert into the end of the tubing. Then insert the end of the tubing and the insert into the coarse-threaded end of the body and tighten the nut and sleeve down over it.

After you have tightened the nut, loosen it again and separate the nut and sleeve from the body. The purpose of tightening the nut at all was to drive the insert into the end of the tubing so that you won't lose it or the nut and sleeve when you remove the tank to finish construction of the wing.

Leave the connector body threaded into the vent line boss, and put a piece of tape over it to keep dirt out. Then un-Cleco the root rib, pull the tank out of the wing and set it aside. Set the vent line aside as well.

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Right [ ]

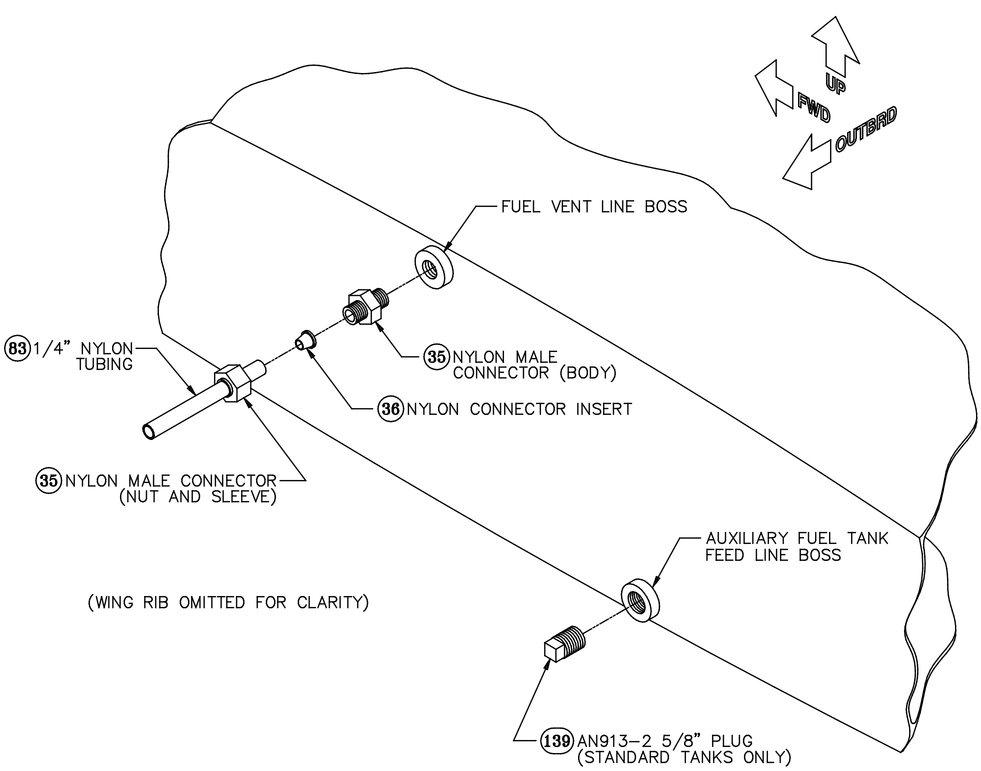

Figure 107: Installing the Outboard-End Tank Fittings

Step 59: Install the Nutplate for the Wing Support Strut Eyebolt (Optional)

Wing Brace Option If you are sure that you **never** intend to fold your wings, **skip this step**.

The folding-wing feature of the GlaStar relies on a temporary steel support strut running from the bottom of the wing strut to the forward wing spar. This rod takes the torsional load imposed by the wing's weight when the forward spar is disconnected from the fuselage cage and keeps the forward spar attach point in proper alignment while the wing is folded. To secure the rod to the wing, you must install a small eyebolt through the lower flange of the forward spar. The eyebolt itself can be installed at any time, but because the fuel tank will restrict access to the lower flange of the spar, it's necessary to install the nutplate for the eyebolt at this time.

Wing Brace Option The nutplates and rivets for this step are included in the standard GlaStar kit. However, the eyebolts themselves, as well as the steel support struts and other necessary parts, are included in the Wing Brace Option Kit. Order P/N 902-01000-01. These nutplates and rivets are the **only** parts of the wing-fold system that are not easily retrofittable to a GlaStar at any stage of completion, so there's no need to turn to the option instructions or even to purchase the option kit at this time, although you certainly can do so if you wish.

As shown in Figure 108a, drill the central, **#10** hole for the nutplate between the first and second rivets in the forward-most row through the lower spar flange. This location need not be measured too precisely; simply locate the hole on the rivet line and roughly midway between the two rivets.

Next, using standard procedures, drill two **#40** mounting holes for a K1000-3 **nutplate** [156]. Deburr all three holes, both inside and outside the wing. Finally, as shown in Figure 108b, use 3/32" AN470AD3 universal-head rivets to rivet the nutplate to the spar flange. The rivet heads should be on the outside of the wing.

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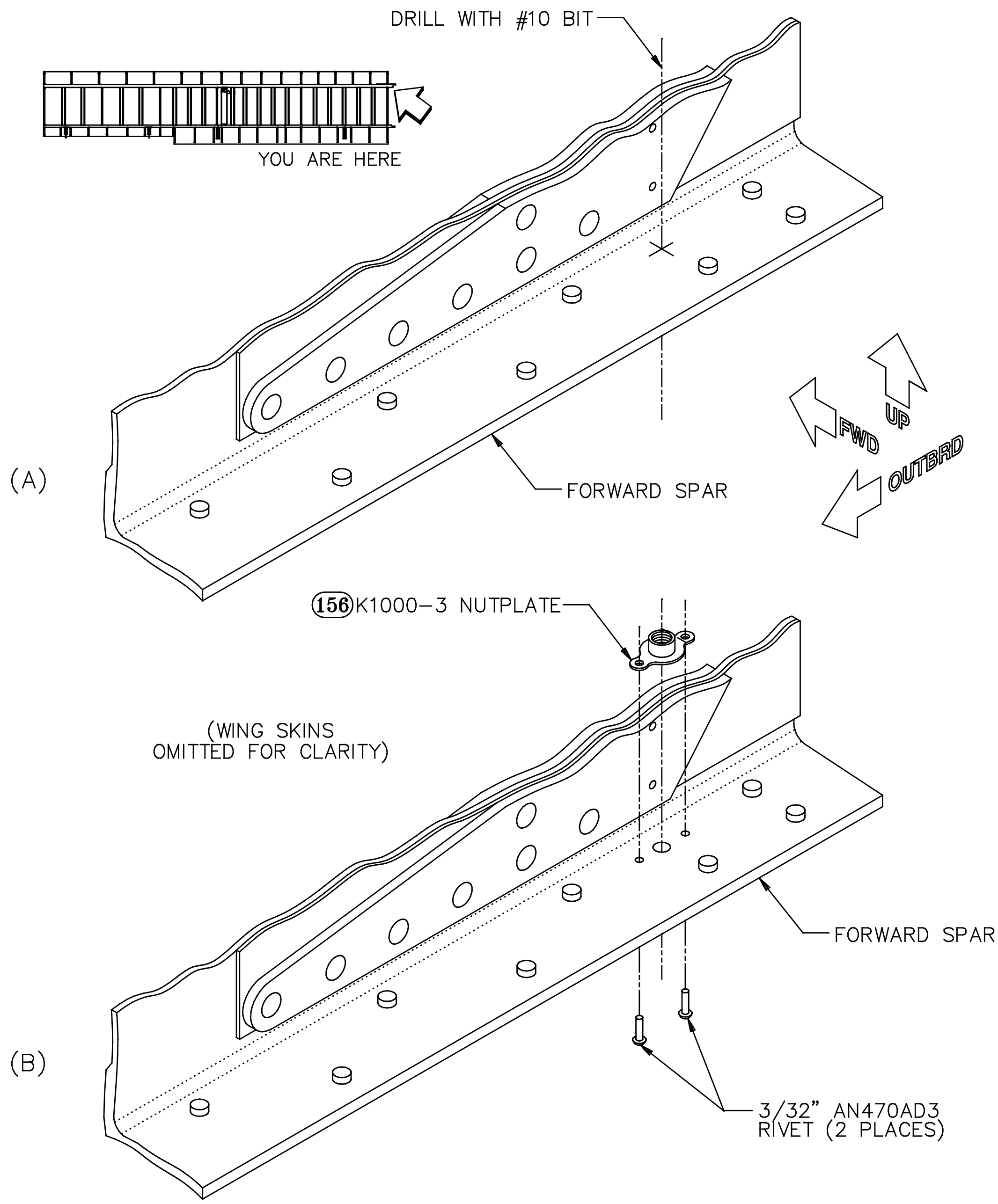

Figure 108: Installing the Nutplate for the Forward-Spar Wing-Fold Eyebolt

Step 60: Drill the Inspection Hole Doublers

There are five inspection holes in the lower wing skins, which provide access for inspection of the flight control, furl and electrical systems of your completed GlaStar. These openings also provide access for riveting on the upper skins, and so it's desirable to leave the holes as open as possible for as long as possible in the construction process. Therefore, you won't rivet the inspection hole doublers inside the holes until late in "SECTION X: FINAL ASSEMBLY," but you can drill the rivet holes in the doublers now before you string lots of wires and tubing in the way!

There are three different sizes and shapes of hole, with a corresponding doubler and cover for each. Figure 109 gives the locations of each of the holes, and Table 1 specifies the appropriate doubler and cover for each.

HOLE	SIZE	COVER KEY NO.	COVER PART NO.	DOUBLER KEY NO.	DOUBLER PART NO.
A	6.2" X 4.7"	271	201-34001-01	29	201-34002-01
B	4.45"	270	201-33001-01	28	201-33002-01
C	5.75"	272	201-35001-01	30	201-35002-01
D	4.45"	270	201-22001-01	28	201-33002-01
E	5.75"	272	201-35001-01	30	201-35002-01

Table 1: Inspection Hole Covers and Doublers

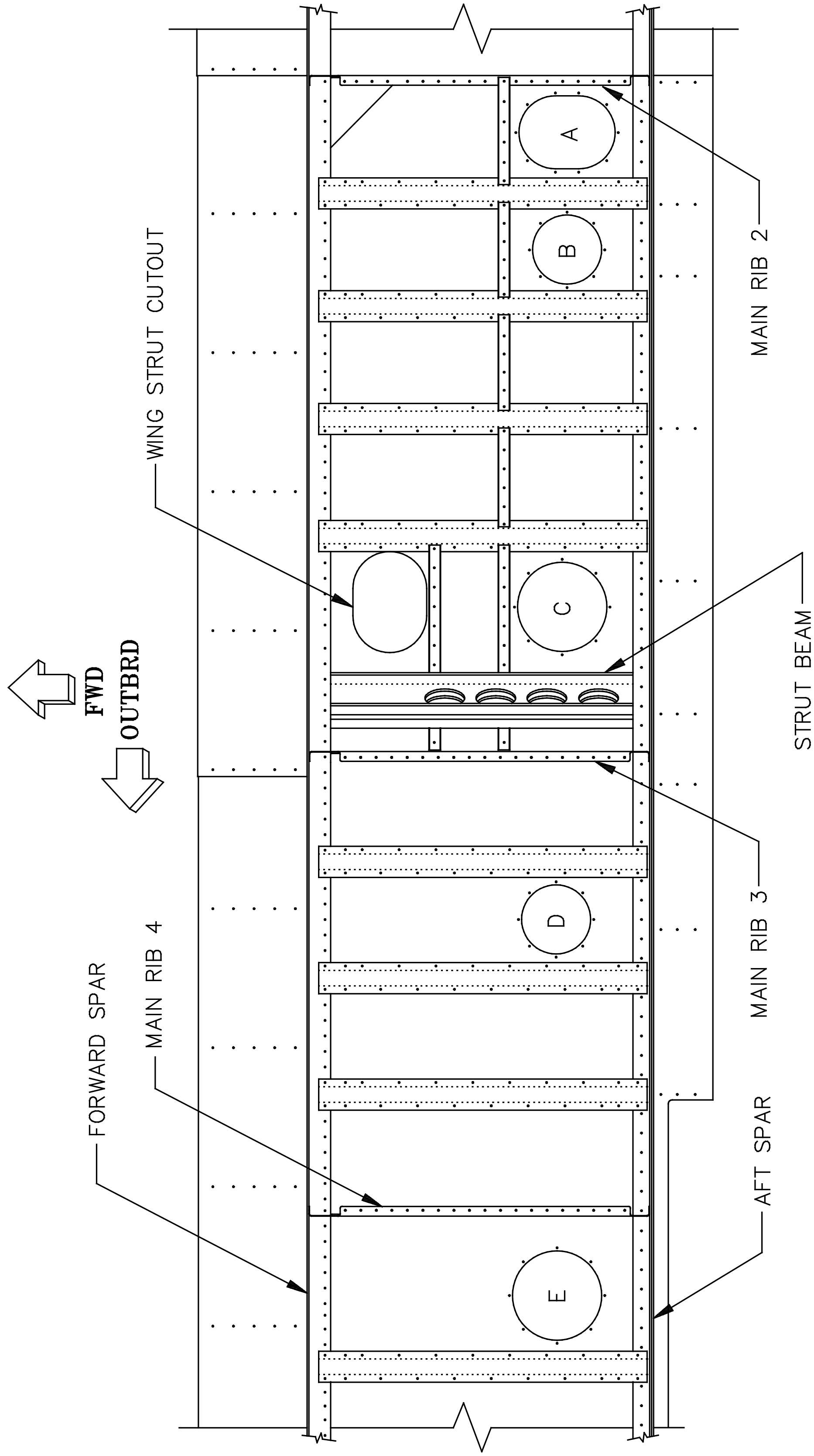

Figure 109: Inspection Hole Locations

The procedure for positioning and drilling the doublers is identical in all cases. As shown in Figure 110a, Cleco an appropriate cover to the doubler with 5/32" Clecos, and then seat the cover in the inspection hole so that the doubler rests on the **inside** surface of the skin. When the cover and doubler are properly positioned, tape the doubler to the inside surface of the skin with several generous strips of duct tape or wide masking tape. As shown in Figure 110b, the tape can lap right over the cover, which should remain Clecoed in place.

Now, working from **outside** the wing skin, you can drill through the skin and the doubler at each of the pre-punched pilot holes in the skin, as shown in Figure 110c. Use a **#40** bit. If possible, have an assistant hold a block of scrap wood tightly against the doubler from inside the wing to back up the drilling. It will also be helpful to Cleco the drilled holes as you go.

After all the skin/doubler rivet holes are drilled, mark all the doublers with their specific locations **and orientations** so that you can match them up again later hole-for-hole. (We used an engraving tool to permanently etch the locations and orientation of each cover on its inside surface.) Un-Cleco the doublers from the skin and the covers from the doublers. Position K1000-08 **nutplates** [282] on the doublers at the cover screw holes and drill **#40** rivet holes. After deburring, dimple the nutplate rivet holes in the doublers to accommodate 3/32" AN426AD3 flush-head rivets.

Completed: Left [ ] Right [ ]

Step 61: Corrosion-Proof the Doublers and Rivet the Nutplates to Them

Apply the corrosion-protection of your choice to the doublers (transferring the location and orientation marks as necessary). Then flush-rivet a K1000-08 nutplate at each screw hole, with the rivet heads on the undersides of the doublers. When you're finished, use masking tape to secure the doublers on the **inside** of the lower wing skins immediately beside their final locations. This will allow you to reach inside the wing easily to buck the upper-skin rivets, but then you'll be able to release the tape to final-position the doublers.

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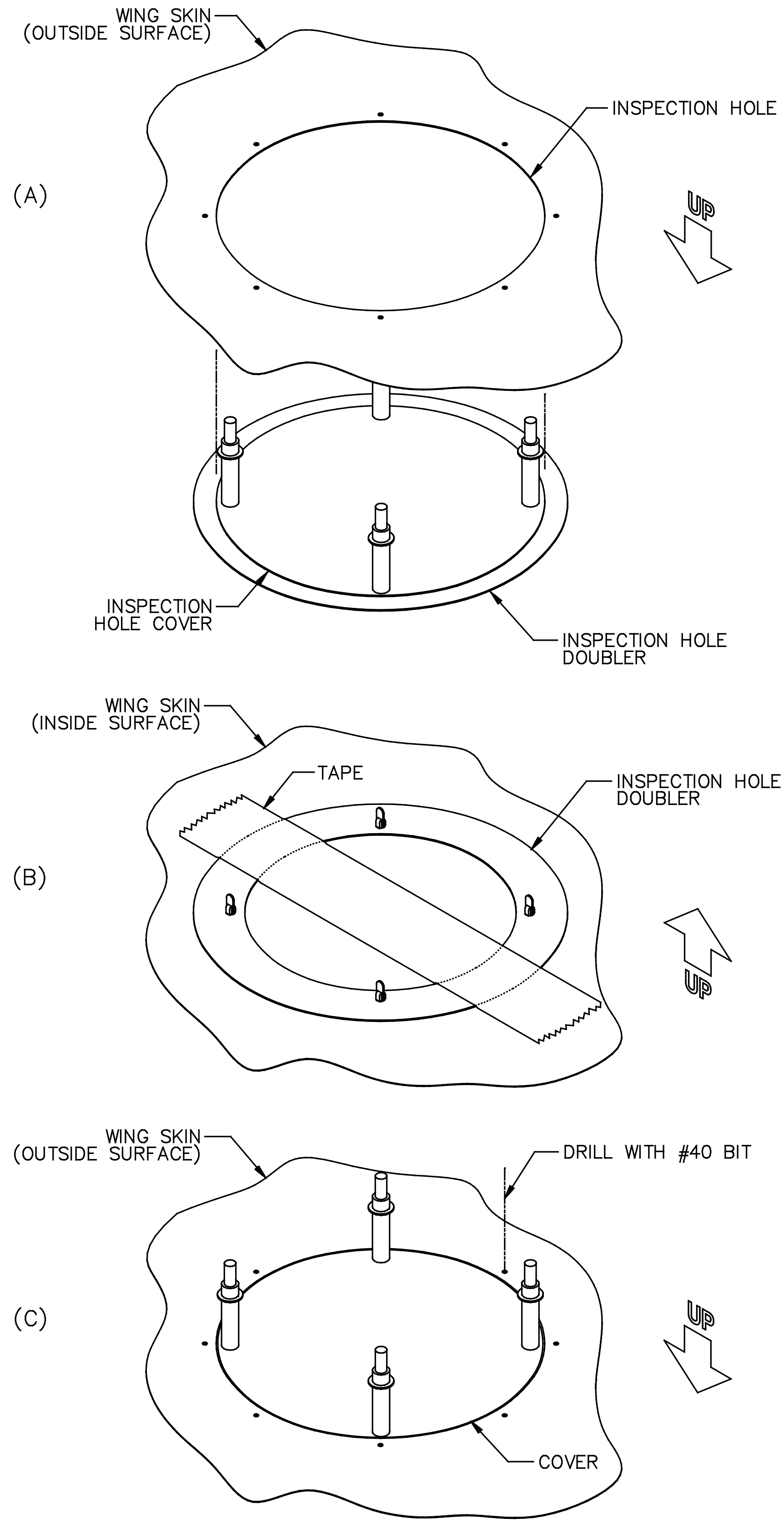

Figure 110: Drilling an Inspection Hole Doubler

Step 62: Install the Pitot Tube

Since an airspeed indicator is required for even the most basic VFR operations, you'll need to install a pitot system. However, because of the variety of possible installations, the standard kit does not contain the components of such a system.

Pitot/Static System Options Stoddard-Hamilton offers two pitot/static system option kits for the GlaStar. The Non-Heated Kit (P/N 912-01000-01), which is suitable for VFR flight only, includes a simple, non-heated pitot tube, two custom-designed static ports, all tubing and fittings, all installation hardware and detailed instructions. The Heated Kit (P/N 912-02000-01), which is intended for IFR operations, does **not** include the pitot tube itself. The reason for this is that we have been unable to secure a reliable supply of standard, AN5812 heated tubes at competitive prices. Since they are readily available at retail prices through a variety of aircraft parts suppliers, we leave it to the individual builder to purchase the tube, but we do supply the static ports, all tubing and fittings, all electrical wiring and connectors, all installation hardware and detailed instructions.

If you are installing on of these kits, **turn to the *Option Instructions* now**. Return to Step 63 of this *Assembly Manual* when the specified option steps have been completed.

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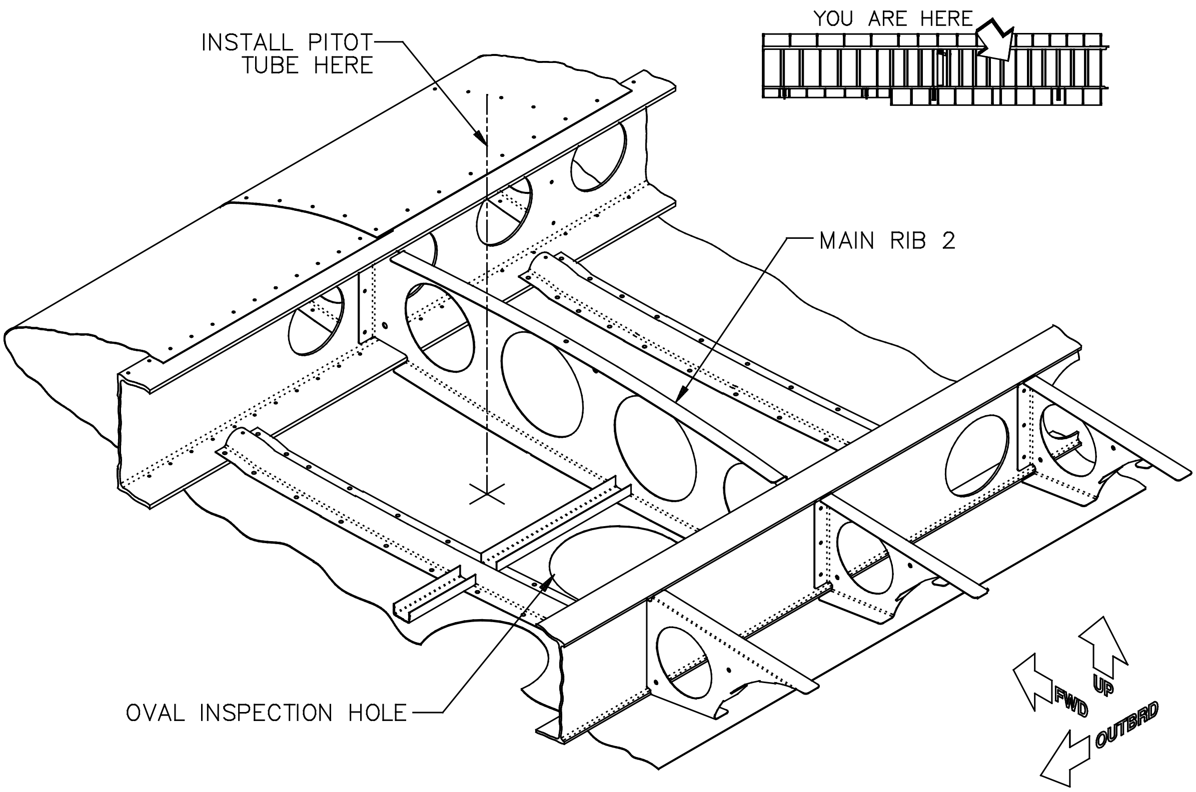
The pitot tube can be located on either wing, although the left wing seems to be the conventional choice of just about everyone, perhaps simply because the airspeed indicator is typically on the left side of the panel, thus shortening the tubing run by a foot or two. Figure 111 shows the recommended location for the tube on the left wing—centered between Main Rib 2 and the first hat section outboard of the rib and about **1"** forward of the skin stiffener channel. We have found this location to provide accurate pressure readings and to minimize the potential for poking unwary pedestrians in the eye.



Although the pitot tube could be installed through the inspection holes in a finished wing, we strongly recommend installing the tube now, when it's much, much easier! Be aware that the center skin is relatively thin aluminum; it should be reinforced on the inside for the pitot tube mounting. Also, be sure to properly deburr all mounting holes and corrosion-proof exposed aluminum surfaces as you deem necessary.

Completed: [ ]

Step 63: Install the Fuel Vent Line (Standard Fuel Tanks Only)

Auxiliary Fuel Tank Option If you are installing auxiliary fuel tanks, **skip this step**.

The solid line in Figure 112 illustrates the suggested path of the fuel vent line from Main Rib 2, where it connects to the tank, to the wingtip. This route is not especially critical, but there are a couple of important considerations. First, the vent line should be run as high as possible before exiting the wing. This suggests that the line should be secured to the **tops** of the ribs through which it passes and, ultimately, to the **upper** hat sections. Also, it should pass **over** the strut beam. Second, it's good practice to maintain separation between fuel system plumbing and electrical wiring wherever practical, and as Figure 112 shows, the optional navigation and strobe light wiring (indicated by the dashed line) travels mainly along the forward spar. Thus, the vent line should be routed aft of that. Also, both the vent line and the wiring should be routed to clear the inspection holes in the lower skins as much as possible.

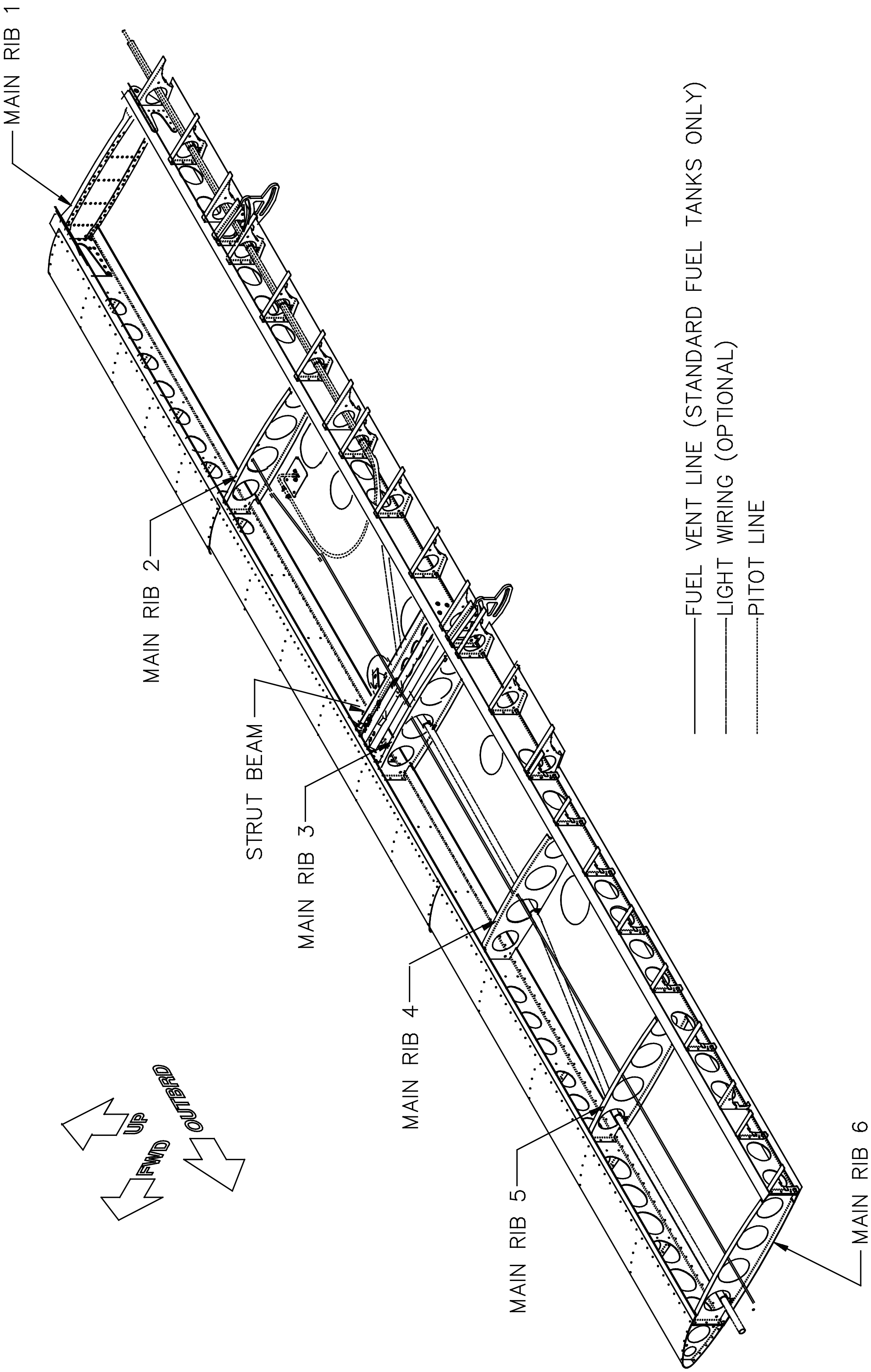


Figure 112: Suggested Routing of the Wing Plumbing and Wiring

MS35489-6 **7/16" rubber grommets** [161] will be installed in Main Ribs 3–5 to provide chafe protection to the vent line. As shown in Figure 113, the tooling holes near the top of each rib can be enlarged to accommodate these. Use either a Unibit or a series of standard drills in 1/16" increments to drill this hole up to a final size of **7/16"**. Insert the grommet and then run the vent line through it. Position the inboard end of the line just inboard of Main Rib 2.

Note Some early kits included -9 grommets, which are slightly oversized. These will not hold the vent line tightly in position, but this is not a problem, since the line will be further secured to the upper-surface hat sections immediately before the upper skins are riveted in place in "Section X: Final Assembly." However, these grommets require a **9/16"** hole for installation.

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Right [ ]

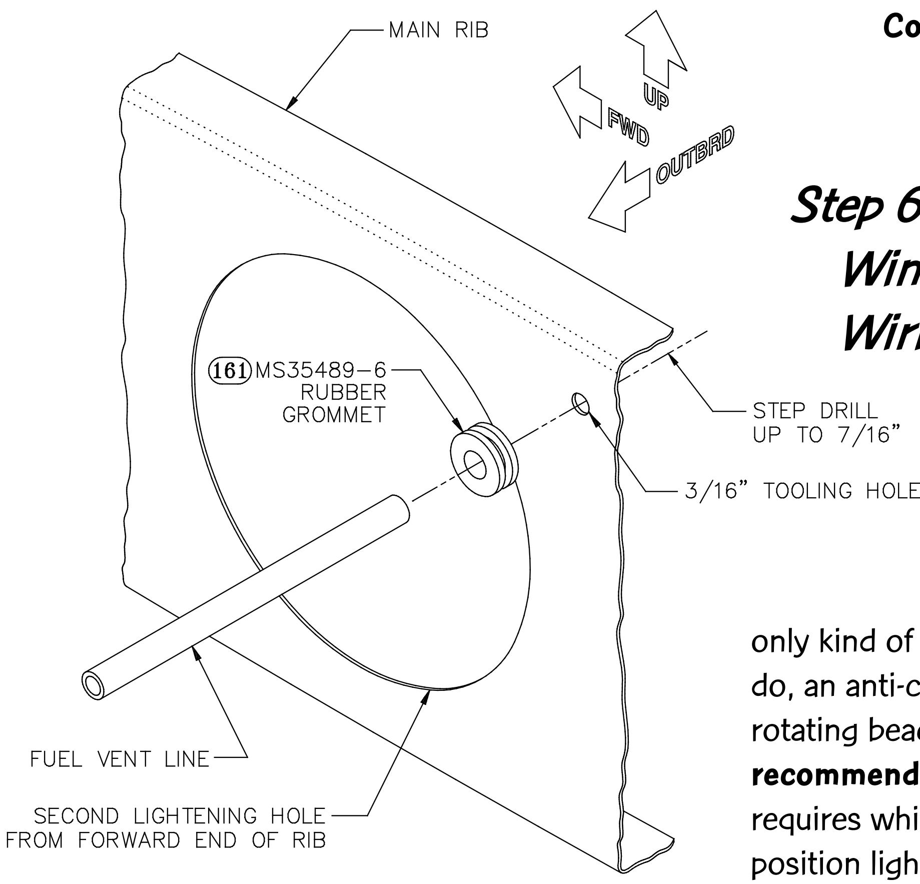

Figure 113: Installing the Vent Line Grommet in a Main Rib

Step 64: Install the Wing Light Wiring (Optional)

Lighting isn't required for daytime VFR operation, but even if that's the only kind of flying you plan to do, an anti-collision strobe or rotating beacon is **strongly recommended**. Night flying requires white, red and green position lights as well as a strobe or beacon. Refer to FAR Part 91.33 for precise lighting requirements.

Nav/Strobe Light Option Stoddard-Hamilton's Nav/Strobe Light Option Kit (P/N 921-02000-02) provides everything necessary to bring your GlaStar into conformity with all FAR Part 91 standards for aircraft position and anti-collision lighting. The system consists of two wingtip-mounted light units, each of which contains an appropriately colored position light, a white strobe and an aft-shining white position light. These light heads are manufactured by Whelen Engineering, a world leader in aircraft lighting systems. The kit also includes a Whelen 14-volt power supply for the strobe system; complete wiring harnesses for both the strobe and navigation lights; all electrical connectors and supplies; and all installation hardware, as well as complete installation instructions. The kit does not include switches or circuit breakers, although these items are available separately.

If you are installing the Nav/Strobe Light Option Kit, **turn to the *Option Instructions* now**. Return to Step 65 of this *Assembly Manual* when the specified option steps have been completed.

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Route the wiring harness(es) for any wingtip lighting systems you're installing approximately as shown in Figure 112. If you run more than one wire, bundle the individual strands with 4" nylon **cable ties** [34]. Secure the wiring every 8" or so to a lower-surface hat section or a main rib. You can drill holes in the rib webs to accommodate rubber grommets or simply run the wiring through the forward-most lightening hole in each rib. IF you elect the latter option, however, wrap the wiring in short lengths of **3/8" spiral wrap** [82] to provide anti-chafe protection where it passes over the sharp edge of the rib web.

Auxiliary Fuel Tank Option If you are installing auxiliary fuel tanks, you must route your light wiring through the forward spar between Main Ribs 4 and 5 and then through the nose ribs to the tip of the wing in order to leave the bay between Main Ribs 5 and 6 free for the tank.

Inboard of the strut beam, where the wiring is routed through the aft spar and the flap cove ribs, be sure the wiring is secured well clear of the control cables, pulleys and flap pushrod. We recommend securing it to every cove rib to ensure that it cannot interfere with the controls.

Note Read ahead to Step 65 before securing the light wiring inboard of the strut beam. You may want to bundle your wiring along with the pitot line discussed in that step.

Hint If you don't plan to install a lighting system right away but contemplate doing so at some point in the future, you can save a tremendous amount of trouble by installing a conduit for future wiring at this stage. Select a flexible nylon tubing with an inner diameter of about **5/8"** and route it exactly as you would the wiring. Then, when you add lighting later, you can simply snake the wiring through the tubing without having to perform all kinds of gymnastics through the inspection holes. In fact, the conduit is a good idea even if you're installing your lighting system right now, because it makes replacement of the wiring much easier if this should ever be necessary.

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Step 65: Install the Wing Pitot Line

Pitot/Static System Options If you are installing either of Stoddard-Hamilton's pitot/static system option kits, **turn to the *Option Instructions* now**. Return to Step 66 of this *Assembly Manual* when the specified option steps have been completed.

☞

As Figure 112 shows, the pitot line should be routed outboard from the pitot tube before looping around in a wide arc to join the optional light wiring as it passes through the aft spar. If you are installing lighting, you should bundle the wiring and the pitot line together with nylon cable ties before securing both to the cove ribs. Be sure they are well clear of the control cables, pulleys and flap pushrod. Similarly, be sure the pitot line is secured well clear of the flap bellcrank assembly.

Completed: Left [ ] Right [ ]

MAIN GEAR LEG INSTALLATION

It's finally time to put your GlaStar on its landing gear! You'll begin by installing the main gear legs. The parts and procedures for doing this are virtually identical regardless of whether you're building a tricycle- or a conventional-geared GlaStar. The main thing is to remember to use the **aft** gear sockets for a nosedragger and the **forward** ones for a taildragger. You'll have a lot of flying fun in either case—just don't use one of each! Other differences in procedure will be noted in the text.

Step 66: Support and Level the Fuselage

The first step is to support the fuselage high enough off the floor to allow you to insert the legs into the sockets. The best method is to rest the fuselage on a sturdy, narrow table about 32" high. Does your wing jig table come to mind? Perfect! Pad the surface with an old blanket and set the fuselage on it, with the long axis of the airplane parallel with the long axis of the table. Put a padded support under the aft fuselage to bring the waterline level. Use a level clamped between the waterline marks on the inside edges of the door cutout to check this, just as you did in "SECTION VIII: FUSELAGE ASSEMBLY."

Next, level the fuselage laterally using the cross-tube between the forward wing-attach lugs as your datum. If this tube doesn't provide a flat surface for your level because it is slightly bowed, then place short lengths of 2 X 4 on the wing attach lugs themselves and run your 4' carpenter's level between them. (Check to make sure the chunks of 2 X 4 are actually of equal thickness.) Whatever your method, keep in mind that your goal is to bring the two wing attach lugs level; the rest of the fuselage will follow! Be as precise as you can, and once you've leveled the fuselage, wedge sand or shot bags under it on both sides to keep it that way.

Note If for any reason you don't want to use your wing jig table for this procedure, you can use any suitable table or bench in the same way described above. Alternatively, you can rest the forward-most end of the fuselage on one table or bench and support the tail of the airplane on another. Whichever method works best given your workspace is fine.

Completed: [ ]

Step 67: Insert and Position the Gear Legs

The **main gear legs** [39] are interchangeable, both from left to right and between tricycle and conventional gear configurations. Installation of the legs is very similar for both types of gear. Begin by **liberally** coating the bearing surfaces at the upper ends of the legs with an anti-seize compound. This will make it much easier for you get the legs in and possible to get them out again, if you should ever want to. Insert each leg into one of the gear sockets in the fuselage cage until the upper end of the leg is flush with the top of the socket. The fit will be snug, but if you rotate the leg as you push it in you should be able to insert it without too much trouble. When you're done, the axle portion of the leg should point in approximately the proper outboard direction.

The only difference between the main gear leg installation in tricycle- and conventional-geared GlaStars is the degree of "toe-in" or "toe-out." The main wheels on **tricycle**-geared GlaStars should be slightly toed-**in**, which means that they angle slightly **inboard** at their forward ends rather than being perfectly parallel with the aircraft centerline. By contrast, **taildragger** mains must have a slight amount of toe-**out**—that is, a slight angle **outboard** at their forward ends. Proper toe-in and toe-out is essential for good ground handling and straight, easily controllable take-off and landing rolls.

At the same time that you're setting the proper toe-in or toe-out, you must also ensure that the axle portions of the gear legs are level relative to the fuselage so that your GlaStar will sit level on its gear. The procedure for leveling the legs and setting the toe-in or toe-out is illustrated in Figures 114 and 115. As Figure 114 shows, an 8' length of angle stock is clamped between the gear legs to provide a means of leveling the axle ends of the legs. As Figure 115 shows, this angle also allows the toe-in or toe-out to be established by means of a shim between the outboard end of the axle and the vertical flange of the angle. The location of the vertical flange of the angle and the shim either forward of or aft of the axles determines whether toe-in or toe-out is established. This will be further clarified below.

The 8' length of angle stock should ideally be at least **2" X 2"** and heavy enough to be rigid—i.e., not to sag in the middle when supported at the ends. It can be made of any metal, although aluminum is preferable simply for ease of handling.

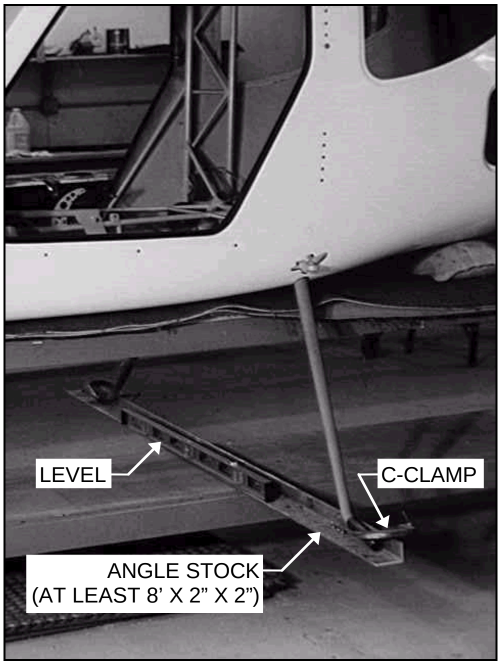
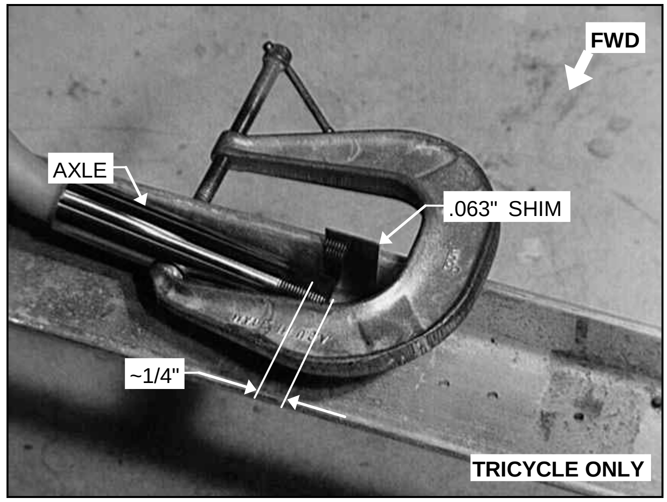
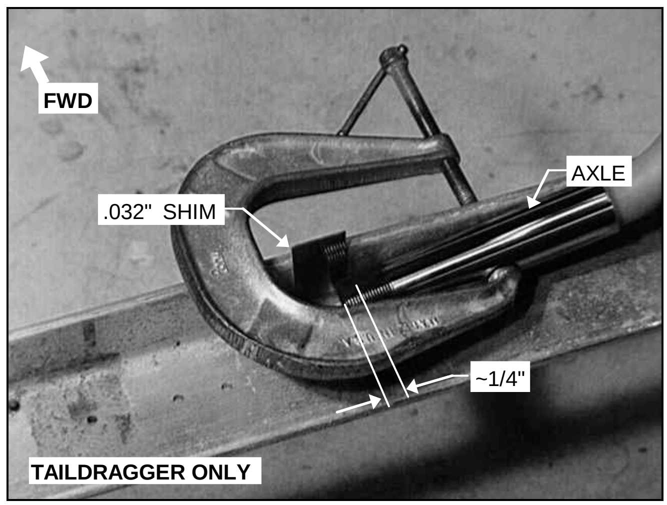


Figure 114: Leveling the Gear Legs



(a)



(b)

Figure 115: Establishing Toe-In for Tricycle Gear (a) or Toe-Out for Taildragger Gear (b)

Hint This angle stock is used only for this procedure, so you don't want to spend an arm and a leg on it. At the same time, however, this is a vital procedure that will have an important impact on how easily your GlaStar handles on the ground. We recommend scouting out local salvage yards for a suitable piece of angle. It doesn't have to be pretty—just straight!

With the GlaStar fuselage leveled laterally and the gear legs inserted into the sockets, position the angle under the axle portions of the legs. As shown in Figure 115, the **vertical** flange of the angle should be **aft** of the axles for a **tricycle**-geared GlaStar and **forward** of the axles for a **taildragger**. Not shown in the photos but a real help in managing this procedure is to support the ends of the angle from below with any convenient props—boxes, paint cans, whatever. With the angle held in its approximate position, insert a scrap-aluminum shim between the **outermost 1/4"** of the axle and the vertical flange of the angle, as shown in Figure 115. The shims should be **.063"** thick for **tricycle** gear and **.032"** thick for **taildragger** gear. With the shims in place, draw the axles in tight against the vertical angle flange with large C-clamps, located as shown in Figures 114 and 115. Rotate the gear legs in their sockets by hand as necessary to allow the clamps to hold the axles tightly against the angle and shims. When tightening the clamps, be sure the axles are firmly in contact with the **horizontal** flange of the angle as well.

Hint To avoid damaging the axles, it would be a good idea to use scrap wood blocks between the jaws of the clamp and the axles, especially if your axles are polished as nicely as the ones in the photos!

The clamps need to be tightened only until the axles are firmly in contact with the vertical angle flange at the inboard ends and with the shims at the outboard ends. As long as you don't overtighten the clamps, the aluminum shims will not damage the axle threads.

Hint You can clamp with lighter pressure if you shim the angle to precisely the proper height from below. That way, the clamps don't need to do the work of holding the angle up.

With the clamps in place, the proper degree of toe-in or toe-out has been established; all that remains is to make sure the axles are level relative to the fuselage. To check this, set a level on the horizontal flange of the angle, as shown in Figure 114. Adjust the gear legs as necessary by inserting them further into or withdrawing them from the sockets. This is a tricky procedure, since sliding the legs in and out will tend to upset the clamped axles. Just keep adjusting until the level reads level with the axles clamped as described, and try not to get frustrated—it's downhill from here!

Note When the gear legs are leveled, they won't necessarily be even with the tops of the gear sockets. However, neither **tricycle** leg can stick out more than **1/8" above** the top of its socket, or else the bolt hole may fall below the hollow portion at the top of the leg, which is unacceptable. By contrast, neither **taildragger** leg can be more than **1/8" below** the top of its socket, or else there won't be enough edge margin between the bolt hole and the end of the leg. When adjusting the legs in or out, try to divide the necessary adjustment between the left and right legs, but be sure to honor these conditions.

If you are unable to bring the axles level within these constraints, try switching the gear legs from left to right. In some cases, slight variations in the bend angle of the axles will make it impossible to achieve level axles without making such a switch.

Hint A common difficulty is that one or both gear legs will try to slip out of the sockets, making it tough to level the angle. A very large C-clamp tightened on the gear socket itself will hold the legs in place temporarily.

With the angle leveled, beef up your supports under the ends of the angle so that they, rather than the clamps, are taking the weight of the angle and the legs.

Note In Figure 114, it may appear that the angle is resting on the shelf under the bench, but this is only an optical illusion. It is in fact hanging above the shelf from the clamps.

Completed: [ ]

Step 68: Drill and Bolt the Main Gear Legs

A single bolt holds each gear leg in place in the sockets. This might not sound like much, but bear in mind that all the bolt is really responsible for is supporting the weight of the legs against gravity—that is, keeping them from falling out in flight! In take-off, landing and taxiing operations, it's the gear sockets that are taking most of the load, not these bolts.

The gear leg **bolts** [134] are AN5-23As, which require a **5/16"**-diameter hole. However, this is too large a hole to drill easily in one pass. Instead, you'll drill all the way through each socket and gear leg with either a **#10** or a **3/16"** bit first; then step up to an "**L**," "**M**" or **19/64"** bit; and finally ream the holes to final size with either a **5/16"** bit or a **.3125"** straight reamer.

Hint These holes **can** be drilled with ordinary, high-speed steel drill bits. However, because the gear legs are made of hardened steel, you will probably destroy many bits of each size in the process, and the job will take a lot of time and effort. Considering this, you may wish to use special cobalt bits, which are designed especially for drilling through hardened steel. These bits cost a little more than standard bits, but they'll cut considerably faster and last longer. Even cobalt bits will probably have to be sharpened two or three times to complete this step, so you may want to have several bits on hand or know how to sharpen them.

Regardless of which bits you use, drill both sets of holes with a heavy-duty, variable speed electric drill turning at **low RPM**. Do **not** use a pneumatic drill. Also, use the shortest bit long enough to go all the way through the socket, and make **liberal** use of a **good-quality cutting oil** to lubricate the bit while drilling.

After drilling so many holes in thin aluminum, these holes will seem to take a long time and a lot of effort! You will have to apply considerable pressure on the drill to keep it cutting. In fact, we recommend making this a two-person operation: one person can bear down on the drill while the second keeps an eye on the perpendicular alignment of the bit with the socket.

As Figure 116 shows, the aft, tricycle-gear sockets are drilled at different angles and different distances from the top of the socket than the forward, taildragger sockets. The angles are dictated by the geometry of the tubing junctions in the cage, and the distances by the internal shape of the sockets, but these differences also allow you to use the same gear legs for either landing gear configuration if you ever want to switch.

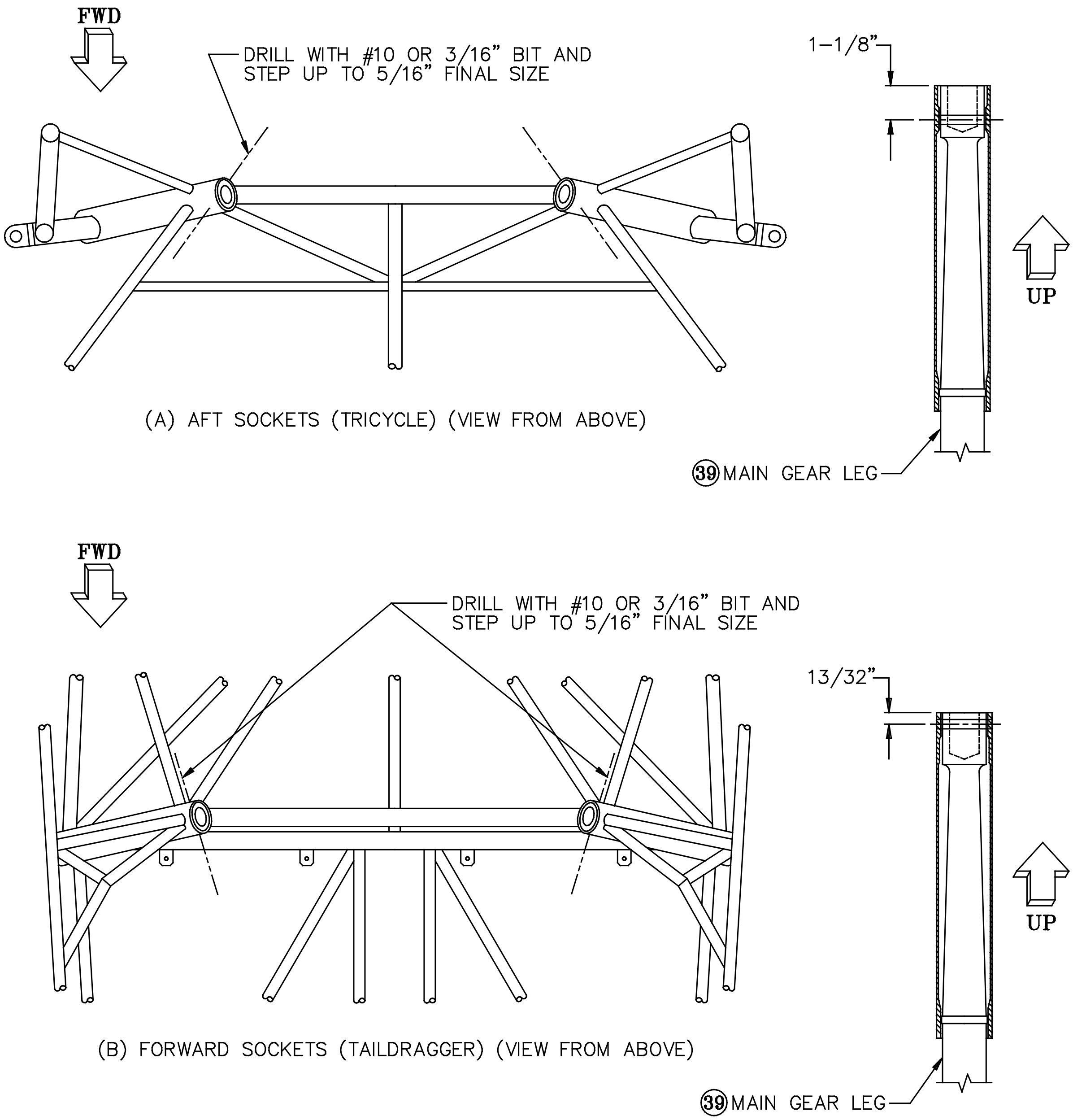


Figure 116: Drilling Angles for the Main Gear Leg Bolts

> **Note** If one of your tricycle gear legs sticks out beyond the top of its socket (remember, no more than **1/8"** is acceptable!), then measure the **1-1/8"** distance shown in Figure 116 **from the top of the leg**. All other distances should be measured from the top of the socket.

Refer to Figure 116 and mark the locations of the holes appropriate to your gear configuration on the sockets. Mark holes for tricycle legs **1-1/8"** below the tops of the sockets and holes for taildragger legs **13/32"** below the tops. Before proceeding, hold an AN5-23A bolt across the top of each socket over your proposed drilling location just to check to see that the bolt head and the washer and nut will clear all the welds on the tubes, and adjust the location and angle as necessary. Center punch each location. Position the drill against the punched location and have an observer help you ensure that the bit is as perpendicular to the socket as possible in all dimensions, as shown in Figure 117. Drill the holes and then remove the legs from the sockets. Use a small rat-tail file to deburr the holes in both the legs and the sockets.

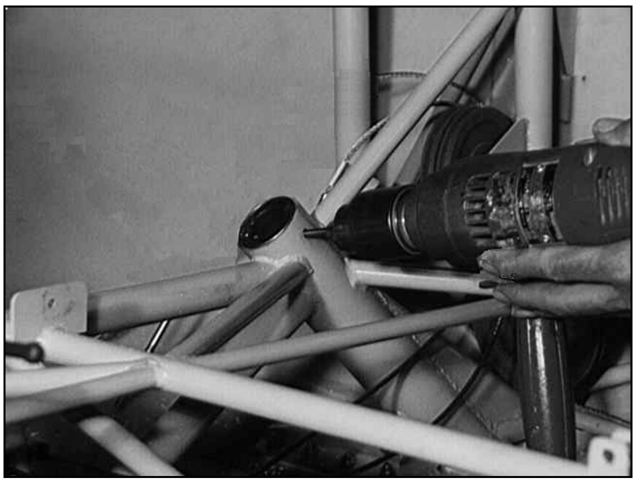


Figure 117: Drilling the Main Gear Leg Bolt Hole

> **Note** You did corrosion-proof your gear legs back in "SECTION VIII: FUSELAGE ASSEMBLY," didn't you? If not, refer back to the instructions for treating unprotected steel parts and take care of that before proceeding.

Re-install the legs (applying more anti-seize if necessary) and insert AN5-23A bolts with the heads forward. Secure these bolts with AN960-516 **washers** [144] and AN365-524A **nylon self-locking nuts** [112].

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Main Gear Wheel and Brake Installation

> **Note** The instructions in this sub-section apply equally to standard (i.e., 5.00 X 5 wheels) tricycle **and** taildragger installations.

> **6.00/8.00 X 6 Taildragger Option** If you are installing the large-tired 6.00 X 6 or 8.00 X 6 Taildragger Option, **turn to the option instructions now**. Return to Step 90 of this *Assembly Manual* when the specified option steps have been completed.
>
> ☞

Step 69: Fabricate the Wheel Pant Backing Plates

You won't assemble or install the wheel pants until "SECTION X: FINAL ASSEMBLY," but it's easiest to fabricate and install the backing plates for mounting the pants at this stage because to do so you'll need the **brake mounting flanges** [177], and by the time you return to the wheel pants in Section X, these flanges will be bolted to the airplane for good.

The two wheel pant backing plates are made from the **.090" X 12" X 12" aluminum sheet** [178]. Mark the dimensions given in Figure 118 onto the aluminum sheet and use a scroll saw or a bandsaw to cut out the plate, cutting just outside the pattern lines. The plates are identical, so you may wish to first cut the sheet in half and then cut out both plates at once. In any case, clamp them together back to back and use files and/or sandpaper to smooth the edges after they're cut out.

> **Note** Early kits included **.063"** aluminum for the backing plates, which is perfectly serviceable, but which will likely not provide as long a service life as the .090" material. If you have one of these kits and wish to upgrade to the thicker material, order P/N 075-01091-01. The thicker backplate will also require two (2) additional **AN4-13A bolts** and two (2) additional **NAS43DD4-39 spacers**.

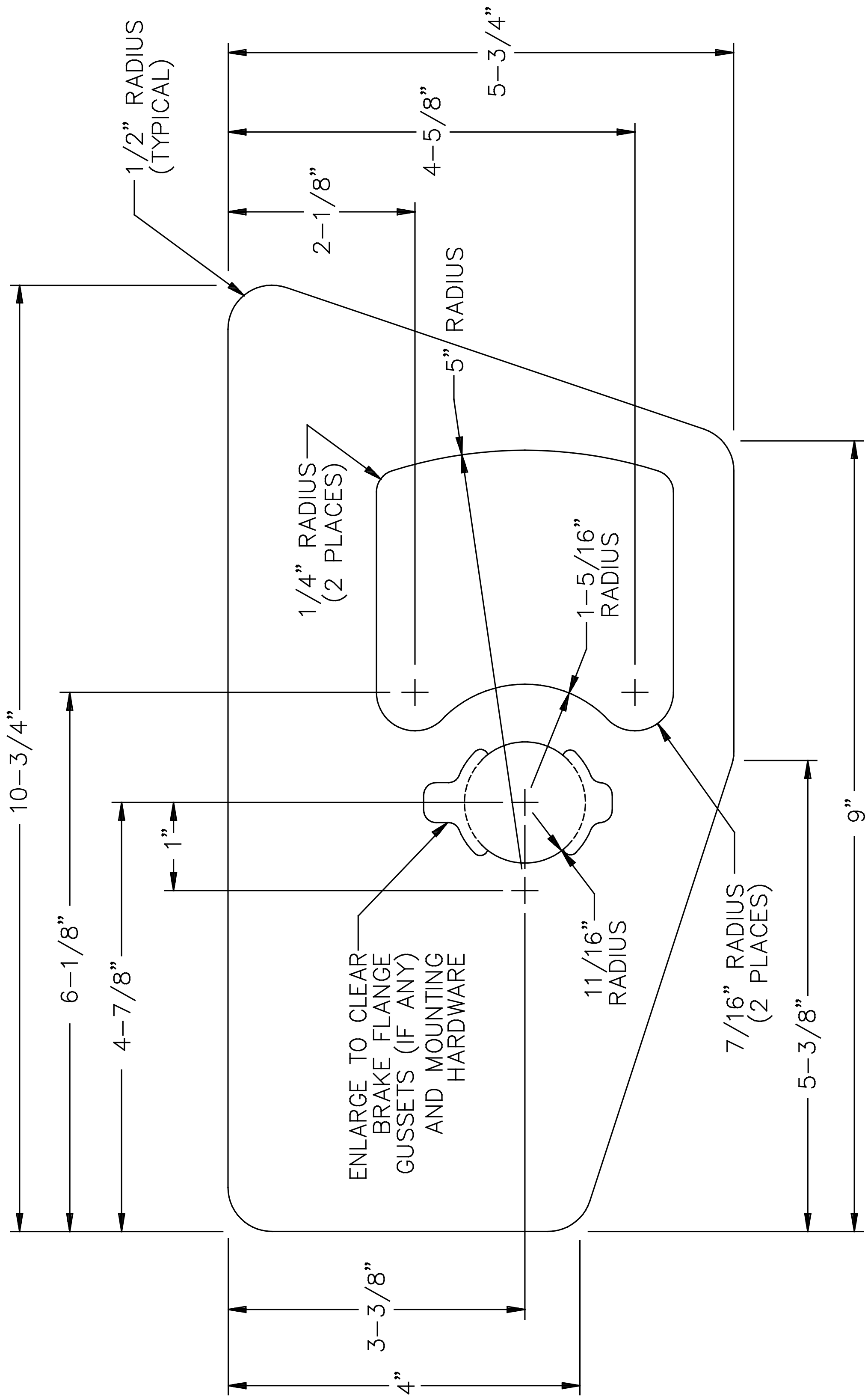

Figure 118: Wheel Pant Backing Plate

Note Early GlaStar kits included P/N 401-01000-**01** brake-mounting flanges rather than the current -03 flanges. These flanges lack the reinforcement gussets shown in Figure 119. Builders with -01 flanges should adjust the shape and size of the wheel pant backing plate center cutout shown in Figure 118.

Insert one of the brake mounting flanges into the circular hole in each plate, as shown in Figure 119. Note that the reinforcement gussets on the sleeve portion of the assembly go through the backing plate and are oriented **vertically**. Rotate the flange until the two rows of holes in the flange are parallel to the top of the plate. When the parts are aligned, clamp them together and drill through the backing plate at the four marked locations using the holes in the mounting flange as guides. Use a **1/4"** bit.

Unclamp the flanges and plates, deburr all the holes and set the plates aside.

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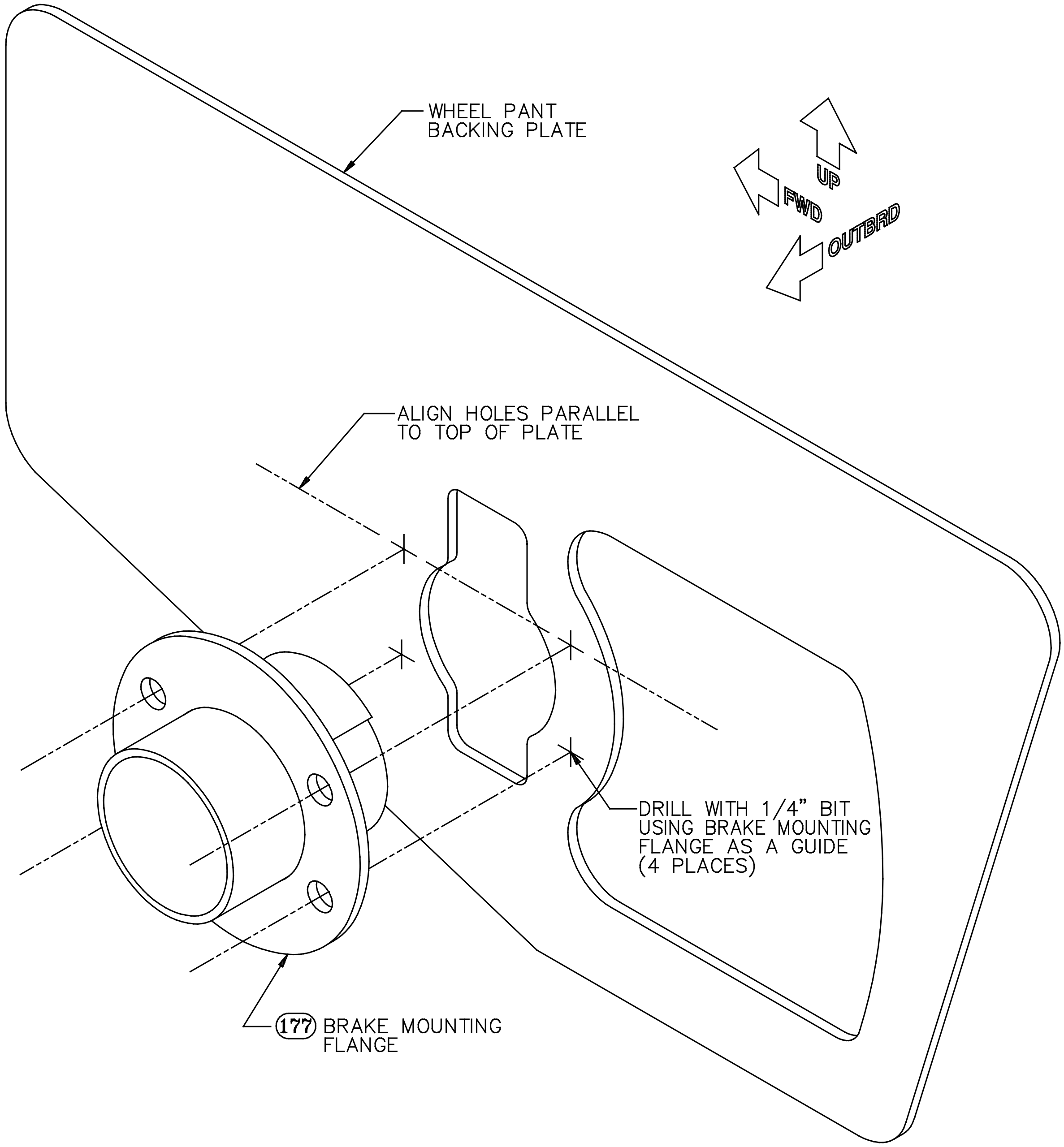

Figure 119: Drilling the Wheel Pant Backing Plate Bolt Holes

Step 70: Install the Brake Mounting Flanges on the Axles

Drilling the main gear leg bolts made you something of an expert in drilling through hardened steel. Now it's time to apply what you learned in installing the brake mounting flanges, which require a bolt hole apiece through the axles. As shown in Figure 120a, slide the mounting flange over the axle and align the inboard end of the sleeve with the shoulder of the axle (that is, the place where the axle necks down from its full diameter). Be sure that the weld radius between the sleeve and the flange itself is oriented **inboard**, as shown in the figure.

With the mounting flange in the proper inboard-and-outboard position, rotate it around the axle until the four holes in the flange are oriented as shown in Figure 120b: the holes should be at the **2**, **4**, **8** and **10 o'clock** positions when viewed from outboard, and the two horizontal rows of holes should be parallel with the fuselage waterline. If you leveled your fuselage longitudinally in Step 66, then this means that the rows of holes should be parallel with the floor. There's no need to measure this—simply eyeball the orientation as best you can.

When you're satisfied with the orientation of the flange, tighten a large C-clamp on the outboard end of the sleeve to hold it in position relative to the axle, as indicated in Figure 120c. Not too much pressure is needed—just enough to prevent you from being able to rotate the sleeve easily by hand. Then mark a hole location on the top of the inboard portion of the sleeve. As indicated in Figures 120a and c, the mark should be **5/16" outboard** of the inboard end of the sleeve. Center punch this location.

As with the gear leg bolt holes, begin drilling at this location with a short, sharp **#10** or **3/16"** bit and have an observer help you keep the drill perpendicular to the axle as you drill. Again, use a slow, heavy-duty electric drill and plenty of cutting oil. Step up to an "**L**," "**M**," or **19/64"** bit, and finally, as before, use a **5/16"** bit or a **.3125"** straight reamer to ream the hole up to final size.

Hint Once the brake mounting flange is clamped to the axle, there's no reason you can't pull the whole gear leg and do the drilling in a drill press or mill. If you have access to this machinery, by all means use it here!

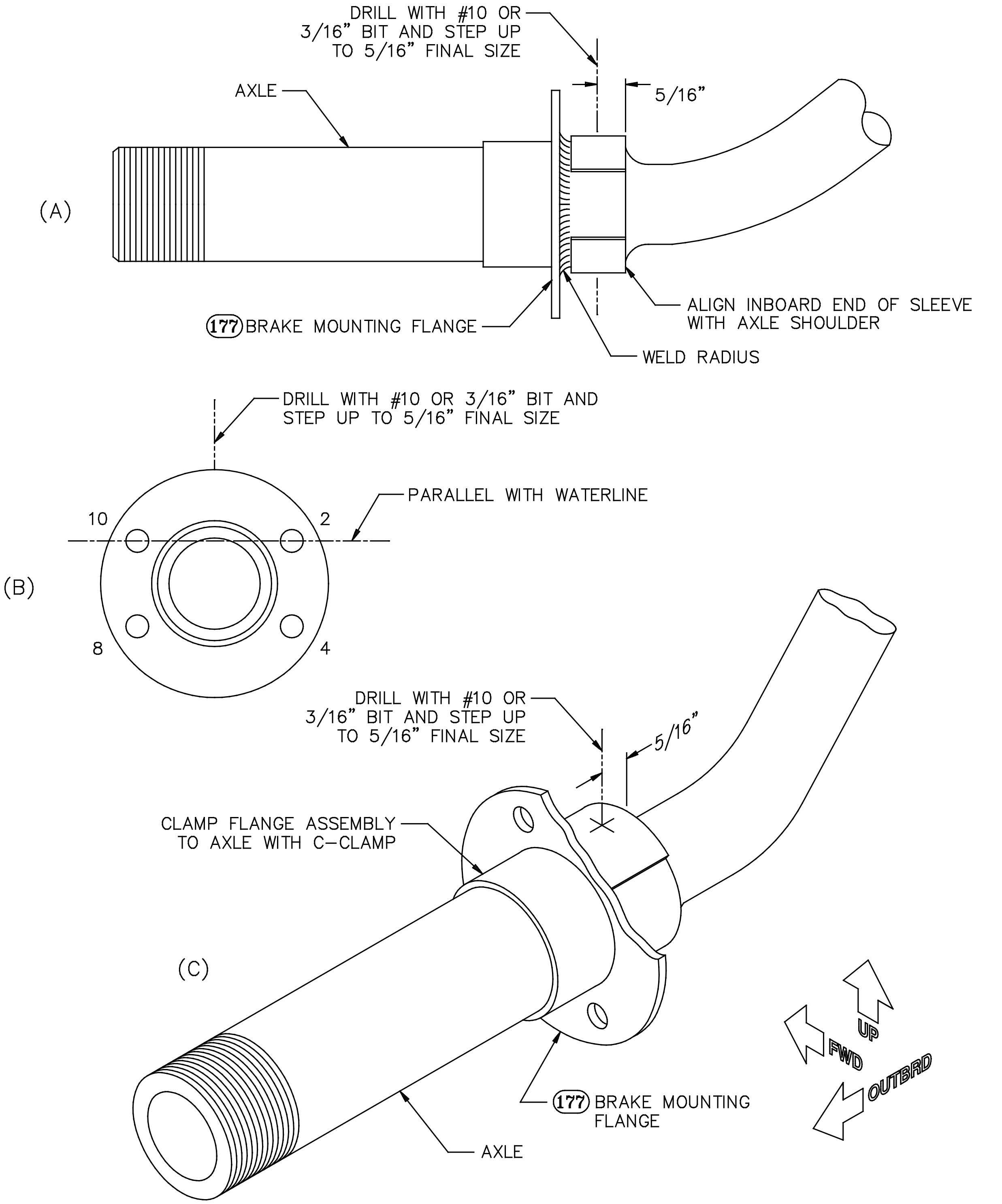

Figure 120: Drilling the Brake Mounting Flange/Axle Bolt Hole

6.00/8.00 X 6 Taildragger Option If you plan in the future to mount 6.00 X 6 or 8.00 X 6 wheels and brakes on the same gear legs that you are now drilling for standard, 5.00 X 5 wheels and brakes, it is **vital** that you take great care to keep the bolt holes for the standard, 5.00 x 5 brake mounting flanges **precisely centered** on the axles and **precisely 5/16"** from the inboard end of the sleeve, as shown in Figure 120. This is because this hole is common to the heavy-duty brake flanges, and it will be difficult or impossible to drill a matching hole in the heavy-duty flange if the initial axle hole is not where it belongs.

After drilling, deburr the parts and apply corrosion protection to the brake mounting flange. When the part is dry, slide it back onto the axle and secure it with an AN5-21A **bolt** [185.1] (head up) and an AN363-524 **high-temperature self-locking nut** [107]. Install at least one AN960-516 washer under the nut and use additional AN960-516 and/or -516L washers as necessary to adjust the grip length of the bolt.

Note Builders of early kits with **-01** brake-mounting flanges should use **AN5-17A** bolts to secure the brake mounting flanges to the axles.

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Step 71: Install the Brake Torque Plate and Wheel Pant Backing Plate on the Brake Mounting Flange

Remove the two brake caliper assemblies from the **main wheel and brake kit** [181] and set the rest of the kit aside. Disassemble the calipers into their five major components by removing the two 1/4" bolts, as indicated in Figure 121.

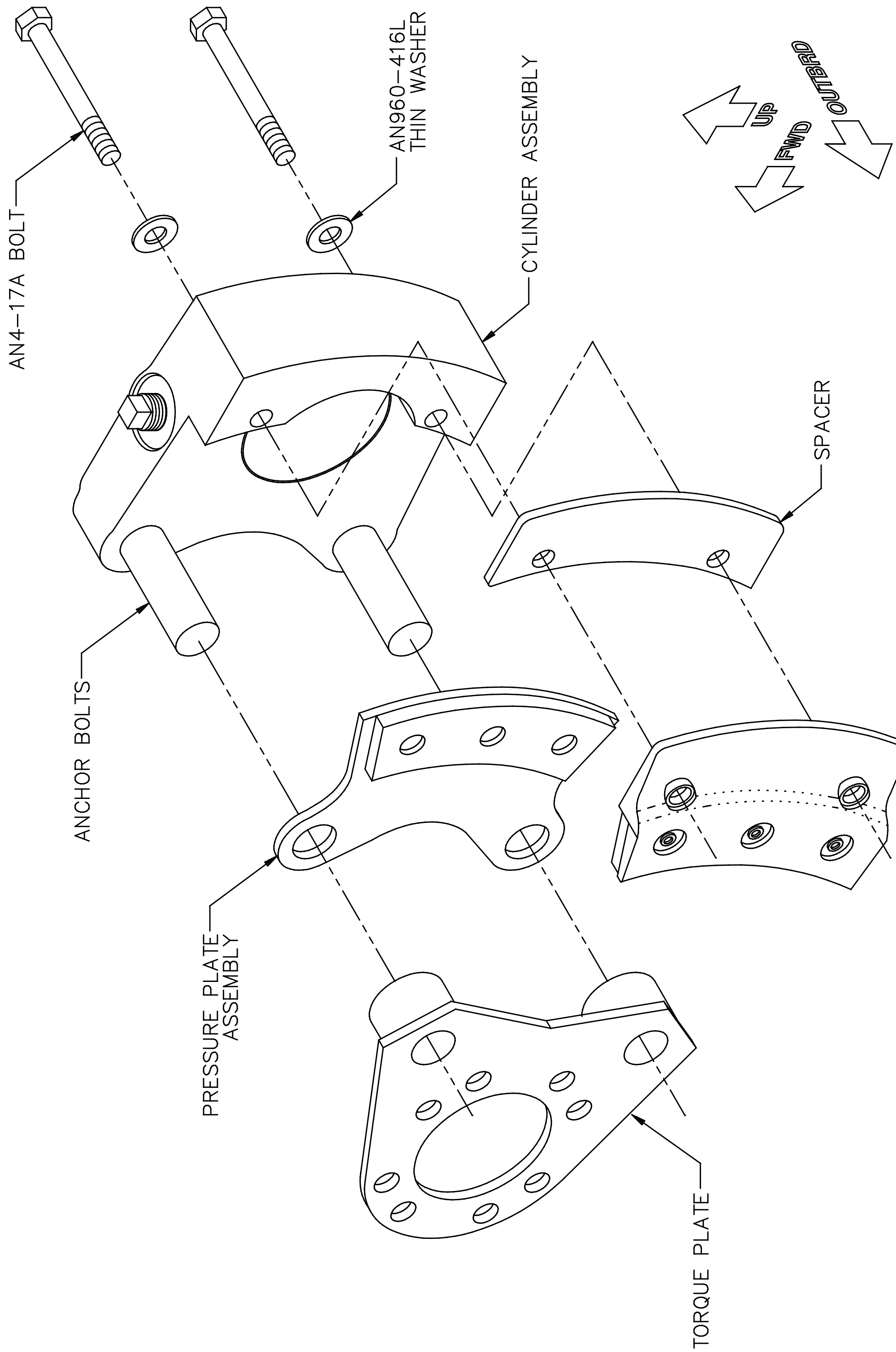

Figure 121: Components of the Brake Caliper Assembly

Orient the **torque plate** as shown in Figure 122, with the wide end **aft** and the flat face **outboard**. Slide the plate onto the axle. The plate should fit over the sleeve of the brake mounting flange to fit tightly against the flange. However, it's likely that the fit will be too snug initially. Use medium-grit sandpaper to very slightly enlarge the large center hole in the torque plate until it will slide easily over the sleeve.

Hint A small sanding drum in a drill motor or drill press is ideal for enlarging the hole in the plate.

With the torque plate tight against the brake mounting flange, rotate it as necessary to bring the 1/4" holes in the plate into alignment with those in the mounting flange, keeping the caliper mounting holes oriented aft. From the outboard side, insert AN4-13A **bolts** [184] through the common holes in both parts at the **2, 4, 8** and **10** o'clock positions and slip NAS43DD4-39 **aluminum spacers** [189] over the ends of these bolts, as shown in Figure 122.

The purpose of the spacers is to hold the wheel pant backing plate out away from the brake rotor. Slide the plate over the four bolts and up tight against the spacers now. The holes should line up, since you used the brake mounting flange to guide their drilling, but you may have to file or sand the plate to get it to fit cleanly around the mounting flange bolt.

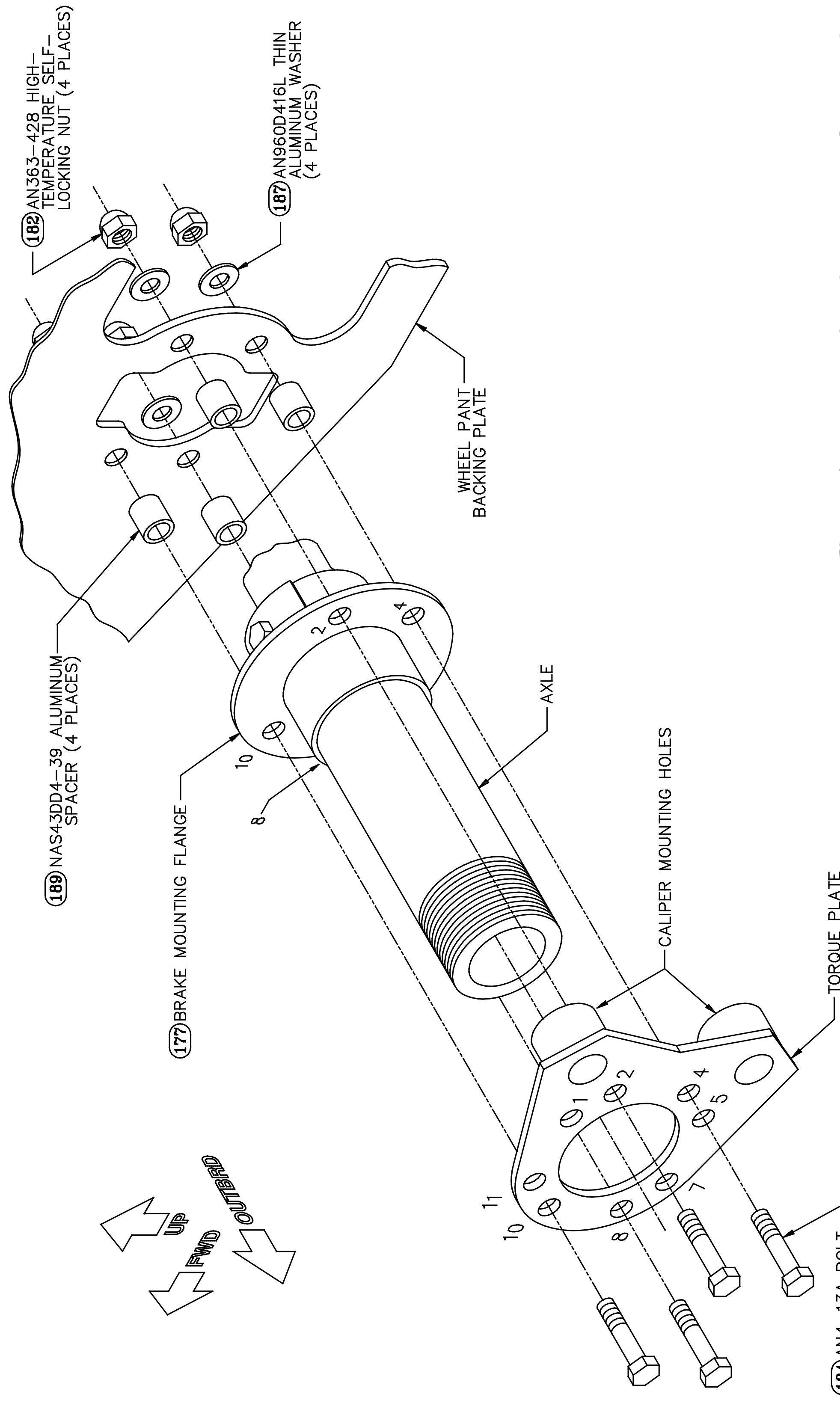

Figure 122: Mounting the Torque Plate on the Brake Mounting Flange

When you have the backing plate fit to your satisfaction around the mounting flange, try sliding the brake cylinder assembly into place from inboard, as shown in Figure 123. (The pressure plate assembly should be in place on the anchor bolts for this test fitting.) Orient the assembly as shown in the figure and try to slide the anchor bolts into the holes in the torque plate. IF you can slide the assembly all the way to the torque plate without hitting the wheel pant backing plate, then you're all set. If not, note the point(s) of interference and file the backing plate to fit.

Note The backing plate should not actually contact anything but the aluminum spacers and the sleeve of the brake mounting flange. Aim for between 1/32" and 1/16" of clearance around all the brake parts.

Once the newly filed edges of the plate have been sanded smooth, replace it on the four AN4-13A bolts, as shown in Figure 122, and secure the bolts with AN960D416L **thin aluminum washers** [187] and AN363-428 **high-temperature self-locking nuts** [182].

Set the brake cylinder and pressure plate assemblies aside.

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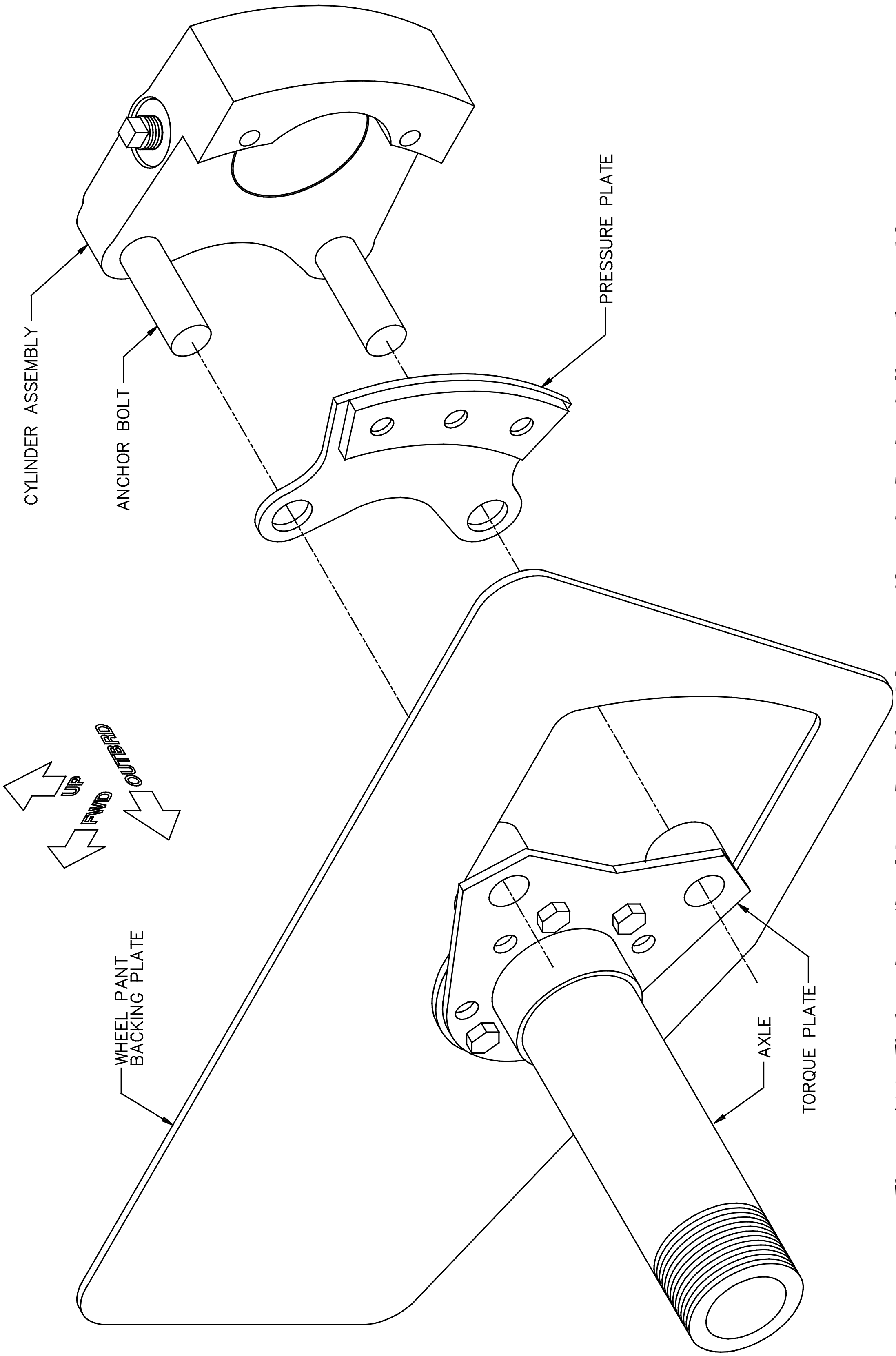

Figure 123: Fitting the Wheel Pant Backing Plate to Clear the Brake Caliper Assembly

Step 72: Mount the Tubes and Tires on the Main Wheel Assemblies

Using a 7/16" socket on the nuts and a 7/16" open-end wrench inserted endwise on the bolt heads, remove the three bolts to separate the two halves and the brake rotor of each main wheel, as shown in Figure 124.

> **Hint** The use of the open-end wrench is necessary because the thick walls of the brake rotor prevent the use of a standard socket. However, an alternative is to grind down a 7/16" socket on one side so that it clears the rotor wall. If you do this, you'll have a handy tool that will be useful every time you need to change a tire or tube.

Insert a **5.00 X 5 tube** [180] into one of the **5.00 X 5 tires** [179] with the valve stem aligned with the painted reference mark on the tire. This mark is used to confirm that the tire doesn't move in relation to the wheels when in service. (If your tire doesn't have such a mark, make one yourself and align the valve stem with it.) Inflate the tube with just enough pressure to give it shape inside the tire, and then insert the two wheel halves into the tire, taking care to avoid pinching the tube between them. Guide the valve stem through the rubber-grommeted hole in the outboard wheel half as you bring the halves together.

When the halves are joined, use an inspection mirror and a flashlight to double check that you haven't pinched the tube, and then reassemble the wheel unit, including the brake rotor, with the original bolts, washers and nuts. Inflate the tire to **40 psi**.

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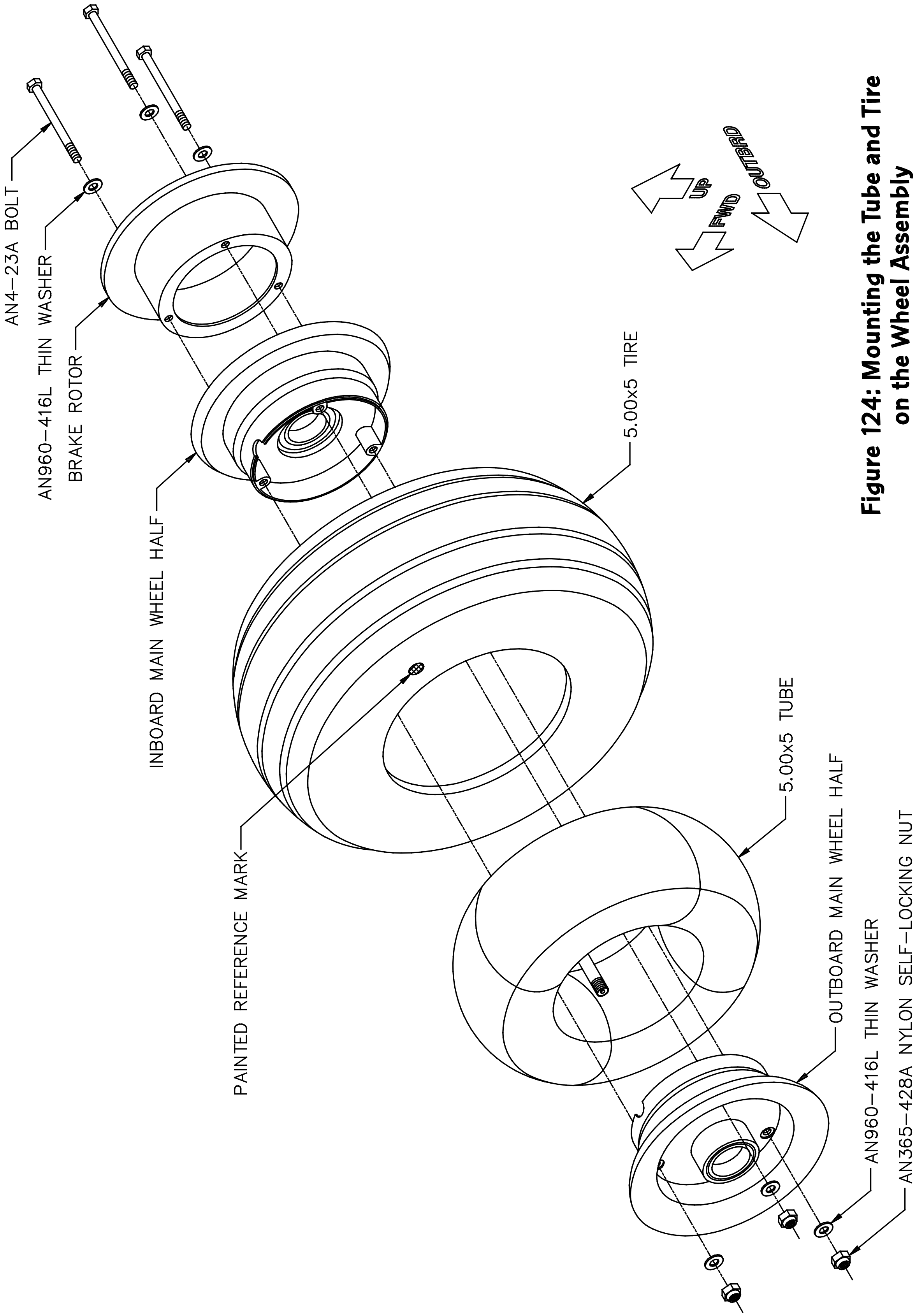

Figure 124: Mounting the Tube and Tire on the Wheel Assembly

Step 73: Install the Outboard Wheel Pant Nutplates on the Axle Nuts

In "Section X: Final Assembly," you will secure the wheel pants to the axles by means of three machine screws into nutplates. The outboard screw of this trio attaches to a nutplate that is riveted to a welded strap on the castellated **axle nut** [175]. Since you will secure this nut to the axle in the next step, it's necessary to rivet that nutplate in place now.

Figure 125 shows where the MF5000-4 **floating nutplate** [188] is mounted on the nut. Center the nutplate on the 9/32" hole in the nut strap and drill **#40** rivet holes using standard procedures. Countersink the rivet holes on the **outside** of the strap to accommodate AN426AD3 flush-head rivets, and then rivet the nutplate in place.

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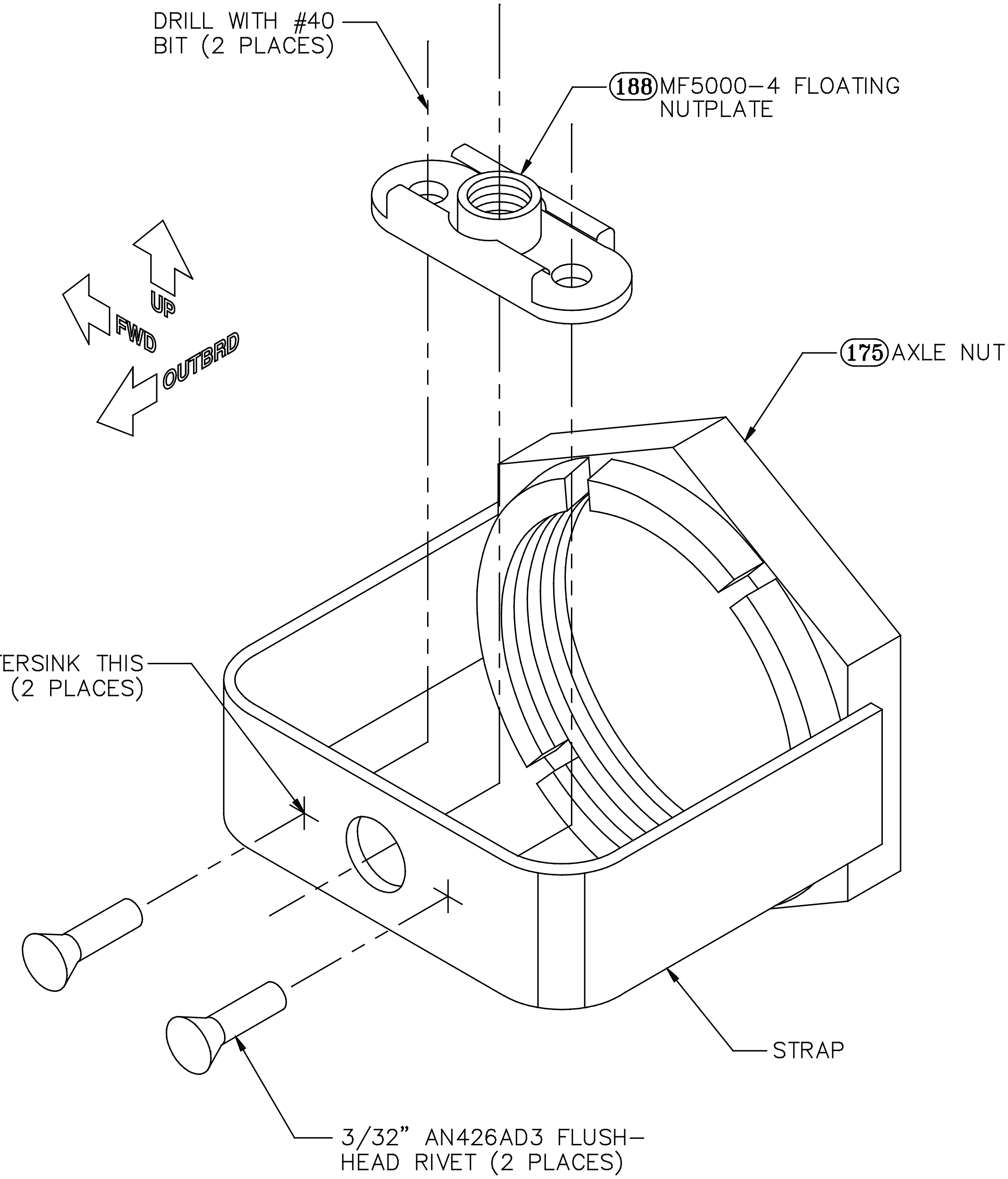

Figure 125: Installing the Outboard Wheel Pant Nutplate on the Axle Nut

Step 74: Mount the Wheels on the Axles

Before you can mount the wheels, you must pack the wheel bearings with grease. There are two sets of roller bearings in each wheel, one on the inboard side and one on the outboard side. To access the bearings for packing, use the tip of a screwdriver to remove the snap ring from its groove near the axle hole on each side of the wheel (pry the snap ring inward, toward the axle hole, to remove it). Remove the seal rings and the felt grease seal, noting their positions and orientations, and then the roller bearings themselves. The traditional way to pack wheel bearings is to put a gob of grease in the palm of one hand and use your other hand to force the bearing into the grease with a scraping motion as if you were trying to clean the grease off your palm with the bearing. (Have a mechanic show you how if you don't understand.) Continue all around until all the rollers are coated with grease and the grease thoroughly fills all the spaces between the rollers. Alternatively, use a bearing packing tool; this consists of a pair of cones, between which the bearing is clamped, and a grease fitting, into which grease is pumped with a grease gun. When finished, reinstall the bearings (with their seals, seal rings and snap rings) into the wheel.

Figure 126 shows how the wheel assembly is mounted on the axle. First, slide the **axle washer** [40] and **axle spacer** [38] onto the axle and tight up against the sleeve of the brake mounting flange. As with the torque plate, you may have to slightly enlarge the hole in the washer with a sanding drum. Next, slide the wheel assembly onto the axle, with the brake rotor onboard and the valve stem outboard. Finally, slide the other **axle spacer** [176] onto the axle and nest it tightly inside the wheel bearing, followed by the axle nut.

> **Note** The two axle spacers are **not** identical. The **inboard** spacer (Key No. 38) is **thicker** than the **outboard** spacer (Key No. 176).

Finger-tighten the axle nut against the outboard spacer. Then, while continuing to tighten the nut with a wrench, simultaneously rotate the wheel assembly by hand. Tighten the nut until you begin to feel resistance in the wheel bearings, and then back the nut off until the resistance disappears. This will probably entail backing off between 1/8 and 1/4 of a turn. When the nut is set in its final position, there should be no resistance to rotation and no side-to-side play in the wheel bearings.

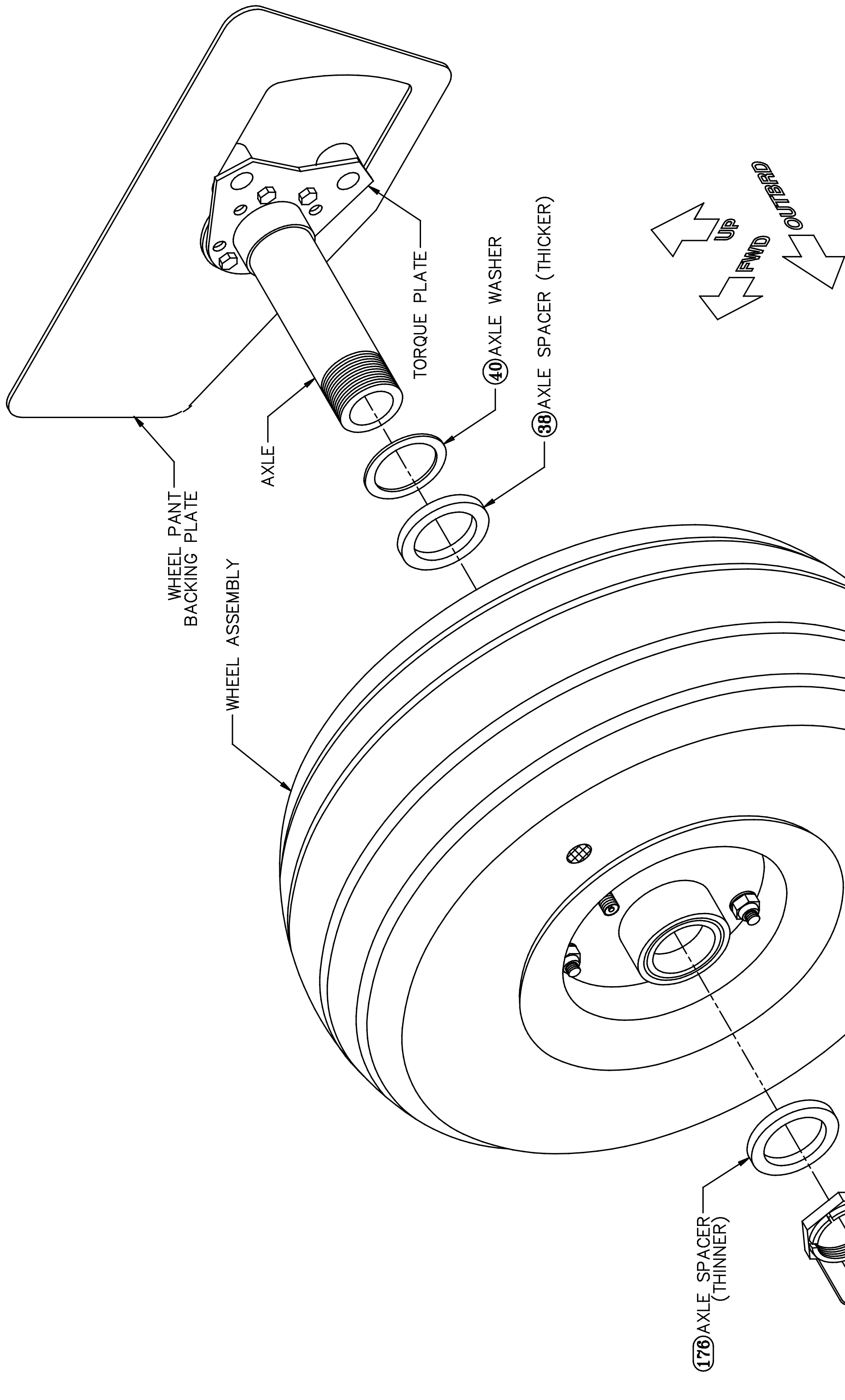

Figure 126: Mounting the Wheel on the Axle

The nut will be secured with an AN380-4-8 **cotter pin** [117] through the castellated axle nut, and you must drill a hole through the end of the axle to accommodate this. Select the notch in the crown of the nut that is nearest the 12 o'clock position and use either a **1/8"** or a **#30** bit to drill through the axle near the base of the notch, as shown in Figure 127. Have an assistant monitor the drilling from outboard to make sure that you keep the bit aligned with the opposite notch on the other side of the castle nut crown.

Hint With the tire and wheel in place, you'll probably need to use a 90° drill motor and a short bit to drill this hole. You may find it easier to mark the axle through the castle nut notch with a felt-tip pen, remove the wheel assembly temporarily, and replace the nut on the axle, aligning it with the mark before drilling.

After both holes are drilled, insert an AN380-4-8 cotter pin from above and secure the ends.

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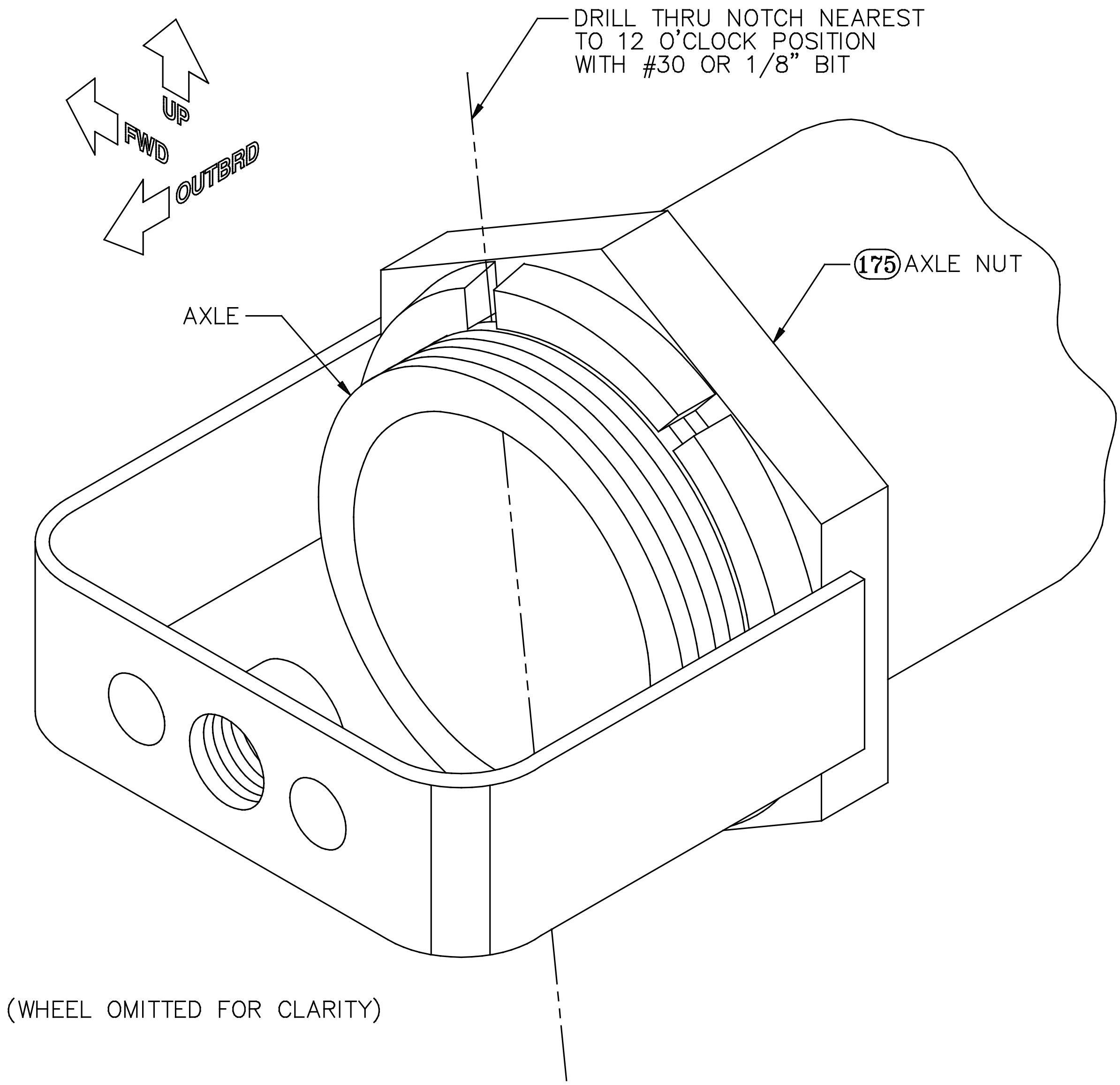

Figure 127: Drilling the Cotter Pin Hole in the Axle

Step 75: Mount the Brake Calipers

Figure 128 illustrates the mounting procedure for the brake caliper assembly. From inboard of the wheel, slide the cylinder assembly into the torque plate, which is now bolted inside the hub of the wheel. The pressure plate assembly and the spacer should be in place on the cylinder assembly when you do this. Then, with the cylinder assembly held tightly against the inboard face of the brake rotor, slide the backplate assembly in between the brake rotor and the inboard wheel hub flange. Align the backplate assembly with the spacer and the cylinder assembly, and re-attach all the components with the pair of AN960-416L thin washers and AN4-17A bolts. Tighten these bolts with a 7/16" socket wrench.

Caution To avoid foreign object contamination, be sure to leave the plugs in the upper and lower ports in the cylinder assembly until you attach the brake line fittings in a subsequent step.

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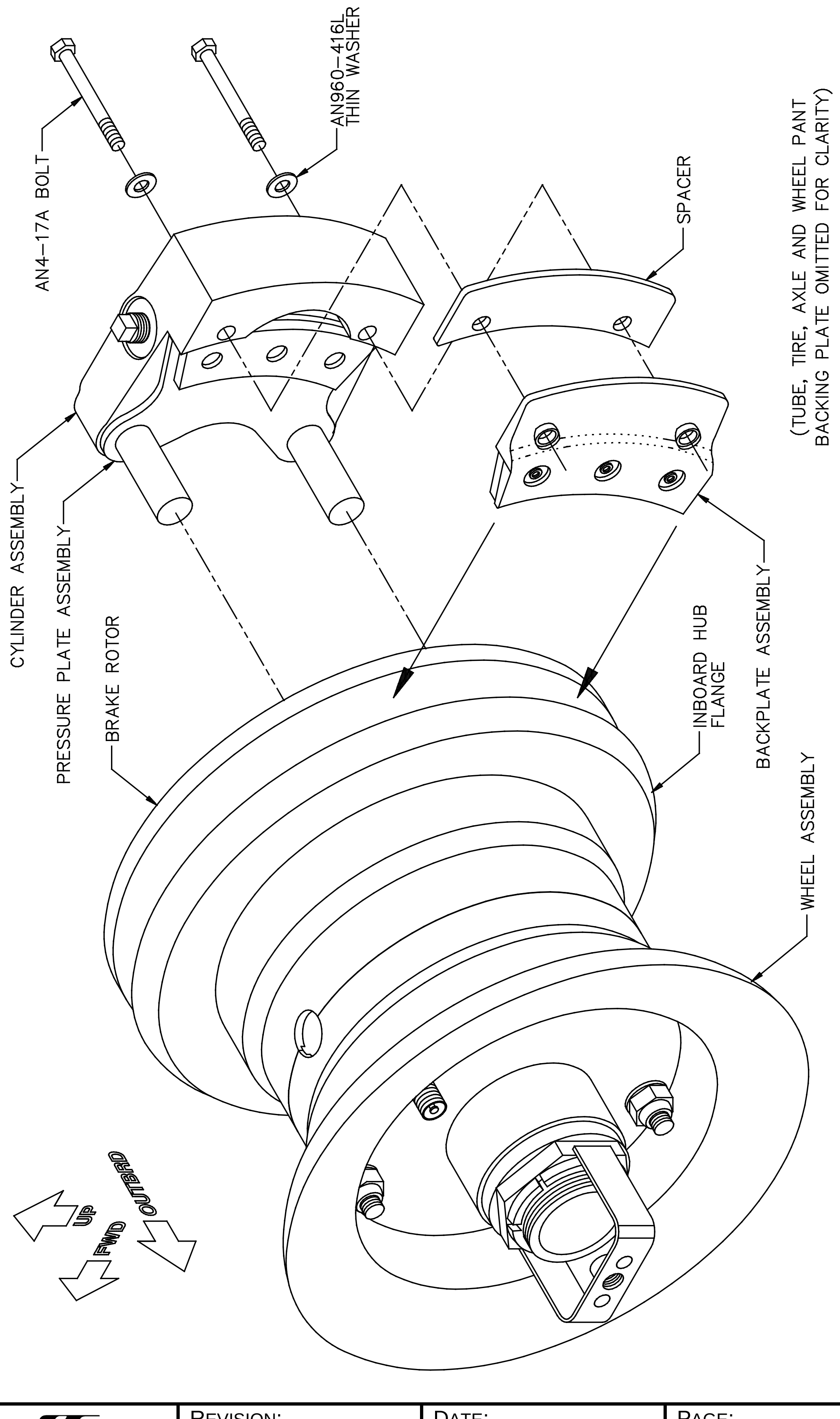

Figure 128: Mounting the Brake Caliper Assembly

Nose Gear Installation (Optional)

Taildragger Options If you are installing either the standard, 5.00 X 5 taildragger gear or the 8.00 X 6 Taildragger Option Kit, **skip to Step 90**.

Hint For installing the nose gear, it's easiest just t o set the fuselage on its main gear with the tail on the floor.

Step 76: Position the Nose Gear Trunnions and Cut the Nose Gear Slot in the Fuselage Floor (Tricycle Gear Only)

Two trunnions bolted into the cage anchor the nose gear leg. Figure 130 shows the locations and orientations of the trunnions in the forward cage structure. Slide them into place between their respective bushings and temporarily pin them there with **7/16"-20 bolts** [212]. There is no need for washers or nuts at this point.

With the trunnions pinned in place, run an 18" ruler or other straightedge through the trunnions, as shown in Figure 130, and mark the approximate point where the projected centerline of the trunnions intersects the fuselage floor. Transfer this point to the outside of the fuselage shell and, as shown in Figure 129, drill through the fuselage floor from below with a **1-5/8"** hole cutter. Then use a saber saw or hacksaw to cut back from the forward edge of the fuselage to the hole along the tangent lines.

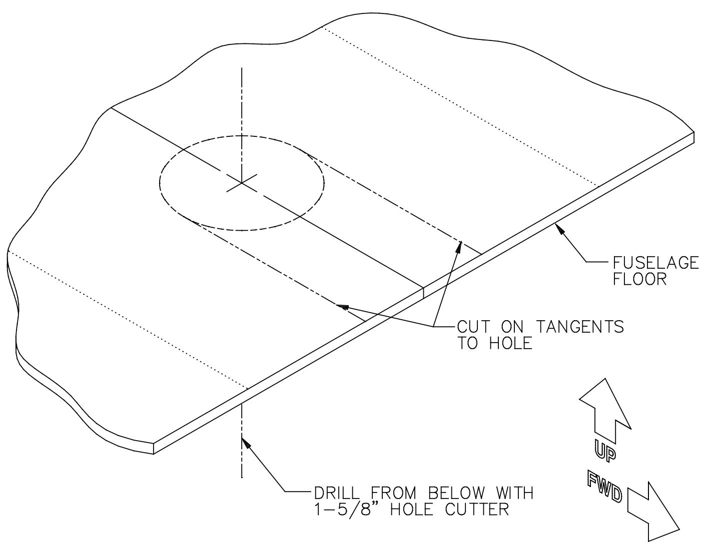

Figure 129: Cutting the Nose Gear Slot

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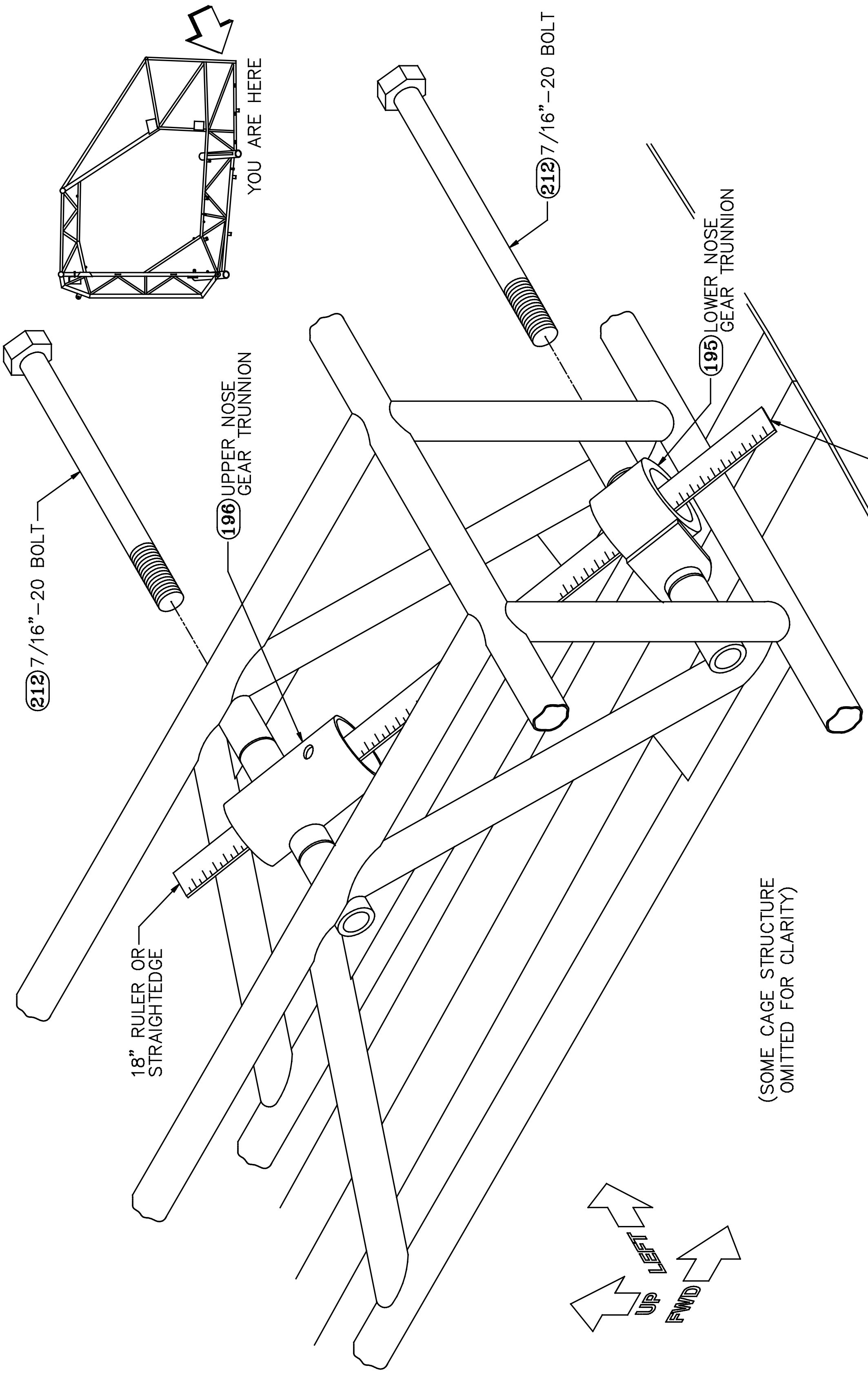

Figure 130: Positioning the Nose Gear Trunnions on the Cage

Step 77: Position and Drill the Nose Gear Leg (Tricycle Gear Only)

With the slot cut in the fuselage, you can now slide the **nose gear leg** [194] into the trunnions from below, as shown in Figure 131. **Liberally** coat the bearing surfaces of the leg with anti-seize compound and work it through the trunnions until the top end of the leg is seated firmly against the shoulder inside the upper trunnion (see Figure 131, Detail A).

The axle portion of the nose gear leg needs to be oriented vertically. Raise the tail of the airplane until the fuselage is approximately level longitudinally, and then use a plumb bob to check the alignment of the gear leg, as shown in the figure. A digital level could also be used, if you have one. Rotate the leg in the trunnions as necessary until the axle is vertical in the side-to-side plane.

The leg may well remain in position due to friction, but if necessary, support the end of the axle from below to keep it in position. Then, with a **1/4"** bit, drill through **one wall** of the hollow gear leg using the pilot hole in the upper trunnion as a guide (see Figure 131, Detail B). As on the main gear legs, use a high-torque electric drill motor turning at very low RPMs and use cutting oil.

Once you have drilled into the hollow center of the leg, you can remove the leg and the trunnion from the airplane and complete the drilling much more conveniently. Finish drilling through the aft walls of the leg and trunnion with a 1/4" bit,, and then step the hole up to a final size of **5/16"**. IF you have one, use a drill press or a mill for this job.

When the drilling is complete, use a rat-tail file to deburr the holes in the trunnion and in the gear leg. If you've already corrosion-proofed these parts, just touch them up wherever the primer may have gotten scratched during the drilling; if you haven't yet corrosion-proofed them, do so now.

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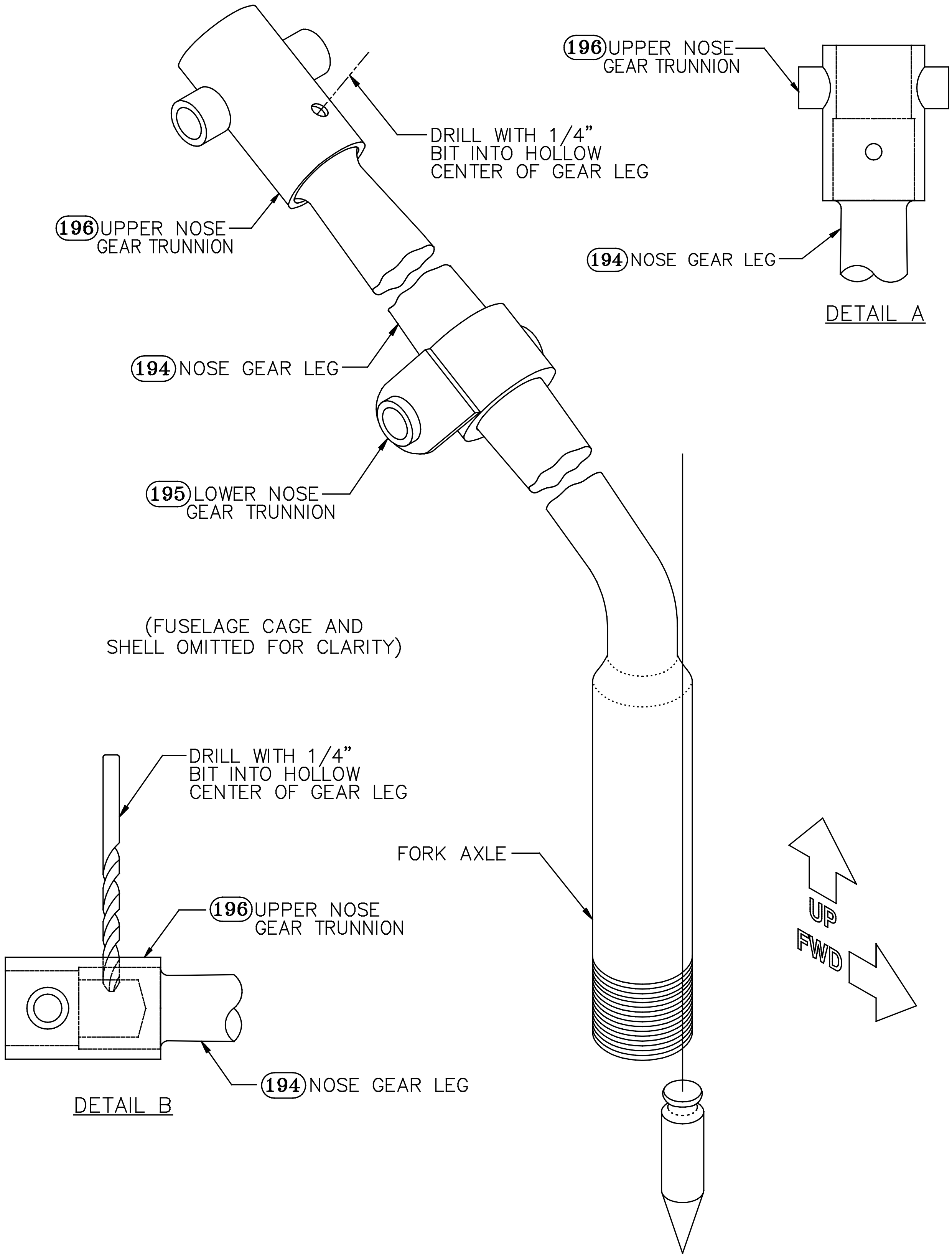

Figure 131: Drilling the Nose Gear Leg Bolt Hole

Step 78: Bolt the Trunnions and Gear Leg in Place
(Tricycle Gear Only)

Slide each trunnion into position between its bushings and check the side-to-side clearance. Ideally, the gap should be **between 1/64" and 1/32"** on each side. However, some cages may display larger gaps, and you may need to insert one of more AN960-716 **washers** [214] or -716L **thin washers** [215] between the trunnion and the bushings, as indicated in Figure 132. Use whatever washers are necessary. IF you need to insert only one, it doesn't matter which side you insert it on, but to the extent possible, try to use the same number of washers on a given side of both trunnions so the gear leg won't be cocked to one side.

Temporarily bolt both trunnions in place with the 7/16"-20 bolts, AN310-7 **castle nuts** [274] and AN960-716 washers (under both the bolt heads and the nuts). With the nuts torqued down tightly (see the torque table in "SECTION II: TOOLS AND TECHNIQUES"), use a felt-tip pen to mark each bolt at the base of one of the notches in the castle nuts. Then remove the hardware from the trunnions. Center punch the bolts on the marks and drill a cotter pin hole through each one with a **#40** bit.

Hint Center punching and drilling the bolts will be much easier if you use a vise and drill press. Punch the bolts **hard** to keep the bit from walking.

Note Our Purchasing Department tried without success to locate a reliable supplier of standard, AN7 drilled-shank bolts for the nose gear trunnion application. The 7/16"-20 bolts supplied are manufactured from identical material and are equally as serviceable as the AN bolts they replace.

After the cotter pin holes have been drilled, apply anti-seize compound to the bolt shanks and reinstall the trunnions, safetying the castle nuts with AN380-3-3 **cotter pins** [277].

Slide the gear leg into the trunnions until the bolt holes in the upper trunnion and the leg line up. Secure the leg, as shown in the figure, with an AN5-20A **bolt** [210], an AN960-516L **thin washer** [213] and an AN364-524A **nylon self-locking nut** [205]. The bolt head should be up.

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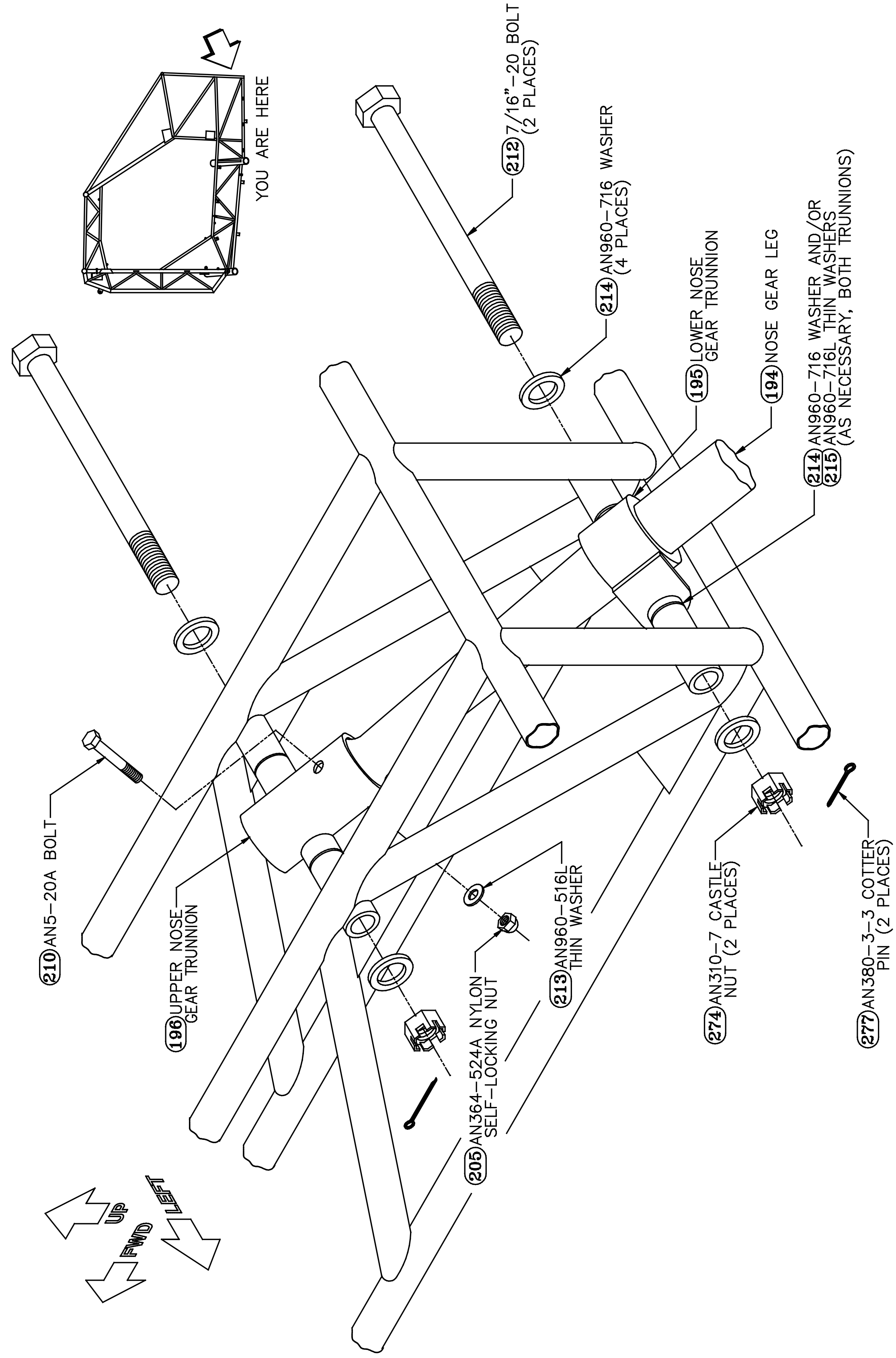

Figure 132: Bolting the Trunnions and Gear Leg in Place

Step 79: Drill the Nose Gear Stop Assembly (Tricycle Gear Only)

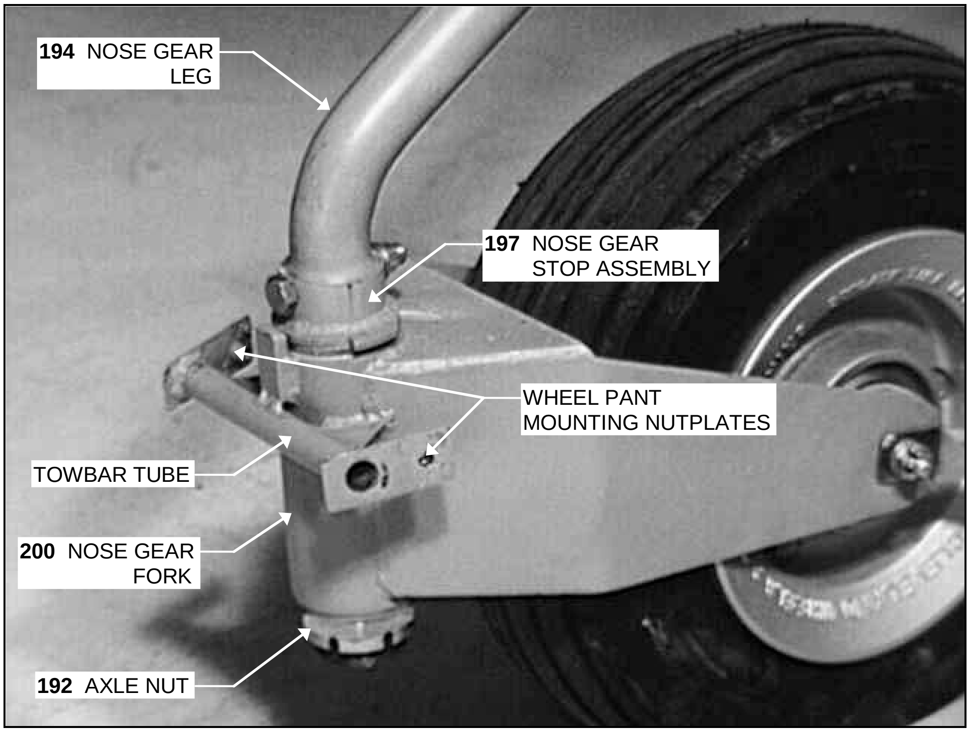

Figure 133: Nose Fork Installation

Now you're ready to begin installation of the **nose gear fork** [200]. Figure 133 shows the completed installation. Start by sliding the **nose gear stop assembly** [197] over the nose gear fork axle until the top of the collar is aligned with the shoulder of the axle, as shown in Figure 134a. Be sure that the flat stop plate is **on the bottom**. Rotate the assembly around the axle until an imaginary line between the prongs of the stop plate is perpendicular to the aircraft centerline, as shown in Figure 134b, and then use a small C-clamp to hold the assembly in place, as indicated in Figure 134c.

With the stop assembly in position, mark and center punch a hole location on the forward side of the collar **9/32"** below the top of the collar. Drill through the collar and the axle at this point using standard procedures: begin with either a **#10** or a **3/16"** bit; step up to an **"L," "M"** or **19/64"** bit; and then ream the hole up to final size with a **5/16"** bit or a **.3125"** straight reamer.

When the drilling is completed, remove the stop assembly and deburr the holes.

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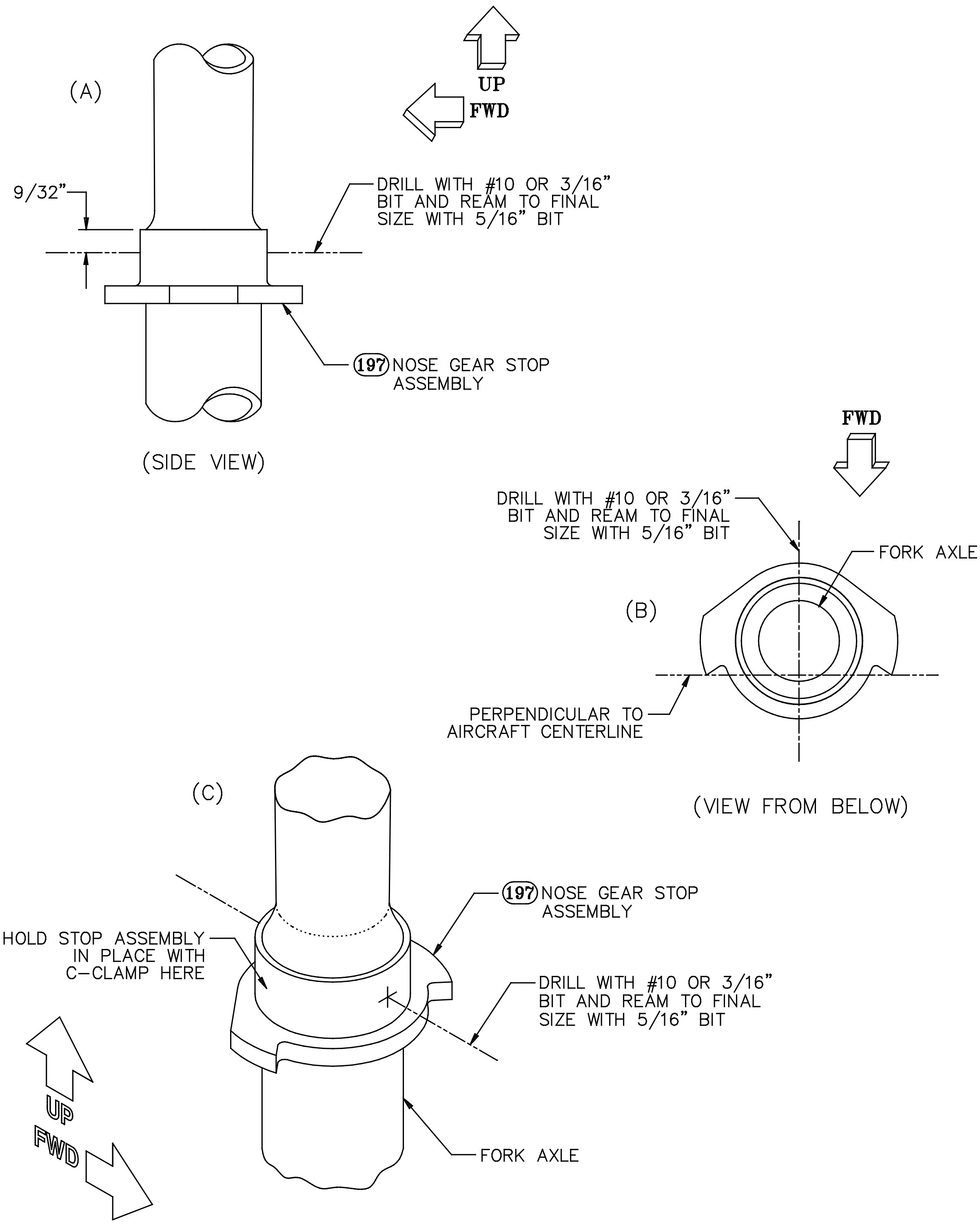

Figure 134: Positioning and Drilling the Nose Gear Stop Assembly

Step 80: Position and Drill the Forward Wheel Pant Mounting Nutplates *(Tricycle Gear Only)*

The nose wheel pant attaches to the fork at four points, two of which are on the brackets at either end of the towbar tube (see Figure 133). In this step, you will position and drill nutplates at these locations.

As shown in Figure 135, the two MF5000-3 **floating nutplates** [216] are mounted at an angle on the inboard faces of the two brackets. The angle is necessary to allow adequate edge margin for the nutplate rivets, but it need not be set precisely. Simply align the center holes of the nutplates with the pre-drilled #10 holes in the brackets and drill the rivet holes in the nutplates and brackets up to **#40** size. Then countersink each bracket on its **outboard** face to accommodate a 3/32" AN426AD3 flush-head rivet. Thoroughly deburr all the holes after drilling.

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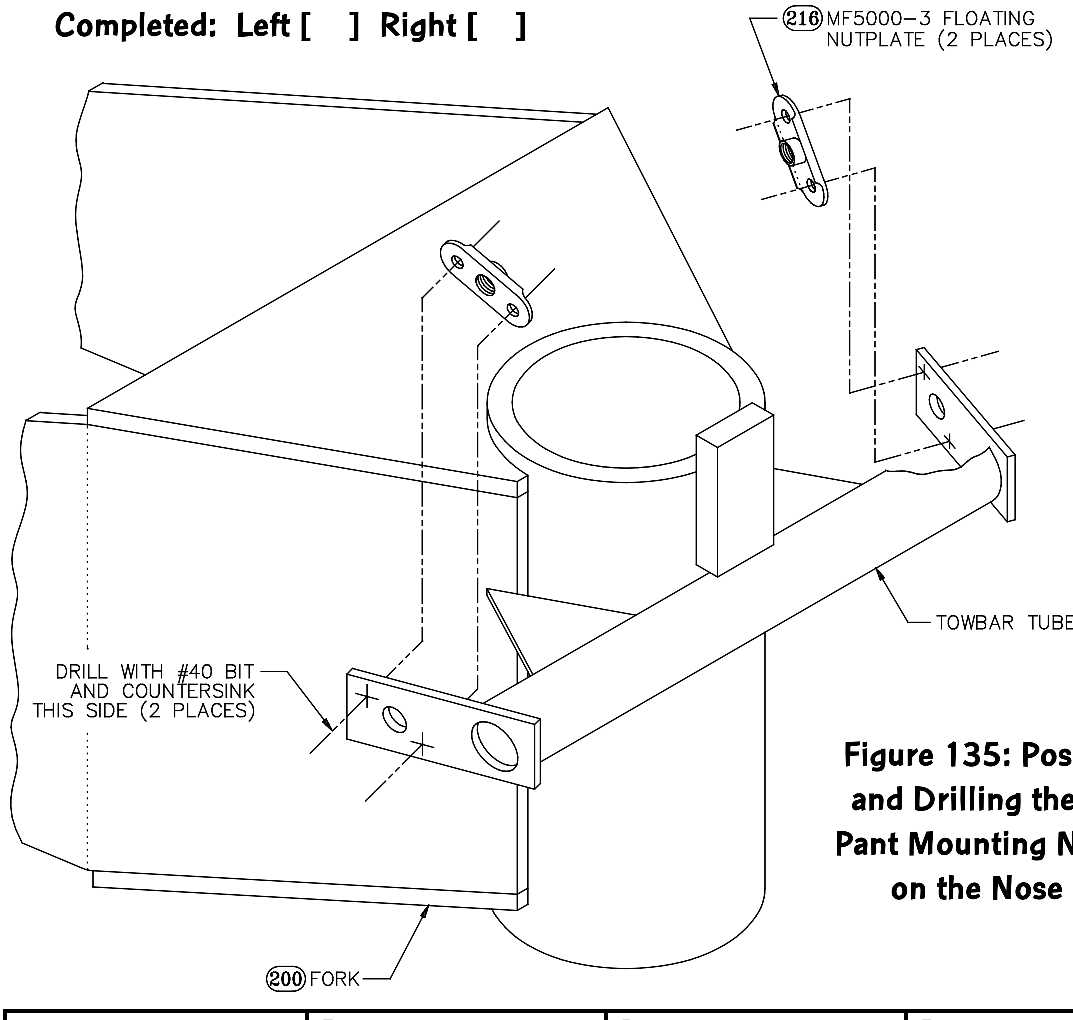

Figure 135: Positioning and Drilling the Wheel Pant Mounting Nutplates on the Nose Fork

Step 81: Fabricate the Aft Nose Wheel Pant Mounting Brackets (Tricycle Gear Only)

The aft wheel pant mounting brackets extend outward and aft from the arms of the nose fork. The brackets must be fabricated from the **.063" X 1" X 8" steel sheet** [190] according to the dimensions shown in Figure 136. Use a bandsaw or hacksaw to cut two pieces to a length of **3-3/4"**, as shown. Then mark and center punch two hole locations according to the dimensions shown at the left-hand end of Figure 136a. Drill through the bracket stock at the **right-hand** location with a **5/16"** bit.

Next, mark bend lines on each piece as shown in Figure 136b. Place the brackets in a bench vise and bend them as shown in Figure 136c; each bend should be approximately **45°**. When you're done, the ends of the brackets should be **parallel** with one another and the distance between their faces should be **3/4"**.

After you have both pieces bent to your satisfaction, use a fine-toothed file or a belt sander to slightly round the corners and smooth all the edges. Deburr the holes, too.

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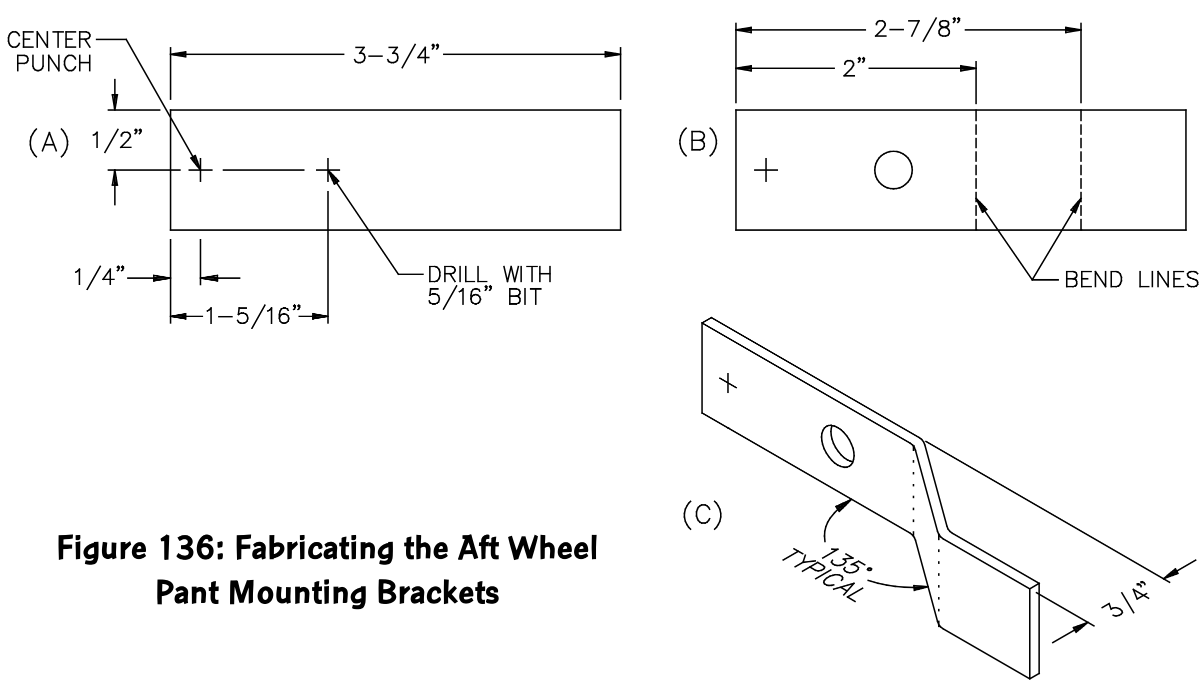

Figure 136: Fabricating the Aft Wheel Pant Mounting Brackets

Step 82: Position the Aft Nose Wheel Pant Mounting Brackets and Drill the Screw Holes *(Tricycle Gear Only)*

The aft nose wheel pant mounting bracket is positioned by the nose wheel axle bolt. You can simulate that in this step with any old short AN5 bolt. As shown in Figure 137, insert such a bolt through the mounting bracket and the axle hole in the fork. Rotate the bracket until its lower edge is parallel with the lower edge of the fork, and then tighten a -524 nut on the bolt. With the bracket thus held in position, use a **#19** bit to drill through the bracket and the fork at the center-punched location just forward of the bolt head. This hole will accommodate a screw that will serve to prevent the bracket from rotating around the axle bolt.

Remove the bracket after drilling and deburr the holes in both the bracket and the fork arm.

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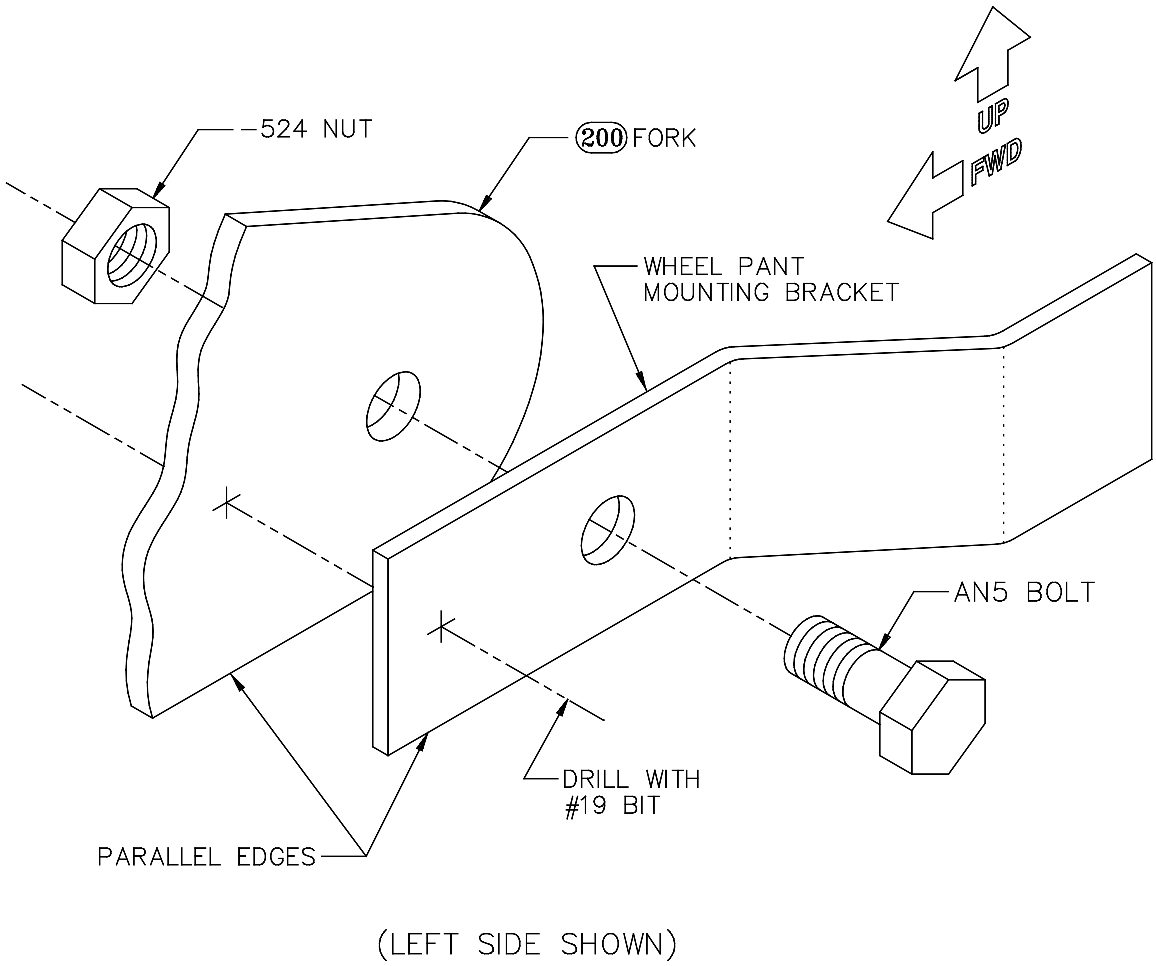

Figure 137: Positioning and Drilling the Aft Wheel Pant Mounting Bracket

Step 83: Corrosion-Proof the Remaining Nose Gear Components (Tricycle Gear Only)

If you haven't already done so, corrosion-proof the nose fork, the stop assembly and the **spring washers** [191] at this time.

> **Note** The aft nose wheel pant mounting brackets are stainless steel, and thus require no extra protection.

Completed: [ ]

Step 84: Rivet the Nutplates to the Forward Wheel Pant Mounting Brackets *(Tricycle Gear Only)*

As shown in Figure 138, use 3/32" AN426AD3 flush-head rivets to rivet the two MF5000-3 floating nutplates to the inboard faces of the forward wheel pant mounting brackets. The heads should be on the outboard faces of the brackets.

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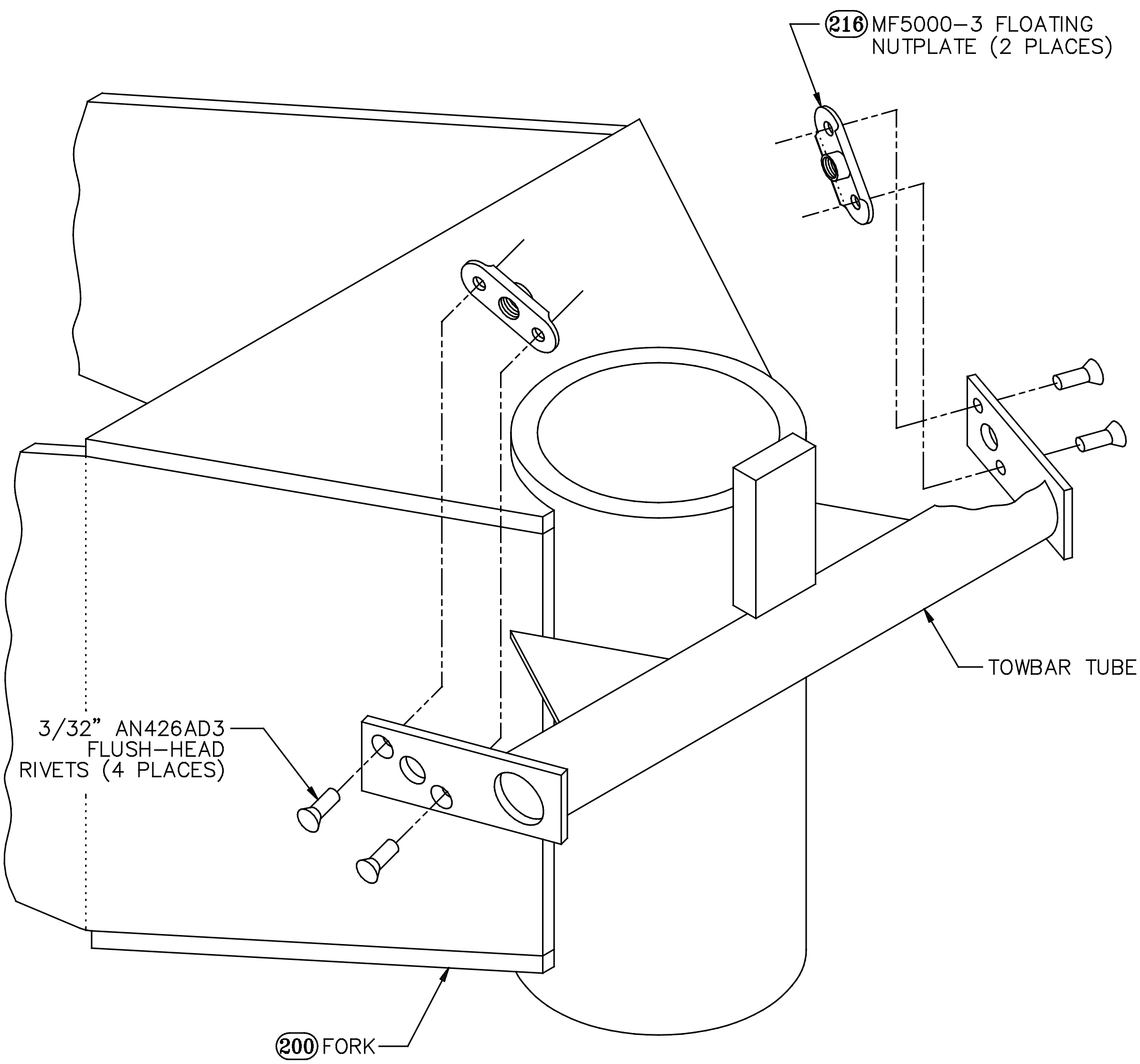

Figure 138: Riveting the Nutplates to the Forward Wheel Pant Mounting Brackets

Step 85: Screw the Aft Wheel Pant Mounting Brackets to the Fork Arms (Tricycle Gear Only)

As before, position the aft wheel pant mounting brackets with an AN5 bolt and a -524 nut. Then install an AN526-8R8 **round-head machine screw** [278] and secure it with an AN960-8 **washer** [280] and an AN364-832A **nylon self-locking** nut [274], as shown in Figure 139.

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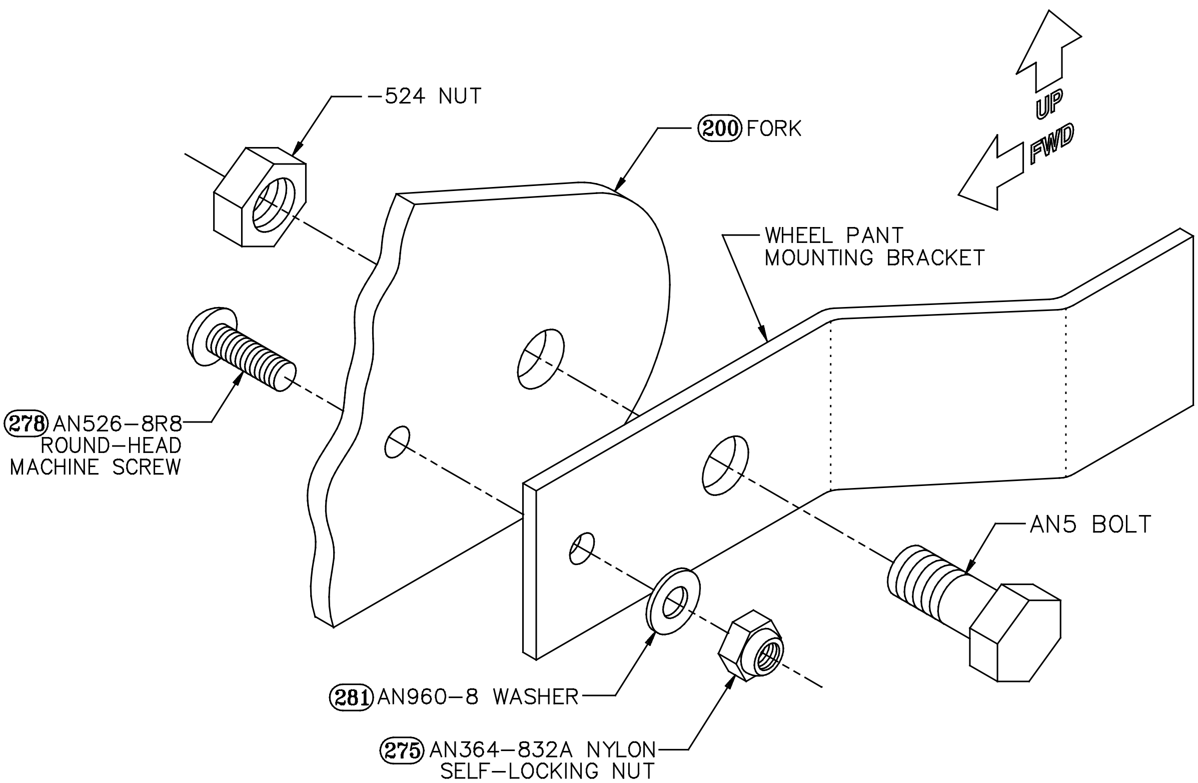

Figure 139: Screwing the Aft Wheel Pant Mounting Bracket to the Fork Arm

Step 86: Mount the Fork on the Axle *(Tricycle Gear Only)*

Slide the stop assembly back into position on the fork axle as you did for drilling. Secure it as shown in Figure 140 with an AN5-17A **bolt** [209], an AN960-516L thin washer and an AN364-524A nylon self-locking nut.

Next, thoroughly grease the axle from the bottom of the stop plate down to the threads with a waterproof, wheel bearing grease. Then slide the fork over the axle until the upper fork bushing is tight against the stop plate. Follow this with the two spring washers.

Note The **upper** spring washer should be placed over the axle with its **convex** face up; the **lower** spring washer should have its **concave** face up. See the side view detail in Figure 140.

Finally, thread on an **axle nut** [192]. As you tighten this nut with an adjustable wrench, it will become harder and harder to rotate the fork around the axle. Tighten the nut until it requires a **10–15 pound** pull on the end of the fork arm to rotate the fork around the axle.

Note The purpose of tightening the axle nut against the compression of the spring washers is to eliminate nose wheel shimmy, which can be a serious problem if this is not done correctly.

Hint Use a fisherman's pocket spring scale to measure the required pull.

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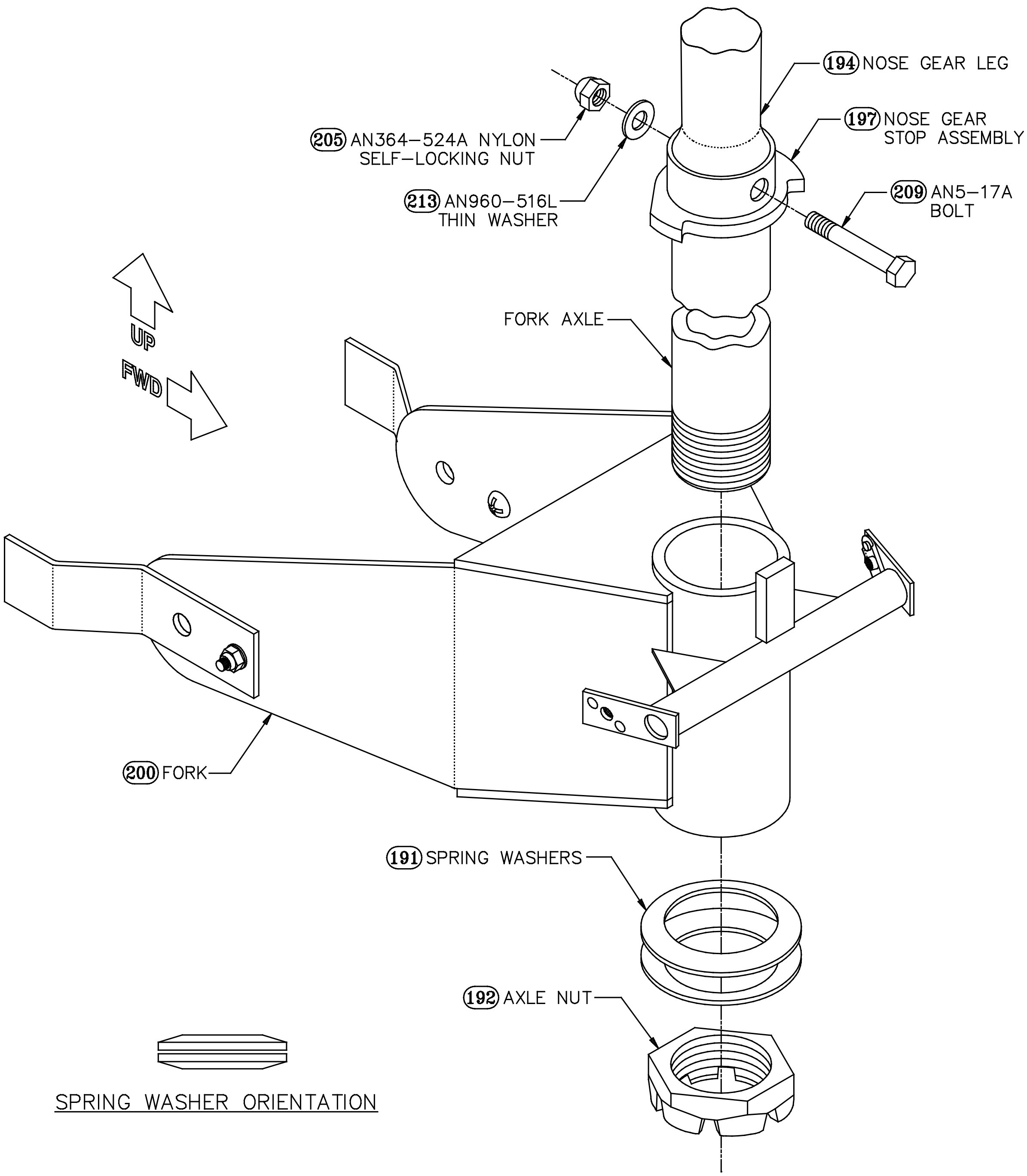

Figure 140: Mounting the Fork on the Axle

Step 87: Drill the Axle Nut Cotter Pin Hole and Secure the Nut (Tricycle Gear Only)

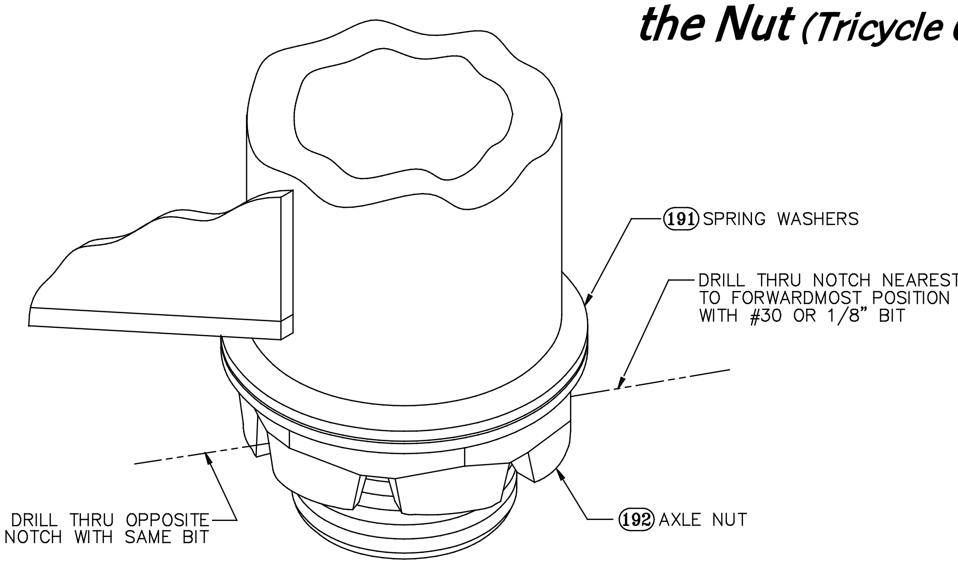

Figure 141: Drilling the Nose Gear Axle Cotter Pin Hole

As with the main gear axles, a hole must be drilled through the nose gear axle to accommodate a cotter pin for securing the axle nut. As shown in Figure 141, drill this hole with a **#30** or **1/8"** bit. Begin the hole in whichever notch of the axle nut's crown is nearest to the forwardmost position relative to the aircraft and take care to keep the bit perpendicular to the axle while drilling.

After the hole has been drilled, insert an AN380-4-8 **cotter pin** [208] from the front and secure the ends.

Completed: [ ]

Step 88: Mount the Tube and Tire on the Nose Wheel (Tricycle Gear Only)

The **11.4 X 5 tire** [201] and **tube** [202] are installed on the **nose wheel assembly** [203] just as the main tires and tubes were installed, except that the nose wheel lacks a brake rotor. Figure 142 illustrates the relationships among the parts. As with the mains, inflate the nose wheel to **40 psi** after it's mounted.

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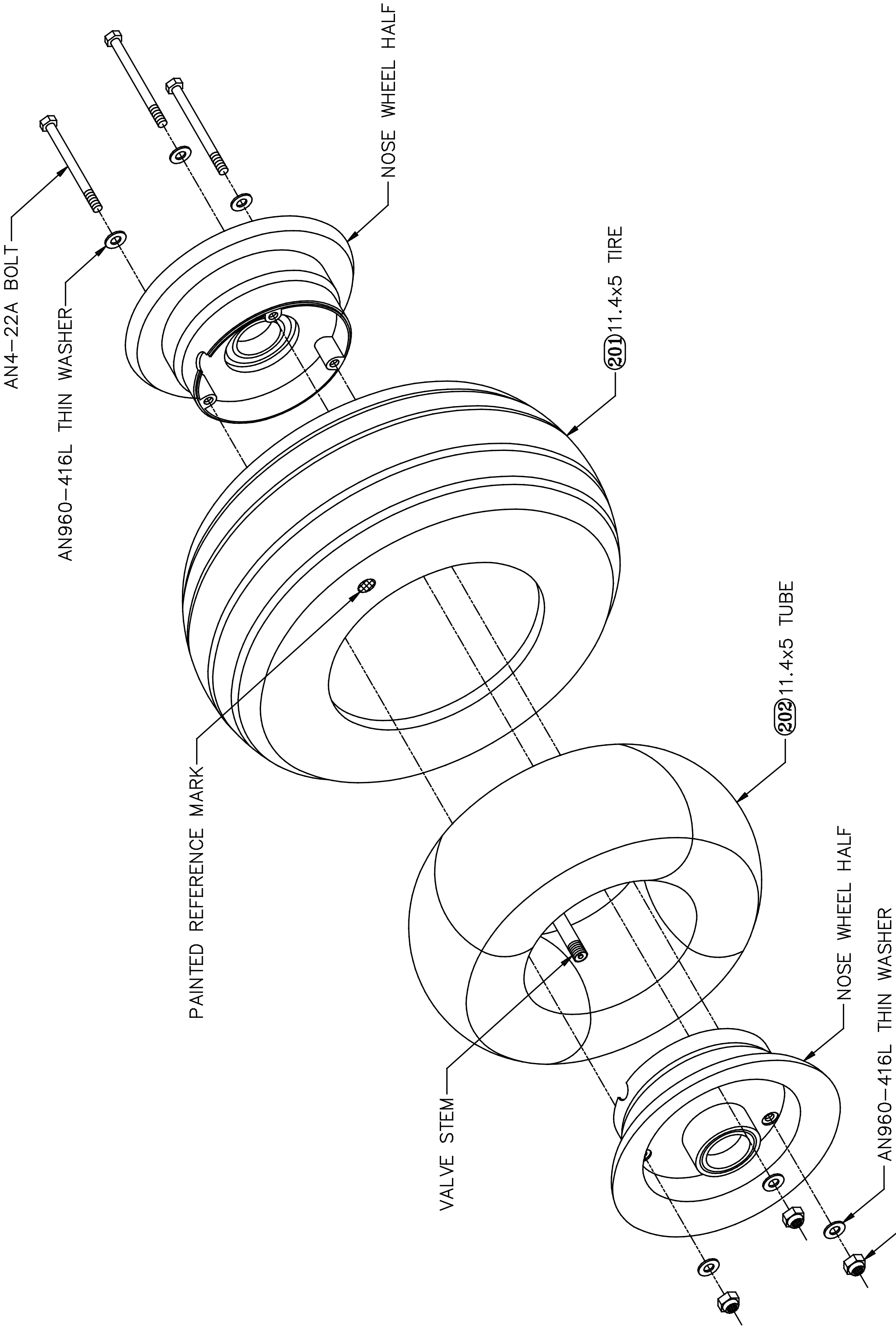


Figure 142: Moutning the Tube and Tire on the Nose Wheel

Step 89: Install the Nose Wheel in the Fork *(Tricycle Gear Only)*

Begin the final installation of the nose wheel in the fork, as shown in Figure 144, by sliding the aluminum **nose wheel axle** [199] into the wheel bearings, followed by a **nose wheel axle spacer** [198] on each side. Seat the spacers inside the bearings so that each protrudes outboard of the bearings by approximately **1/2"**.

Ideally, when the spacers are seated and the axle is centered, the ends of the axle will be exactly flush with the spacers. This way, when the fork arms are bolted around the wheel assembly, the axle will take the load (preventing excessive loading of the bearings) and yet there will be no side-to-side-play in the wheel. In practice, because of tolerances in the wheel bearings, the axle may appear to be too short—that is, its ends may not quite be flush with the spacers. If this is the case, you'll have to insert a **laminated washer** [193] at one end to make up the difference.

The laminated washer is made up of many .003"-thick circles of aluminum bonded together with adhesive. Although it looks like a solid washer, in fact it can be "sliced" to the required thickness. First, however, you must enlarge the 1/4" center hole in the washer to accommodate the **5/16"** axle bolt.

Hint The laminated washer is slightly more difficult to drill cleanly than solid aluminum. As shown in Figure 143, drill a **1/4"** hole in a small block of scrap wood or metal. Clamp the washer between this block and a similar block without a hole, aligning the holes in the top block and washer. Then drill through the top block and washer with a **5/16"** bit.

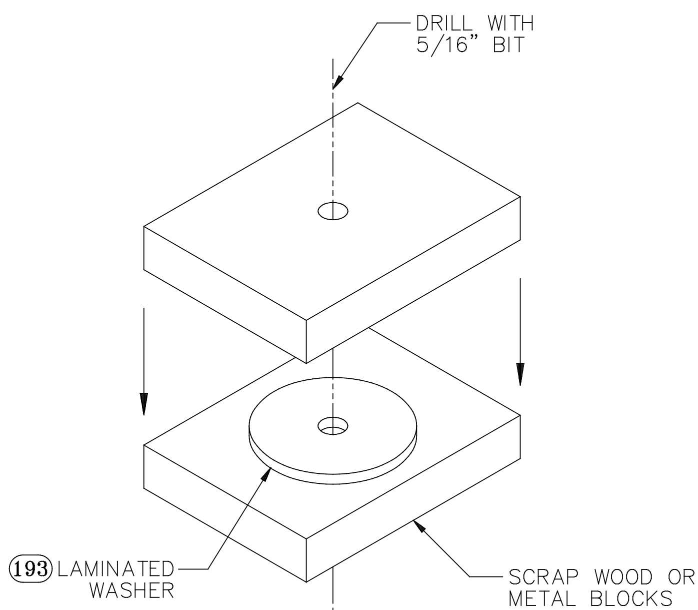


Figure 143: Drilling the Laminated Washer

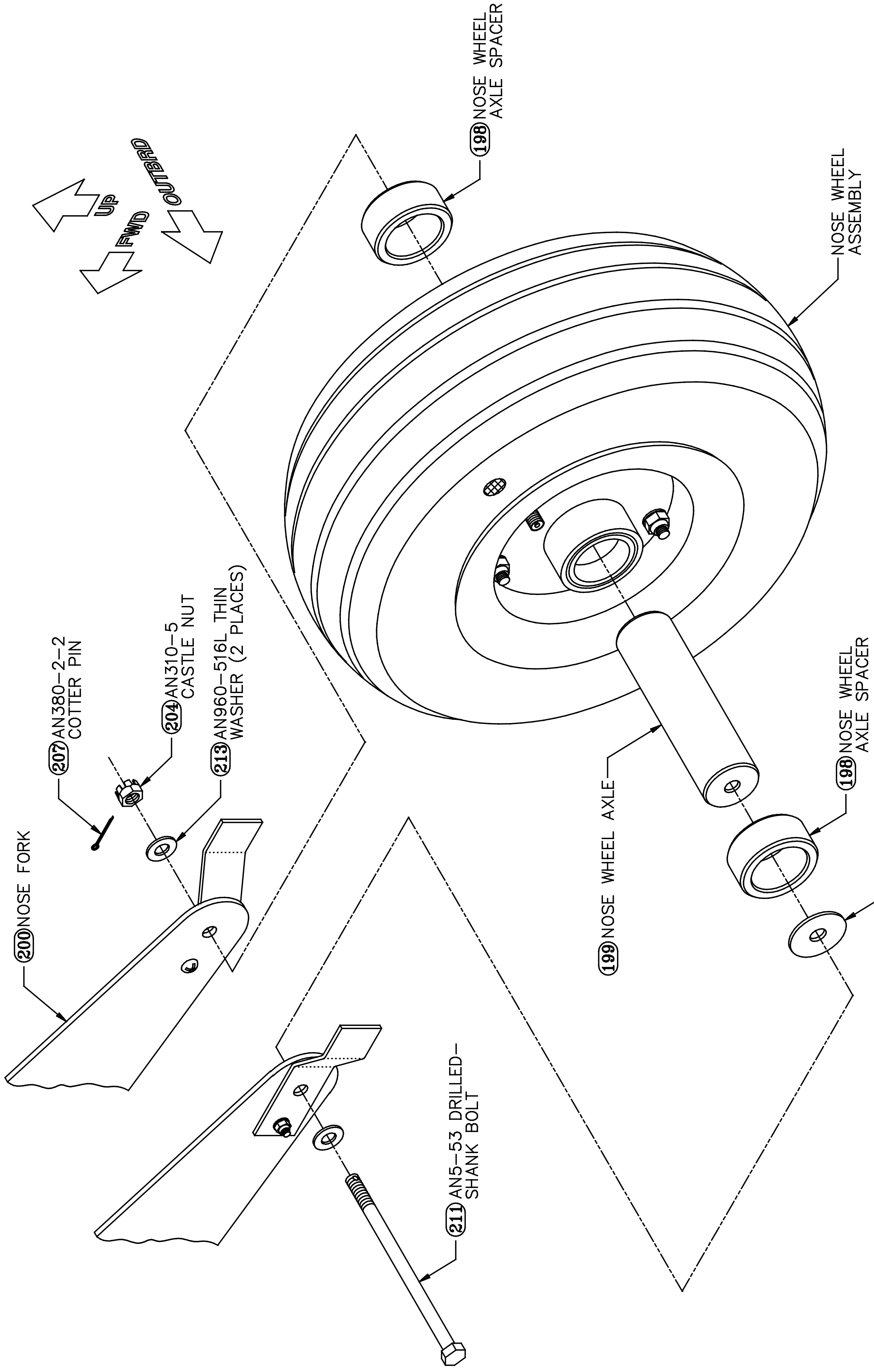


Figure 144: Installing the Nose Wheel in the Fork

Once the washer is drilled to size, begin peeling layers off it until it's **slightly too thick** to bring the end of the axle flush with the spacers. Peel the washer by placing it gently in a bench vise and pushing the blade of a utility knife down from above where you want to make the split.

Slide the whole wheel assembly between the fork arms and insert an AN5-53 **drilled-shank bolt** [211]. Use AN960-516L thin washers under both the bolt head and the AN310-5 **castle nut** [204]. Tighten the castle nut to the proper torque value specified in the torque table in "SECTION II: TOOLS AND TECHNIQUES." Then shake the wheel from side to side to check for play in the bearings. If there is side-to-side movement, this means the laminated washer is still too thick. Remove the axle bolt, shave the washer down and try again. Repeat this process until the play disappears.

> **Note** If you take too much off the laminated washer, you will feel resistance in the bearing when you rotate the wheel by hand. Check this when you think you have the washer the right thickness, and if any resistance appears, **add** a couple layers of washer.

> **Note** Now that the nose wheel bearings are adjusted to your satisfaction, remove the wheel and pack the bearings with grease, using the procedures described for the main wheel bearings in Step 74 of this section. We didn't instruct you to pack the bearings sooner because the presence of grease could interfere with your ability to feel side-play or resistance.

Reinstall the nose wheel and secure the nut with an AN380-2-2 cotter pin.

> **Note** The axle and spacers are anodized aluminum; no further corrosion protection is necessary.

Completed: [ ]

TAILWHEEL INSTALLATION (OPTIONAL)

Tricycle Gear Option The entire tailwheel installation can be completed after the airplane has been finished and flown as a trike. However, if you're installing tricycle gear initially but contemplate converting to conventional gear someday, you may wish to complete at least some of the steps in this sub-section now. For example, installing the internal brackets and fiberglass reinforcements now will speed your conversion to conventional gear later. On the other hand, these steps will add time and weight to your project. You'll have to make your own judgment about what will work best for you. If you're sure you don't want to install a tailwheel, **skip to Step 104**.

Hint For installing the tailwheel, it's easiest to set the airplane on its main gear with a padded sawhorse or stool supporting the tail about **24"** forward of the tailcone. The fuselage should be roughly in a level-flight attitude.

Step 90: Fabricate the Forward Spring Attach Bracket (Taildragger Only)

Figure 145 illustrates the configuration of the tailwheel installation. The three leaf springs are secured at the forward end by a bolt that goes through the bottom of the fuselage into the **forward spring attach bracket** [225], which in turn is bolted to the aft face of Bulkhead D. This bracket can be seen in Figure 146.

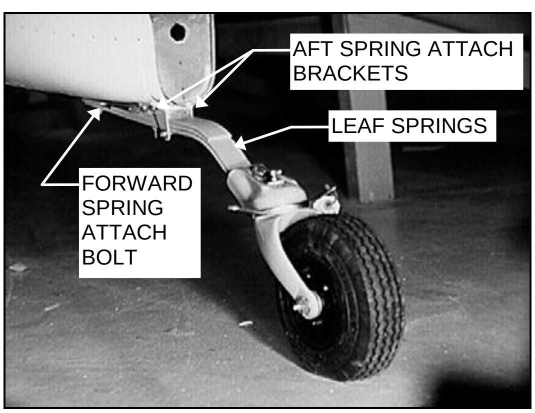


Figure 145: Tailwheel Installation

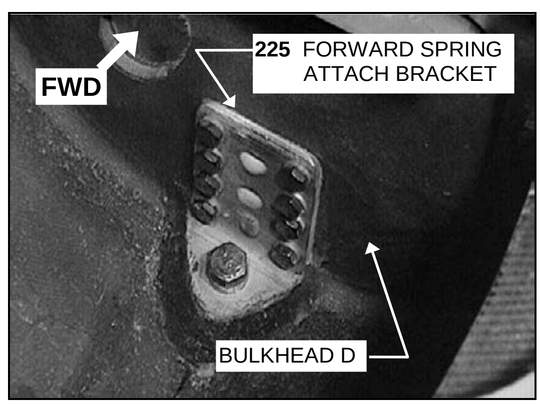
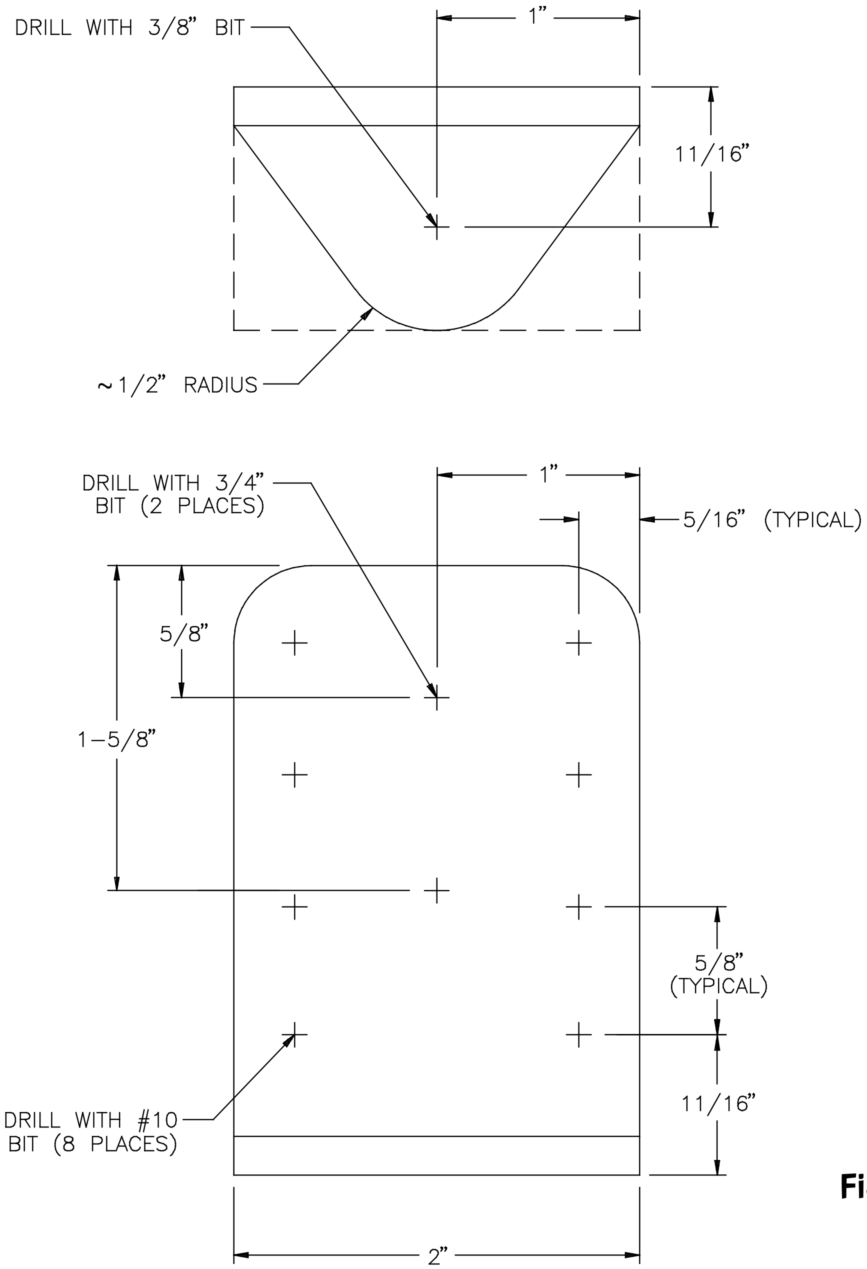


Figure 146: Forward Attach Bracket

Rough angle stock is provided for fabricating the forward spring attach bracket; you must trim the bracket to shape and drill a number of bolt and lightening holes. The dimensions for this trimming and drilling are given in Figure 147.

Begin by trimming off the corners of the horizontal flange with a hacksaw or bandsaw. Then radius the forward edge as well as the upper corners of the vertical flange with a file or a belt sander.



Next, lay out the hole locations as shown and drill the holes. As indicated in the figure, use a **#10** bit for the eight bolt holes in the vertical flange, a **3/4"** hole cutter for the two lightening holes in the vertical flange, and a **3/8"** bit for the single bolt hole in the horizontal flange.

After drilling, deburr all the holes and smooth all the edges.

Completed: [ ]

Figure 147: Fabricating the Forward Spring Attach Bracket

Step 91: Install the Forward Spring Attach Bracket (Taildragger Only)

When you install the bracket, you will bed it in a thick resin/mill fiber mixture, but nevertheless, for maximum strength, the bracket should be seated as closely to the fuselage floor as possible. The first step in achieving this is to radius the lower, aft corner of the bracket with a file or a belt sander. Your goal is to make the bracket nest as closely as possible into the fillet on the aft side of Bulkhead D, as shown in Figure 148. However, you shouldn't radius the bracket any more than about **5/16"** to avoid compromising its strength.

If you kept your Q-cell fillet fairly small when you installed Bulkhead D, the 5/16" maximum radius on the bracket should be sufficient to allow the bottom of the bracket within **1/8"** of the fuselage floor. If your fillet is too large to allow this, then you'll have to grind some of it away for about **1-1/4"** on either side of the aircraft centerline. Grind it down until the bracket sits within 1/8" of the floor. Then cut two small pieces of bi-directional cloth large enough to cover the entire ground-down area and laminate them in place to replace the DBM cloth you ground through to get at the Q-cell fillet.

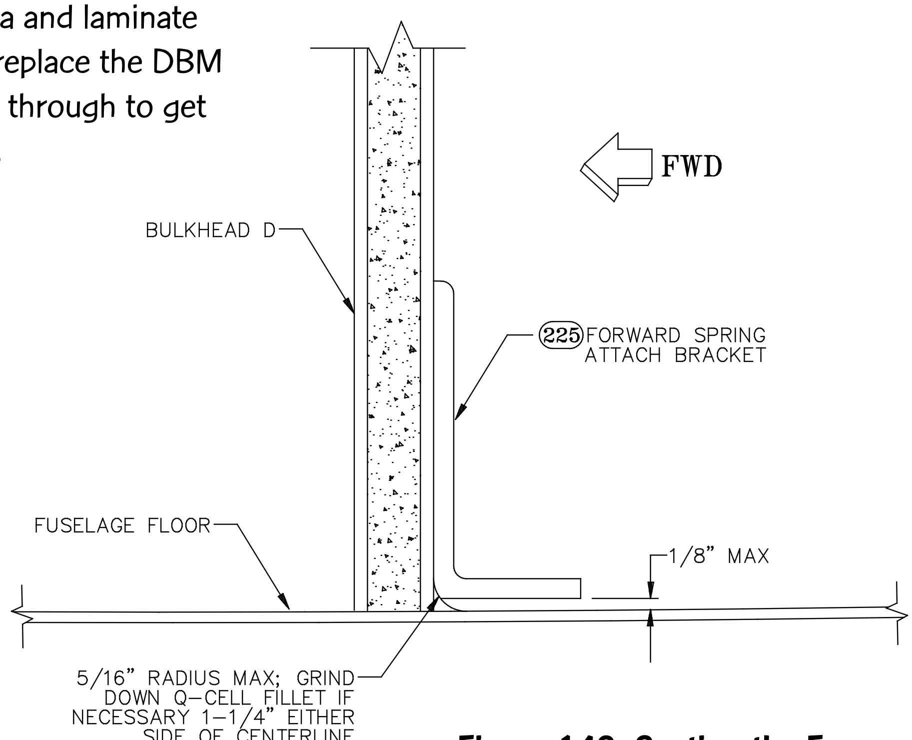


Figure 148: Seating the Forward Spring Attach Bracket Against the Fuselage Floor

Next, drill the eight bolt holes through Bulkhead D. Hold the bracket tightly in place against the bulkhead, within **1/8"** of the fuselage floor and aligned with the aircraft centerline. As shown in Figure 149, use a **#10** bit to drill through the bulkhead at each hole in the bracket. Pin the bracket in place temporarily with an AN3 bolt through each of the first two holes drilled to help maintain alignment while drilling the remaining six. After all the holes have been drilled, remove the bracket from the bulkhead. Thoroughly deburr the holes and corrosion-proof the bracket as you see fit.

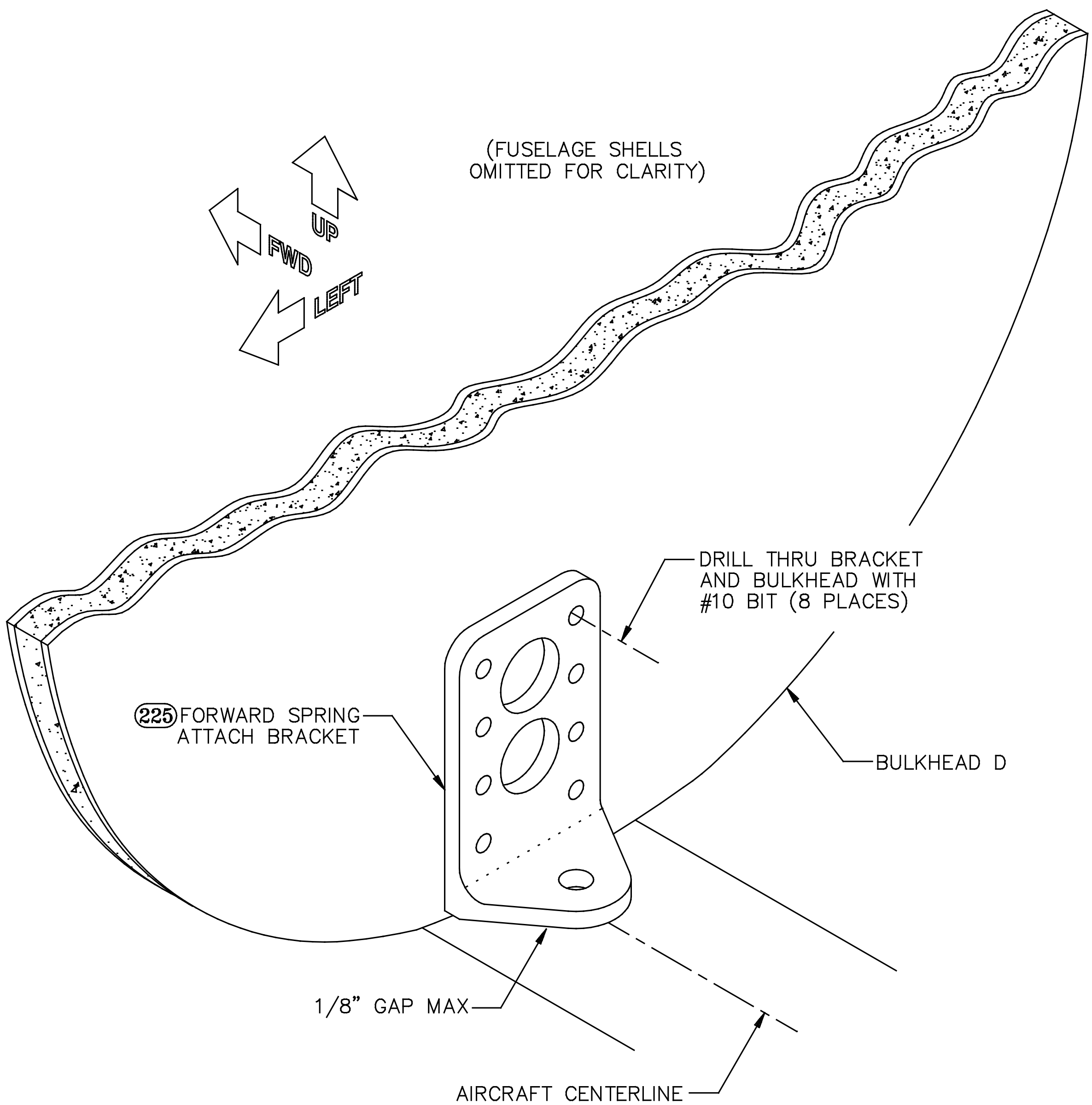


Figure 149: Drilling the Forward Spring Attach Bracket Bolt Holes

Next, prep the area of the fuselage floor directly under the bracket by roughening it with coarse sandpaper and wiping it with acetone. Mix a small batch of thick resin/mill fiber mixture and lay a thick bed of it over the area below the bracket. Push the bracket down into the mixture and, as shown in Figure 150, bolt it in place through each of the eight holes with AN3-10A **bolts** [232], AN960-10 **washers** [244] and AN365-1032A **nylon self-locking nuts** [233]. Use a popsicle stick or a rubber-gloved finger to remove excess resin/mill fiber mixture, leaving a smooth fillet around the bracket.

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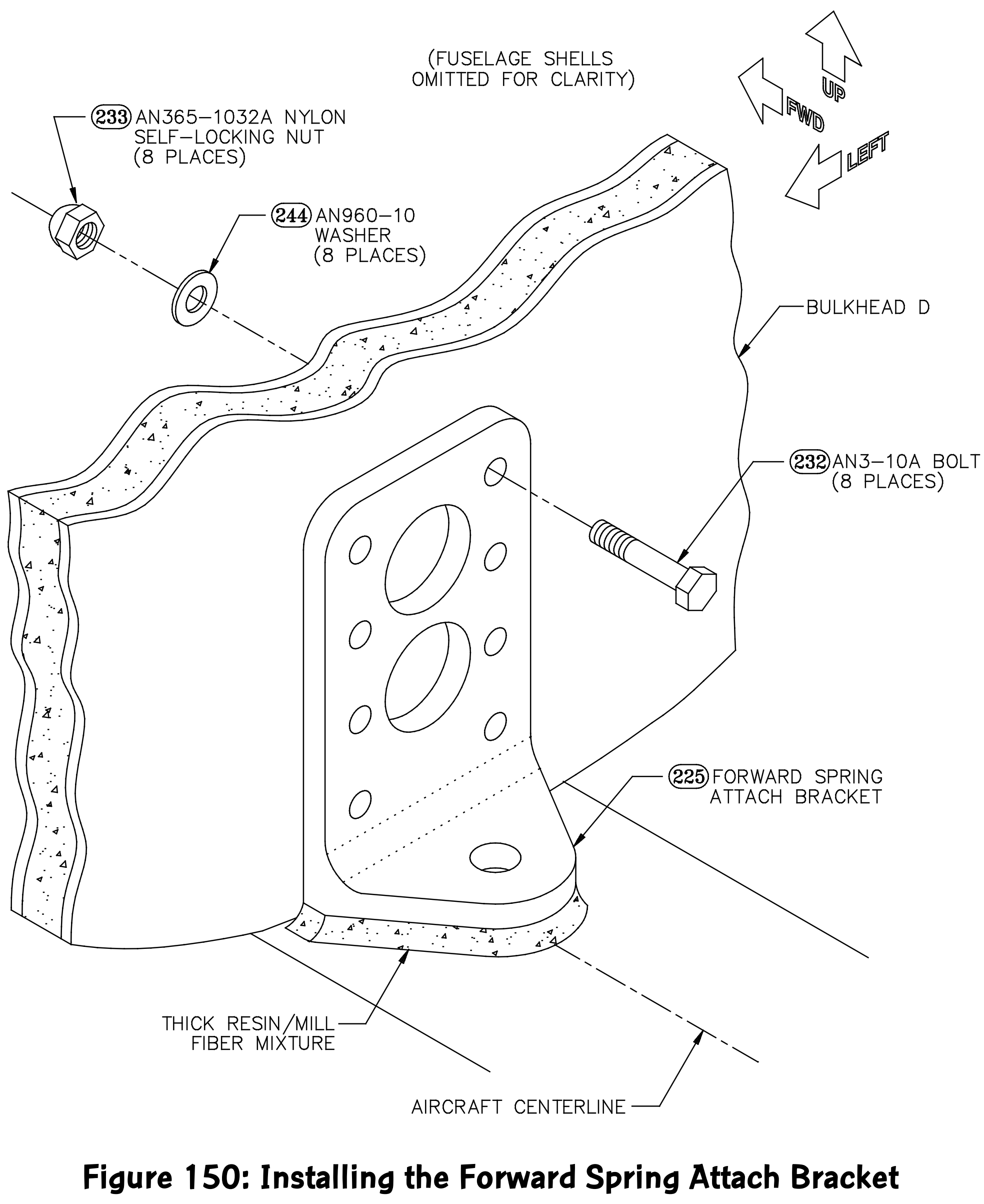

Figure 150: Installing the Forward Spring Attach Bracket

Step 92: Drill the Forward Spring Attach Bolt Hole
(Taildragger Only)

After the resin/mill fiber bed under the spring attach bracket has fully cured, drill downward through the bracket, the resin/mill fiber bed and the fuselage floor with a **3/8"** bit, as shown in Figure 151. Deburr this hole on the upper surface of the bracket and touch up your corrosion protection as necessary.

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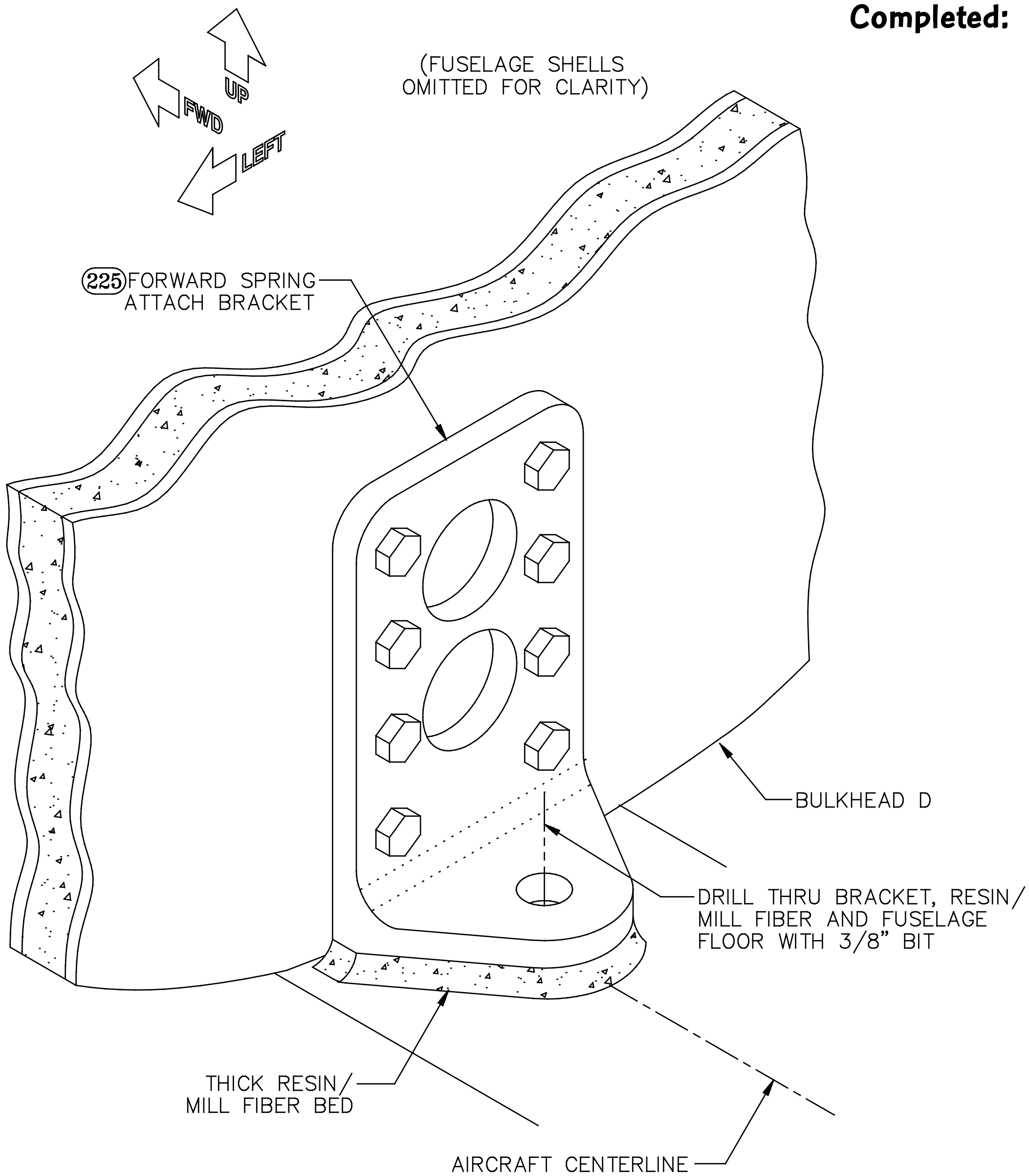

Figure 151: Drilling the Forward Spring Attach Bolt Hole

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Step 93: Fabricate the Forward Spring Block (Taildragger Only)

In this step you will shape an aluminum block that serves as the forward bearing point for the tailwheel springs. The block is made from the supplied **1/4" X 1-1/2" X 1-1/2" aluminum block** [217]. You must shape the block so that its lower surface is parallel with the aircraft waterline plane when its upper surface is tight against the fuselage. As Figure 152a shows, the block will be located directly under the forward spring attach bracket.

Figure 152b illustrates in an exaggerated fashion what must be done to shape the block. First, it must be **tapered** in a fore-and-aft direction from its initial thickness of 1/4" at the aft end to about **3/16"** at the forward end. Second, it must be **hollowed out** to match the curvature of the fuselage. These tasks can both be accomplished most easily using a bench-mounted belt sander. Use the flat of the belt to taper the block to the approximate dimensions shown, and then use the rounded end of the belt to hollow out the upper surface. Stop frequently to trial fit the block against the fuselage.

When you have the block shaped to your satisfaction, mark and drill a **3/8"** bolt hole in the exact center of the block, as shown in Figure 152c. The hole should be centered laterally and drilled **perpendicular** to the **lower** surface of the block. Next, you need to prepare the block for bonding to the fuselage. You will use a thick resin/mill fiber mixture for this bonding, and this will grip the block more effectively if you drill some blind holes in the upper surface of the block. As shown in Figure 152c, use a **#30** or a **1/8"** bit to drill roughly **halfway** through the block in about twelve places. Use a drill stop to avoid drilling all the way through; you don't want holes in the lower surface of the block. Space the holes roughly evenly, but don't bother being too precise about this.

After all the holes have been drilled, deburr them and corrosion-proof the entire block as you see fit.

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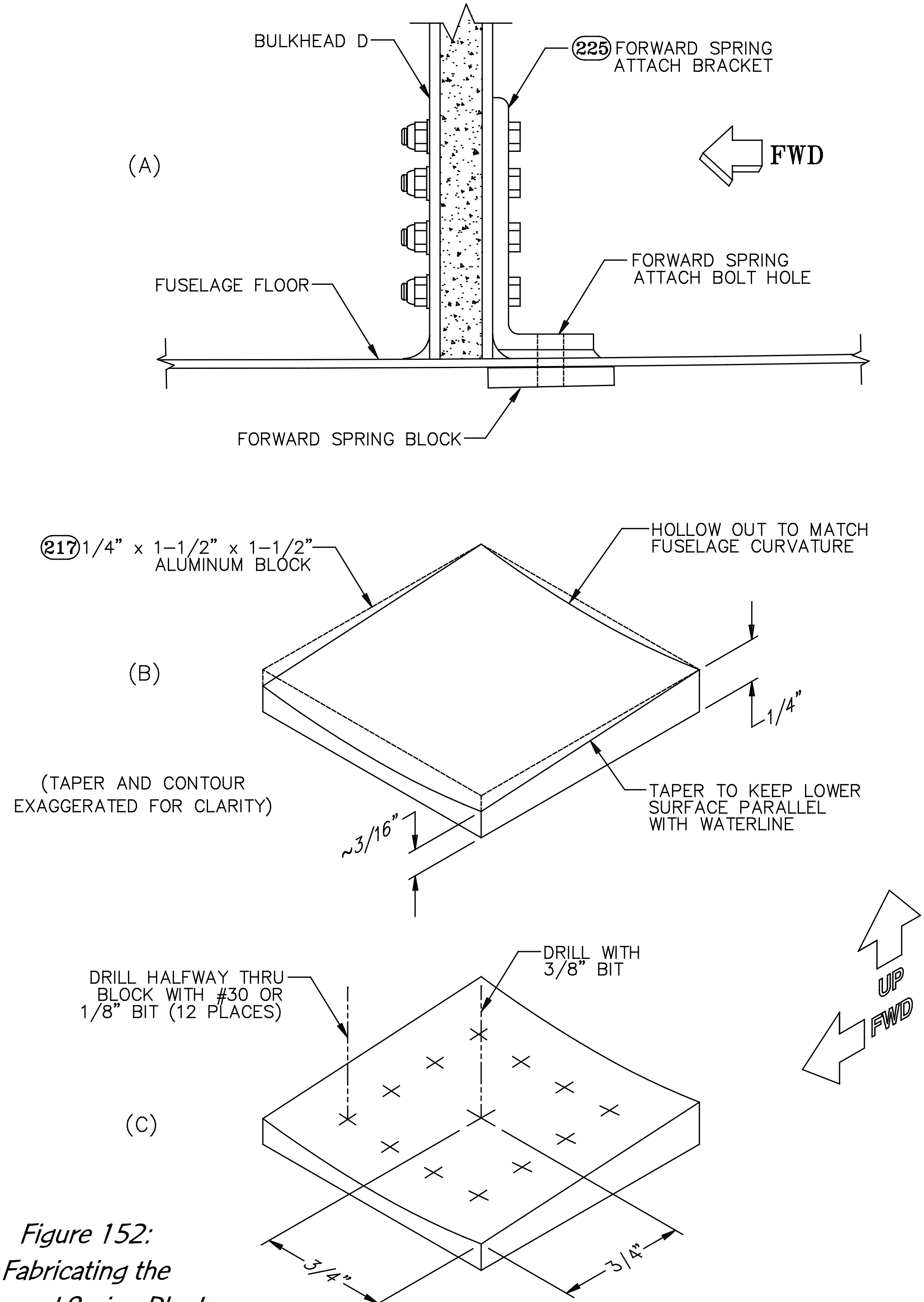

Figure 152: Fabricating the Forward Spring Block

Step 94: "Reinforcements to the aft fuselage" (Taildragger only) Completed in Step 80.1 in Section VIII, Fuselage Assembly.

Step 95: Stack the Tailwheel Springs (Taildragger Only)

Three leaf springs are stacked together to form the tailwheel spring assembly. As shown in Figure 154, nest the **upper** [224], **middle** [223] and **lower tailwheel springs** [222] together. To distinguish the springs, the **upper** spring is the shortest of the three; the **middle** spring has a 1/2"-diameter hole at the aft (shorter) end; the **lower** spring has a 1/2" X 3/4" slot at the aft end.

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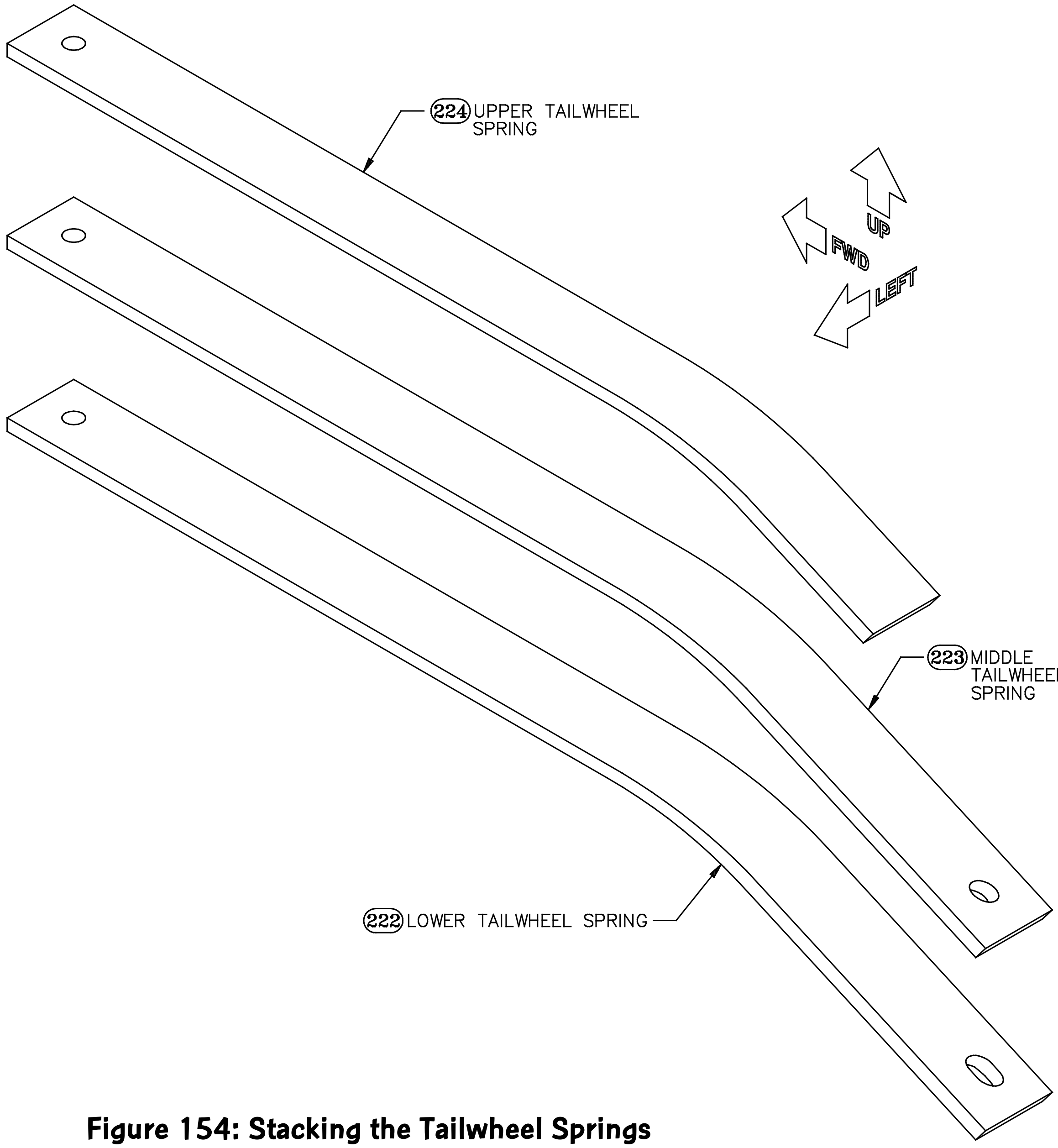

Figure 154: Stacking the Tailwheel Springs

Step 96: Bolt the Springs in Place and Position and Drill the Aft Spring Attach Brackets (Taildragger Only)

As can be seen back in Figure 145, the **left** and **right aft spring attach brackets** [226 and 227] are triangular brackets that come down from the bottom of the fuselage on either side of the spring stack. A 1/4" bolt between the lower ends of the two brackets keeps the springs tight against an aft aluminum spring block.

It's easiest to position these brackets with the spring stack in place. As shown in Figure 155, temporarily bolt the stack in place under the forward attach bracket. Insert an AN6-21A **bolt** [279] through the spring stack and the forward spring block, and secure it with an AN960-616 **washer** [280] and an AN365-624A **nylon self-locking nut** [276].

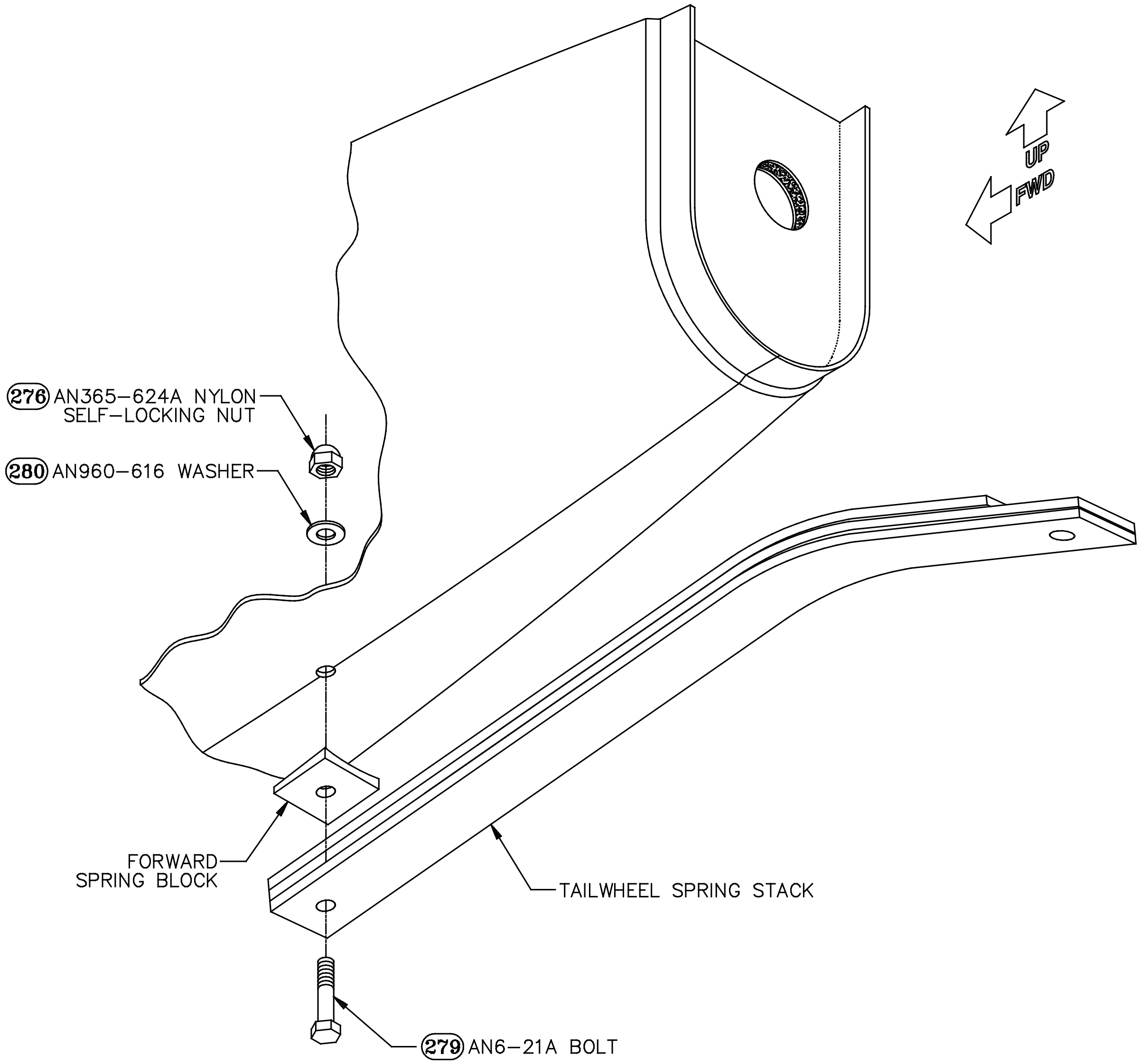

Figure 155: Temporarily Bolting the Tailwheel Spring Stack in Place

With the spring stack bolted to the fuselage bottom at its forward end, rotate it left or right as necessary to bring it into alignment with the aircraft centerline.

The next step is to bring the aft spring attach brackets together on either side of the spring stack and to position them against the fuselage for drilling, as shown in Figure 157. First, as shown in the detail in the lower, right-hand corner of the figure, join the left and right brackets by inserting an AN4-20A **bolt** [240] through the bottom holes in each. Use AN960-416 washers under both the bolt head and the AN365-428A nylon self-locking nut. The purpose of this bolt at this stage is simply to help align the brackets fore-and-aft relative to one another, so there's no need to tighten the nut. Just finger-thread it on a few turns.

Next, position the joined brackets on either side of the spring stack. The lower, vertical flanges of the brackets should be tight against the springs and the upper, bent flanges should be tight against the fuselage. As shown in Figure 156, the brackets should be positioned fore-and-aft so that the **center** of the bottom bolt hole in each is **1/4" forward** of the tailcone joggle. A small C-clamp is useful to help hold the brackets in place.

When you're satisfied that the brackets are properly aligned, drill through the brackets and the fuselage with a **1/4"** bit, using the two holes in each upper flange as guides. Insert an AN4-10A **bolt** [239] into each hole after it's drilled and secure it temporarily with an AN970-4 **large washer** [248] and an AN365-428A **nylon self-locking nut** [234]. When the drilling is completed, remove the brackets, deburr them and apply corrosion protection. Leave the springs bolted in place for now.

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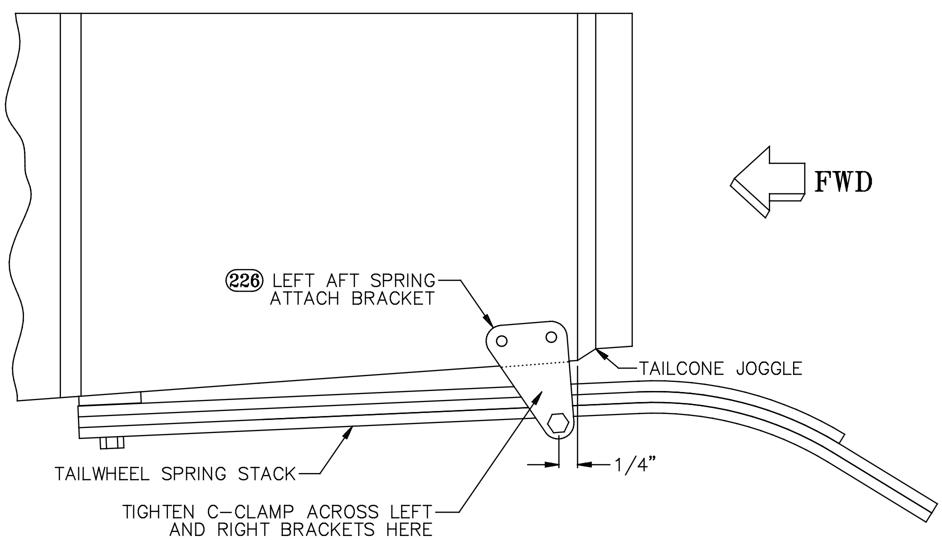

Figure 156: Fore-and-Aft Position of Aft Spring Attach Brackets

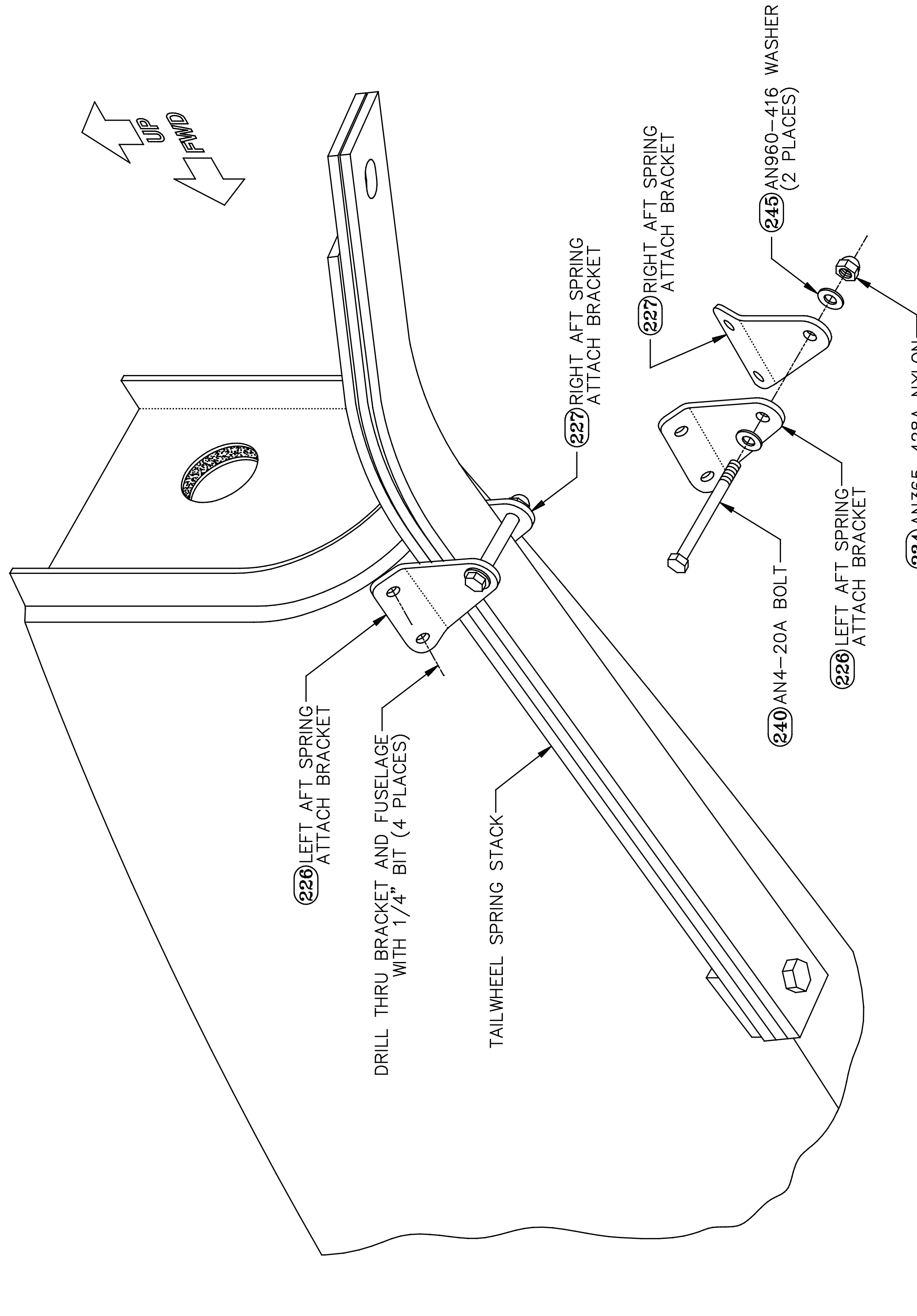

Figure 157: Positioning and Drilling the Aft Spring Attach Brackets

Step 97: Fabricate the Aft Spring Block *(Taildragger Only)*

A second spring block, fabricated from the supplied **1/2" X 1-1/2" X 2" aluminum block** [218], serves as the aft bearing surface for the stacked springs, as shown in Figure 158. As with the forward block, the aft one must be both tapered and hollowed out to conform to the shape of the fuselage.

Use the same techniques you used on the forward block to shape this one. Since the position of the springs in part determines the shape of the block, begin by bolting the aft spring attach brackets in place around the springs. Also, tighten a C-clamp on the spring stack at the aft-most end of the flat portion of the springs, as indicated in Figure 158. This compresses the springs as the weight of the GlaStar tail compresses them, and this is the condition you want to fit the aft spring block for.

Figure 158 illustrates where the spring block must be made to fit. It must fill the vertical space between the fuselage and the springs, with the springs tight against the bolt between the attach brackets. Furthermore, the **lower, aft edge** of the block must be **no further aft** than the center of the cross-bolt.

Caution If the lower, aft edge of the aft spring block is aft of the center of the cross-bolt between the brackets, unacceptably high shear loads may be imposed on this bolt. You may wish to slightly chamfer or radius the lower, aft edge of the block in order to ensure that this condition is met. If necessary, it is also permissible to shorten the block by up to **1/4"**.

Note You may find in fitting the aft block that the forward block needs to be adjusted slightly. Feel free to unbolt the springs and reshape the forward block as necessary to get the best fit for the aft block.

When both blocks fit the fuselage contour to your satisfaction, locate and mark the center point of the aft block. At this location, use a **#10** bit to drill a hole all the way through the block. As indicated in Figure 159, the hole should be drilled **perpendicular** to the **lower** surface of the block. After it's drilled, countersink the hole on the lower surface to accommodate an AN509-10R flush-head machine screw. Next, drill twenty-eight blind holes for resin adhesion. As before, use a **#30** or **1/8"** bit and drill about halfway through the block at each hole location.

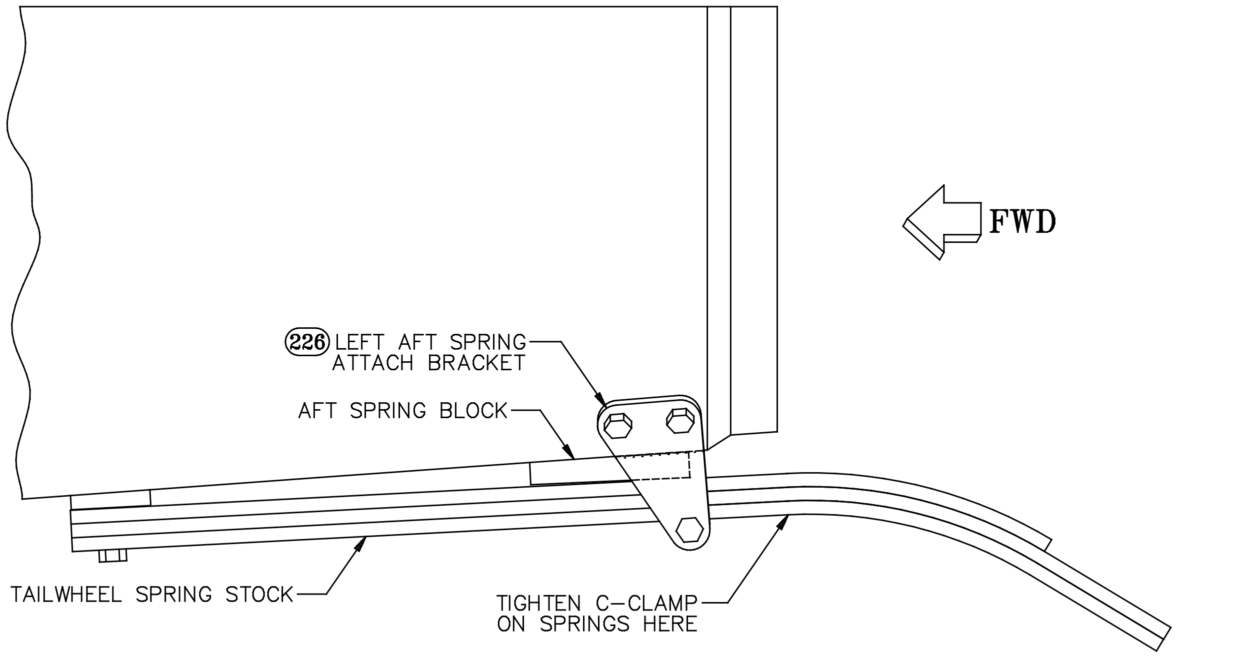

Figure 158: Positioning the Aft Spring Block

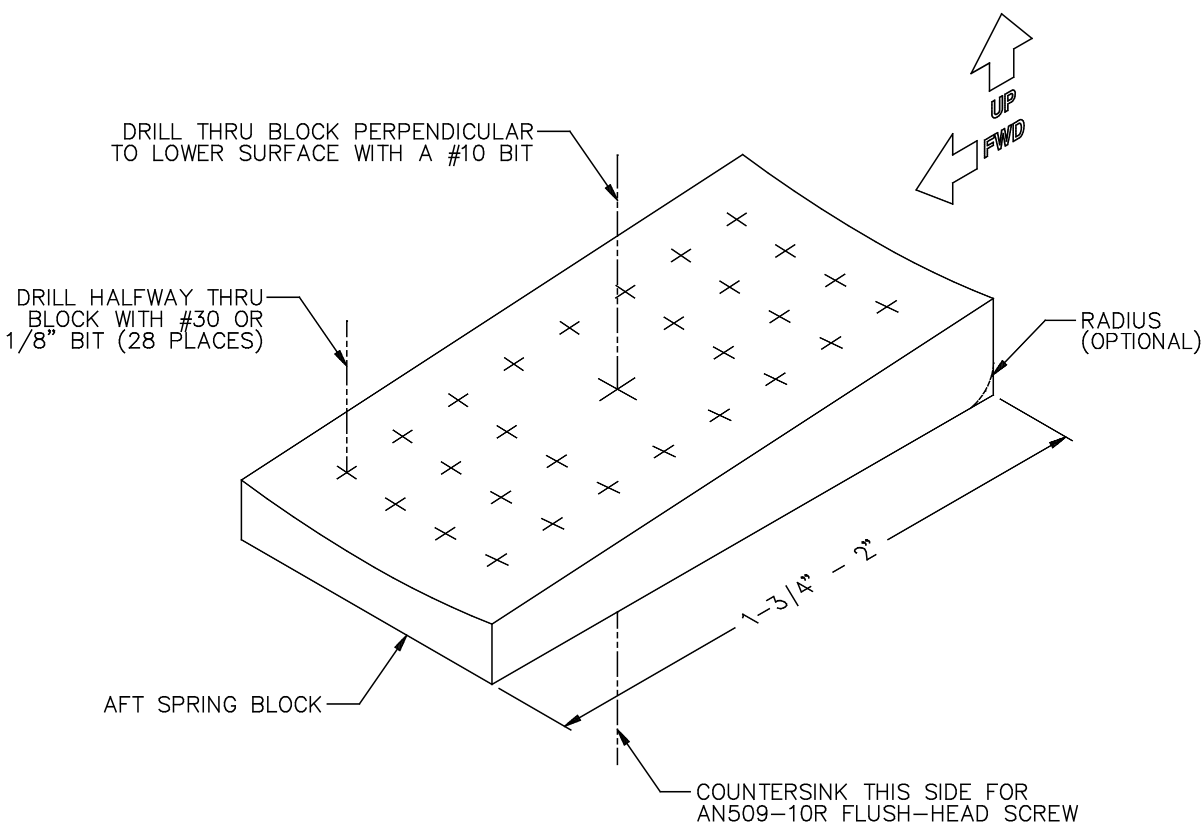

Figure 159: Fabricating the Aft Spring Block

After all the holes have been drilled, deburr them, and then corrosion-proof the block as you see fit.

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Step 98: Install the Spring Blocks and Attach Brackets (Taildragger Only)

Remove the springs, blocks and aft brackets, and use coarse sandpaper to remove the gelcoat from the areas on the fuselage where the blocks and brackets will be attached. Then mix a small batch of thick resin/mill fiber mixture.

Spread the mixture liberally on the upper surface of the forward spring block. Insert the AN6-21A bolt through the springs and the block, and secure it permanently with an AN960-616 washer and an AN365-624A nylon self-locking nut. Remove excess resin/mill fiber that squeezes out from between the block and the fuselage.

Note If you have removed it, replace the small C-clamp that you used in Step 97 to compress the springs.

Next, loosely join the two aft spring brackets with the hardware specified in Figure 157. Apply a moderate layer of resin/mill fiber mixture to the inside faces of the upper, bent bracket flanges and press the brackets into place around the springs, aligning the upper holes with the corresponding holes in the fuselage. Insert AN4-10A bolts in these holes, with AN960-416 washers under the bolt heads. Inside the fuselage, apply a thick layer of resin/mill fiber mixture around each bolt where it emerges from the fuselage floor. Place an AN970-4 large washer over each bolt end and tighten an AN365-428A nylon self-locking nut down over it, pushing it into the resin/mill fiber bed, as shown in Figure 160.

After the brackets are bolted in place, apply a liberal layer of resin to the upper surface of the aft spring block. Slide the block into position between the fuselage and the springs, making certain that the lower, aft edge is forward of or even with the cross-bolt between the brackets. Support the aft end of the fuselage directly under the aft spring block just forward of the brackets. Let the resin fully cure.

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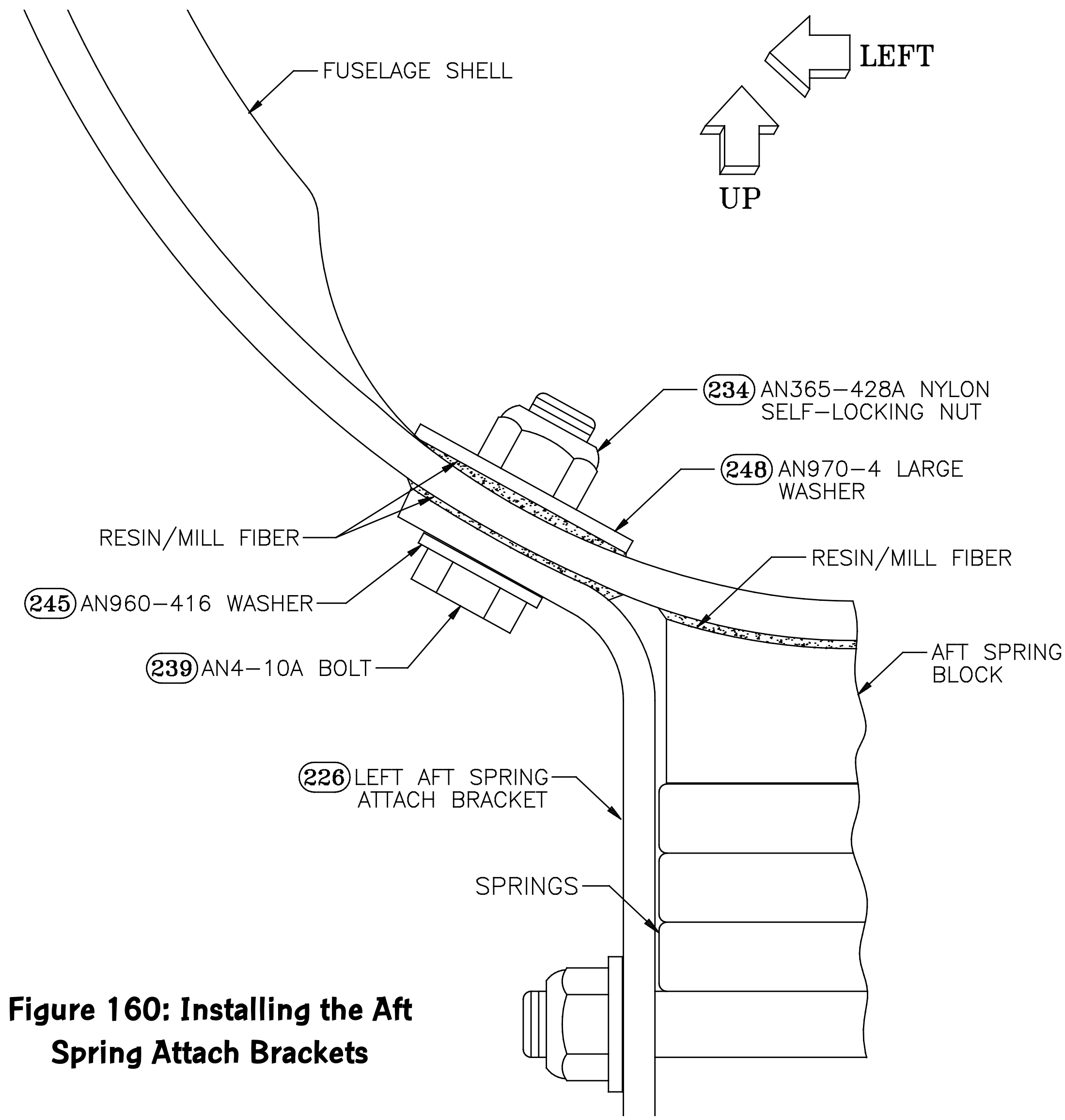

Figure 160: Installing the Aft Spring Attach Brackets

Step 99: Install the Aft Spring Block Retainer Screw (Taildragger Only)

As a supplement to the resin/mill fiber bond holding the aft spring block in place, it's a good idea to install a screw through the block and the fuselage shell. That, of course, is what you drilled and countersunk the #10 hole for in Step 97. Remove the springs to gain access to the underside of the block and, again with a **#10** bit, drill up from below through the resin/mill fiber and the fuselage shell. If necessary, ream out the countersink as well and touch up the corrosion protection.

When you're done, insert an AN509- or AN507-10R flush-head machine screw of the appropriate length. Secure this on the inside of the fuselage with an AN960D10 aluminum washer and an AN364-1032A nylon self-locking nut.

> **Note** You will have to determine the appropriate screw length for your particular aft spring block, as the thicknesses of the block, of the resin/mill fiber bed and of the fuselage floor can all vary from GlaStar to GlaStar. There should, however, be an ample selection of screws left over from the fuselage assembly

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Step 100: Re-Install the Springs (Taildragger Only)

Re-bolt the spring stack to the fuselage at the forward attach point using the hardware specified in Step 96 and Figure 155. Use a C-clamp to compress the stack, if necessary, and install the cross-bolt between the aft spring attach brackets. Refer back to Step 96 and Figure 157 for the required hardware. Tighten the nut on this bolt until the brackets are clamped firmly against the sides of the springs, but not so tightly that the brackets bend.

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Step 101: Install the Tailwheel Assembly (Taildragger Only)

Installing the **tailwheel assembly** [219] couldn't be simpler: as shown in Figure 161, stack the assembly and the **tailwheel spacer** [220] on top of the middle and lower tailwheel springs. Apply a coating of waterproof wheel-bearing grease to the shank of an AN8-23A **bolt** [243] and insert the bolt from above (the grease helps prevent wear to the bolt when the springs slide over one another). Secure the bolt with an AN960-816 **washer** [247] and AN365-820A **nylon self-locking nut** [236].

> **Note** There must be a minimum of **1/4"** clearance between the aft end of the upper spring and the tail wheel assembly to allow spring movement while in service. For early kits, it may be necessary to trim the upper spring to achieve this clearance. Use a bench grinder for best results.

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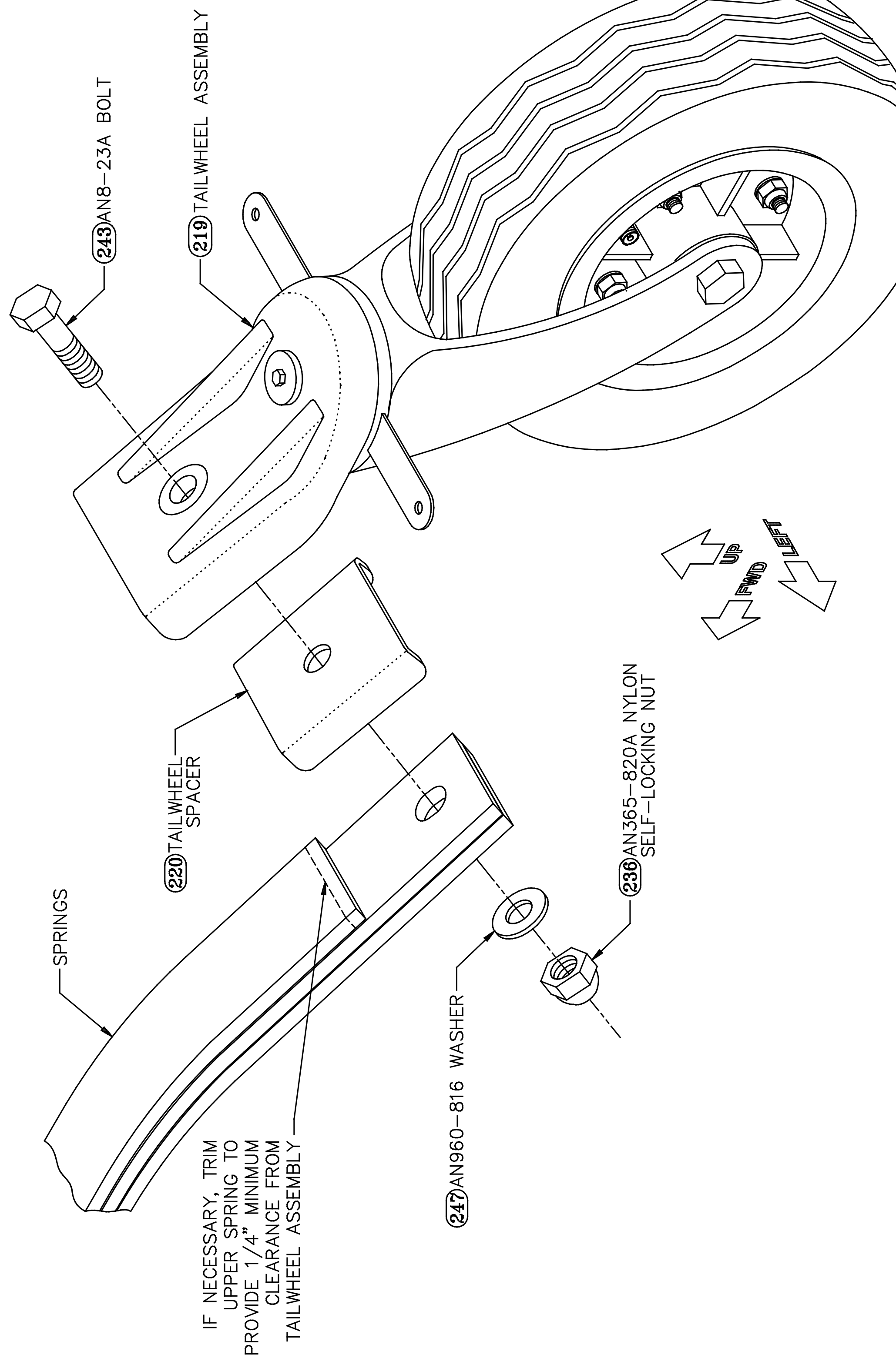

Figure 161: Installing the Tailwheel Assembly

Step 102: Install the Steering Cables (Taildragger Only)

Earlier, in Steps 60.5 and 60.7 of "SECTION VIII: FUSELAGE ASSEMBLY," you installed a pair of NAS77-3-014 bushings in the arms of the rudder stop plate. Now you can connect the tailwheel steering linkage to the bushings.

The first step is to drill holes in Bulkhead D and in the fuselage sides for the **steering cables** [230]. These run aft from the bushings in the rudder stop plate to the steering arms on the tailwheel assembly. These holes can most easily be located more or less by eye. Hold a straightedge on the outside of the fuselage on each side with one end on the steering arm and the other approximately aligned on the rudder stop plate (see Figure 162a). Mark this line on the outside of the fuselage. Then, looking down from above, again hold a straightedge (or stretch a string) on the line between the two cable attachment points (see Figure 162b). Make marks where this line intersects Bulkhead D and the fuselage sides. Refer to the first line you marked and transfer the new marks downward on Bulkhead D and on the fuselage sides to the height of the first line. These intersection points indicate where the cable holes should be drilled.

Because this method is not completely precise, there are likely to be some slight misalignments in these hole locations. The solution to this problem is to install abrasion-resistant fairleads in Bulkhead D and in the fuselage shell where the cables pass through. With fairleads in place, the cables can make slight bends in their runs from the rudder stop plate to the tailwheel steering arms without any difficulty.

Short pieces of nylon tubing make good fairleads for the 1/8" steering cables. The Bulkhead D fairleads don't need to be any longer then the thickness of the bulkhead; the fuselage fairleads will have to be a bit longer because of the acute angle at which the cables pass through the shell. Drill appropriate holes through Bulkhead D and the fuselage shell at the marked locations, and bond the fairleads in place with thick resin/mill fiber mixture. After the mixture has cured, trim the fuselage fairleads where they emerge from the shell.

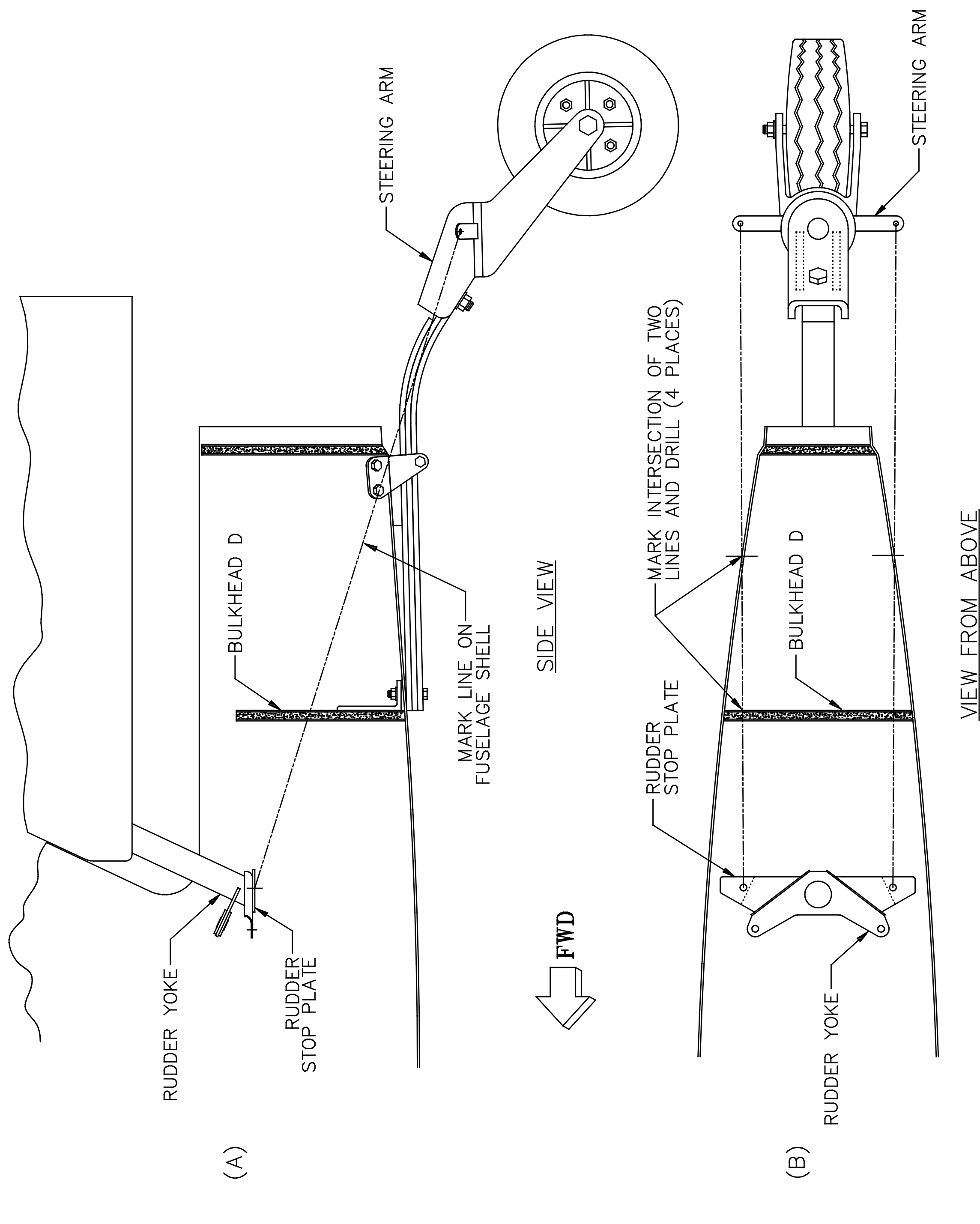

Figure 162: Locating the Tailwheel Steering Cable Holes

Begin the cable installation by sliding an NAS1435K4 **strap shackle** [249] onto the swaged end of the steering cable, as shown in the lower, left-hand corner of Figure 163. Secure this to the bushing in the rudder stop with an AN393-13 **clevis pin** [238], an AN960-10L thin washer and an AN380-2-2 **cotter pin** [237]. Then run the cable aft through the fairleads.

Your **tailwheel steering spring kit** [221] consists of three components for each side—a steering spring, a steering chain and a connector clip. Begin by cutting the supplied length of chain into two equal segments. Next, as shown in the upper portion of Figure 163, fasten the **larger** hook on the spring to the tailwheel steering arm. Attach one of the segments of chain to the other end of the spring and attach the connector clip to the free end of the chain. (The chain will be too long, but don't worry about that for now; you will adjust the tension and length in "SECTION X: FINAL ASSEMBLY.")

> **Note** The steering chains and connector clips may look somewhat flimsy to you, but this is by design. To avoid transferring unacceptably high loads from the tailwheel to the rudder control system, it's important to have a weak link in the system that will give before more important components. The chains and clips serve this purpose.

Next, slide an AN100C-4 **thimble** [231] inside the connector clip. Slide a **NicoPress sleeve** [228] over the unswaged end of the steering cable and run the cable around the thimble and back through the NicoPress sleeve.

At this point, if you have not already done so, set the tail of your GlaStar down on the floor so that the tailwheel is taking the airplane's weight. In this configuration, pull the cable around the thimble tight enough to take up all the slack in the cable, but not so tight as to compress the spring, and then crimp the NicoPress sleeve.

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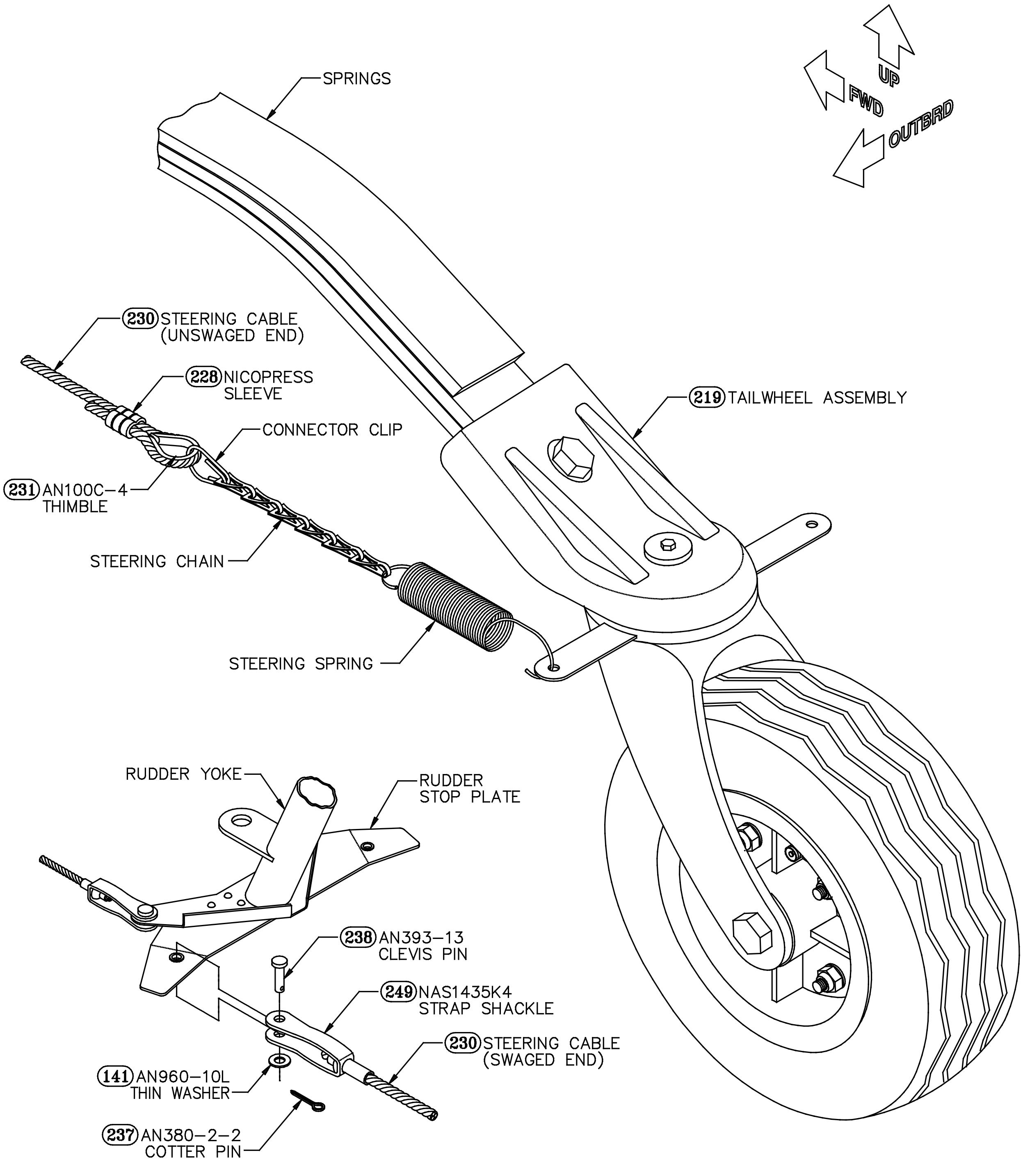

Figure 163: Installing the Steering Cables

Step 103: Install Fittings in the Caliper Assemblies

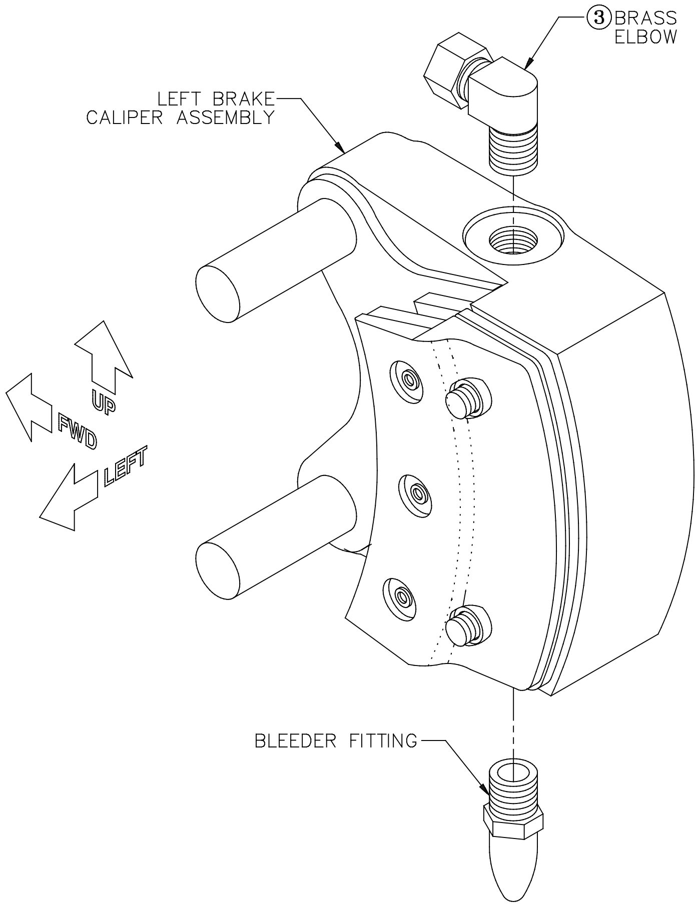

Figure 164: Installing Fittings in the Brake Caliper Assembly

You will plumb the brake system from the calipers up. As shown in Figure 164, you need to install a **brass elbow** [3] in the upper port and a bleeder fitting in the lower port of each caliper assembly. The bleeder fittings come with the calipers, and in fact on one side, the fitting will already be installed in the lower port. On the opposite caliper, however, you will find the bleeder fitting in the upper port and a plastic plug in the lower. Remove the plug and swap the bleeder fitting into the lower port. Then install an elbow in the upper port. Thread the elbow in several turns, stopping with the elbow pointing forward, as shown in the figure.

Then remove the plastic plug from the other caliper and install an elbow there in the same fashion.

Note Use of a thread sealant is recommended for all metal-to-metal fitting connections in the brake system.

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Step 104: Install Fittings in the Master Cylinders

Remove the plastic plugs from the upper and lower ports of each master cylinder and replace them with brass elbows, as shown in Figure 165. When installed, both elbows should point downward and slightly forward.

> **Note** Some early GlaStar kits were supplied with slightly different brake system fittings. These kits include two elbows, a union and a union tee that come packaged in a plastic bag along with a coil of 1/4" nylon tubing. These fittings can be distinguished from the standard ones by their round, knurled nuts and their black collars. If your kit includes such fittings, thread the two non-standard elbows into the **upper** ports of the master cylinders.

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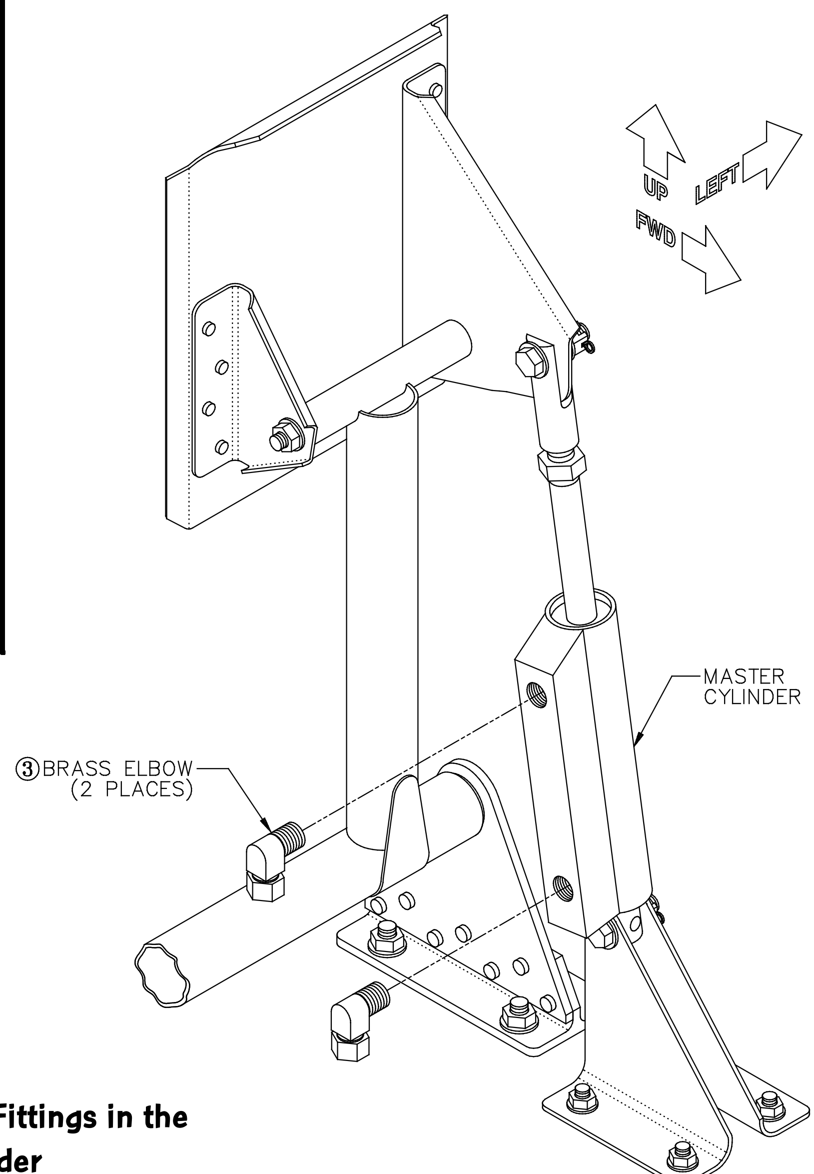

Figure 165: Installing Fittings in the Master Cylinder

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Step 105: Route the Brake Lines from the Calipers to the Master Cylinders

Dual Brake Option If you are installing copilot-side brakes, **turn to the *Option Instructions* now**. Return to Step 107 of this *Assembly Manual* when the specified option steps have been completed.
☞

The routing of the 3/16" nylon tubing brake lines varies depending on whether you're building a tricycle-geared or taildragger GlaStar, as well as which side your master cylinders are on. In any case, the lines should run from the elbow on the **left** caliper to the **lower** elbow on the **left** master cylinder and from the elbow on the **right** caliper to the **lower** elbow on the **right** master cylinder.

Begin by making the connections shown in Figure 166 at the bottom end of each line. For each side, cut a piece of blue **5/8" rubber tubing** [15] about **6"** long. Slip this over the end of the brake line. This tubing prevents the brake line from chafing against the gear leg fairings and wheel pants that you'll install later and prevents damage from rocks and other debris encountered in ground operations. Remove the nut from the elbow on the caliper and slide it over the end of the nylon tubing. Seat the tubing end in the elbow and tighten the nut over it, crimping the fitting's internal ferrule over the tubing. Finally, slide the outer rubber tubing down tightly against the elbow nut.

Just **aft** of where the gear leg enters the fuselage, drill a **1/2"** pass-through hole for the tubing. The hole should be drilled to this larger-than-necessary size so that you can pot the tubing in place with RTV to prevent the fuselage shell from chafing on the tubing. (Because the oversized hole is big enough for the nut from the elbow at the caliper, it also allows the brake lines to be rerouted more easily if you should ever change gear configurations.) Use a liberal amount of sealer; any excess on the outside of the shell will be covered by the gear leg fairings.

At the upper end of each line, connect it to the master cylinder elbow in the same way as at the lower end. No anti-chafe tubing is needed at the master cylinders, but be sure you leave enough slack in the line as it enters the cylinder to allow it to flex as the rudder pedals are operated.

Secure the brake lines to the gear legs and the cage structure with the supplied 4" cable ties every six or eight inches and avoid making tight bends that might cause the tubing to kink. Also, avoid bundling the brake lines with electrical wiring.

Hint If you're building a taildragger, you may want to leave enough slack in your brake lines to allow them to serve in the tricycle-gear configuration as well. Even if you never intend to convert, the resale value of your GlaStar will be enhanced by retaining the option of easy conversion. Route the slack in the lines in a large-radius curve under the seat pan areas, securing them to the cage according to standard practices.

Completed: Left [ ] Right [ ]

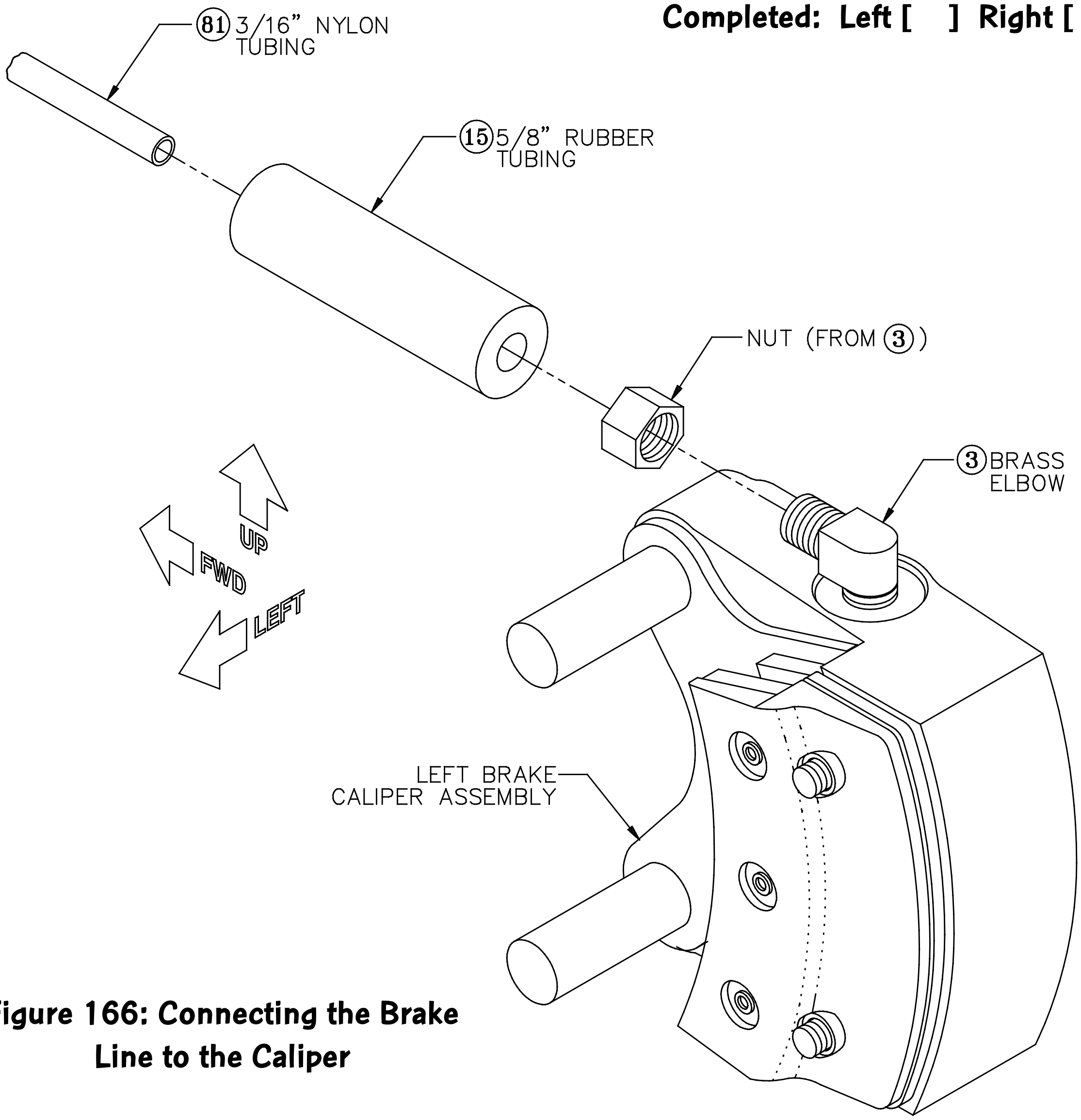

Figure 166: Connecting the Brake Line to the Caliper

Step 106: Route the Brake Lines from the Master Cylinders to the Reservoir

Figure 167 shows schematically the connections to be made between the master cylinders and the **brake reservoir** [19]. From the upper elbows in the master cylinders, lines must be run to join at the **brass union tee** [269]. Depending on your preference, this tee can be installed down low, fairly near one or the other of the master cylinders, or up high, close beneath the reservoir. The tee can also be oriented in any direction you find convenient. The orientation depicted in Figure 167 is handy if you want to mount your reservoir offset to one side, but an inverted orientation (⊥) might be better if you'll be mounting your reservoir centered above the rudder pedals.

The brake reservoir will be mounted on the firewall, and for this reason, it can't be installed until "SECTION X: FINAL ASSEMBLY." As the preceding paragraph implies, there is a good deal of flexibility in its exact side-to-side placement. However, as Figure 167 indicates, the bottom of the reservoir should be about **19"** above the fuselage floor when installed. Cut your tubing to length accordingly. Install the tee on the ends of the tubing from the master cylinders and secure it to the airframe. Then install the tubing between the tee and the **brass union** [273] fitting, but don't yet secure this run to the airframe.

You can then either screw the union into the bottom of the reservoir and tape the whole assembly out of the way for the time being, or you can simply put the reservoir aside for later. If you chose the latter option, however, seal the open end of the union with tape to keep foreign matter out of the brake line.

> **Note** The non-standard fittings included in early kits require the use of the supplied **1/4"** tubing between the master cylinders and the reservoir. Otherwise, the installation is identical.

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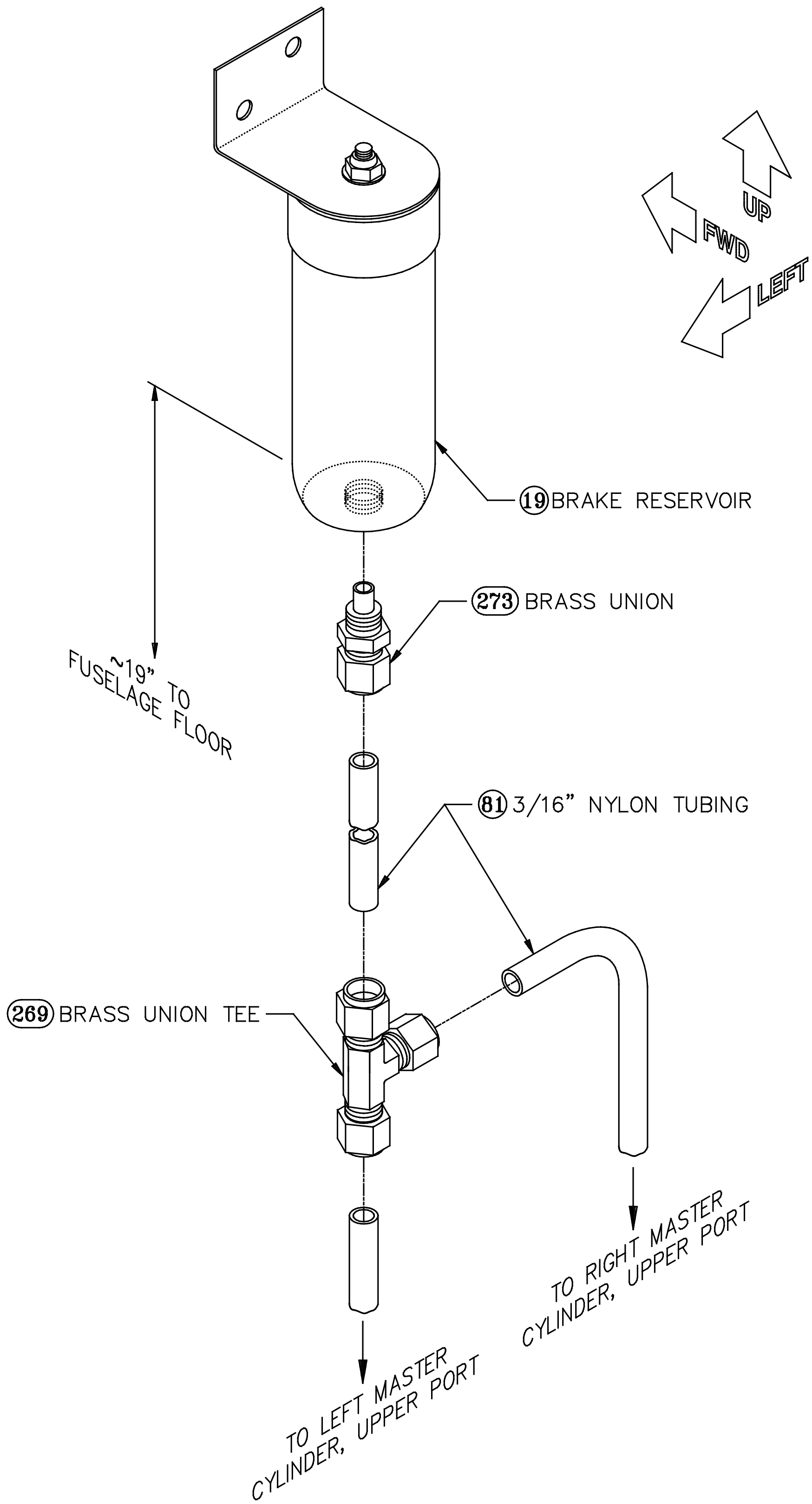

Figure 167: Connecting the Master Cylinders to the Brake Reservoir

FUSELAGE FUEL SYSTEM PLUMBING

This section describes the installation of aluminum tubing fuel lines from the area of the wing pivot brackets on the fuselage cage to a shut-off valve mounted on the center cage truss forward of the flap handle. A drain valve will be installed at the low point of the system to allow water and sediment to be purged from the fuel lines.

Note When installing the fuel system, all fuel lines must be routed so that water or sediment in the lines will flow to the drain valve at the low point in the system. This means that the fuel lines must slope continuously upward from the drain valve to the fuel tanks and to the fuel shut-off valve. Between components or fittings in the system, there must not be any intermediate low points where water or sediment could collect.

Warning Provide a minimum of **3/8"** clearance between the fuel lines and any control cables. Pull the cables tight during fuel line routing to check for clearance. In addition, we recommend protecting the fuel line from cable vibration by installing spiral wrap or an equivalent protective sleeve over the fuel line in the vicinity of the cables. Provide a minimum of **1/8"** clearance between the fuel lines and other moving parts.

Step 107: Reinforce the Drain Valve Mounting Area

The fuel system requires a drain valve at its lowest point for draining condensation from the system. The drain should be located on the fuselage floor just inboard and forward of the left-hand tricycle main gear socket. This is a more convenient location than the aircraft centerline, where fuel drains are often found on other aircraft, because it doesn't force you to reach as far under the airplane to get at the drain. (The right side would work just as well, but the following text and illustrations assume a left-side installation.)

This drain valve will be mounted on the inner laminate of the fuselage floor, but since the inner laminate is only one layer thick, an additional reinforcement laminate is required. As shown in Figure 168, this laminate should be **3" X 3"** in size. It can be laid up of **one** layer of DBM cloth **or two** layers of bi-directional cloth cut on the 45° bias.

Prep the area of the fuselage floor indicated in the figure with coarse sandpaper and an acetone wipe, and apply the reinforcement. Let it cure thoroughly.

Completed: [ ]

Step 108: Drill the Drain Valve Holes in the Fuselage Floor

After the reinforcement laminate has cured, use a **#40** bit to drill a pilot hole through the fuselage floor at the **center** of the reinforced area. Next, you need to drill larger holes through the inner and outer fuselage laminates. These holes must **not** be the same size, however. First, use a piloted **11/16"** hole cutter to drill from the outside through the **outer laminate and the foam core only**, stopping **before** cutting into the inner laminate. Then use a **3/8"** bit to drill from the inside through the inner and reinforcement laminates.

After both holes have been drilled, use sandpaper to smooth the edges on both the inside and outside skins. If necessary, use an awl or a thin utility knife blade to remove clean up any foam remaining within the 11/16" cylinder under the inner laminate. Then seal the foam inside the hole with a small amount of thin-mix Q-cell and resin applied with the tip of your finger.

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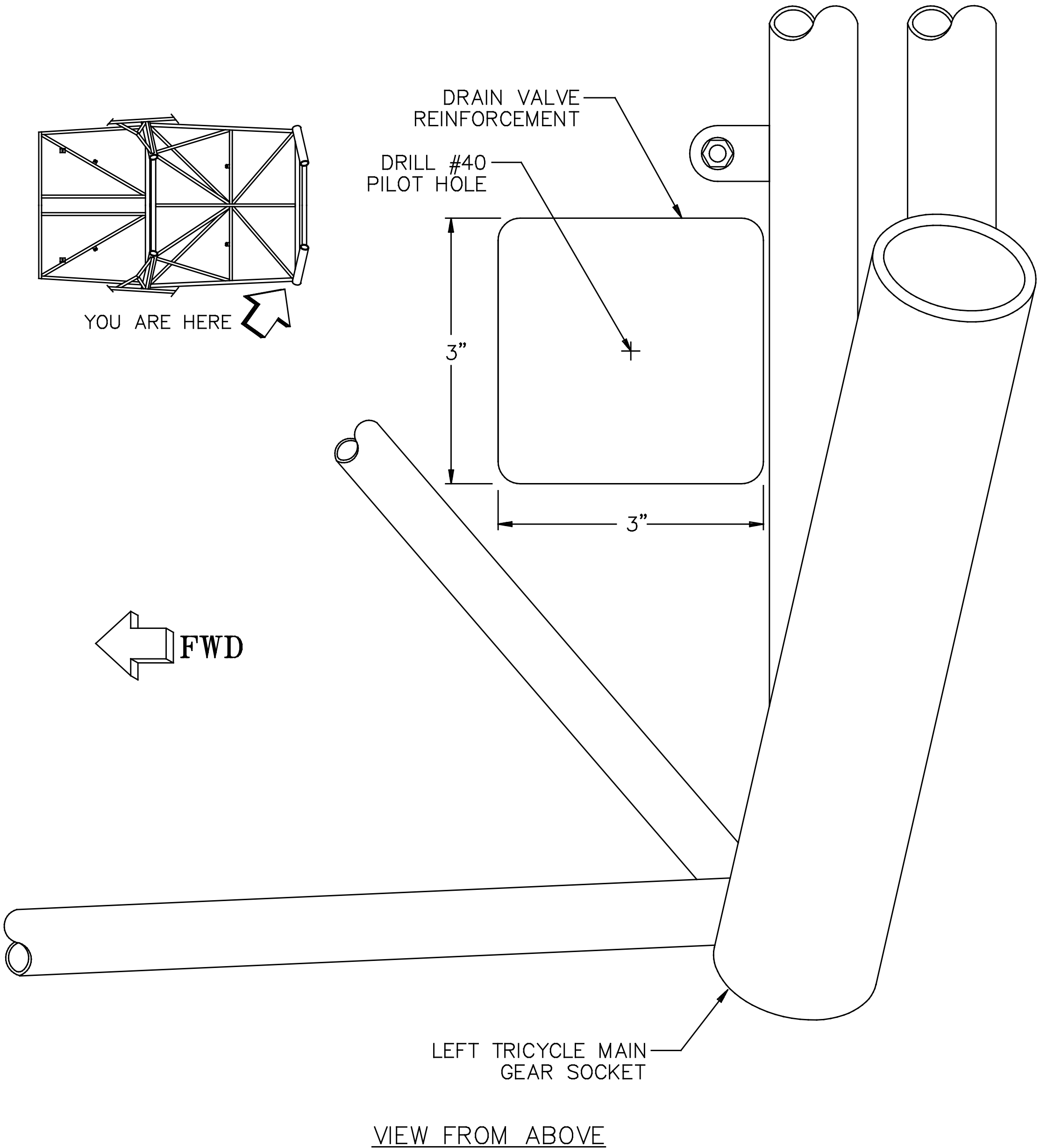

Figure 168: Drain Valve Mounting Area Reinforcement

Step 109: Install the Drain Valve

Figure 169 shows how the **drain valve** [37] is installed in the hole you just made. The larger hole through the outer laminate and the foam core allows the valve to be recessed inside the fuselage floor, keeping it almost entirely out of the slipstream. The smaller hole through the inner and reinforcement laminates serves as a mounting collar.

As the figure shows, put an AN960D616L **thin aluminum washer** [153] over the drain valve, and then insert it up through the fuselage floor. Secure it on the inside with one or more AN960D616 **aluminum washers** [152] and an AN912-1D **reducer bushing** [138]. Use only one washer if you can tighten the reducer bushing down that way, but you may need to add another in order to get the fuselage laminates firmly clamped between the bushing and the valve. This is your goal.

Finally, once the bushing is tight, install a Swagelok **female branch tee** [5]. Thread the tee several turns onto the bushing, stopping when the tee is oriented **perpendicular** to the aircraft centerline.

> **Note** Use of a thread sealant is recommended for all metal-to-metal fitting connections in the fuel system.

Completed: Left [ ] Right [ ]

Step 110: Route the Fuel Line from the Left Wing to the Drain Valve

All the fuselage fuel lines are made of **3/8" aluminum tubing** [79]. However, to accommodate the GlaStar's wing-fold feature, short segments of 5/8" rubber tubing are used at the wing roots to connect the fuel tanks to the rigid lines of the fuselage system. In this step, you will cut and bend a segment of aluminum tubing to go from the door post just beneath the wing root to the outboard boss of the drain valve tee.

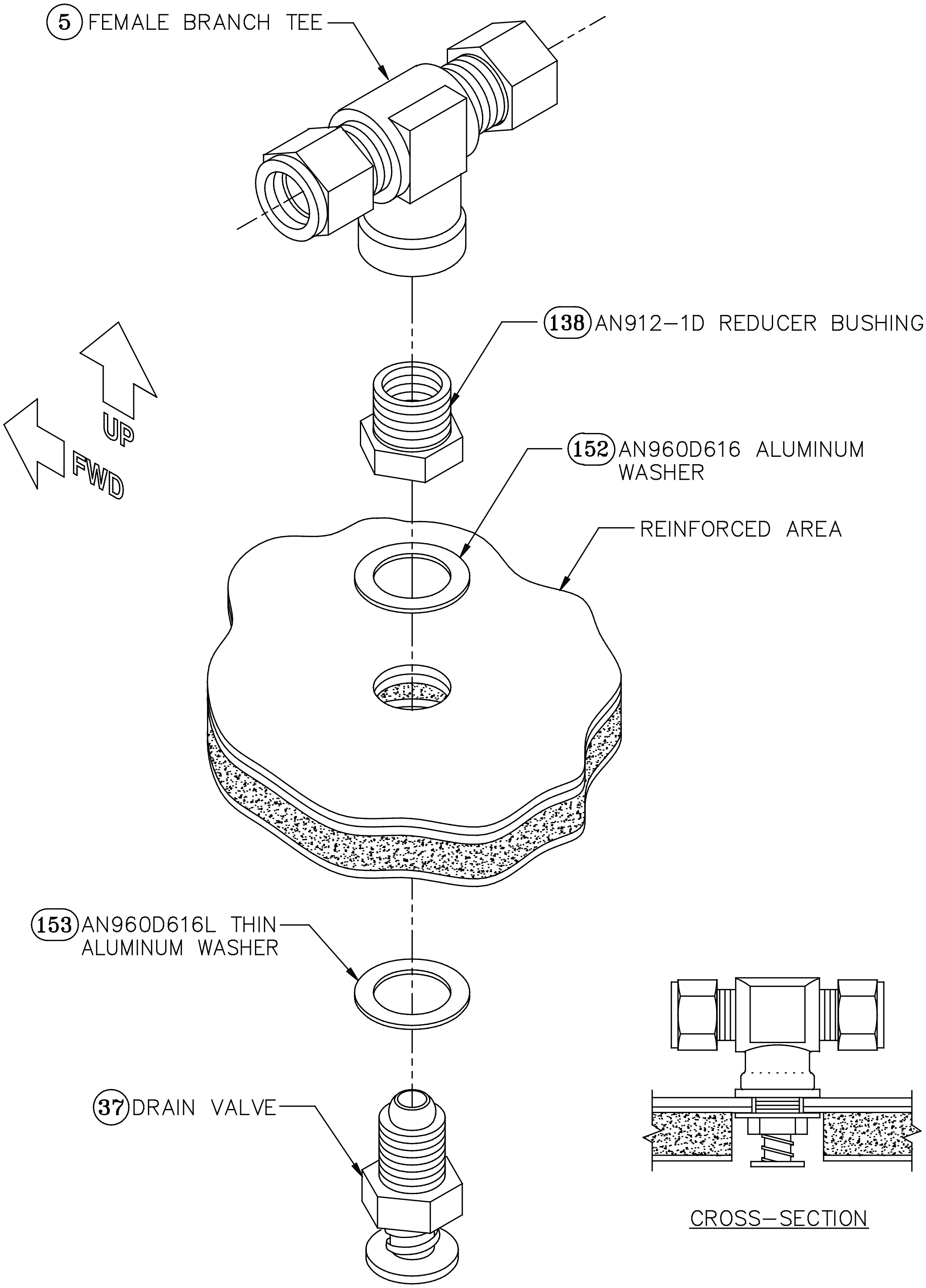

Figure 169: Installing the Drain Valve

As Figure 170 shows, this line should begin at the upper end **3"** below the bottom of the wing pivot, run down the main door post tube **aft** of the cage tabs and shell attach brackets, and then bend around the **forward** side of the lower aft aileron pulley and the tricycle gear socket to the drain valve tee. Including the bends, this run will require about **42"** of tubing.

Note The fuel line must also be routed to clear the seat tracks. Refer to Step 22 in "SECTION X: FINAL ASSEMBLY" to see where the seat tracks go.

Warning Provide a minimum of **3/8"** clearance between the fuel line and all control cables. Pull the cables tight to check for clearance.

Note Bending and fitting the tubing, in this run and those that follow, is a trial-and-error process, more art than science. Just remember to keep your bend radii as large as practical, and try to avoid overbending—that is bending beyond the required angle and then having to bend the tubing back again. Use of a tubing bender is **highly** recommended; successful hand bending is extremely difficult with this size tubing.

Hint Try using 1/8" aluminum welding rod to make a three-dimensional "template" of the fuel line to determine the optimum routing and the best positions of the tubing bends. Also, you may find it easiest to slide the tubing in from above through the quarter window while trial fitting it.

When you're satisfied that you have the tubing bent and sized properly, then you need to bead the upper end with a tubing beader for connection to the rubber hose from the wing.

Hint A tubing beader is an expensive, specialized tool, and we don't recommend that you run out and buy one to make two beads. Ask around your local airport or EAA chapter. More than likely, you'll be able to find an obliging A&P who will either loan you the tool or make the beads for you. The rubber tubing will be connected to the hard fuel lines after the wings are installed for the final time in "SECTION X: FINAL ASSEMBLY."

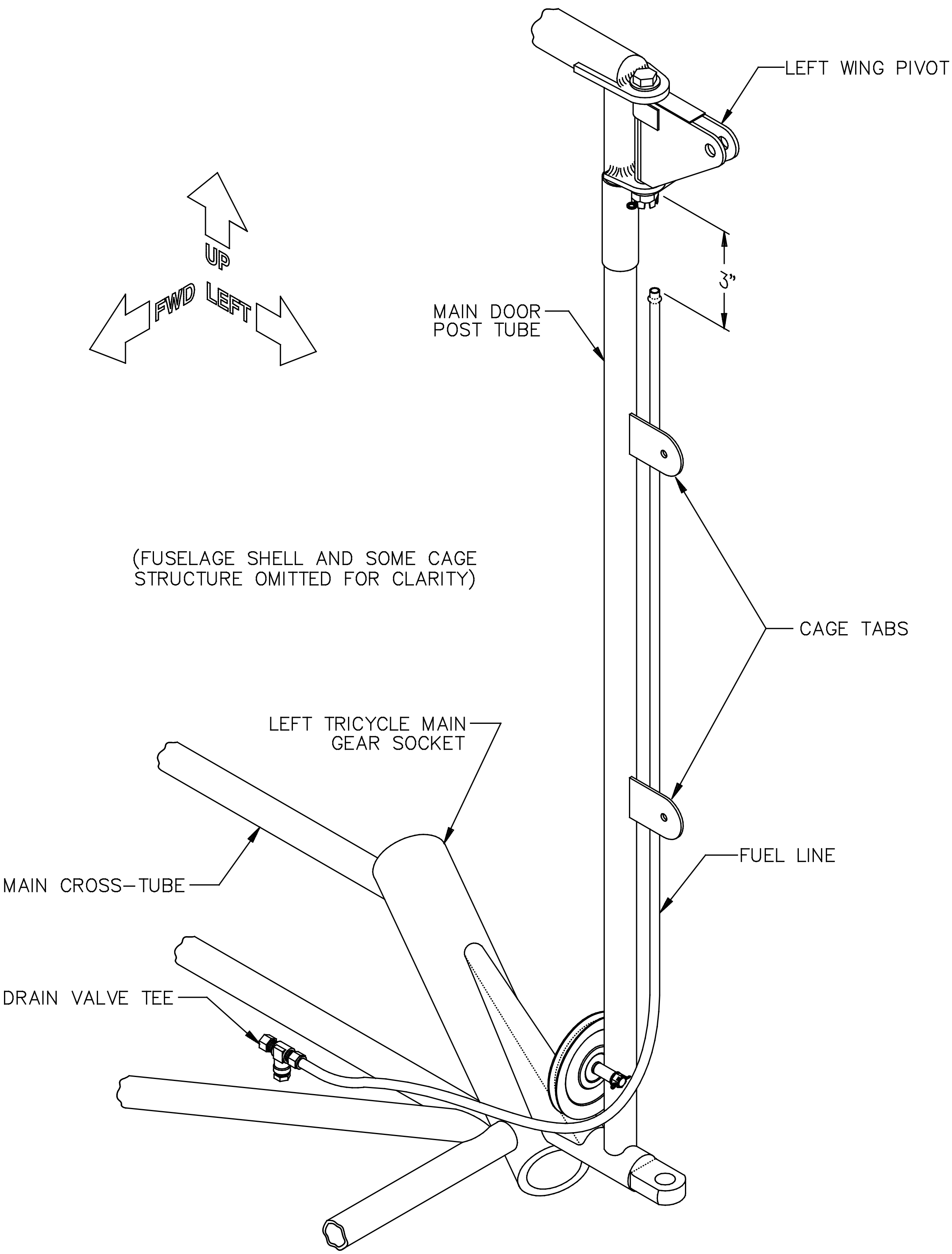

Figure 170: Routing the Fuel Line from the Left Wing to the Drain Valve

After the tubing is beaded, connect its lower end to the outboard boss of the drain valve tee. If necessary, refer to "SECTION II: TOOLS AND TECHNIQUES" for the proper procedure for tightening Swagelok fittings. With the tubing connected to the tee, secure it to the cage structure along its entire length using cable ties.

> **Hint** For better vibration resistance, we recommend standing the fuel line tubing off from the cage tubes rather than securing it directly to them. A good method for accomplishing this is to run the loose end of the cable tie through a **1/2"**-long piece of nylon tubing left over from the brake or pitot lines, then around the fuel line, back through the nylon tubing, and finally around the cage tube. Figure 171 illustrates this technique.

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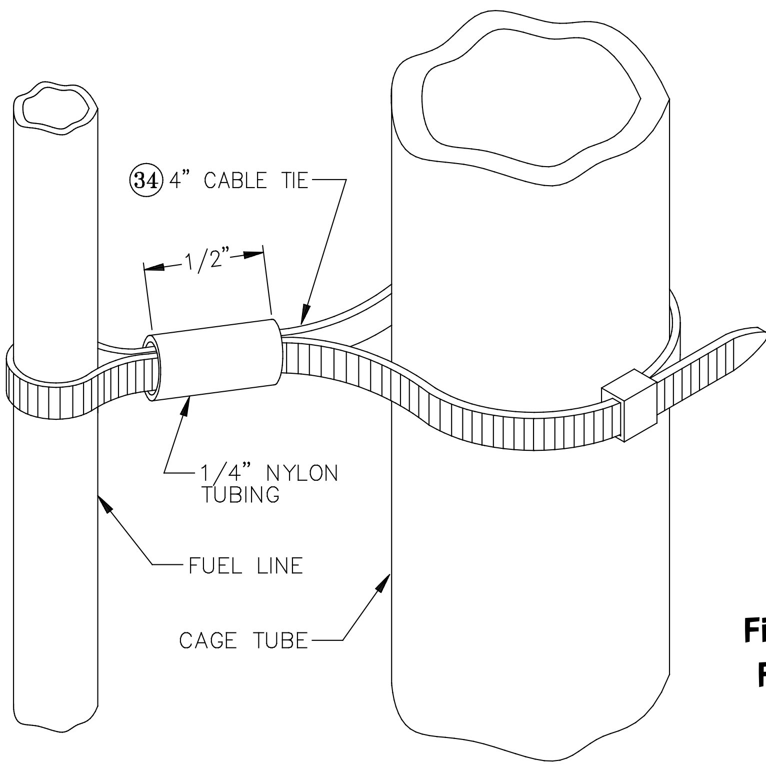

Figure 171: Method for Standing Fuel Lines Off from Cage Tubes

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Step 111: Route the Fuel Line from the Right Wing to the Drain Valve

The line from the right wing is routed just as the left one was, except that rather than running directly to the drain valve tee, the right-hand line first runs to a Swagelok **union tee** [4] at the center of the aircraft just above the fairlead cluster on the tricycle main gear truss, from which lines run across and down to the drain valve tee and forward and up to the **fuel shut-off valve** [6]. Figure 172 illustrates the location and function of this union tee.

> **Note** When properly installed, the forward port of the union tee must angle slightly upward so that the fuel line can slope continuously upward to the fuel shut-off valve (described in the next step) from the drain valve. Otherwise, a local low spot would exist in the line forward of the tee where water or sediment could collect.

Cut, bend, bead, connect and secure the line from the wing root to the union tee just as you did before. This run will require approximately **52"** of tubing

Finally, bend and install a length of tubing between the left-hand port of the union tee and the inboard port of the drain valve tee.

Completed: [ ]

Step 112: Route the Fuel Line from the Union Tee to the Shut-Off Valve

From the union tee, the fuel line must be routed forward along the left side of the central longitudinal cage truss to the fuel shut-off valve. As Figure 172 shows, the tubing coming out of the tee must be bent slightly to the left in order to remain clear of the flap handle. It must not be bent so far to the left, however, as to interfere with the installation of the seat pans in "SECTION X: FINAL ASSEMBLY." Besides avoiding interference with other components, the most important goal in routing the fuel line is to slope it continuously upward from the union tee to the shut-off valve.

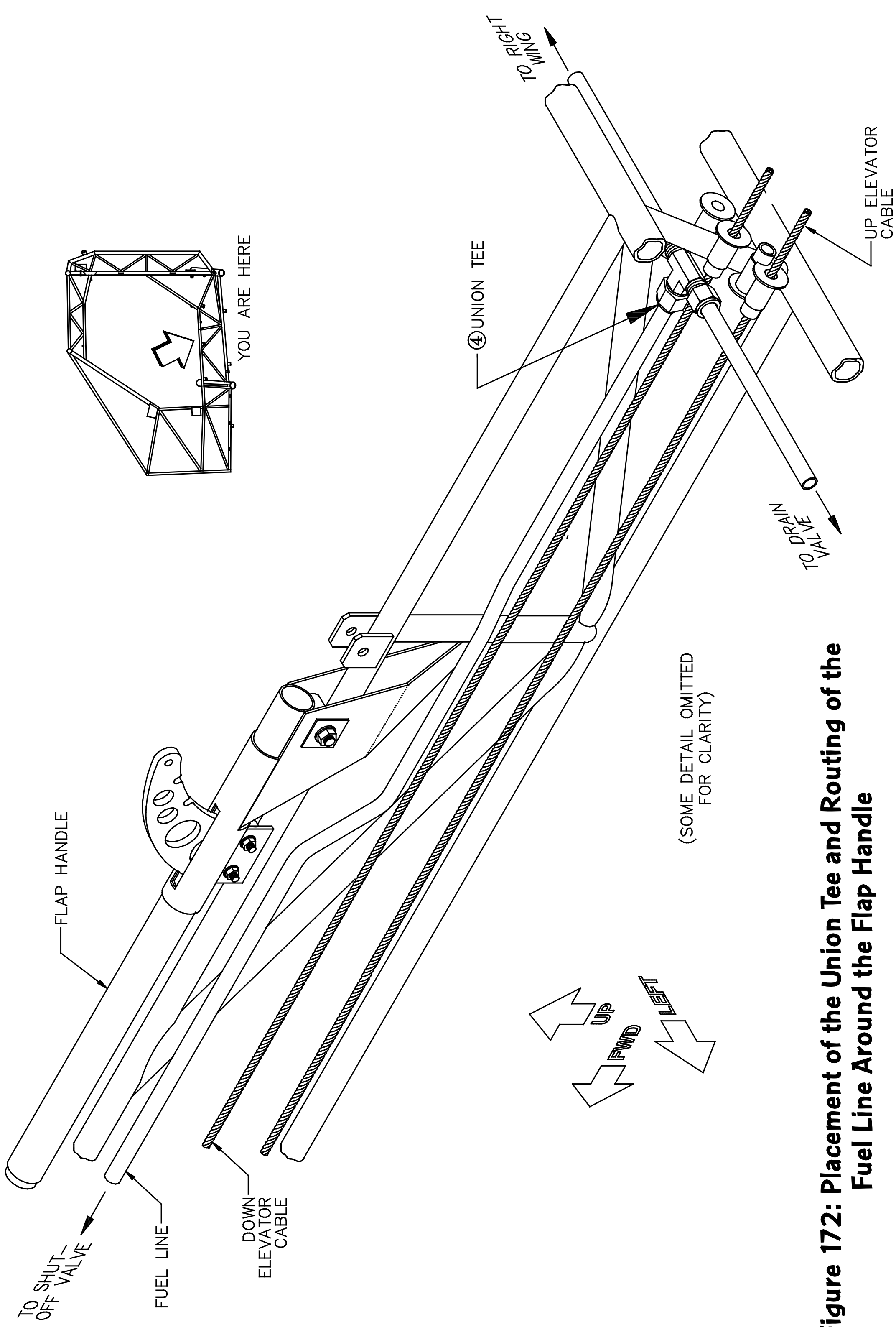

Figure 172: Placement of the Union Tee and Routing of the Fuel Line Around the Flap Handle

Figure 173 shows the suggested location of the shut-off valve, centered in the first triangular space between the cage tubes of the center truss forward of the main cross-tube between the taildragger gear sockets.

Note This space is a bit tight. Before you secure the valve permanently, be sure to check that the handle clears the cage tubes when it is in its OFF as well as its ON position. This will likely require that the valve be angled slightly to the right, rather than being installed perfectly parallel with the aircraft centerline.

Warning If you install the valve between straight sections of tubing and secure these lengths of tubing directly to the cage tubes, as shown in Figure 173, the valve handle will barely protrude above the cage truss. Do **not** raise the valve any higher than this. To do so raises the risk of closing the valve inadvertently in flight by snagging the handle on loose clothing, headphone leads, etc. Also, if the valve is raised any higher, it could interfere with easy operation of the flap handle, which is situated directly above the valve. When you install a metal cover over the cage truss in this area in "SECTION X: FINAL ASSEMBLY," you'll provide a cutout to give convenient access to the valve.

The total length of tubing required for the run from the union tee to the shut-off valve will vary a bit depending on the exact positioning of the valve and how you bend the tubing around the flap handle, but figure in the neighborhood of **31"**.

Note The ends of the valve are **not** interchangeable. Make sure that the arrow engraved on the side of the valve housing points forward.

The fuel line from the shut-off valve forward to the firewall should not be installed until the firewall itself is fabricated and installed in "SECTION X: FINAL ASSEMBLY."

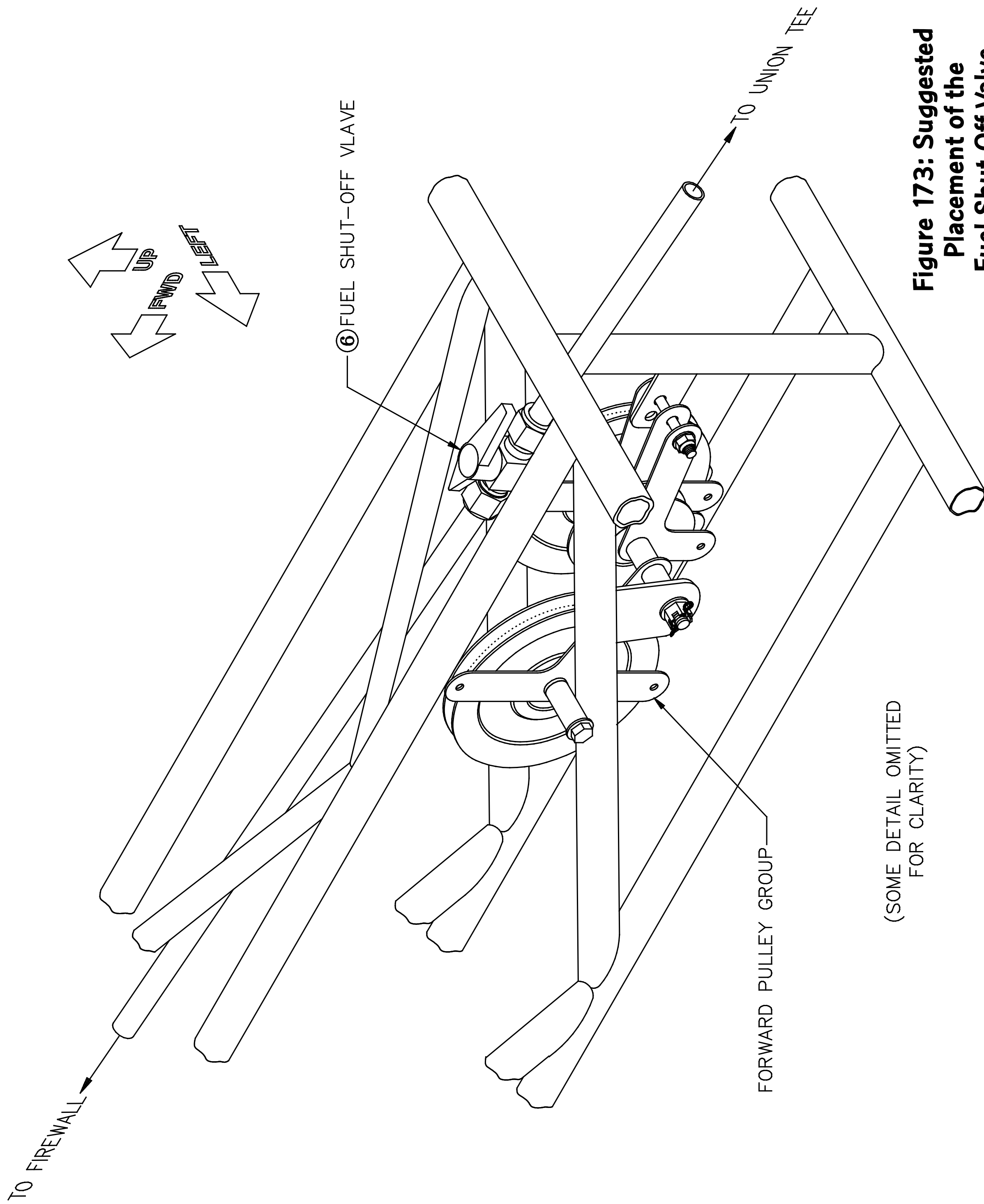

Figure 173: Suggested Placement of the Fuel Shut-Off Valve

Electric Trim Option The reason for positioning the fuel shut-off in the location suggested in Figure 173 is to provide space forward of that for mounting the manual trim system gear box. However, if you are installing electric trim, this space is free, and you may prefer to move your shut-off valve forward into this area.

Figure 174 shows the valve installed in this alternate location. The **7-1/4"** distance shown in the figure between the valve and the main cross-tube between the taildragger gear sockets was taken from an early customer-built GlaStar and represents, in our view, a good location for the valve. However, if you'd prefer a position slightly further forward or aft, suit yourself—there's nothing too critical about this placement. Keep in mind that, as a simple on/off valve, the fuel shut-off valve is not something that you'll have to attend to much while in flight, as you would with a multi-position fuel selector valve. On the other hand, in an emergency, you do need quick and easy access to the valve. Choose your position accordingly.

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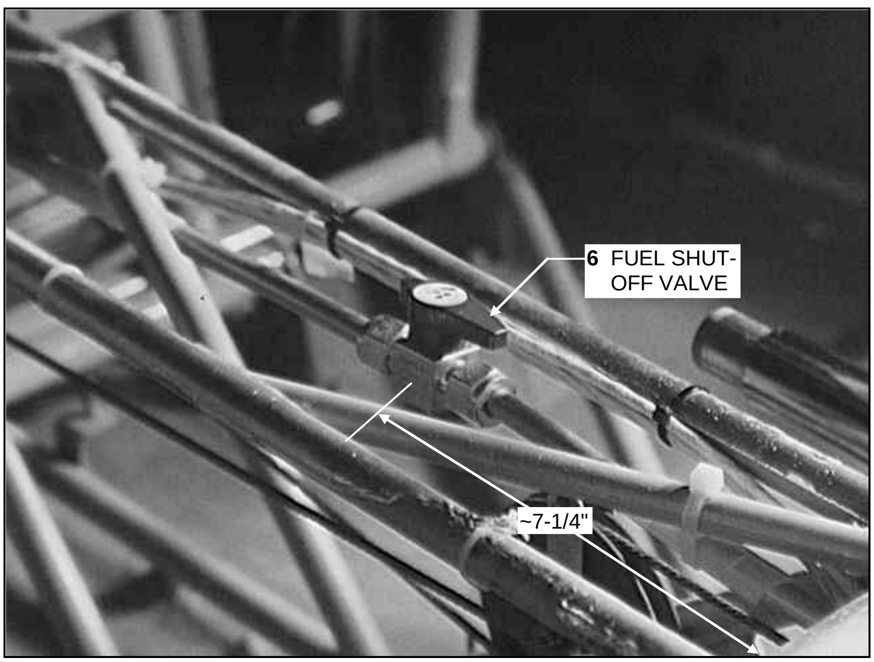

Figure 174: Alternate Placement of the Fuel Shut-Off Valve (Electric Trim Only)

MANUAL ELEVATOR TRIM SYSTEM INSTALLATION (OPTIONAL)

Electric Trim Option If you're installing an electric trim system, **skip to Step 119**.

Step 113: Drill Trim Cable Holes in the Bulkheads (Manual Trim Only)

The manual trim system activates the trim tab via a sheathed, push-pull cable. This cable runs from the elevator forward to a gear box mounted on the cage truss forward of the flap handle. In order to minimize slop in the cable, it's essential that the sheath be firmly secured to the airframe along its entire length, which in practice means that the cable must be routed along the fuselage floor and sidewall. Therefore, the cable can't pass through the large, center cutouts in Bulkheads A, B and C; you need to provide small pass-through holes near the fuselage shell instead.

Figure 175 shows where the **9/16"** hole in Bulkhead A should be drilled. Its location isn't really critical, but keep it as close to the fuselage floor as possible.

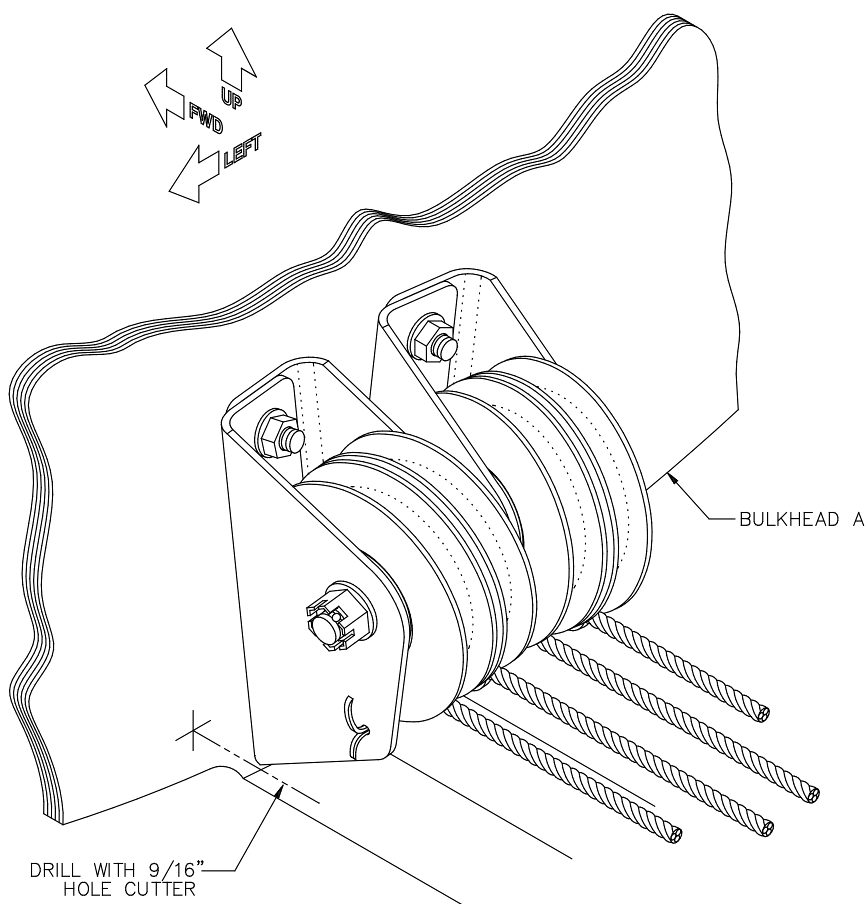

Figure 175: Drilling the Trim Cable Hole in Bulkhead A

Figure 176 shows the location of the **9/16"** hole through Bulkhead B. Keep this hole as close to the fuselage sidewall as possible. And, yes, we're afraid drilling this hole **does** require crawling back into the aft fuselage! Ask the kid next door if he or she wants to make a couple bucks!

Finally, the Bulkhead C hole location is shown in Figure 177. Again, this hole doesn't need to be located with any great precision. Fortunately, it can easily be drilled from outside the airplane! Use a **5/8"** bit. After drilling, insert a **snap bushing** [250] into the hole from the aft side. This will provide anti-chafe protection to the cable sheath.

Note Figures 175, 176 and 177 show the cable holes on the left-hand side of the fuselage, but this is entirely arbitrary, as the cable can be run along the right-hand side with identical results. Just be sure to drill all the holes on the same side!

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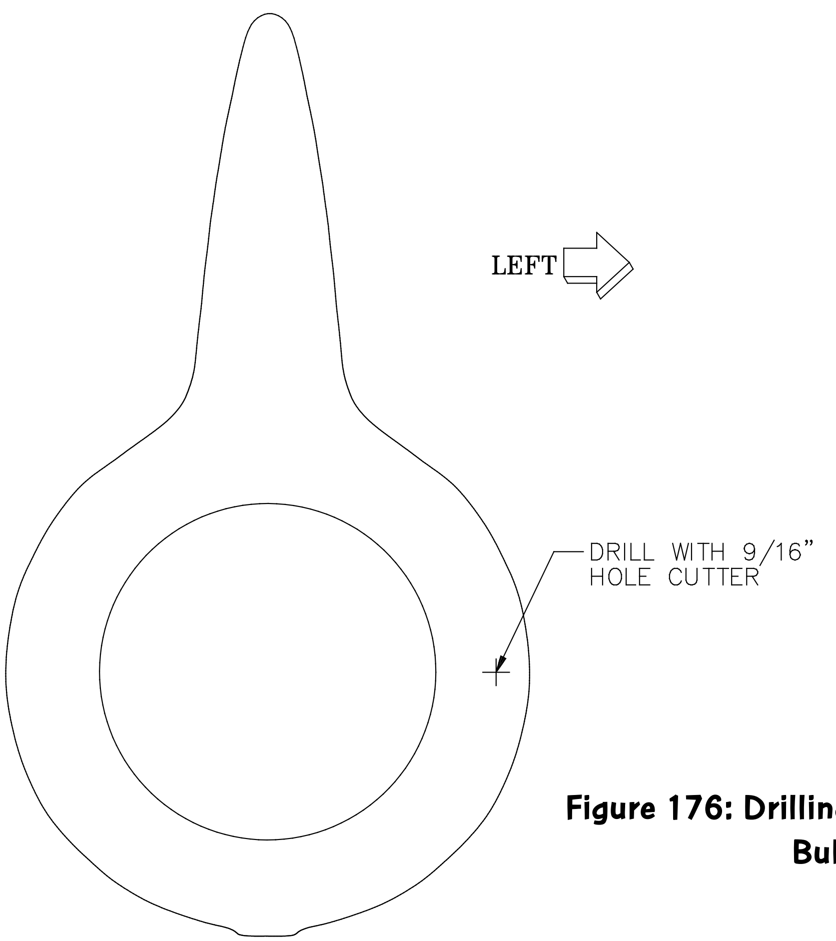

Figure 176: Drilling the Trim Cable Hole in Bulkhead B

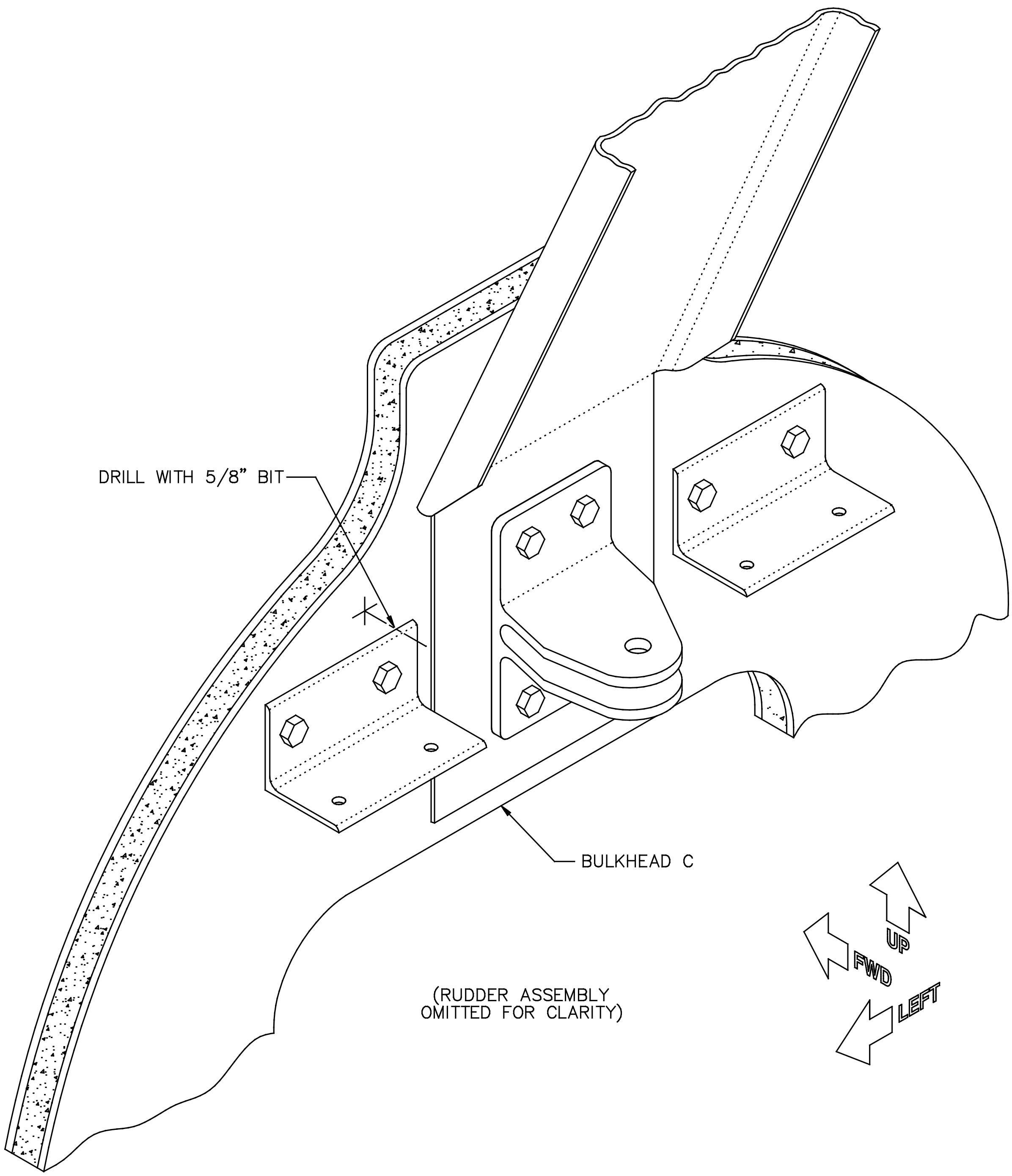

Figure 177: Drilling the Trim Cable Hole Through Bulkhead C

Step 114: Route the Trim Cable Through the Fuselage
(Manual Trim Only)

Now it's time to route the **trim cable** [258] through the fuselage—so don't let that kid go yet! Begin at the tail and feed the forward end of the cable through the hole in Bulkhead C. Have your assistant fish the cable through the holes in Bulkheads B and A, and then pull it forward to the cabin area.

> **Note** The forward end of the cable is the one with the unthreaded wire protruding out of the plastic sheath and the jam nuts and washer. Remove the nuts and washer and set them aside before trying to feed the cable through the holes. The wire will also have two screw-type **cable clamps** [252] on it. Remove these and set them aside. They will be re-installed in "SECTION X: FINAL ASSEMBLY" when you adjust the cable travel.

The cable should first be secured at the elevator. Thinking way back to "SECTION V: ELEVATOR ASSEMBLY," you'll recall that you installed a trim cable bracket between the center pair of elevator ribs. You also cut a pair of slots in the upper and lower skins of the elevator to accommodate the cable. Now it's finally time to see if they work!

Install your horizontal stabilizer/elevator combo on the fuselage, if they're not already in place. Remove the two screws holding the trim cable retainer clip in place on the bottom of the elevator. Then insert the aft (threaded) end of the trim cable down through the slots in the upper and lower elevator skins. Finally, as shown in Figure 178, engage the groove near the end of the trim cable in the bracket slot, and then screw the retainer clip back in place to clamp the cable end tight.

> **Note** The 3/16"-wide groove in the trim cable is between the black plastic sleeve and the crimped metal ferrule where the plastic sheath ends.

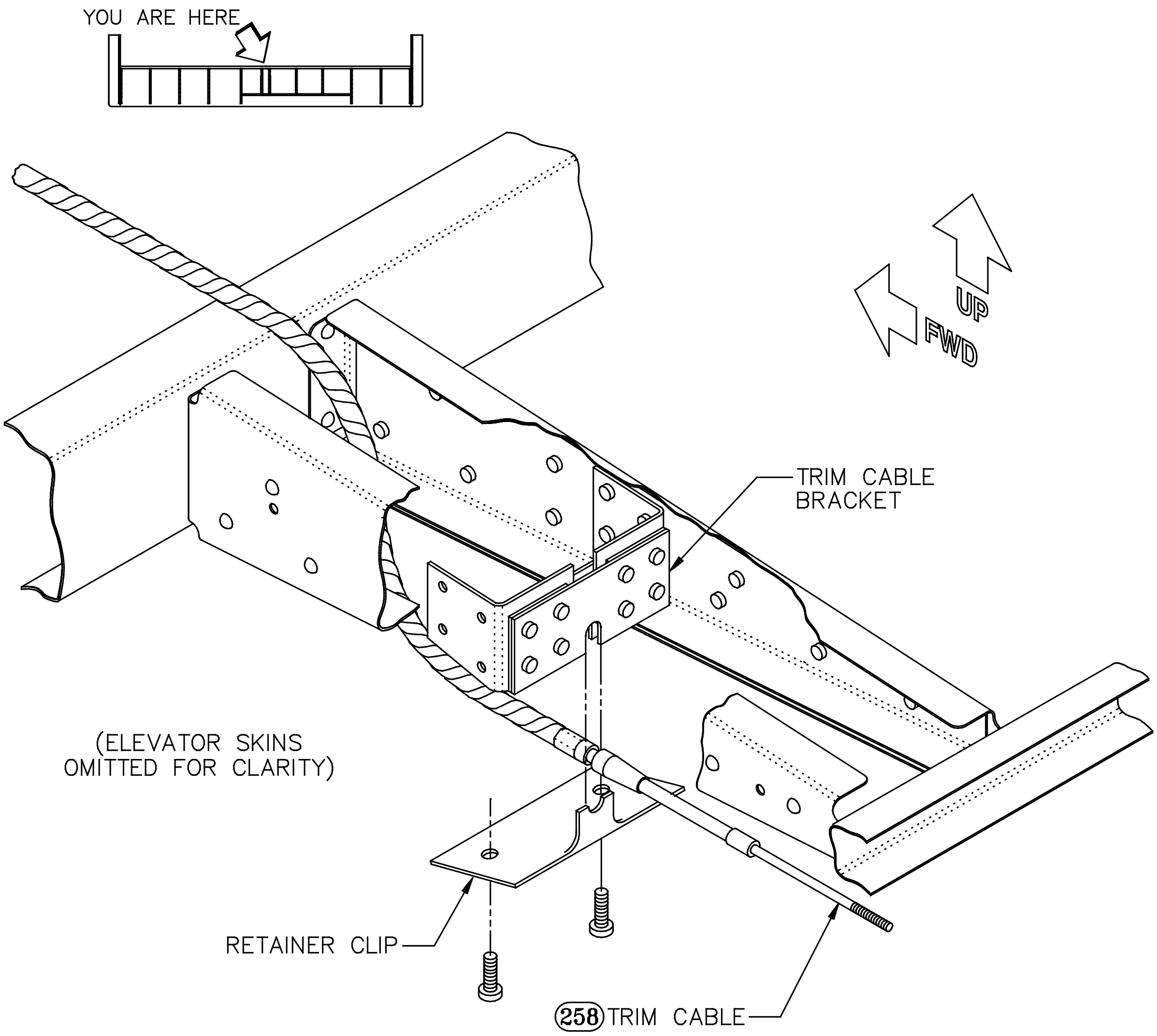

Figure 178: Engaging the Trim Cable End in the Bracket

The trim cable must remain unsecured between the elevator and Bulkhead B in order to allow free elevator movement. However, your goal is to leave as little slack as possible without interfering with free travel. Therefore, once the cable end is secured in the elevator, deflect the elevator fully downward, and then have your assistant pull the cable tight at Bulkhead B. The hole through Bulkhead B was drilled oversized to allow the cable to be potted in place with a liberal amount of RTV silicone sealer. Apply the sealer around the cable on both the forward and aft faces of the bulkhead and allow it to dry thoroughly before proceeding.

Eventually, you will also pot the cable into the hole through Bulkhead A and secure it to the fuselage floor forward and aft of Bulkhead A. However, because the cable cannot be lengthened or shortened, you must first ensure that the forward end of the cable is secured where it belongs. Once that has been accomplished, then any slack that remains can be taken up while securing the cable elsewhere.

Figures 179 and 180 illustrate the recommended routing of the cable through the cage structure. As Figure 179 shows, the cable enters the cage just to the **right** of the central vertical tube in the truss between the tricycle gear sockets. (Although the figure doesn't show this level of detail, this is the tube that bears the control cable fairleads. This routing takes the trim cable directly over the top of the right-hand pair of center flap pulleys.) From a point just forward of the union tee to the point forward of the flap handle ratchet plate where the fuel line bends upwards toward the shut-off valve, the trim cable can be bundled directly **under** the fuel line. When the fuel line begins its upward bend, the trim cable should be bundled **alongside** it on the **right-hand** side, as shown at the left-hand end of the figure.

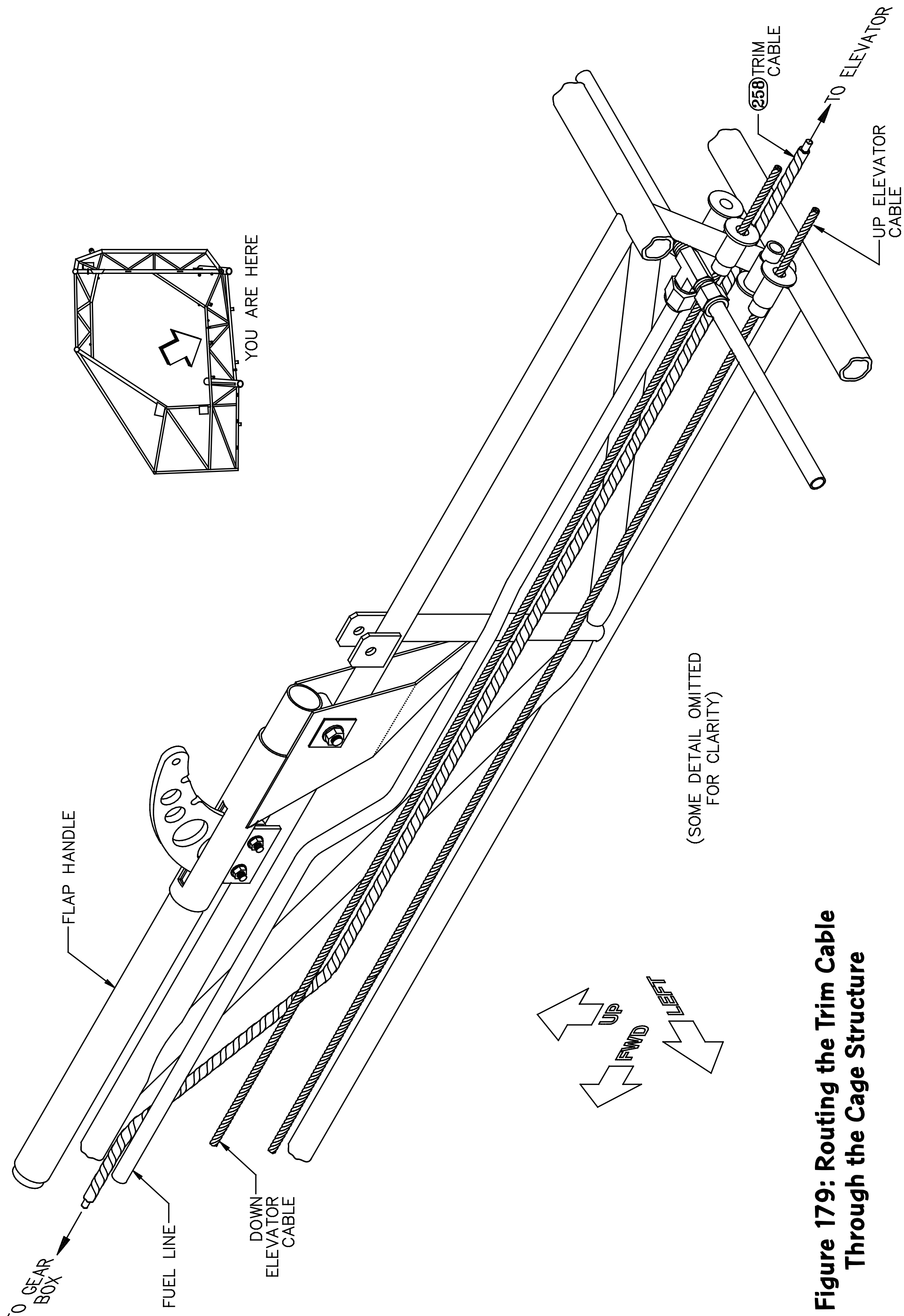

Figure 179: Routing the Trim Cable Through the Cage Structure

Figure 180 shows that the trim cable should then pass to the **right** of the central vertical tube in the truss between the taildragger gear sockets, alongside the fuel shut-off valve, and then up through the aft corner of the second triangular space between the tubes of the center truss.

Don't secure the cable to any of the cage structure yet, but make sure that you have it routed as shown in the figures and described above before moving on to the next step.

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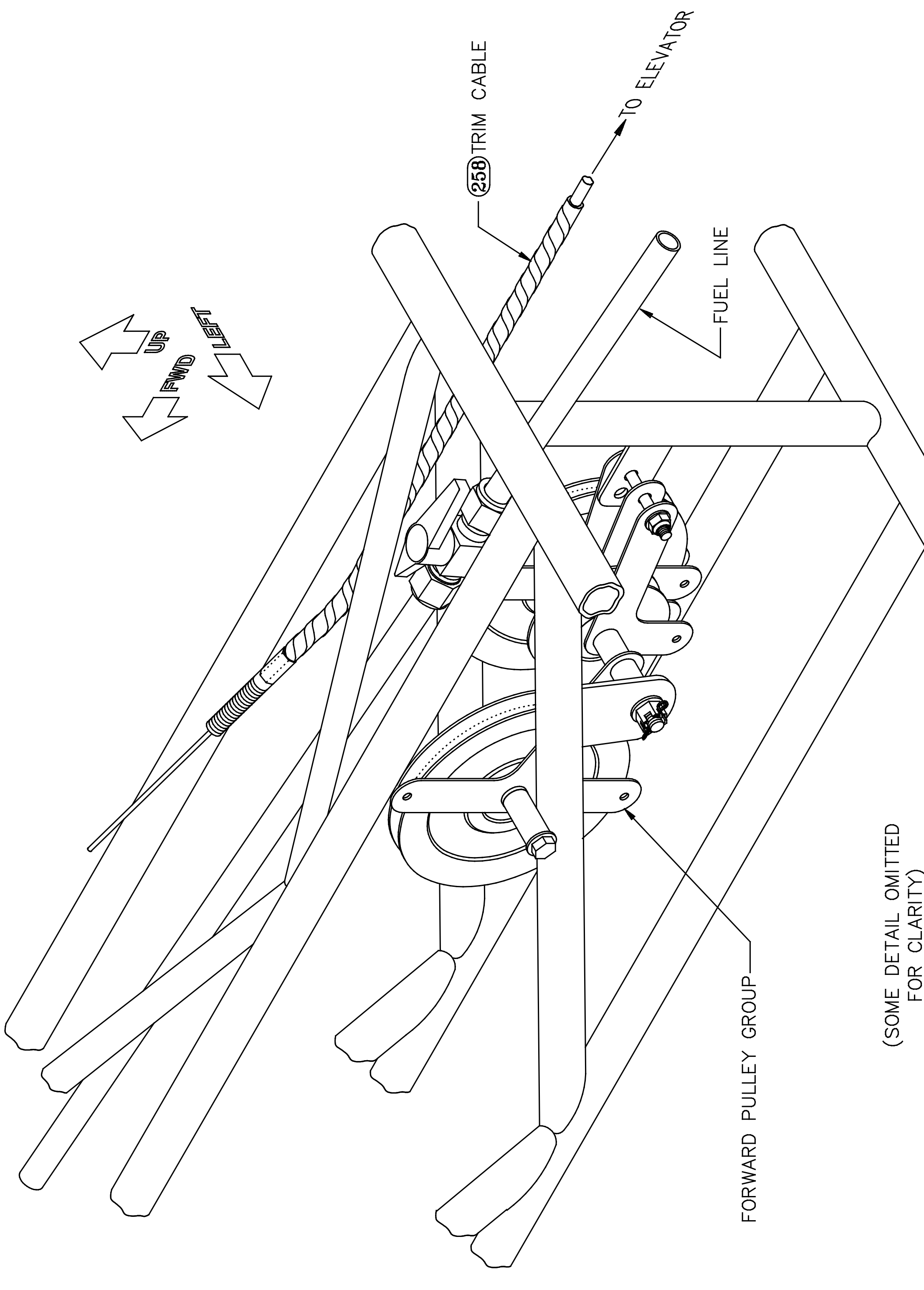

Figure 180: Routing the Forward End of the Trim Cable

Step 115: Fabricate the Trim Gear Box Brackets *(Manual Trim Only)*

The cable must next be secured at its forward end. The easiest way to establish the location of the forward cable end is to go ahead and temporarily mount the **trim gear box** [251], which determines where the cable end belongs. The gear box is mounted directly to the cage truss via two sheet-aluminum brackets.

Figures 181 and 182 are **full-sized** templates for these brackets. Cut each shape out of the supplied **.032" X 6" X 6" aluminum sheet** [253] using a bandsaw or scroll saw, and sand or file the cut edges smooth. Lay out the hole locations shown on the templates and drill the holes with the bits indicated—a **#40** for the four holes in the top half and a **#19** for the two holes in the bottom half of each bracket. Deburr these holes and radius the corners of the brackets, being careful to leave an adequate edge margin of at least **3/32"** around each of the top two holes in each bracket.

Finally, mark the indicated bend line on the **left-hand** bracket only. The lower half of the bracket must be bent **upward 90°** to the upper half along this line. A bend radius of **1/8"** should be maintained. Unless you have a bench brake, we recommend making this bend using the same techniques outlined earlier in the sub-section "RUDDER CONTROL ASSEMBLIES INSTALLATION" for bending the rudder pedals: make a wooden form block, clamp the bracket in a vise with the bend line aligned over the form block radius, and bend the bracket with a hammer.

Corrosion-proof the brackets now, if you wish. They will be exposed parts when the trim installation is complete, so you may also want to give the brackets a finish coat of some kind. However, you might want to wait to do this until you're ready to install the brackets permanently in "SECTION X: FINAL ASSEMBLY."

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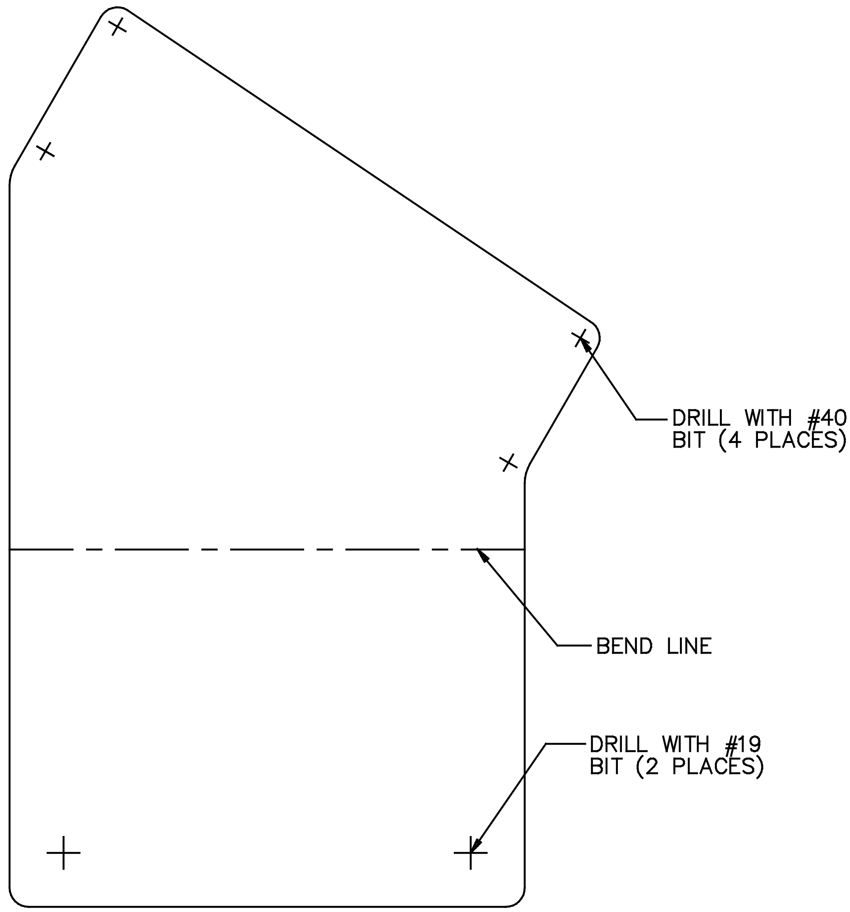

Figure 181: Template for the Left-Hand Trim Gear Box Bracket (Full Size)

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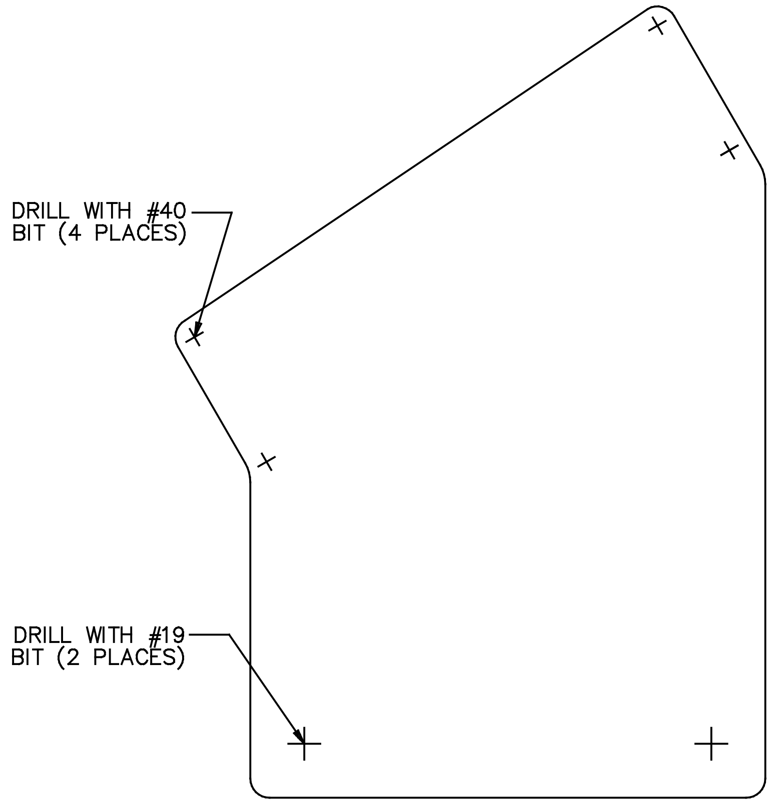

Figure 182: Template for the Right-Hand Trim Gear Box Bracket (Full Size)

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Step 116: Temporarily Mount the Gear Box on the Cage

(Manual Trim Only)

The #19 holes in the lower half of each gear box bracket will accommodate #8 screws into **8-32 nutclips** [257], which will be clipped to AN742D10 **aluminum loop clamps** [263] fastened around the cage tubes. Figure 183 shows the locations of the four clamps. Slip two clamps over the left-hand tube and position them fore-and-aft roughly as shown in the figure—the exact positions aren't important at this stage. Orient these two clamps so that their tabs are **horizontal** and pointing **inboard**. Squeeze the tabs together tightly and slip a nutclip over both tabs, as shown in the detail view of Figure 183, until the screw hole in the nutclip is centered over the hole in the clamp tabs. The nutclip will hold the tabs together, and thus hold the clamp in position on the tube.

The remaining two clamps should be installed in a similar fashion on the right-hand tube of the central truss. However, these clamps should be oriented with their tabs **vertical** and pointing **downward.**

Hint A simple wrap of electrical tape under each clamp will protect the powder coat or primer on your cage tubes from abrasion by the clamps.

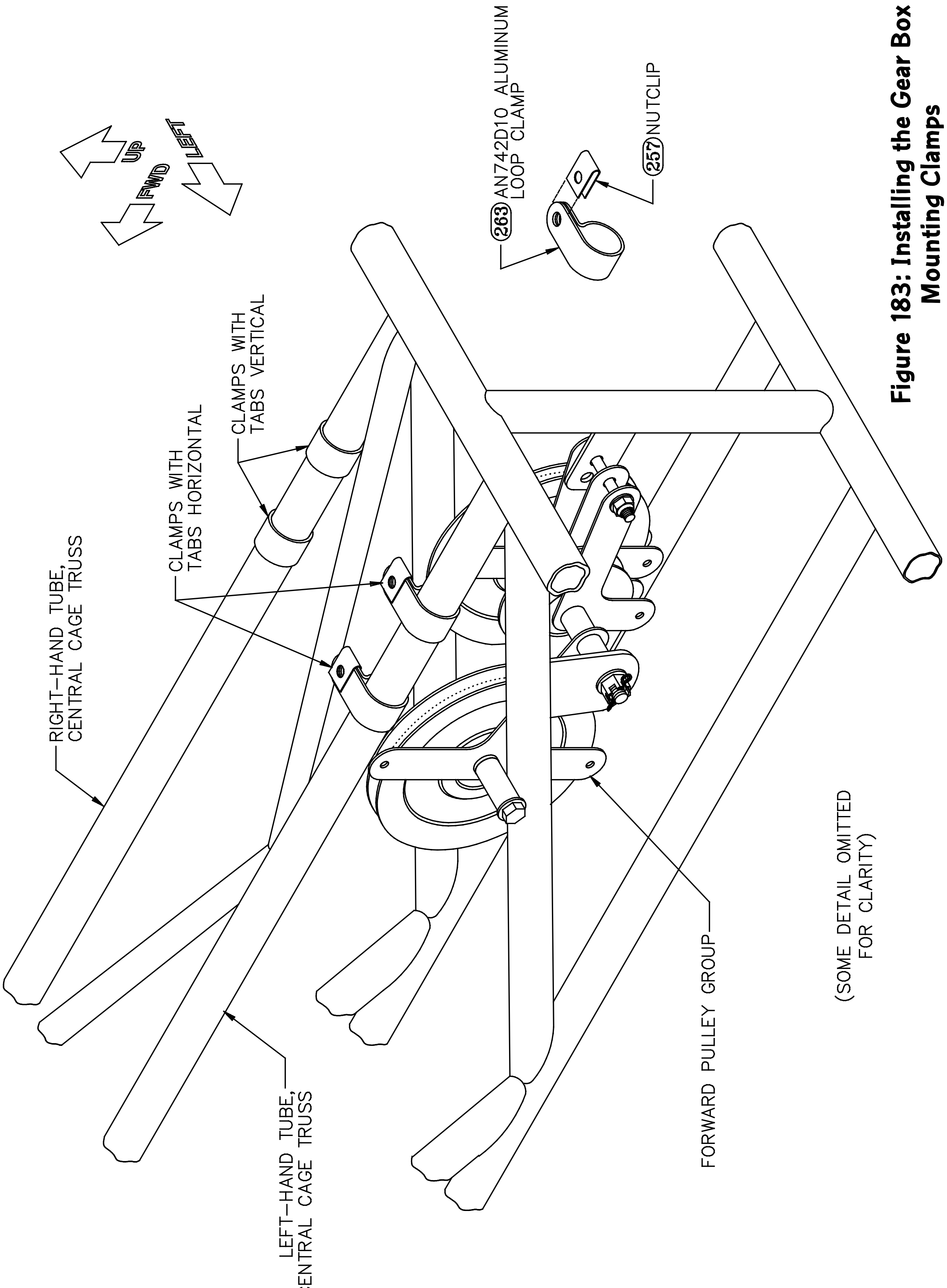


Figure 183: Installing the Gear Box Mounting Clamps

Next, replace the two jam nuts and the washer that you removed from the forward end of the trim cable. Thread these all the way onto the ferrule, with the washer between the two nuts. Then thread the gear box **at least 1/2"** onto the ferrule, stopping when the box is right-side up—that is, with the wheel to the right and the red trim position indicator bar up, as shown in Figure 184. In order to thread the ferrule into the box, you'll have to insert the solid cable end through the small hole in the center of the plastic traveler block; use an Allen wrench to back the set screw out a bit if necessary. With the box in this position, tighten the jam nuts against it to hold it in place.

Now install the brackets on the sides of the gear box. Starting with the left side, remove the four small screws from the box, as shown in Figure 184. Position the left-hand bracket against the box so that the holes match up and re-install the four screws. Then repeat the process on the right side of the box with the right-hand bracket.

Note To gain access to the forward-most pair of right-side screws, simply rotate the trim wheel until the access hole lines up with each screw in turn. **Don't** remove the screws from both sides of the gear box at once, as this will allow the entire worm gear mechanism to fall out of the housing.

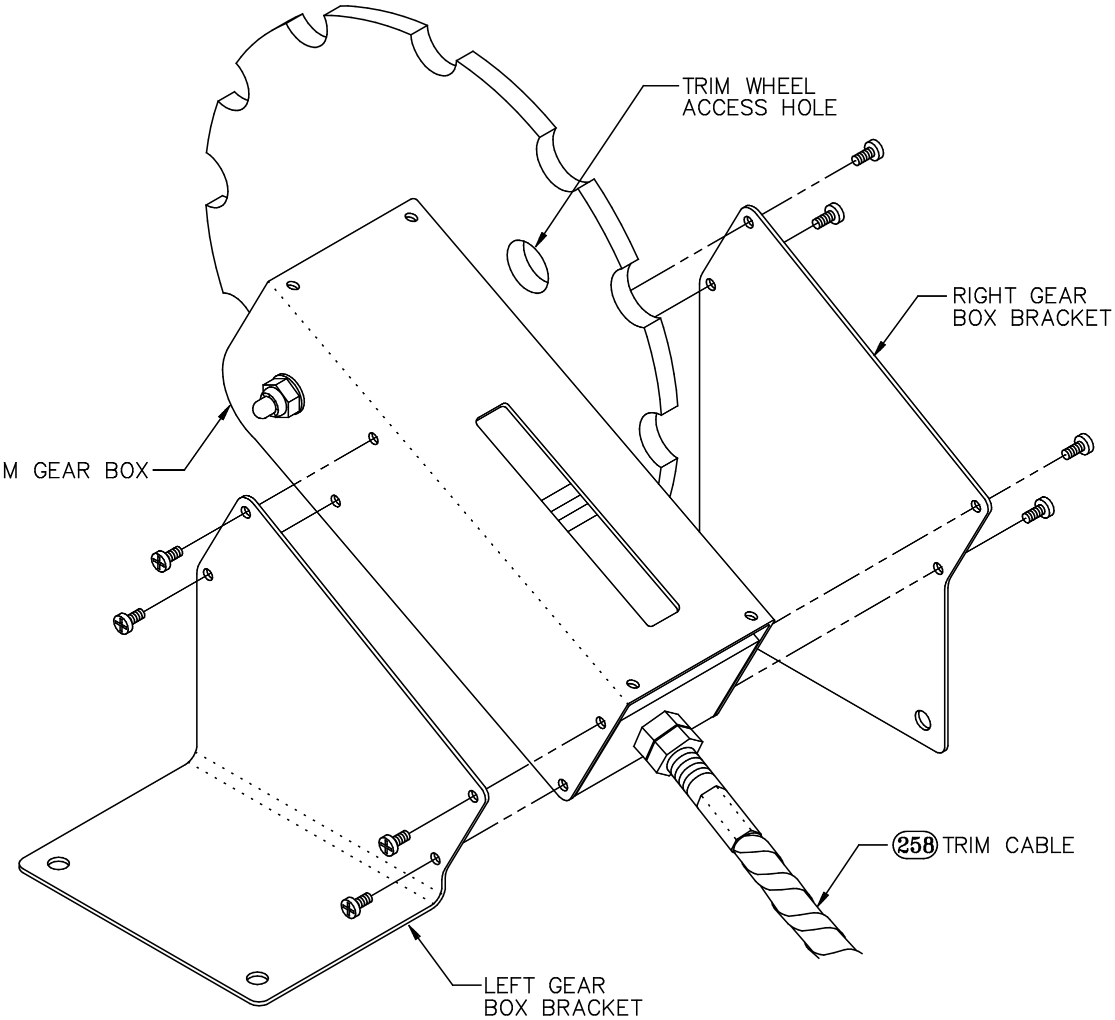


Figure 184: Mounting the Brackets on the Gear Box

Finally, with the brackets in place on the box, use AN526-8R8 **round-head machine screws** [264] to screw the brackets to the nutclips on the tube clamps, as shown in Figure 185. Move the clamps fore and aft as necessary to bring them into alignment with the bracket holes.

Completed: [ ]

Step 117: Secure the Trim Cable to the Airframe Between the Gear Box and Bulkhead B (Manual Trim Only)

Now that both ends of the trim cable are anchored, you can secure it in between. Start from the gear box aft. Use cable ties to bind the cable to the cage structure at several points between the gear box and the aft end of the cage. Be sure that it is secured well clear of all control cables and pulleys. As mentioned before, for much of the run from the gear box to the aft end of the cage, the cable can be bundled along with the fuel line.

From the aft end of the cage to Bulkhead A, the cable must be secured to the fuselage shell about once every **24"**. Small **nylon loop clamps** [256] and AN530-6R4 **self-tapping screws** [265] are provided for this purpose. Drill a **#40** pilot hole through the **inner fuselage laminate only** at each clamp location, loop the clamp over the cable and secure it with the screw, which will penetrate the inner laminate but not the outer. Use an AN960D6 **washer** [267] between the screw and the clamp. The cable should be routed right alongside the belly seam, **but keep it over the foam-core portion of the shell**. Failure to do so will result in a bunch of unsightly screw points hanging out the bottom of your fuselage!

At Bulkhead A, again use a liberal dollop of RTV to pot the cable in place on both sides. Aft of Bulkhead A, use more clamps and screws to secure the cable to the shell—again, about every two feet. The cable should be routed in a gentle curve up the fuselage sidewall toward the pass-through hole in Bulkhead B. However, this is where any remaining slack in the cable must be taken up. Don't make a beeline for Bulkhead B only to end up with a large loop of slack cable when you get there.

Completed: [ ]

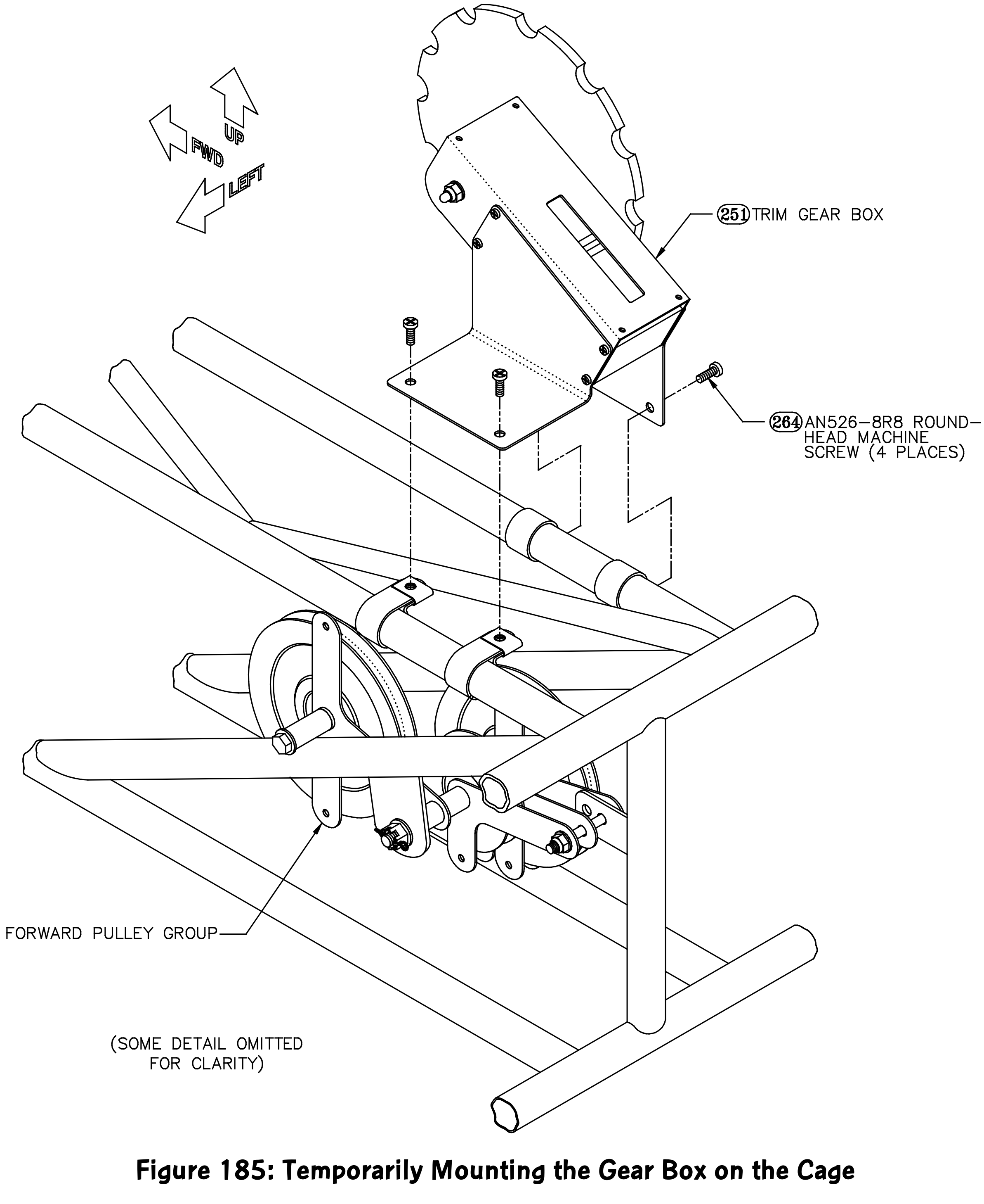


Figure 185: Temporarily Mounting the Gear Box on the Cage

Step 118: Install the Terminal Hardware on the Aft End of the Cable (Manual Trim Only)

Secure the aft, threaded end of the trim cable to the trim tab control horn/ counterweight arm assembly with the hardware shown in Figure 186. Begin by threading an AN315-3R **jam nut** [261] onto the cable end, followed by the **rod end bearing** [254]. Thread the bearing onto the cable end about **1/2"**, stopping when the bolt hole in the bearing is aligned with the hole in the trim tab control horn. Tighten the jam nut against the bearing.

> **Warning** It's **imperative** that the rod end bearing be threaded onto the cable end **at least** beyond the small inspection hole drilled through the shank of the bearing. Test this by inserting a thin piece of wire into the hole. (A bent paper clip will do fine.) If the wire passes through, then the bearing needs to be threaded further onto the rod.

Connect the bearing to the trim tab horn with the hardware shown in the figure: from the left, the AN3-10 **drilled-shank bolt** [259] is inserted through an AN970-3 **large washer** [268], through an AN960-10 **washer** [266], through the bearing, through another AN960-10 washer, through the horn/counterweight arm assembly, and finally through a third AN960-10 washer. The bolt is then secured with an AN310-3 **castle nut** [260] and an AN380-2-2 **cotter pin** [262].

> **Note** You can go ahead and final-safety this bolt by bending the cotter pin ends at this time, because the cable throw will be adjusted at the gear box during "FINAL CONTROL SYSTEM RIGGING" in "SECTION X: FINAL ASSEMBLY."

Completed: [ ]

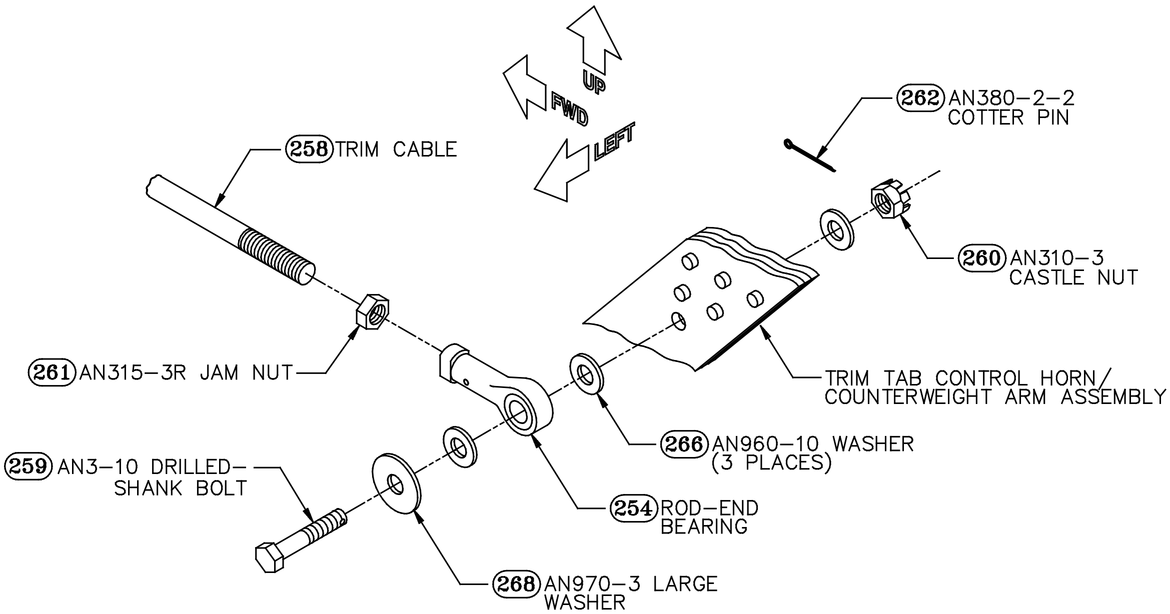


Figure 186: Installing the Terminal Hardware on the Trim Cable End

MISCELLANEOUS FUSELAGE PLUMBING AND WIRING

Step 119: Route the Fuselage Pitot Line

Pitot/Static System Options If you're installing either of Stoddard-Hamilton's pitot/static system option kits, **turn to the option instructions now**. Return to Step 121 of this *Assembly Manual* when the specified option steps have been completed.

☞

The pitot line should be routed from the wing root down the door post, and then forward under the door cutout or up the central cage truss to the pilot's side of the instrument panel. We recommend installing a disconnect fitting near the wing root so that the wings can be removed without cutting the pitot line. Also, because moisture can enter the pitot system through the tube and cause failure or malfunction of the airspeed indicator, we recommend installing a low-point drain in the line somewhere between the wing root and the panel.

Completed: [ ]

Step 120: Install the Static Ports and Lines

The GlaStar pitot/static option kits utilize two custom-designed static ports that are located on the waterline **10"** aft of the cowling joggle on each side of the fuselage. If you choose to install static ports from another source, be aware that this location may no longer be optimal, and inaccurate pressure readings may result.

In any case, since moisture can enter the static system through the ports, make sure that the static lines run only **uphill** from the ports to a common tee connector and then to the instruments.

Completed: [ ]

Note The next several steps all deal with wire routing. Because electrical systems will vary a great deal, no detailed instructions are given for these individual steps. However, keep in mind the following general principles:

1) All wiring should be secured to the fuselage structure at intervals of no more than about **8"**. Be sure to provide adequate chafe protection to wires wherever they might vibrate or rub on any other part of the aircraft.

2) It's good practice to bundle wiring wherever practical. However, keep in mind that not all wires are compatible. In general, high-current wires such as the battery cable and the strobe power leads should be kept separate from antenna cables, and transmitting and receiving antennas should also be separated to the extent practical.

3) Insofar as possible, avoid routing wiring alongside fluid lines. Try also to avoid routing wiring under fluid lines; if the fluid line should leak, it could run down the underlying wiring, causing a short or a fire. Where it is unavoidable to run wiring under a fluid line, route it at right angles to the line. Wiring can always be bundled with pitot and static system lines.

Refer to AC43.13 or any aircraft maintenance handbook for elaboration on standard wire routing practices. See "RECOMMENDED READING" in "SECTION I: INTRODUCTION."

Step 121: Route the Fuselage Nav/Strobe Light Wiring (Optional)

Nav/Strobe Light Option If you're installing Stoddard-Hamilton's Nav/Strobe Light Option Kit, **turn to the *Option Instructions* now**. Return to Step 123 of this *Assembly Manual* when the specified option steps have been completed.
☞

Route the wiring harnesses for any wing lighting you're installing from the wing roots forward to the instrument panel area. We recommend the installation of quick-disconnect plugs near the wing root so that the wings can be removed in the future without cutting any wiring. Also, if you're installing strobes, mount the power supply at this time. We recommend positioning the power supply on the fuselage sidewall aft of Bulkhead A.

Completed: [ ]

Step 122: Route the COM Antenna Cable Forward from the Vertical Fin (Optional)

If you installed a COM antenna inside your vertical fin, you will have left the cable coiled at the base of the fin. Now's a good time to route it forward to the instrument panel area.

Completed: [ ]

Step 123: Route the VOR Antenna Cable Forward from the Vertical Fin (Optional)

If you're installing a VOR antenna on top of your vertical fin, you will have left the cable coiled at the base of the fin. Route it forward to the instrument panel area now. The antenna itself can be installed later in "SECTION X: FINAL ASSEMBLY."

Completed: [ ]

Step 124: Route the Battery Cables (Optional)

The precise placement of the battery is best left to the very end of the assembly process when the airplane has been weighed and you're ready to calculate your weight and balance figures. Retaining flexibility in battery location until the very end can be extremely useful in achieving the desired center of gravity. Nevertheless, in almost all GlaStars, the optimal location for the battery will be somewhere aft of Bulkhead A. This has been true of our prototype with both the Lycoming 0-320 engine installation and the lighter Continental IO-240.

With this in mind, it's easier to route the battery power cable from the aft fuselage to the firewall now rather than waiting until you determine the exact placement of the battery itself. Leave a good bit of extra cable aft of Bulkhead A and forward of the firewall location so you know you'll have enough to complete the installation.

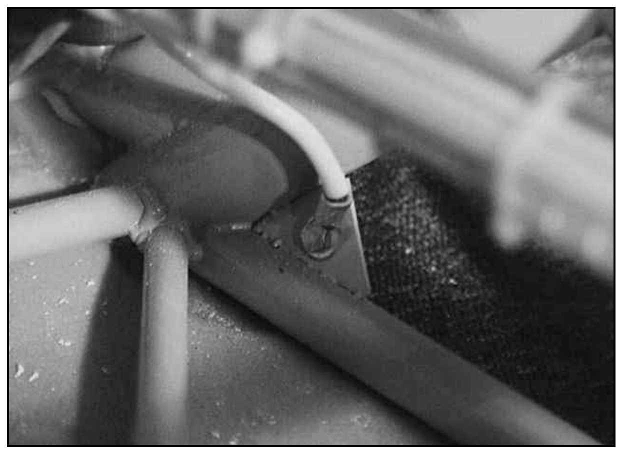


Figure 187: Battery Ground Lead

At this time, also run a ground cable from the cage aft to the battery location. The ground lead can be attached to the cage at any convenient point. Figure 187 shows a neat installation by an early GlaStar builder through the gusset at the base of the right tricycle main gear socket. Remove the paint or powder coating and apply a light grease to the cage under the terminal lug to insure a good electrical connection.

Completed: [ ]

Step 125: Install the ELT and Remote Switch Wiring

An emergency locator transmitter (ELT) with a remote, panel-mounted switch for emergency activation and testing is **required** by current FARs. We recommend installing the ELT on the fuselage side wall aft of Bulkhead A. After installing the unit, route the remote switch wiring forward to the panel area.

Completed: [ ]

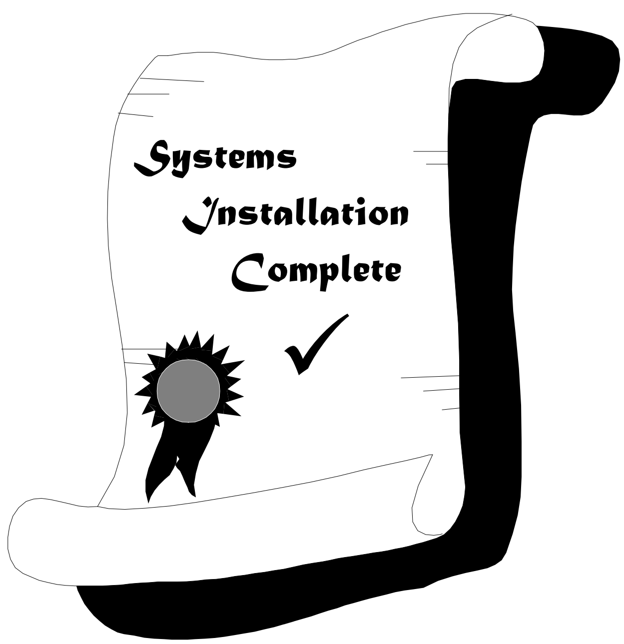
Step 126: Install the Transponder and/or DME Antennas and Cable(s) *(Optional)*

If you're installing a transponder and/or distance measuring equipment, now is a good time to mount the antenna(s). Hopefully, you already installed one or more aluminum ground planes between the cage and fuselage shell. Mount each antenna roughly in the center of a ground plane and route the cable forward to the panel area.

Completed: [ ]

CONGRATULATIONS!

You've conquered systems installation! Now onward to that stage you've been waiting and working so long to reach—**final** assembly!



SECTION X: FINAL ASSEMBLY

MAIN PARTS LIST

Key No.:	Part Name:	Qty:	Part No.:
1	Top deck	1	101-01002-01
2	Lower left wing-fold hatch half	1	101-01003-01
3	Lower right wing-fold hatch half	1	101-01003-02
4	Upper left wing-fold hatch half	1	101-01003-03
5	Upper right wing-fold hatch half	1	101-01003-04
6	Baggage door	1	101-01004-01
7	Tailcone [from Sect. VIII]	1	101-01005-03
8	Rudder base fairing	1	101-01006-03
9	Lower left horizontal stabilizer strake half	1	101-01501-01
10	Lower right horizontal stabilizer strake half	1	101-01501-02
11	Upper left horizontal stabilizer strake half	1	101-01501-03
12	Upper right horizontal stabilizer strake half	1	101-01501-04
13	Left cabin door	1	101-10001-01
14	Right cabin door	1	101-10001-02
15	Aft lower door hinge half, left	1	101-10041-01
16	Aft lower door hinge half, right	1	101-10041-02
17	Aft upper door hinge half, left	1	101-10051-01
18	Aft upper door hinge half, right	1	101-10051-02
19	Forward left door hinge half	2	101-10052-01
20	Forward right door hinge half	2	101-10052-02
21	Windshield	1	101-14001-01
22	Left door window	1	101-14002-01
23	Right door window	1	101-14002-02
24	Left quarter window	1	101-14003-01
25	Right quarter window	1	101-14003-02
26	Skylight	2	101-14004-01
27	Forward upper door latch, left	1	101-16001-01
28	Forward upper door latch, right	1	101-16001-02
29	Center door latch, left	1	101-16003-11

30	Center door latch, right	1	101-16003-12
31	Exterior door handle	2	101-16008-01
32	Inboard/outboard flap cove skin	2	201-00020-01
33	Center flap cove skin	2	201-00020-03
34	Aileron cove skin	2	201-00023-01
35	Wing trailing edge doubler	8	201-00026-01
36	Left aileron counterweight	1	201-15015-01
37	Right aileron counterweight	1	201-15015-02
38	Lower left wingtip fairing half	1	201-20001-01
39	Lower right wingtip fairing half	1	201-20001-02
40	Upper left wingtip fairing half	1	201-20002-01
41	Upper right wingtip fairing half	1	201-20002-02
42	4.45" inspection hole cover [from Sect. IX]	4	201-33001-01
43	6.2" X 4.7" inspection hole cover [from Sect. IX]	2	201-34001-01
44	5.75" inspection hole cover [from Sect. IX]	4	201-35001-01
45	Fuel cap	2	201-40001-01
46	Fuel tank filler neck [from Sect. IX]	2	201-40002-01
47	Rudder tip fairing	1	301-00015-03
48	Horizontal stabilizer tip fairing	2	302-00015-03
49	Elevator tip fairing	2	303-00014-03
50	Control stick	2	601-01500-01
51	Left seat pan	1	802-00001-01
52	Right seat pan	1	802-00001-02
53	Seat back	2	802-02000-03
54	Seat base	2	802-03000-03
55	Inboard seat track	2	802-04000-01
56	Left outboard seat track	1	802-05000-01
57	Right outboard seat track	1	802-05000-02
58	Aft control cable cover angle	2	805-01003-01
59	Forward control cable cover angle	2	805-02003-01
60	Threaded steel rod, 1/4"-28	18 in.	015-02001-01
61	DBM cloth, 3" width [from Sect. VIII]	n/a	027-00002-01
62	Firewall template	1	040-00110-01
63	Instrument panel template	1	040-00125-01

64	Acorn nut	16	064-00001-01
65	Rivnut	2	064-00003-01
66	Nutclip	12	064-00004-01
67	Aluminum sheet, .020" X 24" X 30"	1	075-01020-01
68	Aluminum sheet, .020" X 12" X 36"	2	075-01022-01
69	Aluminum sheet, .032" X 16" X 16"	1	075-01031-01
70	Aluminum sheet, .063" X 12" X 43"	1	075-01060-03
71	Aluminum sheet, .090" X 3" X 9"	1	075-01090-01
72	Stainless steel sheet, .016" X 32" X 42"	1	075-03001-01
73	Stainless steel sheet, .016" X 4-1/8" X 32"	4	075-03002-01
74	Stainless steel sheet, .090" X 3/4" X 24"	1	075-03003-01
75	Door latch over-center spring, aft	2	077-00002-01
75.1	Door latch over-center spring, forward	2	077-00002-02
76	Seat-back adjustment locking pin spring	4	077-00003-01
77	Rubber hose, 5/8" [from Sect. IX]	approx. 30 in.	083-00001-01
78	Nylon washer, .032" [from Sect. VIII]	n/a	085-00003-01
79	Nylon washer, .064" [from Sect. VIII]	n/a	085-00004-01
80	Nylon washer, small	4	085-00005-01
81	Aluminum angle, .063" X 1/2" X 1/2"	120 in.	100-0640-002
82	Aluminum angle, .063" X 1" X 1" [from Sect. VIII]	approx. 14 in.	100-0640-003
83	Cable tie, 4" [from Sect. IX]	n/a	210-0018-001
84	Phenolic sheet, 3/16" X 3" X 4"	1	210-0495-008
85	MEKP catalyst [from Sect. VIII]	n/a	270-0105-001
86	Bi-directional cloth, 50" width [from Sect. VIII]	n/a	270-0110-002
88	Foam sheet, 5-lb., 1/2" X 12" X 12"	3	270-0123-407
89	Foam sheet, 40-lb., 1/2" X 3" X 4"	1	270-0126-408
90	Mill fiber [from Sect. VIII]	n/a	270-0130-001
91	Cabosil	100 g	270-0131-102
92	Cobalt promoter [from Sect. VIII]	n/a	270-0135-001
93	DMA accelerator [from Sect. VIII]	n/a	270-0135-002
94	Q-cell [from Sect. VIII]	n/a	270-0140-001
95	Vinyl ester resin [from Sect. VIII]	n/a	270-0155-001

96	Drain valve	2	320-0334-001
97	Finger screen	2	330-0340-001
98	Roll pin, 1/8" X 5/8"	2	450-0070-003
99	Hose clamp, 7/32"–5/8"	4	450-0190-004
100	Roll pin, 3/32" X 1/2"	4	450-0420-003
101	UHMW polyethylene, .125" X 2" X 2"	1	620-0420-001
102	Door seal	26 ft.	620-4100-316
103	Knob	2	622-1050-001
104	Aluminum blind rivet, 3/32"	92	700-0003-002
105	Aluminum blind rivet, 1/8"	4	700-0045-001
106	Stainless steel rod, 1/4"	18 in.	710-0420-001
107	Self-tapping screw, #6 X 3/8"	2	720-0420-004
108	Aluminum sheet, .125" X 6" X 12"	1	750-0280-004
109	Lead sheet, 12" width [from Sect. III]	n/a	750-0372-002
110	Aluminum tubing, 5/16", 6061-T6	12 ft.	820-0623-001
111	Bolt	4	AN3-10A
112	Bolt	4	AN3-13A
113	Bolt	46	AN3-4A
114	Bolt	9	AN3-5A
115	Bolt	6	AN3-6A
116	Bolt	4	AN3-7A
117	Jam nut	20	AN315-3R
118	High-temperature self-locking nut	2	AN363-1032
119	High-temperature self-locking nut	10	AN363-832
120	Nylon self-locking nut	101	AN364-1032A
121	Nylon self-locking nut	13	AN364-428A
122	Nylon self-locking nut	4	AN364-832A
123	Nylon self-locking nut	9	AN365-428A
124	Bolt	1	AN4-10A
124.1	Bolt, drilled-shank	2	AN4-11
125	Bolt	2	AN4-12A
126	Bolt	4	AN4-14A
127	Bolt	2	AN4-26A
128	Bolt	1	AN4-32A
129	Bolt	6	AN4-5A

130	Bolt	4	AN4-6A
131	Flush-head machine screw [from Sect. VIII]	n/a	AN507-10R16
132	Flush-head machine screw [from Sect. VIII]	n/a	AN507-10R20
133	Flush-head machine screw	2	AN507-8R8
134	Flush-head machine screw	2	AN509-10R13
135	Flush-head machine screw	16	AN509-10R18
136	Flush-head machine screw	16	AN509-10R20
137	Flush-head machine screw	4	AN509-10R24
138	Round-head machine screw	2	AN515-8R10
139	Round-head machine screw	92	AN526-8R6
140	Round-head machine screw	76	AN526-8R7
141	Round-head machine screw	52	AN526-8R8
142	45° aluminum elbow	2	AN844-6D
143	Plug	2	AN913-1D
144	Lock washer	20	AN936A10
145	Washer	25	AN960-10
146	Thin washer	58	AN960-10L
147	Washer	14	AN960-416
148	Thin washer	13	AN960-416L
149	Washer	30	AN960-8
150	Thin washer	10	AN960-8L
151	Aluminum washer	50	AN960D10
152	Thin aluminum washer	48	AN960D10L
153	Aluminum washer	28	AN960D416
154	Thin aluminum washer	14	AN960D416L
155	Thin aluminum washer	15	AN960D8L
156	Large washer	9	AN970-3
157	Large washer	8	AN970-4
158	Nutplate	130	K1000-08
159	Nutplate	10	K1000-3
160	Nutplate	2	K1000-4
161	Nutplate	2	K2000-08
162	Floating nutplate	9	MF5000-08
163	Rolled hinge with pin	19 in.	MS20257P2
164	Rolled hinge with pin	72 in.	MS20257P2

165	Monel universal-head rivet, 1/8"	62	MS20615-4M3
166	Turnbuckle locking clip	11	MS21256-1
167	Steel spacer	6	NAS43HT4-12
168	Round-head machine screw	12	NAS603-7P
169	Plain steel bushing	8	NAS75-3-004

Common Standard Landing Gear Parts List

Note The instructions in this section cover final assembly procedures for the standard, 5.00 X 5 tricycle **and** taildragger landing gear options, and the following list includes parts that are common to these two installations. The 6.00 X 6 and 8.00 X 6 taildragger options are covered in separate option instructions. Landing gear-related parts that are common to **all four** installations are included in the MAIN PARTS LIST above.

Key No.:	Part Name:	Qty:	Part No.:
170	Main wheel pant, left half	2	401-00020-01
171	Main wheel pant, right half	2	401-00020-02
172	Foam, 5 lb., .250" X 12" X 12"	2	270-0123-107
173	Foam, 20 lb., .250" X 2" X 4"	1	270-0125-103
174	Foam, 20 lb., .500" X 3" X 3"	1	270-0125-410
175	Tinnerman washer	8	850-3235-028
176	Tinnerman washer	2	850-3475-020
177	Flush-head machine screw	8	AN507-10R14
178	Flush-head machine screw	2	AN509-416R12
179	Floating nutplate	8	MF5000-3

STANDARD TRICYCLE LANDING GEAR PARTS LIST

Note The following list contains parts that are unique to the standard, 5.00 X 5 tricycle landing gear installation.

Key No.:	Part Name:	Qty:	Part No.:
180	Left nose gear leg fairing half	1	302-5411-001
181	Right nose gear leg fairing half	1	302-5411-002
182	Left nose wheel pant half	1	302-5412-001
183	Right nose wheel pant half	1	302-5412-002
184	Aluminum sheet, .063" [from Sect. VIII]	n/a	075-01011-01
185	Hose clamp, 11/16"–1-1/4"	2	450-0190-007
186	Flush-head machine screw	11	AN507-6R7
187	Flush-head machine screw	4	AN509-10R7
188	Flush-head machine screw	4	AN509-8R8
189	Floating nutplate	11	MF5000-06
190	Floating nutplate	4	MF5000-08
191	Floating nutplate	2	MF5000-3
192	Rolled hinge with pin	18"	MS20257P4

MANUAL TRIM SYSTEM PARTS LIST

Note The following list contains parts that are unique to the manual trim installation. The electric trim installation has a separate parts list contained in the *Option Instructions*.

Key No.:	Part Name:	Qty:	Part No.:
193	Cable clamp [from Sect. IX]	2	045-02001-01

PARTS LIST ERRATUM

Note The following list contains a part that was inadvertently omitted from the MAIN PARTS LIST.

Key No.:	Part Name:	Qty:	Part No.:
194	Nylon loop clamp, 1/4"	2	450-0006-250

TOOL LIST

1. Steel ruler, 12"
2. Fine-tipped marking pen
3. Band saw or hacksaw
4. Wrenches (sizes 3/8" to 3/4"), screwdrivers, hammers and other common hand tools
5. Center punch
6. Electric or pneumatic drill motor with the following bits: #40, #30, #19, #10, #1 (optional); 1/16", 3/32", 1/8", 11/64" (optional), 3/16", 15/64" (optional), 1/4", 5/16", 3/8"; and “A” (optional), “B” (optional) and “F”
7. Hole deburring tool
8. Assorted fine-toothed files
9. Edge deburring tool (optional)
10. Belt sander (recommended)
11. Scissors
12. Offset sheet-metal snips
13. Straightedges, 18" and 48"
14. Measuring tape
15. Hand seamer (recommended)
16. Bench brake (optional)
17. Bench vise
18. Cleco side-grip clamps or small C-clamps (10-12)
19. #30 extension bit or right-angle drill motor with #30 bit
20. Clecos, 3/32", 1/8" and 5/32", with pliers
21. Air compressor
22. Rivet gun with 1/8" and 3/32" universal sets and flush set
23. Bucking bars
24. Microstop countersink tool with #40, #30, #19, #10 and 1/4" piloted 100° cutters
25. Rivet squeezer with flush set (recommended)
26. Heavy-duty scissors or rotary cloth cutter
27. Resin brushes (one with 14" handle extension)
28. Die grinder with rotary file (recommended)

29. Right-angle drill motor or adapter with #19 and #10 bits
30. 3/32" dimple dies
31. Hole saws, 1/2", 3/4" and 1", or equivalent Unibit(s)
32. Single-ended hacksaw
33. Sheet metal edge rolling tool (optional)
34. Saber saw with carbide grit blade or rotary cutting tool on die-grinder (optional)
35. Bench grinder (optional)
36. Drill press (recommended)
37. Blind rivet puller
38. Digital level (optional)
39. Framing square
40. Large channel-lock pliers
41. Plumb bob
42. Utility knife
43. Scroll saw (optional)
44. Q-cell fillet “radius tool” (see description in Step 33)
45. Heat gun (optional)
46. Rivnut installation tool
47. Sanding blocks, long and short
48. Portable work light and/or flashlight
49. Hot-melt glue gun (optional)
50. Small sanding drum for drill motor or drill press (recommended)
51. 100° countersink bit (uncaged)
52. Spirit level
53. Narrow rat-tail file (optional)
54. Large C-clamps
55. Try square
56. Rubber mallet or lead body hammer
57. Duck bill pliers or safety wire twisters
58. Vise-grip pliers
59. Scriber
60. Non-metallic abrasive wheel in a bench grinder or drill motor (optional)
61. Hole saws, 2-1/4" and 3-1/8", or equivalent fly-cutter or instrument panel cutout dies
62. Vise-grip style locking C-clamps
63. Tubing cutter (recommended)
64. Cable tensiometer
65. Scale accurate to the nearest ounce
66. Articulated inspection mirror
67. 3/32" Allen wrench
68. 1/4"-28 die and handle
69. Aircraft scales

ADDITIONAL MATERIALS

1. Sandpaper, assorted sheet sizes and grits, 220–60
2. Anti-corrosion protection materials
3. Scrap cardboard
4. Rubber cement or artist's spray glue

5. Five 3/8"-diameter, 1/2"-long bolts and nuts (hardware-store quality)
6. Miscellaneous scrap wood blocks, 1 X 4, 2 X 4, 2 X 8, etc.
7. Shop stool or sawhorse
8. CP-25 fire barrier caulk (recommended; available from S-H — P/N 270-0132-001)
9. UHMW polyethylene anti-chafe tape
10. Wide masking tape or duct tape
11. Mold release wax or non-silicon paste wax
12. Acetone
13. Unwaxed resin mixing cups
14. Resin mixing sticks
15. Latex surgical gloves
16. Two pieces of 1/4" X 24" X 15" marine plywood
17. Polyurethane varnish, epoxy paint or equivalent
18. Small amount of household paint, any type or color
19. Light axle grease
20. Push pins or thumb tacks
21. Lightweight body filler (e.g., Bondo)
22. Hot-melt glue
23. Sand or shot bags
24. 20" length of broom stick, wooden dowel or 1" pipe
25. 20" length of 1 X 4
26. 38" length of 1/4" dowel or 1/4"-thick scrap wood strip
27. WD-40, LPS or equivalent spray lubricant
28. Household epoxy (either 5-minute or long-curing is fine)
29. Modeling clay
30. Small scrap lengths of hardware-store 1" X 1" aluminum angle stock
31. Short length of 1"-diameter pipe or dowel
32. .032" stainless steel safety wire
33. Permatex High Tack Adhesive Sealant or equivalent
34. Wire marking materials
35. Nylon cable ties
36. Black vinyl striping tape, 1/2" width
37. Masking tape, 3/4" width
38. Masking paper
39. Black pigment for window bonding (order P/N 027-01000-01 or use used copier toner)
40. Witness paint (order Torque Seal from S-H; P/N 620-0642-501)

WORKSPACE

A good bit of work remains to be accomplished before the wings are mated to the fuselage for the final time, and therefore, there's no immediate need to abandon the friendly confines of your shop for the airport. Keep in mind, however, that when you mount your engine, the fuselage length will suddenly grow by close to 4', not including whatever space you take up while working. Also bear in mind that you'll need either a portable engine hoist and room to maneuver it or an overhead beam in the right place for a come-along or chain hoist.

Ultimately, of course, you'll have to mount the wings permanently, and there's a considerable amount of work that's best done after this has been accomplished. If you have a hangar lined up at the airport, you might prefer to move your GlaStar to its new home before mounting the wings. Alternatively, you can move the airplane outside your shop to mount the wings and finish the remaining work, either covering it with tarps or folding the wings and pulling it back inside at the end of the day. That's GlaStar versatility!

ASSEMBLY SEQUENCE

Details, details, details! This is the part of aircraft construction that many builders find frustrating—their project looks like an airplane and they want to go flying! But of course, there's still a lot of work to be done—some have said that 90% of the work of building an airplane is in the last 10% of the job. Don't let this get you down! Just strive to make steady progress through the pages of this final section of the *Manual*, keeping in mind that while there are a lot of tasks left, they're almost all little ones. In fact, if you approach these final jobs with the right attitude, you may find them to be among the most satisfying ones, because this is where you can really put your own stamp of individuality on your GlaStar.

This section of the *Manual* presents the remaining tasks in an order that we find most logical, but there is a lot more flexibility here than in earlier sections. Although you will generally be more productive if you follow a specific plan and finish one task before beginning the next, you should divide this work up in whatever way keeps you most motivated, and if that entails skipping around, just make sure that you don't leave any steps out before calling in the FAA!

The suggested order of major tasks is as follows:

1) **Firewall Installation**: cutting and joining the firewall and the mounting flanges, and installing the completed firewall assembly in the fuselage shell.
2) **Firewall Forward**: installing the engine, propeller, spinner, cowling and related systems.
3) **Interior Installation**: installing the baggage bulkhead close-out, control cable covers, floorboards, seat pans and seats, and optional cabin air vents.
4) **Fuselage Fairing Installation**: installing the horizontal stabilizer strakes, rudder base fairing, tailcone and rudder tip fairing.
5) **Gear Fairing Installation**: installing the wheel pants and gear leg fairings.
6) **Final Wing Assembly**: riveting the upper and cove skins; installing the fuel tanks and finalizing the details of the wing fuel system; riveting the root ribs; fabricating the delta wings; installing the wingtip fairings; and final-mounting the wings on the fuselage.
7) **Door Installation**: fitting and installing the cabin and baggage doors, as well as the latch and optional lock mechanisms.
8) **Top Deck Installation**: installing the cabin roof and the wing-fold hatches.
9) **Instrument Panel Installation**: installing and wiring the instrument panel and installing the glare shield.
10) **Window Installation**: installing the skylights, quarter windows, door windows and windshield.
11) **Control Surface Balancing and Fairing Installation**: installing the aileron counterweights; calculating and installing the elevator and trim tab counterweights; and installing the horizontal stabilizer and elevator tip fairings.
12) **Final Control System Rigging**: adjusting control surface travel, and tensioning and safetying the control cables.
13) **Miscellaneous Final Assembly Details**: installing the fuel gauges, delta wings, optional antennas, seat belts and shoulder harnesses, manual trim system travel stops, etc.
14) **Weight and Balance**: weighing the completed aircraft, calculating weight and balance figures, and fabricating and installing the battery tray.

15) **Systems Check-Out**: final testing of aircraft systems prior to taxi and flight testing.

16) **Fastener Inspection and Safetying**: inspecting and safetying all flight-critical fasteners, and installing all inspection covers, interior components, fairings, etc.

17) **Go Flying!**

Firewall Installation

Step 1: Fabricate and Install the Instrument Panel Angle Brackets

The first step in the firewall installation doesn't really have anything to do with the firewall, but it needs to be accomplished now because there will be no access for this task after the firewall is in place. The instrument panel is braced along its upper edge by two lengths of aluminum angle that run forward from the panel to the front of the cage. At the forward end, these braces are bolted to angle brackets, which in turn are bolted to the inboard pair of triangular forward shell attach fittings. As you may recall, you laminated and riveted these fittings to the fuselage shell and bolted them to the cage in "Section VIII: Fuselage Assembly." You used AN3-4A bolts with the heads forward. These bolts will also be used to secure the panel brace angle brackets, and it is their heads that are inaccessible once the firewall is installed.

As shown in Figure 1a, the angle brackets are cut from the length of **.063" X 1" X 1" aluminum angle** [82] left over from "Section VIII: Fuselage Assembly." Cut two brackets, each **3/4"** long. Then mark and drill a hole approximately in the center of each flange—a **#19** hole in one flange and a **#10** hole in the other. The locations of these holes aren't critical—just eyeball them. Sand or file the cut edges smooth and deburr the holes. Corrosion-proof both brackets if you wish.

Figure 1b shows how the brackets should be installed on the inboard forward shell attach fittings. First, remove the AN364-1032A nylon self-locking nut and AN960D10 aluminum washer from the AN3-4A bolt securing the fitting to the cage tab. Slide the #10 hole in the angle bracket over the end of the bolt, orient the bracket as shown with its other flange **inboard**, and then replace the washer and nut.

You will return to these brackets in the "Instrument Panel Installation" sub-section below.

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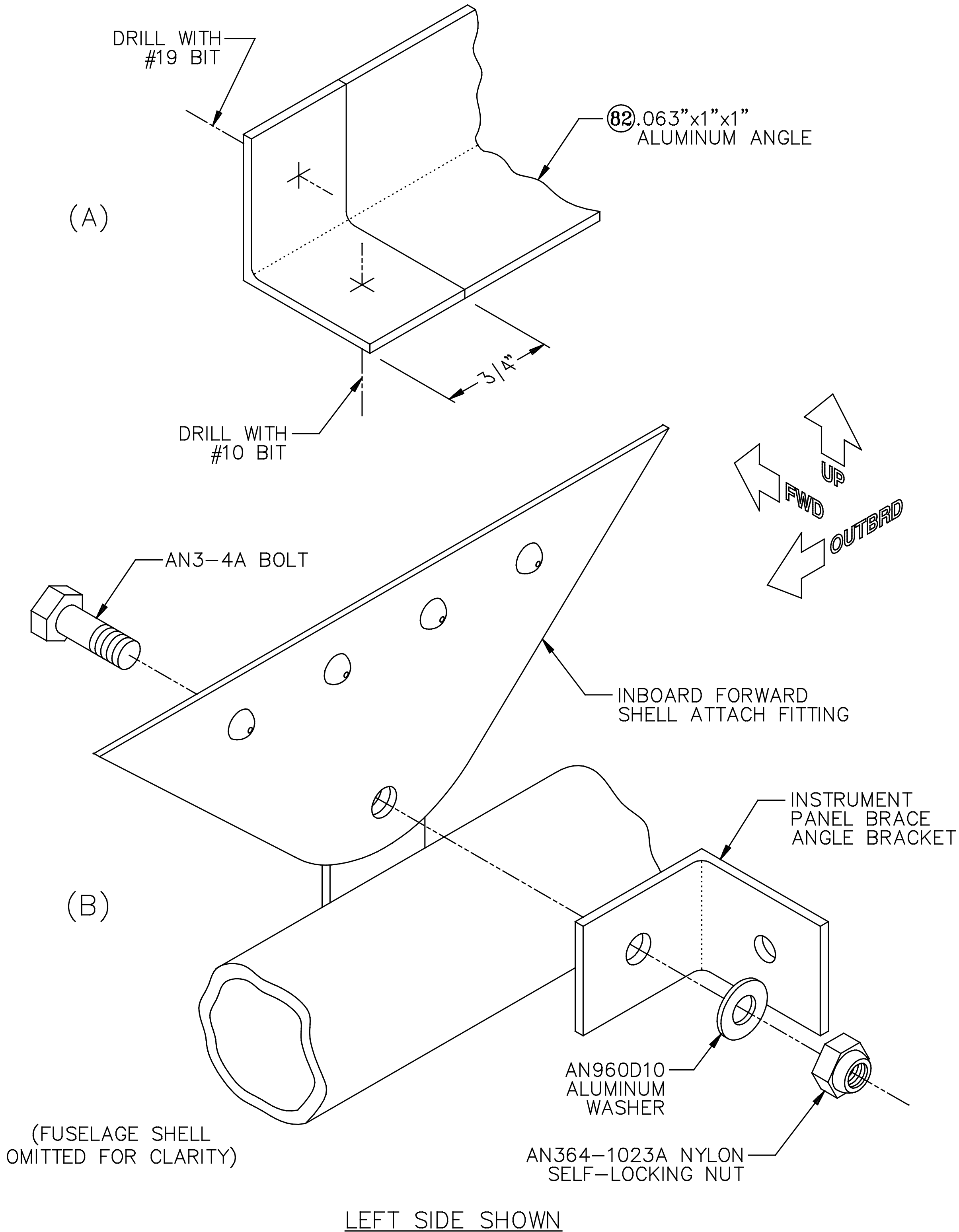

Figure 1: Fabricating and Installing the Instrument Panel Brace Angle Brackets

Hint A final checklist of fastener safetying procedures is included in the "FASTENER INSPECTION AND SAFETYING" sub-section later in this *Manual*, but there's nothing that says you can't get in there now while the getting's good to do most of the cotter pinning and witness painting in the forward part of the cage. If you wait until after the firewall is installed, you'll be doing these on your back with a flashlight, a mirror and a long pair of tweezers!

Step 2: Fabricate the Firewall Components

As Figure 2 shows, the firewall assembly consists of a firewall and four flanges The flanges are riveted to the firewall, and then the entire assembly is slid into the fuselage from the front until the firewall contacts the cage structure. The flanges are then flush-riveted to the cowling mounting flange on the fuselage shells. In this step, you will cut out the firewall and flanges and in subsequent steps you will join them and install the completed assembly.

Begin by using the supplied **firewall template** [62] to cut out a cardboard blank of the firewall to test for fit. Like all the paper templates supplied in the kit, this one was taken from a very early GlaStar and may not match your fuselage opening very precisely in size or shape. Trim the cardboard blank until it just fits between the fuselage shells. You'll notice that, because of the taper of the shells, a tight fit at the forward edge of the cowling flange translates into a slight gap all the way around the blank when it is pushed back against the cage structure. Don't worry about this—it's no problem at all.

Tricycle Landing Gear Option As you go to trial fit your cardboard firewall template, you'll notice immediately that the nose gear leg is in the way! Support the nose of the aircraft on a sawhorse, remove the main bolt and pull the leg temporarily. Use trial and error to cut a slightly oval hole in the firewall template to accommodate the leg. Then set the leg aside; you will reinstall it after the firewall is assembly is riveted in place.

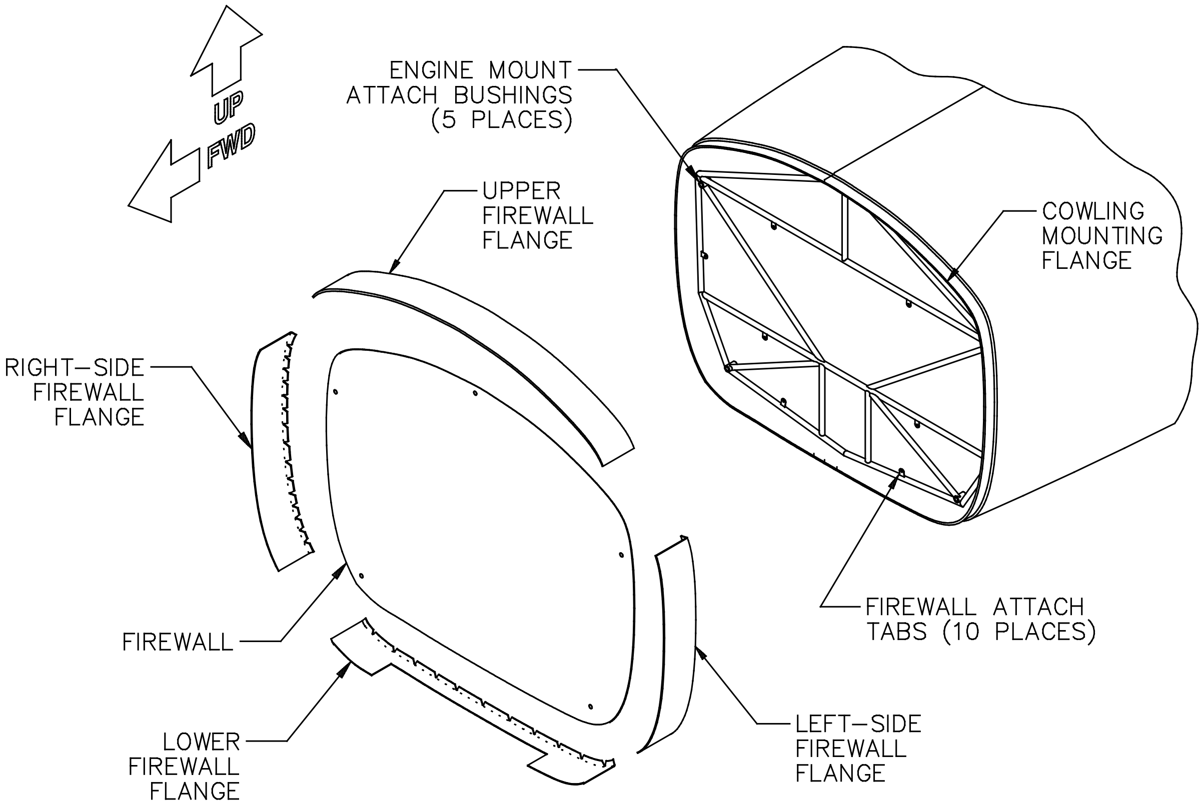

Figure 2: Firewall Assembly

When you're satisfied with the fit of your cardboard template, use it to cut the actual firewall from the supplied **.016" X 32" X 42" stainless steel sheet** [72]. Thoroughly deburr the cut edges.

Caution Shearing stainless steel leaves an especially sharp burr that can inflict some nasty cuts, so be careful handling the firewall and the firewall flanges until they have been deburred.

Figure 3 shows the dimensions for cutting out the flanges; Figure 3a covers the upper and lower flanges, and Figure 3b shows the dimensions of the side flanges. Each flange is cut from one of the supplied **.016" X 4-1/8" X 32" stainless steel sheets** [73].

To cut the flanges, begin by laying out the locations of the crack-stop holes on a line **5/8"** from the aft edges of all four of the flanges in the locations shown in Figures 3a and b. Use a **#30** or a **1/8"** bit to drill these holes, and then deburr them. These holes will form a smooth radius at the "bottom" of each of the **60°** notches shown in the figure, preventing the formation or propagation of cracks in the stainless steel. The notches in turn allow easy bending of the tabs through which the flanges will be riveted to the firewall. Use your sheet metal snips to cut the notches, carefully deburr the cut edges, and then use a **#40** bit to drill a pilot hole through the center of each resulting tab.

> **Note** As indicated in Figure 3, omit the holes at **both** ends of the **lower** flange and at the **upper** end of **both side** flanges.

Next, lay out the **lengthwise** locations of the rivet holes along the **forward** edges of all four firewall flanges, as shown in Figures 3a and b. Since the forward edges of the flanges will be trimmed further in a later step, you cannot lay out the distances of these holes from the edges at this time, but after final edge trimming, the holes will be positioned **1/4"** in from the edge.

> **Note** As indicated in Figure 3a, these forward-edge hole locations can be omitted for **10"** on either side of the centerline on the **lower** flange only. The flange will ultimately be relieved in this area to provide a cooling air exit from the cowling (see Figure 2).

> **Note** Do **not drill** any of the rivet holes through the forward edges of the firewall flanges at this time. These holes will be drilled later, after the firewall assembly has been fitted to the fuselage shell.

Use a hand seamer, a small bench brake or a form block in a vise to bend up the tabs on all of the firewall flanges. The bend line should go right through the middle of the crack-stop radii at the "bottom" of the notches. Be careful to bend the tabs on the **side** flanges in the proper direction to make mirror-image parts (since both the upper and lower flanges are completely symmetrical, they will work no matter which direction the tabs are bent).

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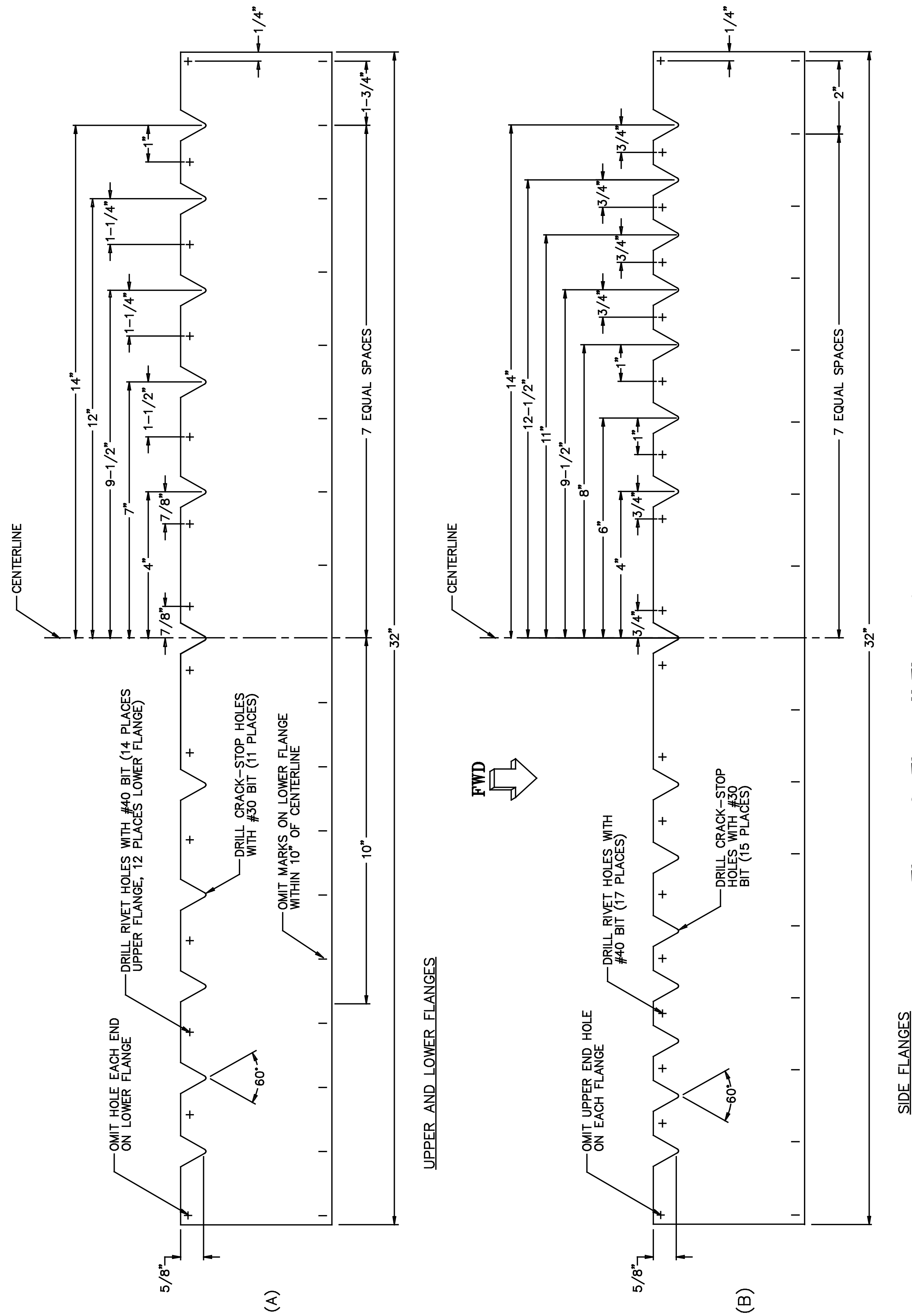

Figure 3: Firewall Flange Layout

Step 3: Fit the Firewall to the Fuselage and Drill the Engine Mount Bolt and Attach Tab Holes

Fit the firewall sheet into the front of the fuselage and position it so that the gap between the firewall and the inside of the shell is as equal as possible all the way around, as shown in Figure 4. Have a helper hold the firewall sheet in position from the forward side while you mark the positions of the five **3/8"** engine mount bolt holes from the aft side (or vice versa, if you can con your helper into crawling inside the cage!).

Note If you have a very compact drill motor, you might be able to drill the holes right through the cage engine mount bushings with the firewall in place. Otherwise, mark each hole location by inserting a 3/8" drill bit through each bushing until it contacts the firewall and then spinning it with your fingers. Alternatively, use a felt-tip pen to mark the hole locations; a "Pilot RAZOR POINT II" fits the cage bushings very well. Then remove the firewall and drill a **3/8"** hole at each of the five marked locations. Begin by drilling a hole 1/4" in diameter or smaller, and then finish up either with a Unibit or by step drilling up to final size in 1/16" increments

After the five **3/8"** engine mount bolt holes have been drilled, pin the firewall in place temporarily with hardware-store 3/8" nuts and bolts. Then, crawl back inside the cage and drill through each of the ten cage attach tabs and the firewall with a **#19** bit, while your helper supports the firewall in position from the front. Pressing a scrap wood block against the forward side of the firewall opposite the bushing being drilled will help.

Note Don't sweat it too much if you have trouble keeping all these holes aligned; they can easily be filed to fit later.

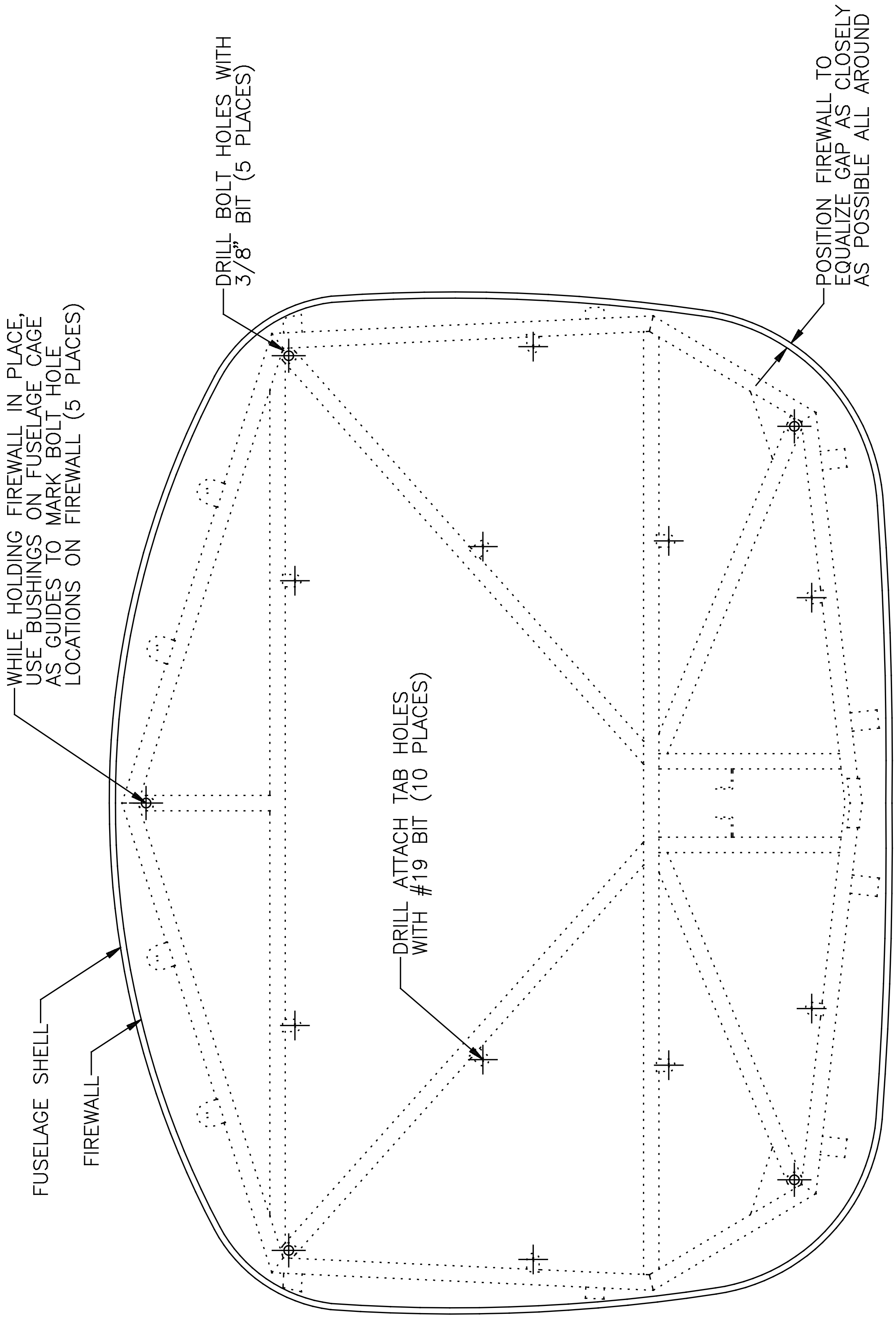

Figure 4: Drilling the Engine Mount Bolt and Attach Tab Holes

Remove the firewall and deburr all the holes. Also, deburr the cage attach tabs. Then replace the firewall, again securing it to the cage with the 3/8" bolts.

Fit the **lower** firewall flange inside the fuselage shell, bending it to match the contour of the shell. Center the flange laterally on the firewall and butt the bent tabs on the aft edge of the flange against the firewall sheet. Use several small C-clamps or Cleco side-grip clamps to secure the forward edge of the firewall flange to the cowling flange of the fuselage shell. Repeat for the two side flanges and then the upper flange. Adjust the positions of the side flanges vertically so that the overlap between the flanges is equal at all four corners.

Note It's important to install the firewall flanges in the order described in the previous paragraph: lower flange, side flanges and then upper flange. This provides a "shingle" effect at the overlaps of the flanges so that liquids inside the engine compartment will tend to remain inside, instead of running down between the firewall flanges and the inside of the fuselage shell.

When satisfied with the fit of the flanges, begin drilling the rivet holes that secure the flange tabs to the firewall sheet with a **#30** drill bit, as shown in Figure 5. You'll need to use either an extension bit or a right-angle drill motor to gain access to these holes. Also, have an assistant hold a block of scrap wood against the firewall from behind to back-up the drilling; this will prevent the pressure of the drill from bending the firewall and flanges. Cleco the holes as you go.

When all the holes have been drilled, mark the forward edge of the cowling flange onto the outside of the firewall flange all the way around, as shown in Figure 5.

Tricycle Landing Gear Option Cut a slot in the lower firewall flange to match the nose gear slot in the fuselage floor.

Remove the firewall flanges from the firewall and trim them to the marked lines. Deburr the trimmed edges of the flanges and all the holes in both the flanges and the firewall. Finally, as shown in Figure 5, mark and center punch rivet hole locations **1/4"** in from the trimmed edges of the flanges at each of the lengthwise locations you marked in Step 2 (see Figure 3).

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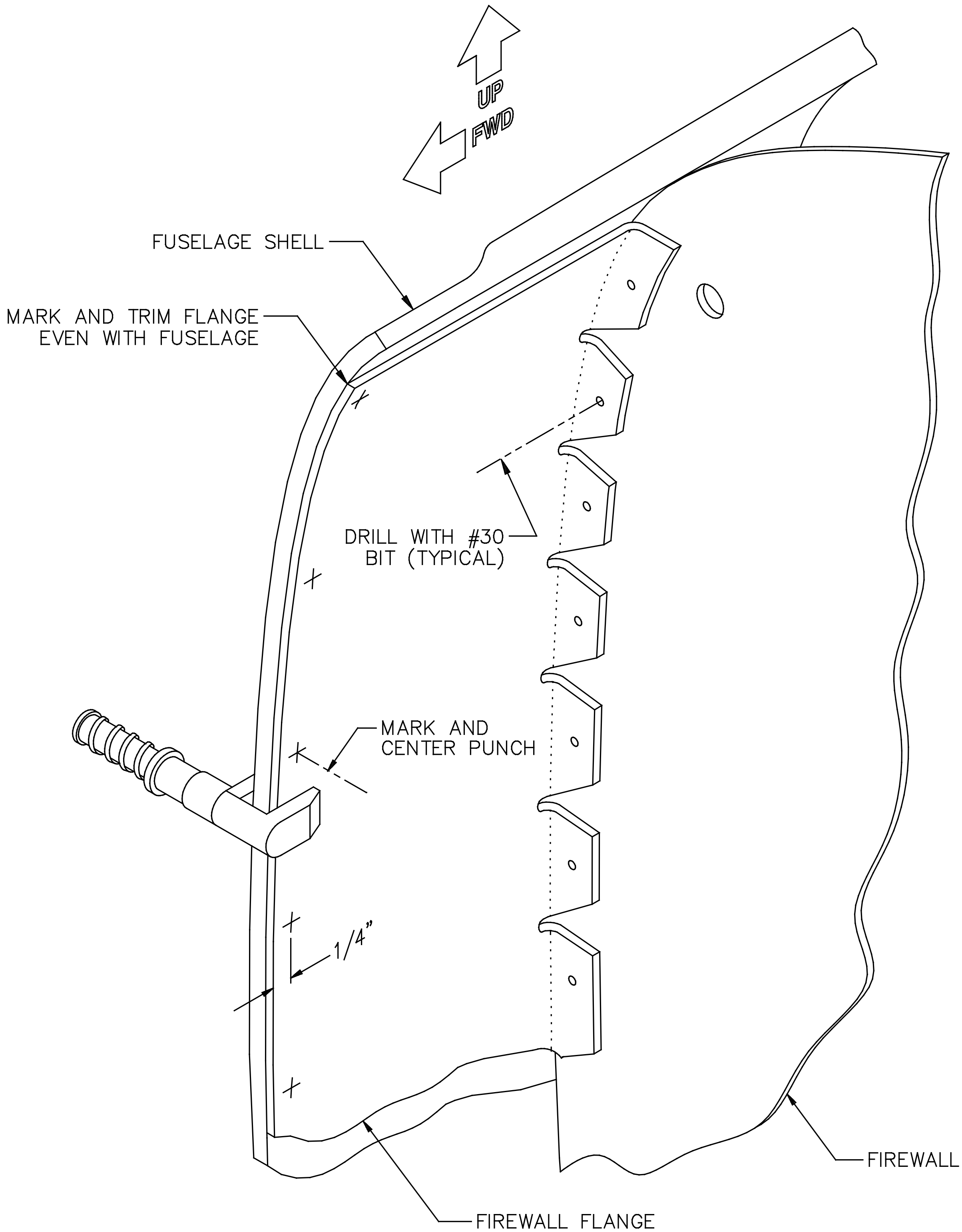

Figure 5: Drilling and Trimming the Firewall Flanges

Step 4: Rivet the Firewall Assembly Together

Now, use **1/8" monel universal-head rivets** [165] to rivet the firewall flanges to the front of the firewall sheet. When riveting on the flanges, be careful to preserve their relationship so that you maintain the shingle effect described in the last step.

> **Note** We recommend sealing the gaps between the firewall and the flanges with a fire-resistant caulk to isolate the cabin from hot gases in the event of an engine compartment fire. Stoddard-Hamilton offers an excellent material for this purpose: CP-25 Fire Barrier Caulk (P/N 270-0132-001). Apply a 1/4"-radius fillet all the way around the inside corner of the firewall assembly to fill any gaps.

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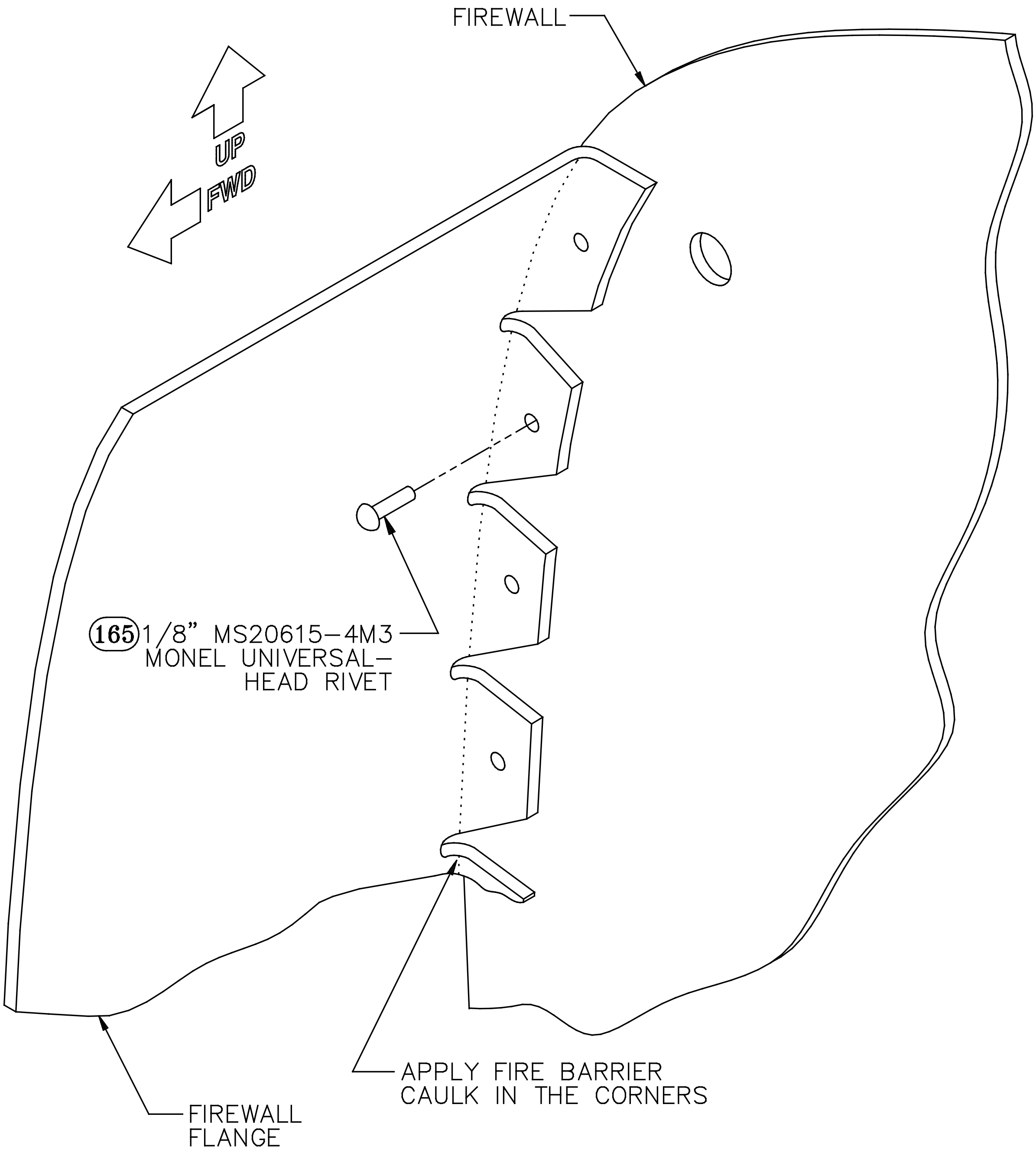

Figure 6: Riveting the Firewall Flanges to the Firewall

Step 5: Fasten the Firewall Assembly to the Fuselage

Note Before installing the firewall assembly, we recommend applying some kind of protective tape to the cage tubes at the front of the fuselage cage. This will help prevent wear on the tubes when the firewall vibrates against it, as well as reducing cabin noise. You can use the same 3/4"-wide anti-chafe tape that you used on the hat sections in the fuel-tank bays of the wings.

Slide the firewall assembly into the front of the fuselage shell until the firewall contacts the front of the fuselage cage. Again pin the firewall assembly to the cage with the 3/8" hardware-store bolts; clamp the firewall flanges to the cowling attach flanges with small C-clamps or Cleco side-grip clamps. As shown in Figure 7, use a **#30** drill bit to drill the rivet holes through the firewall flanges and the cowling joggle at all the marked locations.

Remove the firewall assembly once again and deburr all the rivet holes in the firewall flanges. Use your microstop countersink tool with a #30-piloted cutter to countersink the rivet holes on the **outside** of the fuselage shell. Reinstall the firewall assembly for the final time (whew!), only this time, secure the firewall to the cage at each of the ten attach tabs with AN526-8R7 **round-head machine screws** [140], AN960-8L **thin washers** [150] and AN363-832 **high-temperature self-locking nuts** [119]. The screw heads should be on the firewall, the washers and nuts on the tabs.

Note It may be necessary to add AN960-8 **washers** [149] between the firewall and some of the cage tabs to keep the firewall flat.

Finally, rivet the firewall flanges to the cowling attach flange with 1/8" AN426AD4 flush-head rivets. Use a rivet squeezer if you have one. It would be a good idea to keep the 3/8" bolts in the engine mount holes temporarily to guarantee that they stay properly aligned.

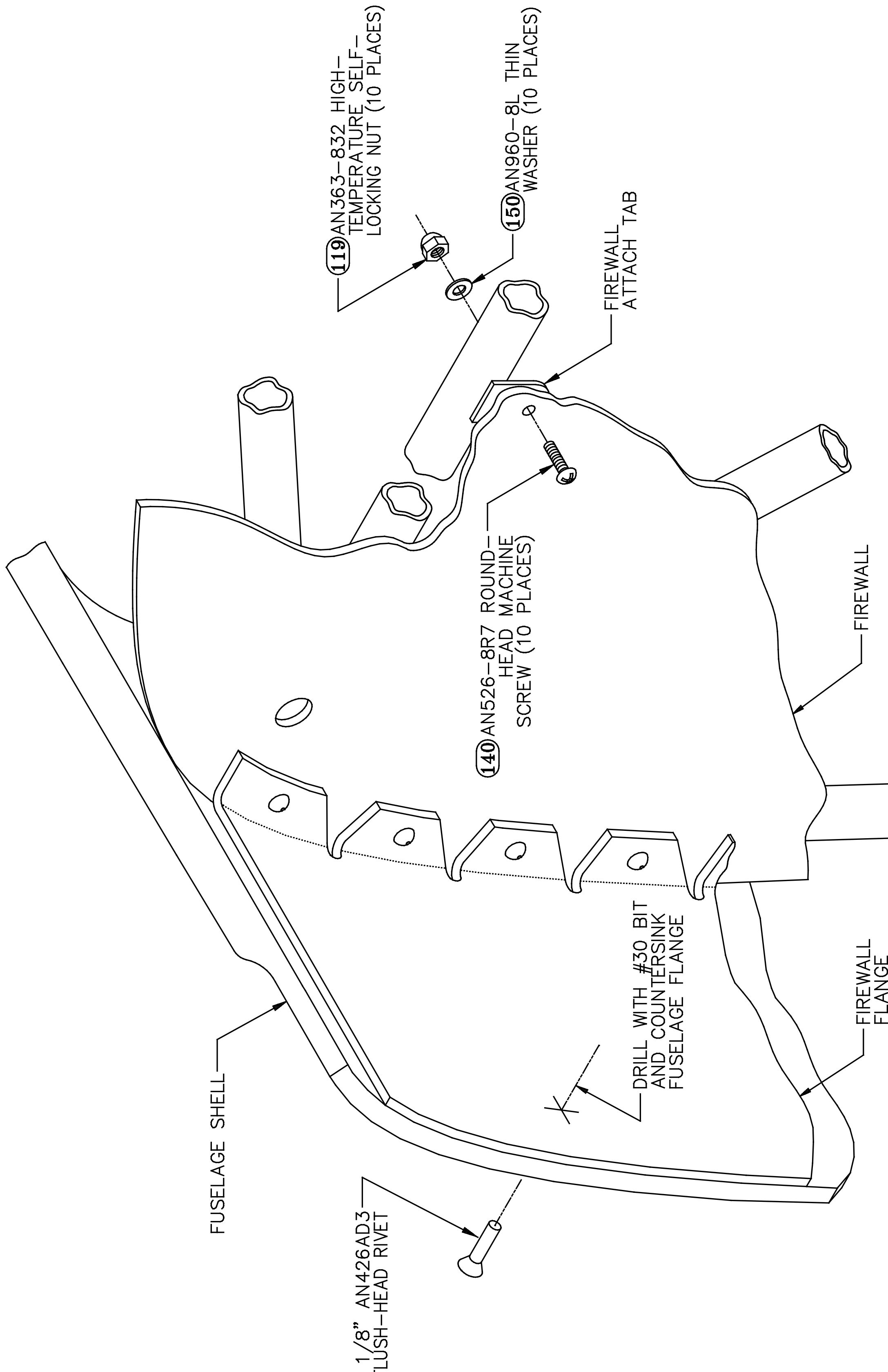

Figure 7: Fastening the Firewall Assembly to the Fuselage

Tricycle Landing Gear Option At this time you can reinstall your nose gear leg. If necessary, use a fine-toothed file to enlarge the hole in the firewall and/or the slot in the lower flange to provide about **1/16"** of clearance all the way around the leg. After you have bolted the leg back in place, apply a generous fillet of fire-barrier caulk all the way around the leg to completely seal the hole in the firewall.

Completed: [ ]

Step 6: Install the Brake Reservoir

The brake reservoir can now be permanently installed on the aft side of the firewall. As shown in Figure 8, hold the reservoir mounting bracket against the firewall such that the bottom of the reservoir is approximately **19"** above the fuselage shell floor. The reservoir can be positioned anywhere from side-to-side, but we recommend a location near one of the cage attach tabs on the top cross-tube of the firewall truss. This provides a little more stiffness to the reservoir mounting.

With the reservoir positioned where you want it, drill through the firewall with a **#10** bit, using the two holes in the mounting bracket as guides. Then cut a **2"-square** doubler out of the **.016"**-thick stainless steel scrap left over from the firewall and drill matching #10 holes in it. Deburr the holes in the firewall and the doubler, and then secure the reservoir with NAS603-7P **round-head machine screws** [168], AN960-10L **thin washers** [146] and AN363-1032 **high-temperature self-locking nuts** [118]. As the figure shows, the doubler and the screw heads should be on the forward side of the firewall.

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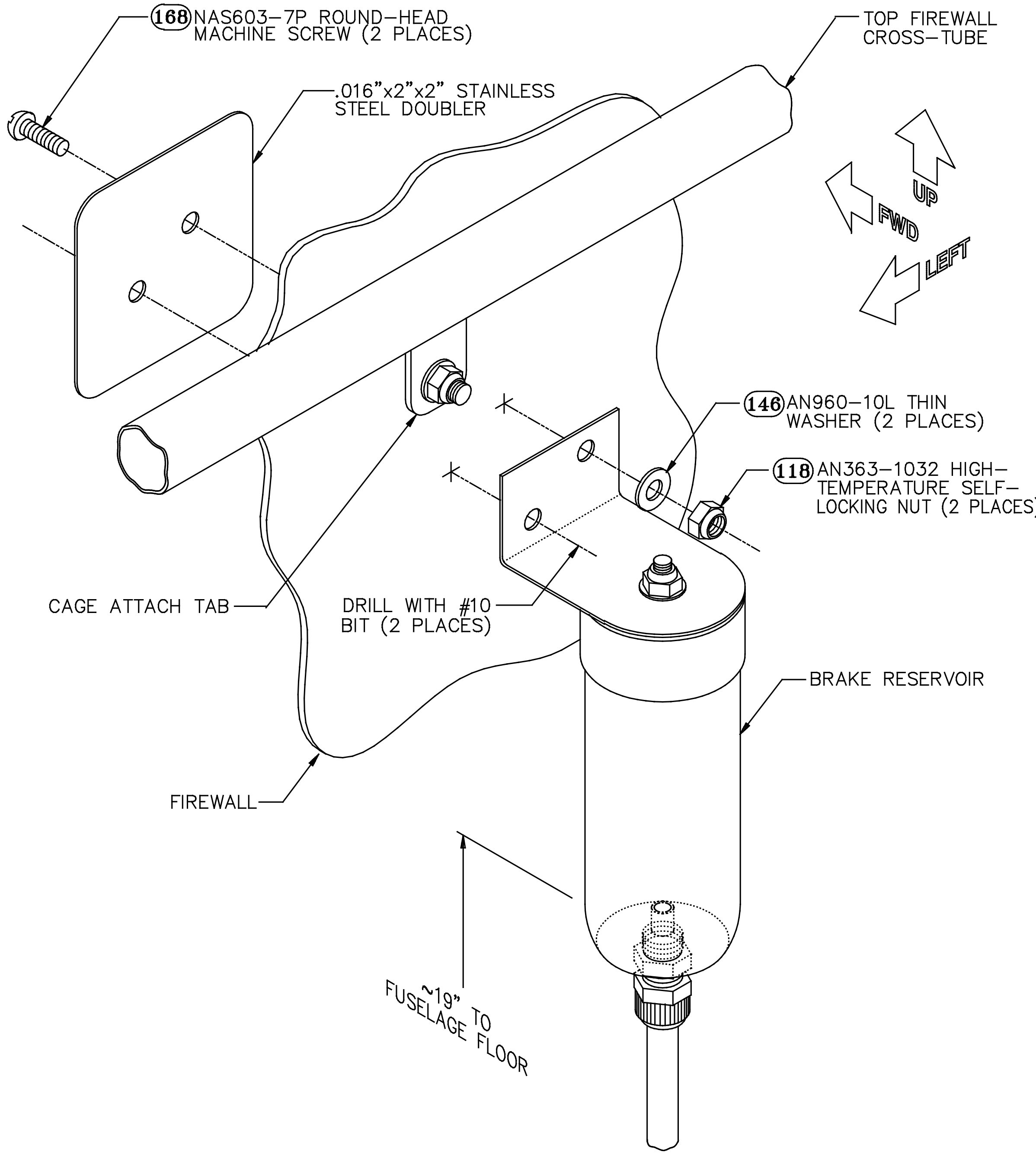

Figure 8: Installing the Brake Reservoir

FIREWALL FORWARD

Step 7: Install <u>Everything</u> Forward of the Firewall

Completed: [ ]

OK, OK, just a little joke! Obviously, the "firewall forward" portion of any airplane project is a tremendous amount of work consisting of many, many steps, and these steps can vary widely depending on the specific combination of engine, propeller and accessories you choose to install. Because of the GlaStar's uncommonly wide performance envelope, it is suited to a wide variety of powerplants depending on the builder's intended mission, budget and inclination.

Stoddard-Hamilton Supported Firewall-Forward Options S-H strongly encourages the use of certified aircraft engines in the GlaStar because of their unparalleled reliability and outstanding safety records. We offer two factory-new engines at very competitive prices—the 125 HP Continental IO-240-B and the 160 HP Lycoming O-320-D1F. Additionally, we offer attractive pricing on Sensenich fixed-pitch and Hartzell constant-speed propellers. To accompany these engine and prop choices, we also offer a wide range of firewall-forward option kits and accessories to allow you to complete your engine installation with as little head-scratching as possible. These installations and accessories include:

- Spinners
- Cowlings
- Engine mounts and shock bushings
- Exhaust systems
- Baffling installations
- Induction system
- Oil cooler installation
- Instrument vacuum system
- Cabin heat installation
- Other kits, parts and accessories

Consult the *GlaStar Options Catalog* for details on these and other options.

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INTERIOR INSTALLATION

In this sub-section, you will fit the baggage bulkhead close-out, the control cable covers, floorboards, seat pans and seats. All of these installations could be put off until near the very end of the assembly process if you wished, and in some ways, this would make the most sense, because once fitted, all these items will have to be removed to complete other work in later sub-sections. The reason we have chosen to put these steps here is to maximize the amount of work that can be accomplished before the wings have to be mounted to the fuselage for the final time. In other words, if space is at a premium, you'd be wise to get as much of this sort of thing out of the way as you can while the airplane's still skinny enough to fit in your shop! If you've got plenty of room, you might prefer to move this whole sub-section to "MISCELLANEOUS FINAL ASSEMBLY DETAILS." It's your call.

Step 8: Cut Out the Bulkhead A Close-Out

Most builders would want to close the opening in Bulkhead A for aesthetic reasons, but safety considerations dictate this as well. Without a close-out, loose baggage could fall back into the aft fuselage and interfere with or jam the control cables there, as well as potentially moving the aircraft center of gravity beyond its aft limit.

Figure 9 shows the dimensions of the close-out. Lay out this pattern on the **.020" X 24" X 30" aluminum sheet** [67] and cut it out with snips. Trial fit the close-out to the bulkhead. It should fit closely all the way around, but should not ride up on the Q-Cell radius on the forward side of the bulkhead. Trim as necessary, and then deburr the edges.

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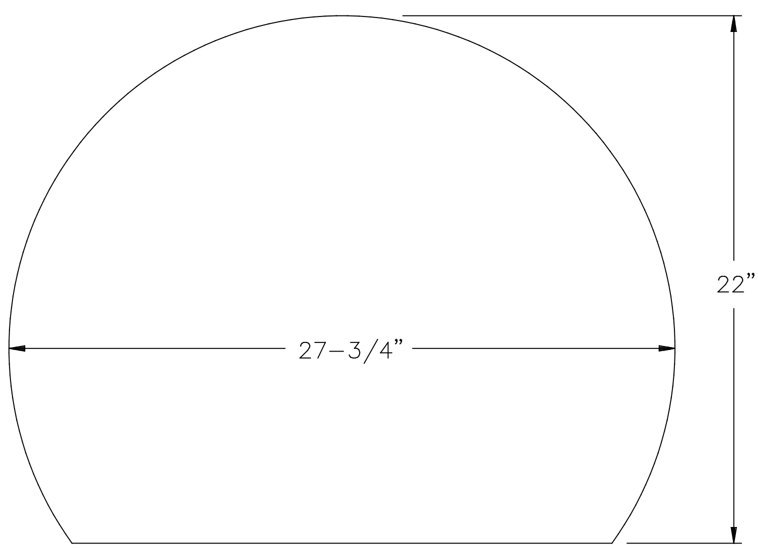

Figure 9: Bulkhead A Close-Out

Step 9: Drill the Close-Out and Install the Mounting Nutplates

Mark and center punch **fourteen** screw holes around the perimeter of the close-out. Each location should be about **1/2"** in from the edge. The spacing of the holes isn't critical—we suggest six holes evenly spaced across the bottom and the remaining nine holes evenly spaced around the circular perimeter.

When all the holes have been marked, position the close-out against the bulkhead and tack it in place with several pieces of tape. Then drill through the close-out and the bulkhead at each mark with a **#19** bit. Cleco as you go. Remove the close-out and deburr all the holes.

Next, drill **#40** rivet holes for K1000-08 **nutplates** [158] at each of the holes in Bulkhead A. Countersink the holes on the forward face of the bulkhead and install the nutplates on the aft face using 3/32" AN426AD3 flush-head rivets.

> **Note** The close-out is now ready for installation with AN526-8R6 **round-head machine screws** [139], but unless you don't have any place to store it, we'd recommend setting it aside until you've installed your battery tray in the last sub-section, "WEIGHT AND BALANCE." You'll still need access to the aft fuselage for several tasks before then.

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Step 10: Install the Baggage Shelf (Optional)

For the purpose of calculating weight and balance, the GlaStar baggage compartment is divided into two zones—a forward and an aft. As in any airplane, the forward zone can carry more weight than the aft without exceeding the center of gravity envelope. If the pilot carefully monitors the distribution of weight in the baggage compartment, there's no need to provide any physical separation of these compartment zones. However, in our GlaStar prototype, we installed a raised shelf in the aft part of the baggage compartment that serves to physically define the two zones, and thereby to discourage overloading the aft zone.

Figure 10: Baggage Shelf

Our prototype shelf consists of a sheet aluminum floor and front bulkhead supported on DBM flanges laminated to the fuselage. A couple aluminum angle stringers are riveted to the floor for stiffness.

If you choose not to install a shelf, just remember that this doesn't mean you can load up the aft zone of the compartment (or the forward one, for that matter) with anything that will fit! In fact, we strongly recommend that you install a placard defining the baggage zones and the weight limit for each, regardless of whether you install the shelf.

Note Detailed information on weight and balance calculations can be found in the "WEIGHT AND BALANCE" sub-section at the end of this *Manual*, as well as in the *GlaStar Owner's Manual*

Completed: [ ]

Step 11: Fit the Aft Control Cable Cover

The kit includes two "L"-shaped pieces of **aft control cable cover angle** [58]. Trimmed to fit the contour of the fuselage floor, these pieces form a protective cover over the control cables and wiring that run along the aircraft centerline from the aft end of the cage to Bulkhead A.

The first step in fitting the covers is to cut them to length. Use a tape measure to find the distance from the main cross-tube between the tricycle gear sockets to the forward face of Bulkhead A and cut both pieces of angle stock to this dimension with a pair of snips. Sand the cut edges smooth.

Baggage Shelf Option If you have installed the optional baggage shelf, cut the angle stock to extend from the tricycle gear socket cross-tube to the partial bulkhead at the forward end of the shelf. Adjust the number of rivets specified below according to the reduced cover length.

Next, as shown in Figure 11, lap the two "L"-shapes over one another to form an inverted "U," with the wider flanges vertical and the narrower flanges horizontal; clamp the two parts together with spring clamps at each end. Then lay out and drill a series of twelve **#40** rivet holes along each edge of the upper cover half. Observe proper edge-margin standards by keeping the hole centers at least **3/16"** from the edges. Drill the holes, Clecoing as you go.

Note The precise width of the overlap between the two pieces can be varied to suit as long as you leave adequate clearance for the control cables and any wiring and as long as you position your rivet lines so as to preserve adequate edge margin on both halves.

Hint When drilling the holes, place the overlapped covers over a scrap length of 2 X 8 set on edge in a bench vise.

Place the Clecoed cover in position in the fuselage and trim the lower edges of each side to fit the slight curvature of the fuselage floor. Trial and error may be about the best method for this, but you might prefer to make a cardboard template first. In either case, the height of the cover sidewalls can be varied to suit, as long as adequate clearance is maintained around the cables and wiring. Sand the trimmed edges smooth.

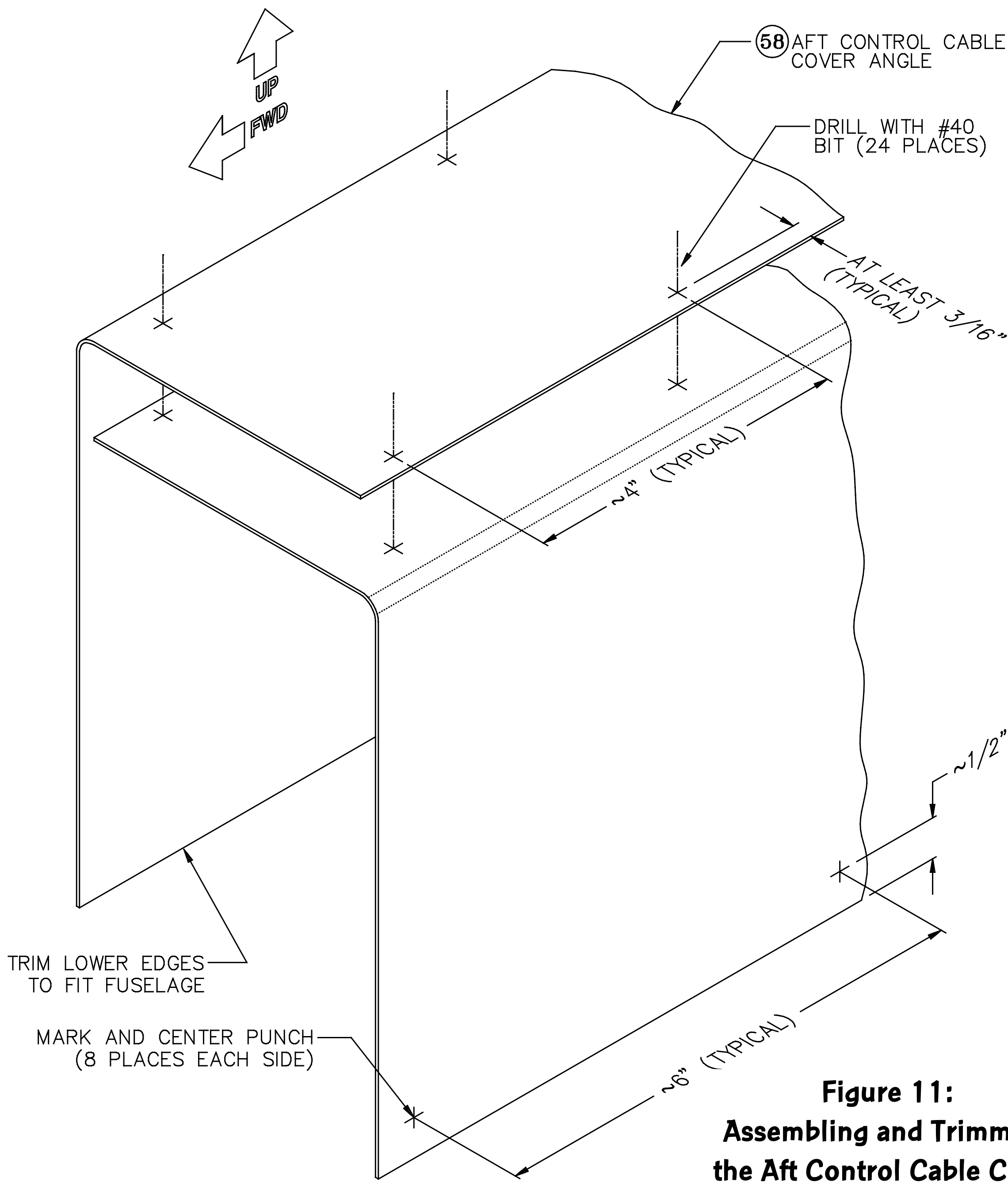

Figure 11: Assembling and Trimming the Aft Control Cable Cover

Finally, after the edges are trimmed to your satisfaction, lay out and center punch a row of hole locations along the lower edge. Space **eight** of these locations evenly along each edge, and mark them about **1/2"** above the lower edge, as shown.

Completed: [ ]

Step 12: Fabricate and Drill Aft Attach Angles for the Aft Control Cable Cover

The aft control cable cover will be attached to the fuselage floor with sixteen mounting tabs that you'll install in the next step. However, it's also desirable to anchor it to Bulkhead A at its aft end in order to stabilize it side-to-side.

Baggage Shelf Option If you have installed the optional baggage shelf, interpret every reference in this step to Bulkhead A as referring to the baggage shelf partial bulkhead instead. All the procedures are otherwise the same.

You will fabricate these aft attach angles from the scraps you cut off the two lengths of aft control cable cover angle in the last step. As shown in Figure 12, each angle should be about **1"** tall, and each flange should be about **1"** wide. These dimensions are not critical. Use snips to cut the angle from the scrap and sand the edges smooth.

Then position the angles as shown in Figure 12, with one flange tight against Bulkhead A and the other flange tight against the side of the cable cover. The vertical positions of the angles isn't critical—simply place one near the top of the cover and one near the bottom. Tape the angles to the cover, and then drill through the center of each Bulkhead A flange with a **#19** bit. Finally, remove the entire cover and, with the angles still taped in place, drill through each taped angle in two places with a **#40** bit, as shown in the figure.

Separate the cover halves, remove the tape, and then use Clecos to re-attach the four attach angles to the cover halves.

Finally, use standard procedures to position, drill and install four K1000-08 nutplates on the aft side of Bulkhead A—one behind each of the #19 aft attach angle holes. Use 3/32" AN426AD3 flush-head rivets to secure the nutplates.

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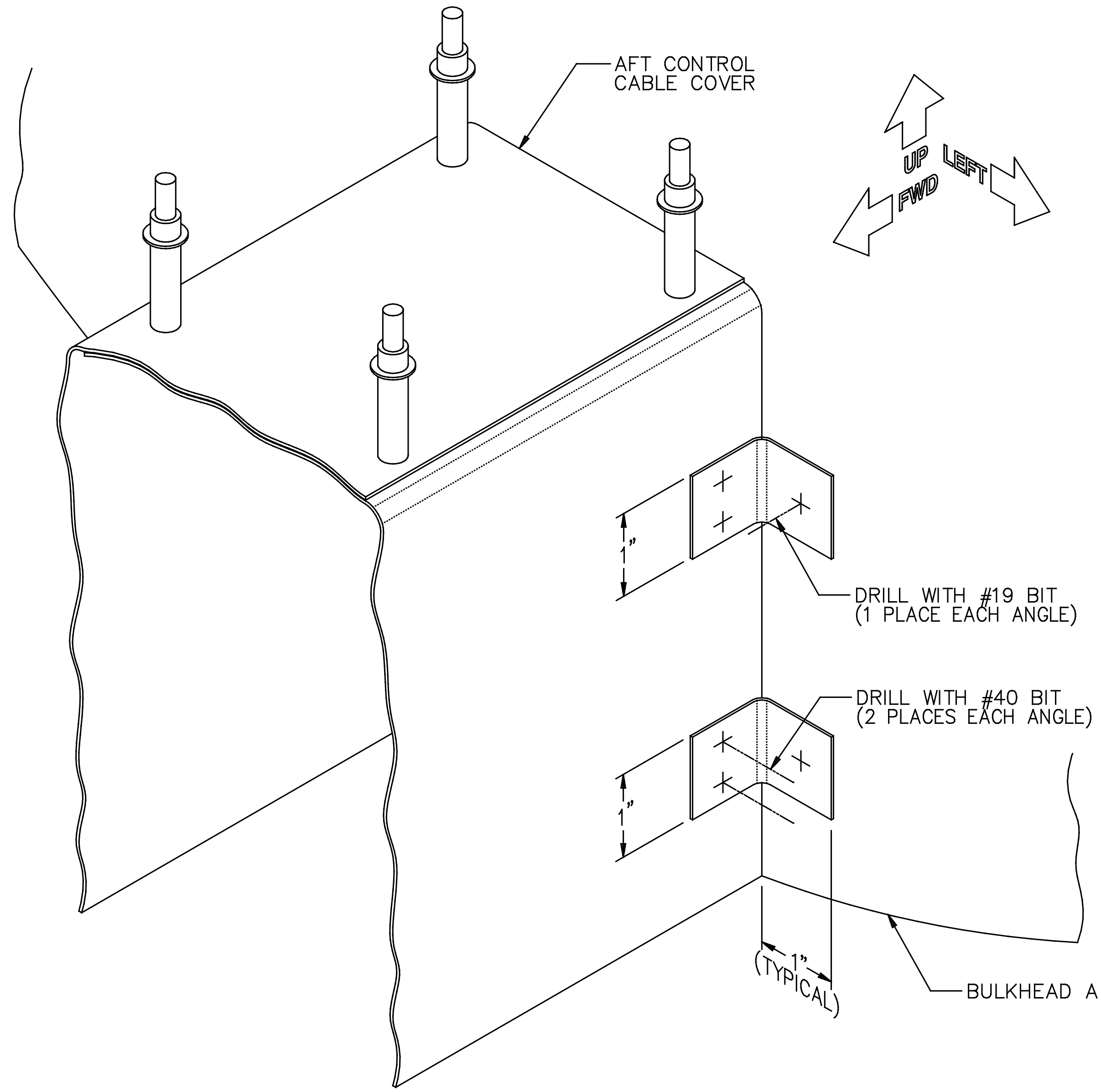

Figure 12: Positioning and Drilling the Aft Attach Angles for the Aft Control Cable Cover

Step 13: Install Mounting Tabs for the Aft Control Cable Cover

The sixteen aft control cable cover mounting tabs will be laminated in place on the fuselage floor using **3"-wide DBM cloth** [61]. The cover halves themselves will be used as forms for laminating the tabs. Prepare them for this role by, first, marking reference lines on the **inboard** side of the cover halves' sidewalls just opposite the hole locations you marked along the lower edges in Step 11. Each line should extend about **2"** above the lower edge of the cover half, as shown in Figure 13a. Second, apply a liberal coating of mold release wax or the equivalent to an area at least **2"** high by **3"** long centered on each reference line you just marked.

Next, position one of the cover halves in the fuselage. At its aft end, secure it to Bulkhead A with a pair of AN526-8R8 **round-head machine screws** [141] through the aft attach angles, as shown in Figure 13a. At the forward end, check to see that the sidewall of the cover half is vertical, and then temporarily secure the half to the cage structure with tape. Apply more tape along the lower edge of the cover half on the **outboard** side to secure it to the fuselage floor. Use a straightedge to ensure that the lower edge doesn't have bends or waves in it.

Next, as shown in Figure 13b, cut **thirty-two** small, **2" X 3"** patches of DBM cloth. Laminate two of these pieces against the fuselage floor and the cover half sidewall at each of the reference marks. The 2" dimension should be roughly centered on the mark and the cloth layers should lap equally onto both the fuselage floor and the cover half.

After the tabs have cured, sand or grind the rough edges smooth and round the corners. Then, as shown in Figure 13c, drill through the cover and the tab at each of the hole locations marked on the **outboard** side of the cover half. Use a **#19** bit in a right-angle drill motor or adapter. Deburr the holes and set the cover aside.

Finally, as shown in Figure 13d, drill and countersink **#40** holes in each tab for K1000-08 nutplates. Rivet these nutplates in place on the **inboard** face of each tab with 3/32" AN426AD3 flush-head rivets.

Repeat the above procedures for the opposite cover half.

Completed: Left [ ] Right [ ]

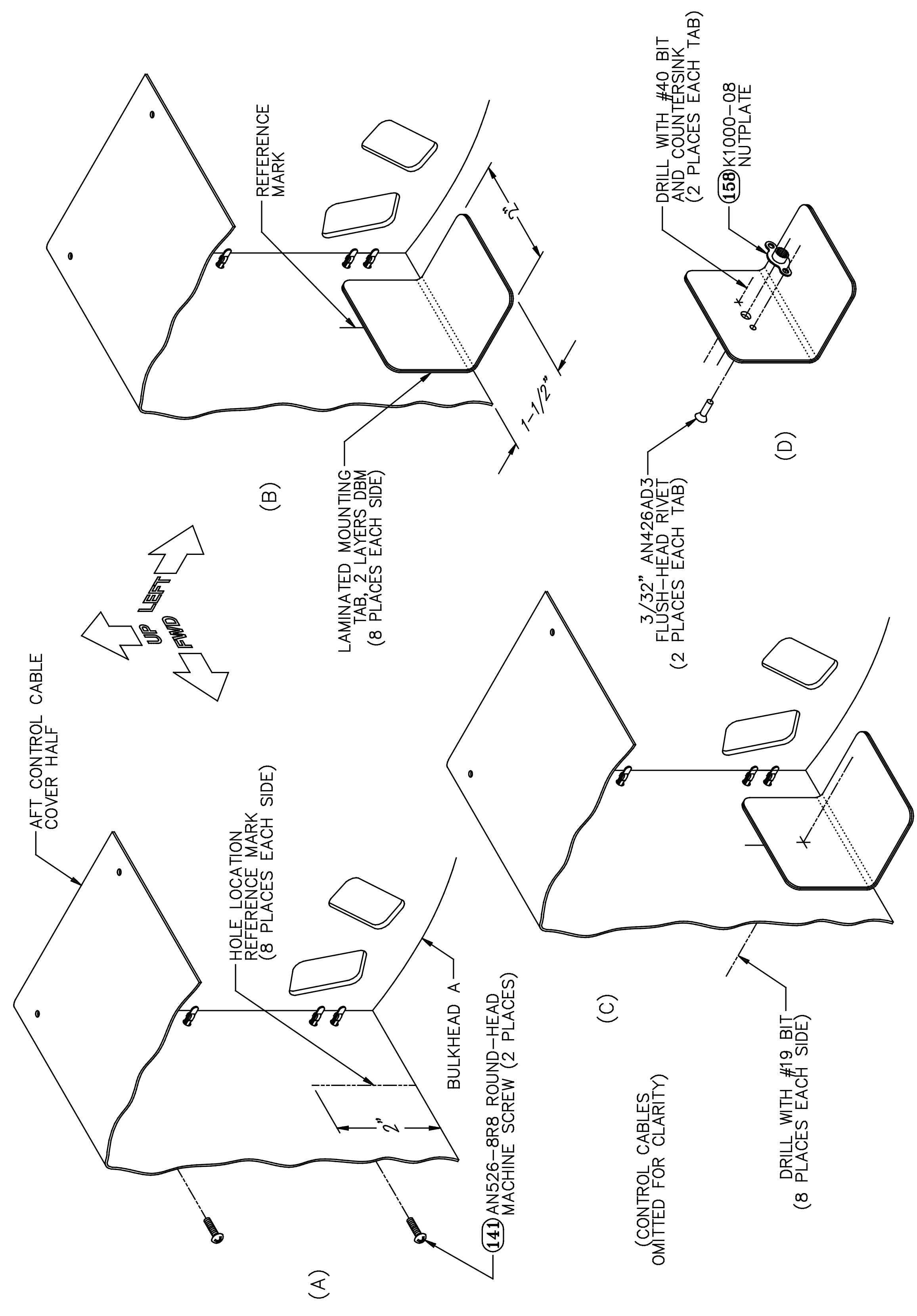

Figure 13: Installing the Aft Control Cable Cover Mounting Tabs

Step 14: Assemble the Aft Control Cable Cover

Deburr all the holes in both cover halves and all four aft attach angles. Apply the anti-corrosion protection of your choice. Then use 3/32" AN470AD3 universal-head rivets to join the two halves and to rivet the attach angles to the assembly.

> **Note** Alternatively, you can certainly dimple the cover halves and attach angles to accommodate AN426AD3 flush-head rivets if you wish.

You can now install the cover with AN526-8R6 round-head machine screws through the mounting tabs and -8R8s through the aft attach angles, but you may prefer to wait, as the cover will have to be removed for final inspection.

Completed: [ ]

Step 15: Fit the Forward Control Cable Cover Halves

The forward control cable cover covers the central cage truss from the main cross-tube between the taildragger gear sockets to the firewall. Since there is little variation in this distance among different GlaStars, the two **forward control cable cover angles** [59] don't need to be cut to length as the aft ones did. However, a cutout must be made near the forward end of each piece to allow it to clear the rudder control weldments and another cutout must be made in the top of each half to accommodate the fuel shut-off valve.

Figure 14 shows the approximate dimensions of the rudder control weldment cutout that must be made in each half. Use snips to cut a bit inside the indicated line; you can use trial and error shortly to trim to final size.

> **Tricycle Gear Option** If you're installing tricycle landing gear, you'll also have to provide clearance holes on both sides of the cover for the upper nose gear trunnion bolt, which protrudes outboard beyond the sidewalls of the cover. Figure 14 shows the location and dimension of these holes. Drill them initially with a bit smaller than the **1"** hole cutter specified in order to double check the locations. Then enlarge the holes to final size.

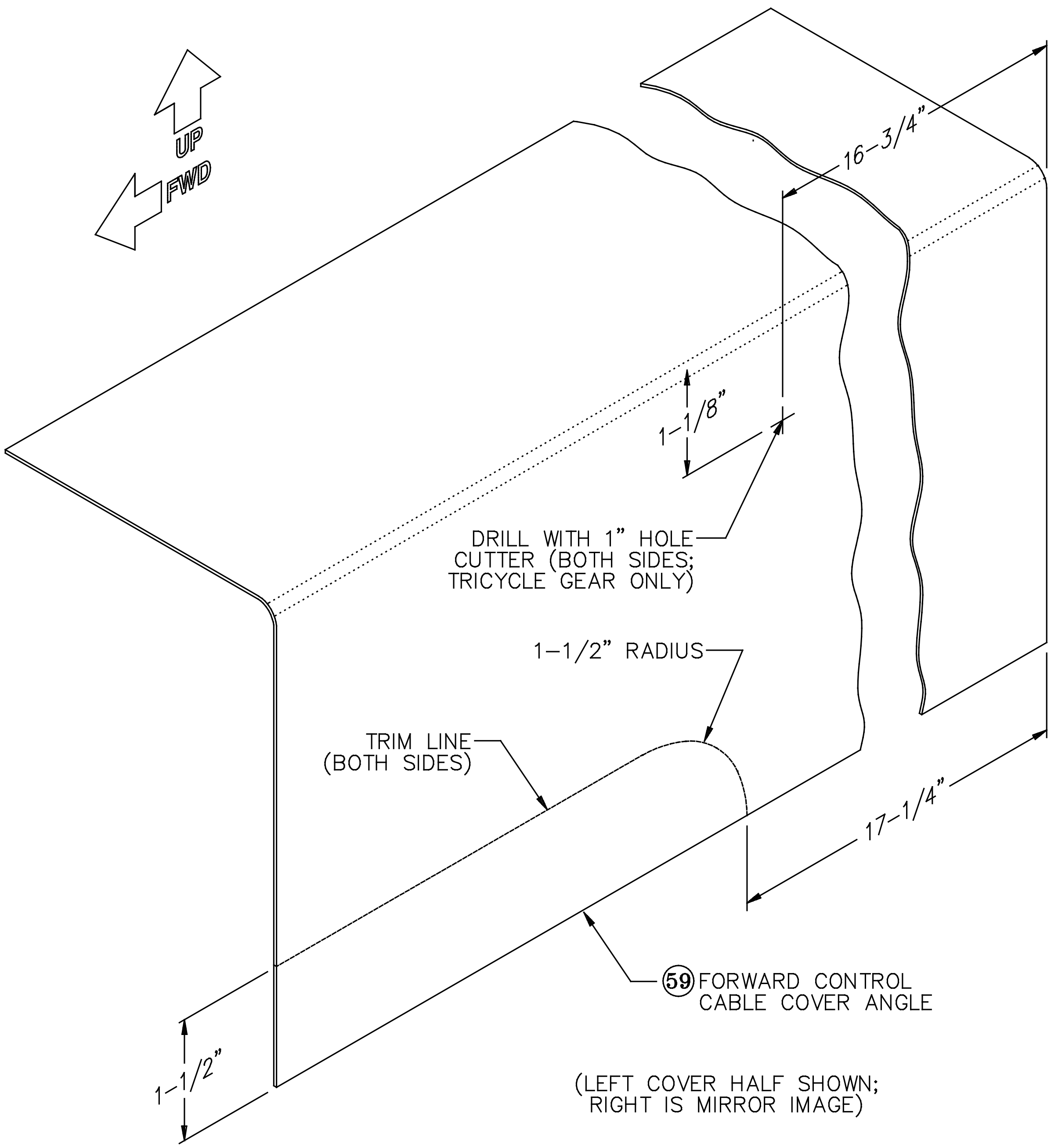

Figure 14: Trimming the Forward Control Cable Cover Halves to Clear the Rudder Control Weldments

Next, you need to make the cutout for the fuel shut-off valve. Begin by overlapping the two halves and clamping them together with spring clamps as you did with the aft pair. The width of the forward cover is not flexible like the aft width was; it is set by the width of the central cage truss. Adjust your clamps until the vertical sidewalls of the two cover pieces are tight against the truss.

Mark the location of your fuel shut-off valve on the temporarily joined cover, either by measuring the location of the valve relative to the cage structure and transferring this location to the outside of the cover or by using the modeling clay method you used in locating the fuel gauge flange on the wing root ribs to mark the valve location on the inside of the cover (see "SECTION IX: SYSTEMS INSTALLATION," Step 54). The cutout can be shaped to suit, but be sure to leave ample room for your fingers between the edges of the cutout and the valve handle. Figure 15 gives a suggested size and shape for the cutout.

Start the cutout using hole cutters and finish it up with a single-ended hacksaw, snips and/or a rotary cutting tool. At a minimum, sand the cut edges very smooth, but you may also want to consider rolling the edges under slightly.

> **Warning** Ultimately, you will need to provide some sort of close-out under the shut-off valve cutout to prevent the possibility of foreign objects falling through the cutout and jamming the control cables below. This can consist of nothing more than a flap of carpeting or upholstery, or it could be a more elaborate sheet-metal or composite close-out.

With the fuel valve cutout complete, you can now position the cover to check the fit over the rudder control weldments. Enlarge those cutouts as necessary to provide at least **1/16"** of clearance around all parts of the rudder control mechanism when the top of the cover is flat against the truss.

Completed: [ ]

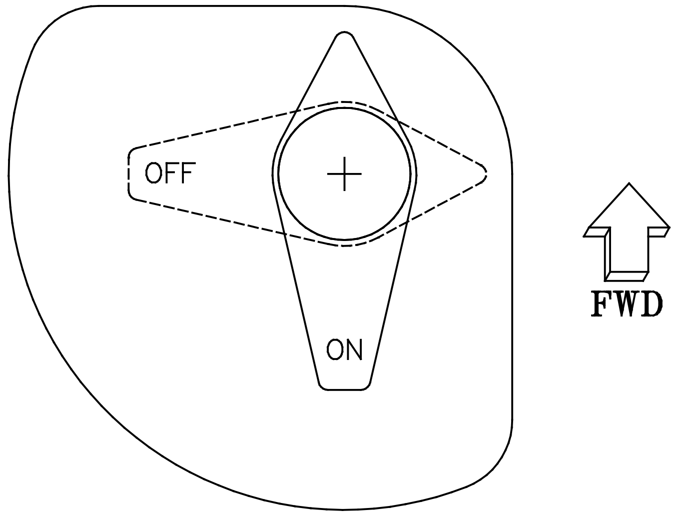

Figure 15: Template for Suggested Fuel Shut-Off Valve Cutout (Full Size)

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Step 16: Join the Forward Control Cable Cover Halves

Now you're ready to join the cover halves. The recommended method for doing so varies depending on whether you're installing a manual or electric trim system. Follow the instructions appropriate to your system; instructions common to both systems begin again with Step 17.

MANUAL TRIM OPTION

The trim gear box and its mounting brackets dictate that the forward cover halves be joined with screws and nutplates rather than rivets. This allows the cover halves to be slid into place individually from the side rather than as a unit from above, which in turn minimizes the size of the holes that must be cut in the cover to accommodate the trim system.

With the cover halves still clamped together to the width of the cage truss, lay out and drill a series of **six #19** screw holes on a line **5/16"** from the edge of the **upper** cover half, which should be the **left-hand** half. As shown in Figure 16, these holes should be spaced roughly on **4-1/2"** centers, with each end hole **5/8"** from the end of the cover. Because the cover is supported from below by the truss, you only need holes along this one edge.

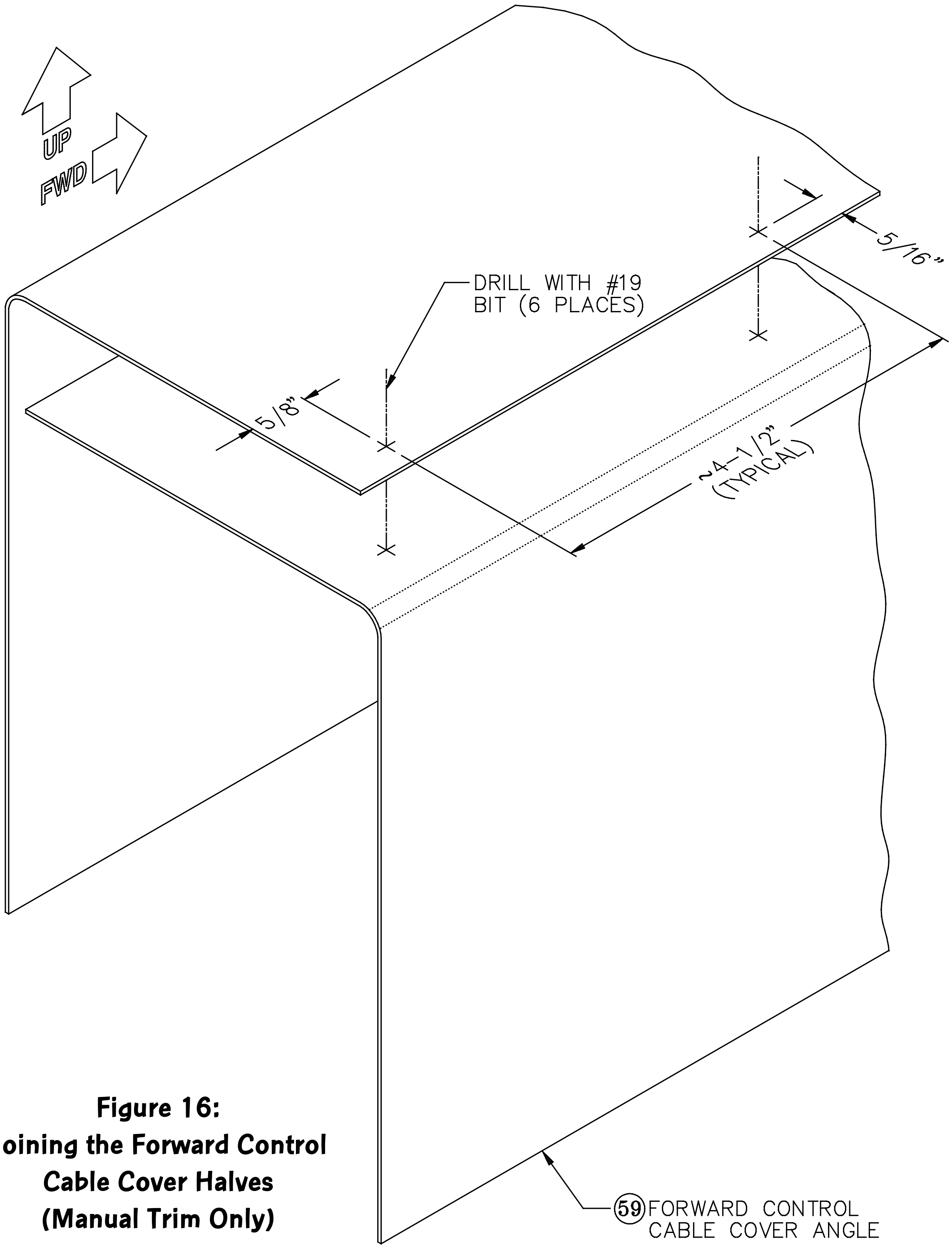

Figure 16:
Joining the Forward Control Cable Cover Halves (Manual Trim Only)

The next step is to cut slots in the cover halves to accommodate the trim cable. The cover will eventually be installed **between** the trim gear box brackets and the cage truss, so there's no need to provide cutouts in the cover for the brackets themselves, but the cable does have to come through the cover.

With the gear box temporarily mounted on the cage truss (as described in Step 116 of "SECTION IX: SYSTEMS INSTALLATION"), measure the **longitudinal** distance between the center of the trim cable where it emerges from beneath the top of the truss and the **forward** side of the main cross-tube between the taildragger gear sockets. This dimension is labeled "**X**" in Figure 18a. Next, measure the **lateral** distance between the center of the trim cable where it emerges from beneath the top of the truss and the **left** side of the left-hand truss tube. This dimension is labeled "**Y**" in Figure 18b.

Join the two cover halves with Clecos, as shown in Figure 18c, and then mark the "X" and "Y" dimensions you just measured on top of the left-hand cover half. Use a Unibit or a hole saw to drill a **3/4"** hole at the intersection point.

After the hole has been cut, disassemble the two halves and, using snips, cut slots from the hole to the edge of each half, as shown in Figure 17. Smooth the cut edges of the slot with a fine-toothed file or sandpaper.

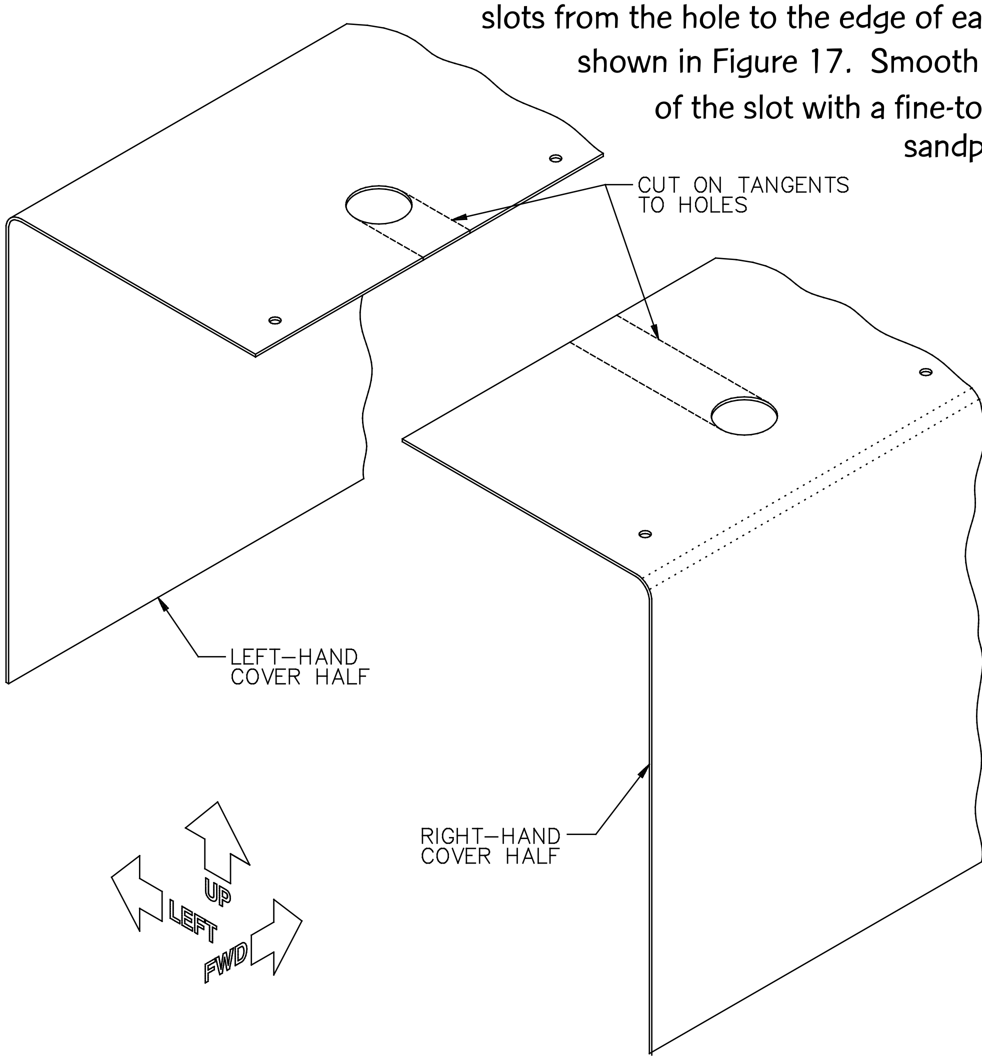

Figure 17: Cutting the Trim Cable Slots (Manual Trim Only)

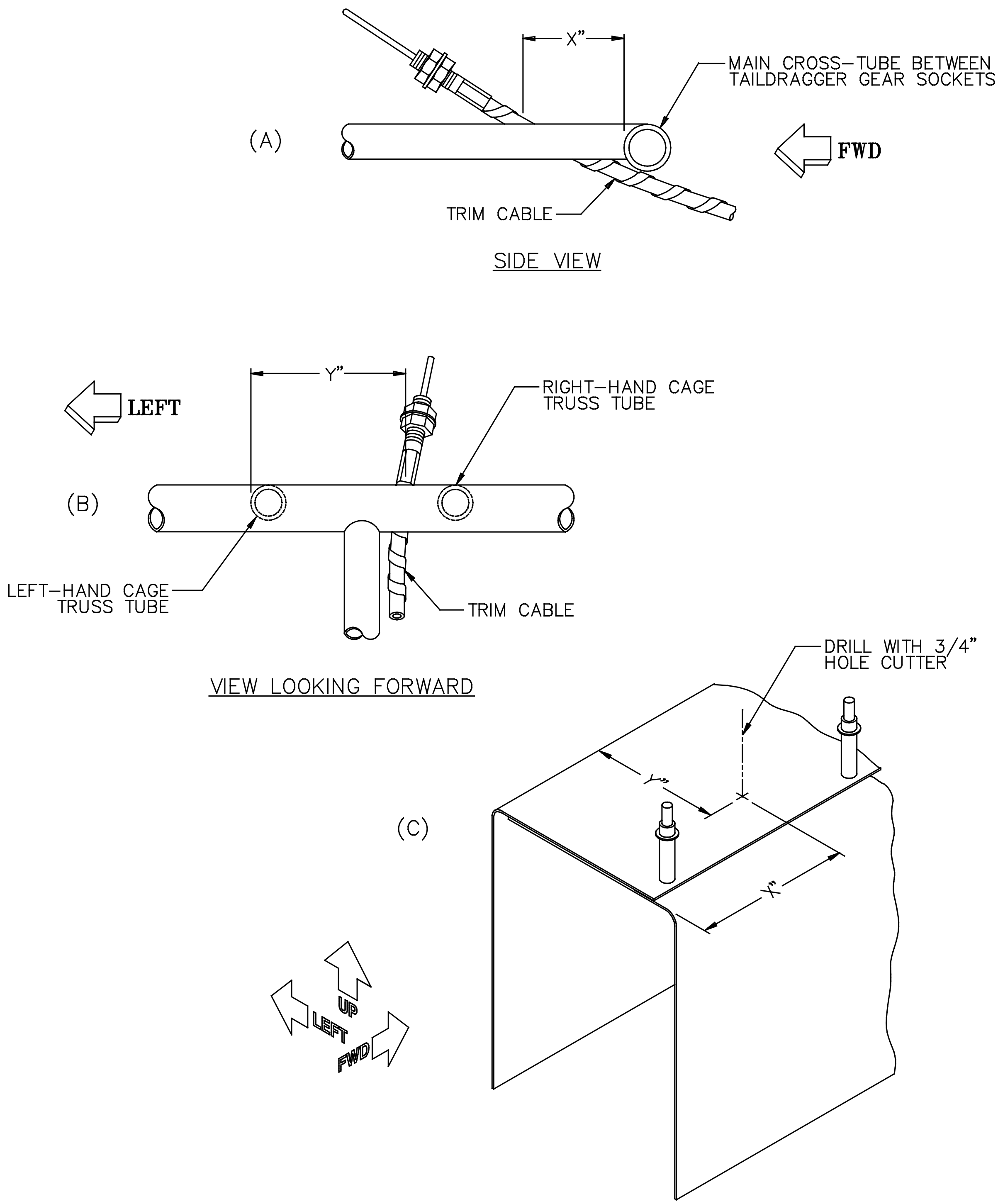

Figure 18: Marking and Cutting the Trim Cable Hole (Manual Trim Only)

Now you need to mark and drill holes through the cover for the screws that hold the trim gear box brackets to the loop clamps. Remove the gear box and brackets from the cage truss, but leave the clamps and nutclips in position. Beginning with the left-hand cover half, slide it into position over the cage truss, with its aft end up against the cross-tube between the taildragger gear sockets. From the right-hand side of the cage truss, reach underneath and use a marking pen to mark the locations of the holes in the two horizontal loop clamps on the underside of the cover half. Repeat the process for the right-hand cover half to mark the locations of the holes in the two vertical loop clamps.

After both halves have been marked, drill at the marked locations in the **left-hand** half with a **#40** bit and in the **right-hand** half with a **#19** bit. Then re-Cleco the two cover halves together and, using the #40 holes in the left-hand half as guides, drill through both halves at those locations with a **#19** bit.

> **Note** It's quite likely that these holes won't line up perfectly with the loop clamp nutclips when it comes time for final installation of the trim gear box, but don't worry about this for now; they can easily be enlarged as necessary when the trim gear box is re-installed in Step 195 of the later sub-section, "SYSTEMS CHECK-OUT."

Next, use standard procedures to position and drill a K1000-08 nutplate at each #19 screw hole along the right-hand edge of the right-hand cover half. Dimple the rivet holes and then corrosion-proof both cover halves as you see fit. Finally, use 3/32" AN426AD3 flush-head rivets to rivet the nutplates to the underside of the right-hand cover half. Assemble the cover with AN526-8R6s and position it over the cage truss. Don't worry about repositioning the trim gear box for now.

ELECTRIC TRIM OPTION

The forward covers can be riveted together just like the aft ones were, although you only need to rivet one edge since the cover is supported from below by the cage truss and thus needs no great strength. As with the aft covers, lay out rivet hole locations on a line at least **3/16"** in from the edge of the upper cover half (which should be the **left-hand** half, as shown in Figure 19). **Six** holes on roughly **4-1/2"** centers are ample.

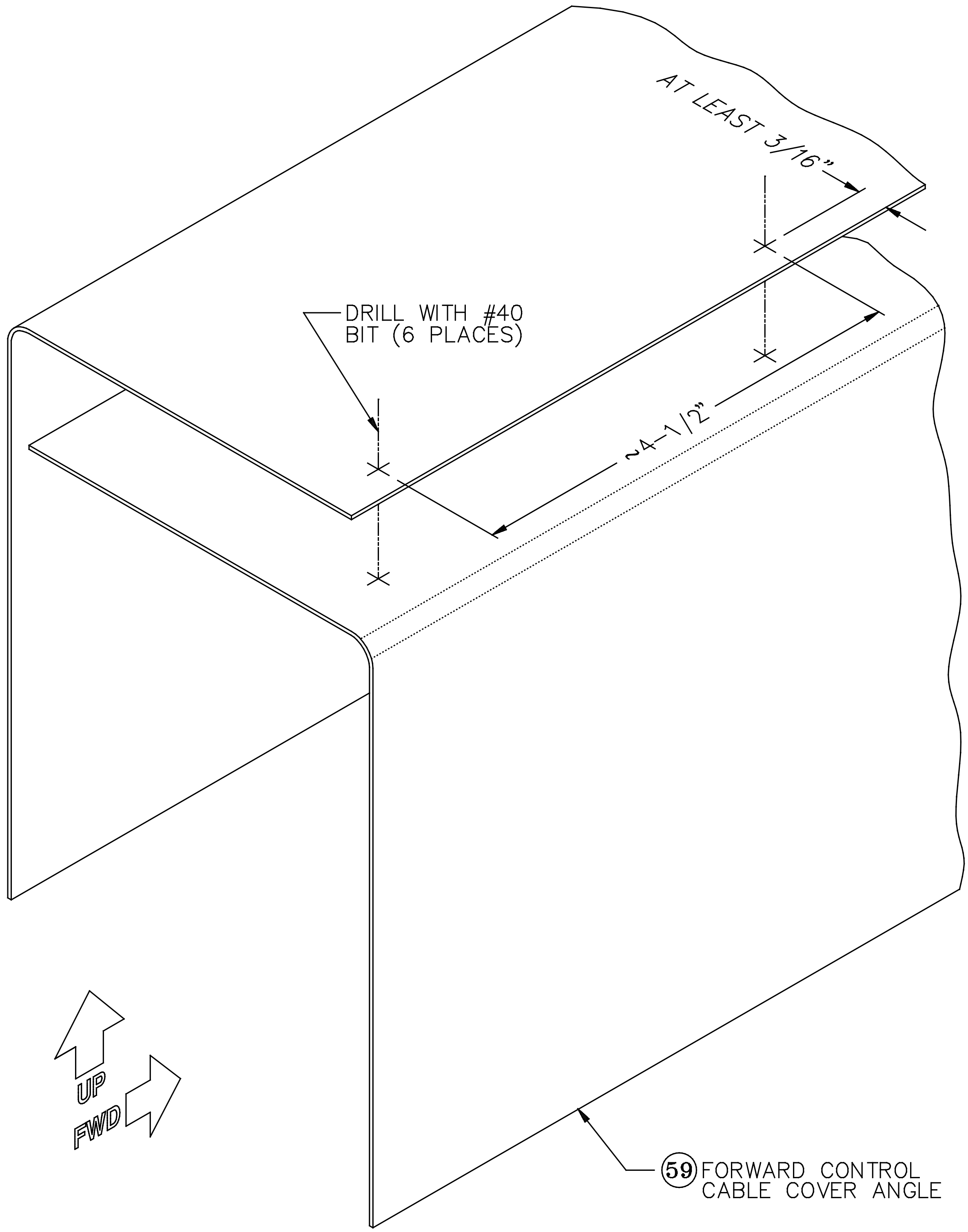

Figure 19: Joining the Forward Control Cable Cover Halves (Electric Trim Only)

Clamp the cover halves together again to the width of the cage truss (if they aren't already), and then drill through both halves at each marked location with a **#40** bit. Deburr all the holes, corrosion-proof the halves as you see fit, and finally use 3/32" AN470AD3 universal-head rivets to join the halves.

> **Note** If you prefer, you can dimple the cover halves and use AN426AD3 flush-head rivets.

Completed: [ ]

Step 17: Fit the Floorboards

As indicated by the shaded areas in Figure 20, the floorboards cover the area between the rudder control weldments and the seat pans in a fore-and-aft direction, and between the fuselage sidewall and the forward control cable cover in a lateral direction. They are held in place at twelve attach tabs welded to the cage; the locations of these tabs are shown in the figure.

Cut the floorboards out of **1/4"** marine-grade plywood, available at any building supply store. Because of small but significant variations in the GlaStar cages, we are unable to provide templates for the floorboards, so make a pair out of cardboard for your own cage. Note that each floorboard must be relieved in three locations: at its forward end (Point A in Figure 20) to fit around the rudder control weldments; along its outboard edge (Point B) to accommodate one of the small, vertical tubes in the truss at the lower edge of the cage sidewall; and at its aft, outboard corner (Point C) to fit around the taildragger gear socket. Also note that the Point A cutouts are **not** the same left and right. Finally, take special care to get a **tight** fit on the inboard edges of both floorboards. This is where they contact the sides of the forward control cable cover, and to prevent the cover from rattling around, the floorboards should fit snugly.

> **Note** The gaps all the way around the floorboards in Figure 20 are exaggerated for clarity; strive for a good, tight fit all around.

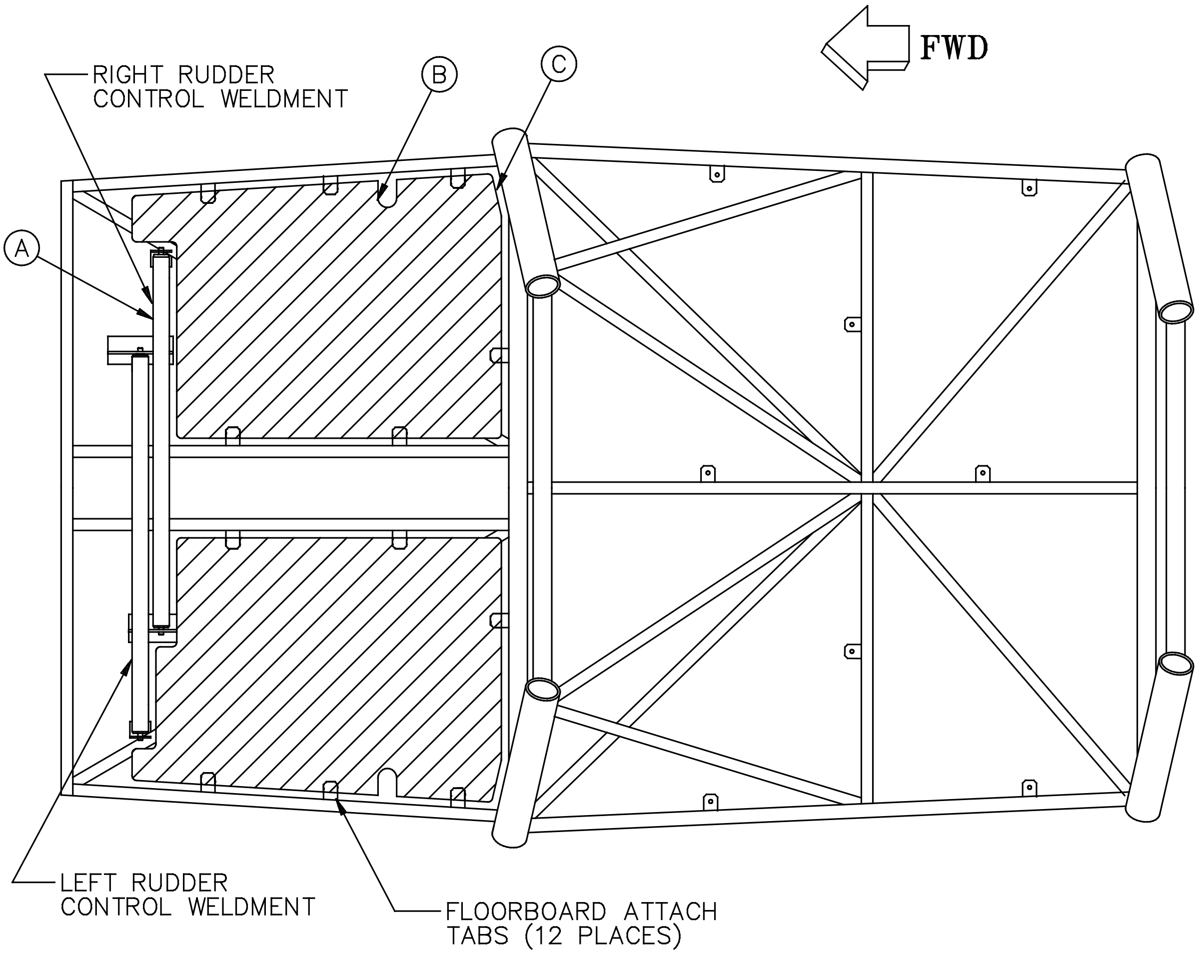

Figure 20: Fitting the Floorboards

Once you have the floorboards fitted to your satisfaction, it's time to address the mounting holes. The locations of the twelve attach tabs will vary slightly from cage to cage, so you'll have to mark the actual locations of the attach tabs on each floorboard. Especially on early GlaStar cages, you may encounter two different styles of attach tabs—one with pre-drilled 3/16" holes and one without. Each style must be handled slightly differently.

If you have any tabs with holes, start with those. The task is to mark and drill a hole in the floorboard that matches the underlying one in the tab. One approach is to dab a small amount of paint onto the upper surface of the attach tabs, and then to carefully lower the floorboard into position. The tab locations will be marked on the bottom of the floorboard, with the hole showing up unpainted. Matching holes can then be drilled through the floorboard. The paint can be wiped off the tab before it dries.

For the tabs without holes, simply position the floorboard, eyeball the location of the underlying tab and drill through both board and tab in a single pass from above. In all cases, use a **#19** bit. Once all the holes have been drilled through both the floorboard and the tabs, remove the board and ream all the attach tab holes up to final size with a **#10** bit. This mismatch in hole size between the floorboard and the tabs simply makes it easier to align the screws when the board is installed.

Sand the floorboards to your satisfaction and finish them with polyurethane varnish, epoxy paint or any other durable surface finish you choose.

Caution Even if you intend to carpet your floorboards, you should apply a moisture-resistant finish to prevent dry rot.

The boards are secured to the attach tabs with **nutclips** [66] and AN526-8R8 round-head machine screws. At this time, slide the clips over the attach tabs (with the nut body **down**) until they're centered on the screw holes in the tabs. You may find it helpful to use the blade of a small, standard screwdriver to hold the clips open for easier installation. You can use the AN526-8R8 screws to secure the floorboards now if you wish, but it would probably be smarter to wait until after final inspections of the aircraft systems have been completed.

Warning As with the fuel shut-off valve cutout mentioned earlier, it's important that the gaps between the floorboards and the fuselage shell be closed out—especially at the forward end near the rudder control weldments—in order to prevent loose objects in the cabin from jamming the controls. Thin aluminum sheet, rubber molding and/or carpeting and upholstery can all be adapted for this purpose.

Completed: [ ]

Step 18: Fit the Seat Pans

The **left** [51] and **right seat pans** [52] must be trimmed to fit around a variety of cage tubes and attach tabs, as well as the control sticks. The pans come with pre-molded scribe lines all the way around their perimeters to guide this trimming. Use files, sandpaper, a saber saw with a carbide grit blade and/or a rotary file in a die grinder to trim the excess fiberglass up to the line.

Note The scribe lines represent **minimal** trimming. In all likelihood, you'll need to take off a bit more than indicated. You need to decide how precise a fit you need. If you're striving for show-plane quality, you'll want to keep the tolerances tight, but count on this being quite a painstaking process. On the other hand, if you're motivated by more practical concerns, trim the pans to fit more loosely—even the most minimal upholstery will hide the gaps.

There is also a scribe line for an oblong cutout at the front of each pan to accommodate the control stick. Once again, this scribe line represents an **absolutely minimum**-sized cutout. In fact, we recommend that you continue the oblong all the way to the bottom of the pan, creating a slot for the control stick rather than a closed hole. This will allow you to install and remove the pans without having to unbolt the control stick, which is an extremely difficult task with the seat pans in place. However, if you insist on the smallest possible cutouts, the oblong shape will permit the sticks to be unbolted.

Continue trimming until the seat pans fit to your satisfaction.

Note Be sure to test fit both pans together; you don't want to fit each one beautifully by itself only to find that they interfere with one another when both are in place!

Warning Regardless of the size or shape of your control stick cutouts, you must ultimately provide some sort of flexible close-out over the cutouts to prevents loose objects from jamming the controls. Either a rubber boot or simply a slit in your upholstery fabric will work fine.

Completed: [ ]

Step 19: Fabricate the Seat Track Slider Angles

Cut and drill **four** seat track slider angles from the supplied **.063" X 1/2" X 1/2" aluminum angle** [81], according to the dimensions given in Figure 21a. Use standard procedures to position and drill K1000-3 **nutplates** [159] on each angle, as shown in Figure 21b. Corrosion-proof the angles as you see fit and rivet the nutplates to them with 3/32" AN426AD3 flush-head rivets.

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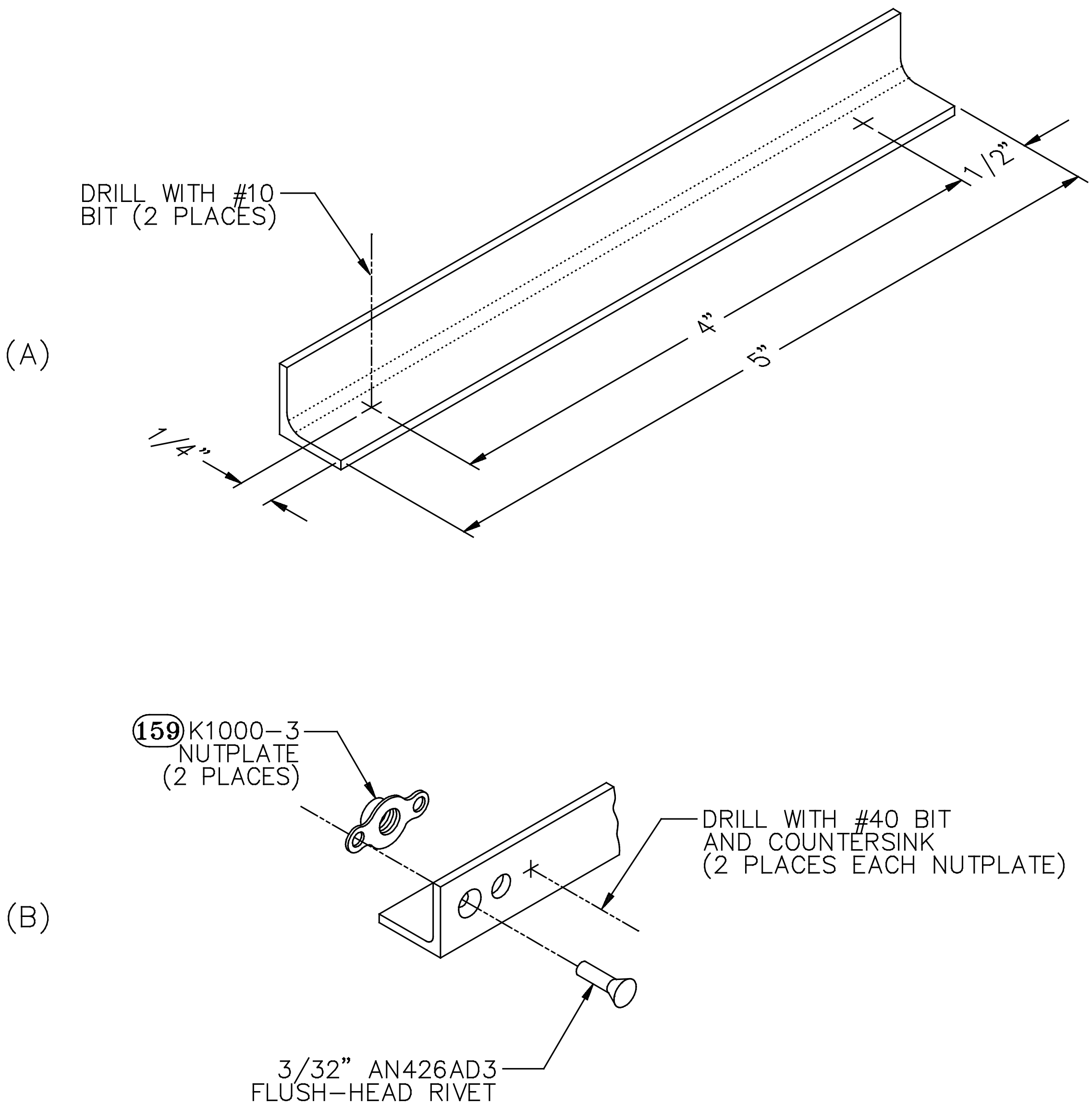

Figure 21: Seat Track Slider Angles

Step 20: Fabricate the Seat-Back Adjustment Locking Pins

Use the supplied length of **1/4" stainless-steel rod** [106] to fabricate **four** seat-back adjustment locking pins, as shown in Figure 22. To make the bend, clamp the rod in a vise and use a hammer to bend the rod over to 90°. Make the bend as tight as possible; the annealed stainless steel is quite malleable and can be bent rather sharply without cracking. Then use a grinding wheel or a file to taper the long end of each pin. Finally, drill a **3/32"** hole through the rod **11/16"** from the bottom, as shown in the figure. This hole should be approximately perpendicular to the short, bent end of the rod, but this isn't critical. Keep the hole centered on the rod as closely as you can; using a drill press and a V-block vise will make this much easier.

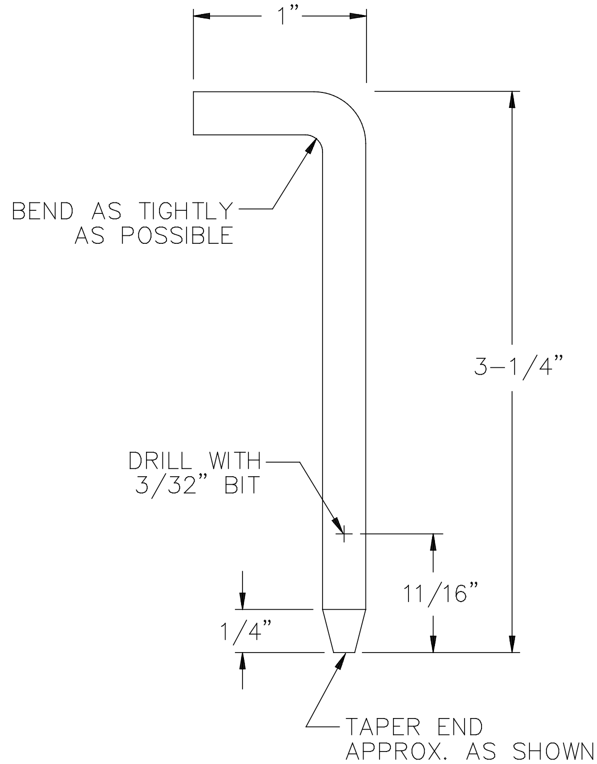

Figure 22: Seat Locking Pin

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> **Note** The design of the **seat backs** [53] was changed slightly between the first and second runs of parts. The first-run seat backs (P/N 802-02000-**01**) require a sheet-aluminum back rest, while the second-run seat backs (P/N 802-02000-**03**) do not. The two designs can easily be distinguished because the second-run backs have a crossbar between the hinge arms while the first-run backs do not.
>
> **If you have second-run seat backs, skip the following step**. Rather than riveting an aluminum seat back rest to the seat back, as you would if you had first-run seat backs, you will need to provide some sort of back rest as part of your upholstery. An early builder using custom seat backs very similar in design to the second-run kit seat backs has had very good success with a sewn canvas sleeve fit to slide over the seat back from above. The sleeve is secured with Velcro straps to the crossbar, and the seat back cushions are in turn Velcroed to the sleeve. Another alternative would be to weave a seat back rest of cord or webbing, as on a lawn chair.

Step 21: Cut and Rivet the Seat Back Rest (First-Run Seat Backs Only)

Cut a back rest for each seat back from one of the .020" X 12" X 18" aluminum sheets (P/N 075-01021-01) supplied with early kits; use the dimensions given in Figure 23. Thoroughly deburr all four edges of both seat backs.

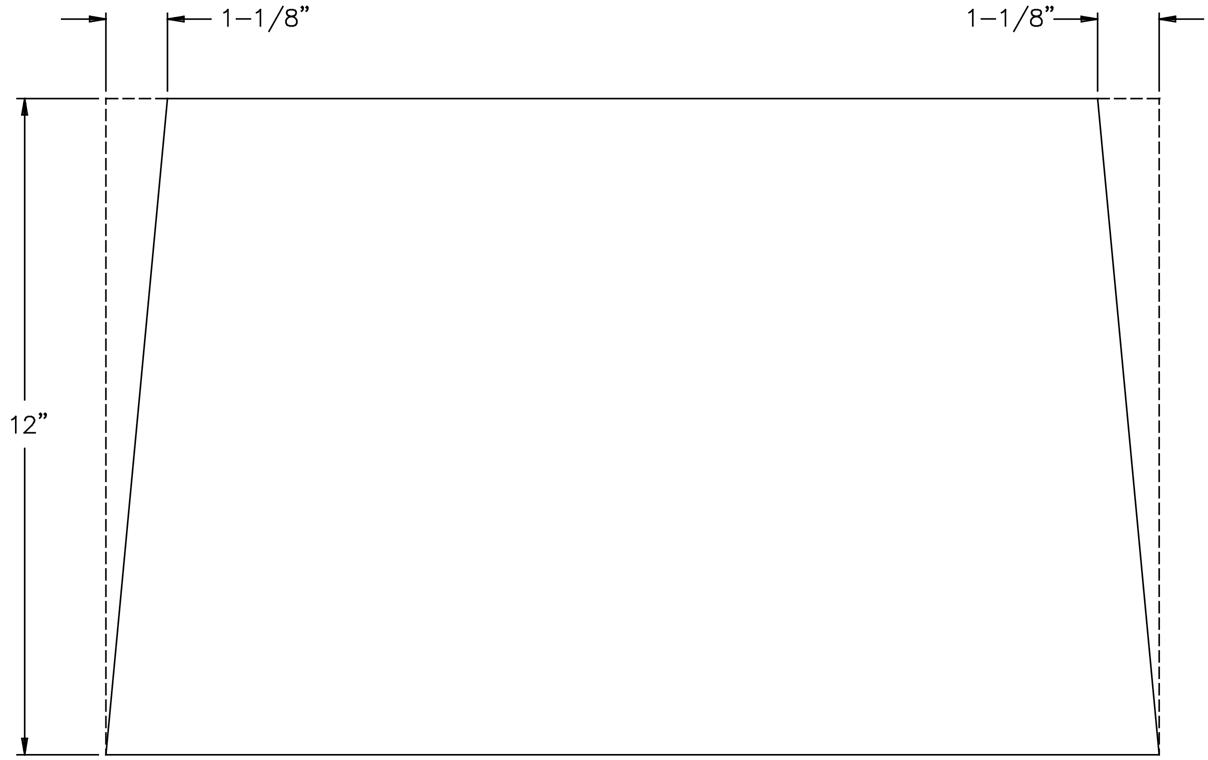


Figure 23: Cutting Out the Seat Back Rests (First-Run Seat Backs Only)

Lay the seat back (the weldment, not the aluminum back rest) flat on a bench with the **forward** side up (see Figure 24). Then lay the back rest over it so that it is centered on the seat back in a side-to-side direction and so that its top edge is even with the top of the top tube of the seat back. Then bend the left and right edges of the back rest over the side tubes of the seat back until the back rest wraps around the tubes as far as possible. As shown in Figure 24, this means that the bottom portion of the back rest sheet will wrap approximately one quarter of the way around the side tubes, while the top part will wrap about one half of the way around.

The .020"-thick aluminum sheet should be fairly easy to bend by hand. When you have it approximately where you want it, try holding it in place with some small C-clamps and then tap it against the seat back tubes with a light hammer to tighten the bends.

Next, mark and center punch **thirty-nine** rivet hole locations, as shown in Figure 24. Position the rivet holes as follows:

A) Mark **seven** holes along the **centerline** of the top tube on the **forward** side of the seat back. Space these holes on roughly 1-3/4" centers.

B) Mark **eight** holes along the **centerline** of each side tube on the **forward** side of the seat back. Space the **lower five** of these holes on each side on roughly **1"** centers; space the **upper three** on roughly **2"** centers.

C) Mark **eight** holes **1/4"** in from the edge of the back rest sheet on each side. Because of the shape of the back rest sheet, these holes will "spiral" around the side tubes: the uppermost holes on each side will be on the **aft** side of the seat back side tubes, while the lowermost holes will be approximately **90° forward** of the uppermost holes (i.e., on the sides of the side tubes). Space this spiral row of holes approximately the same way you did the holes you located in **B)** above.

With the back rest clamped in place, use the marked hole locations to drill thirty-nine **#30** rivet holes through the back rest and one wall of the seat back tubes, Clecoing as you go. Deburr all the holes and corrosion-proof the seat backs and rests as you see fit. Then use 1/8" monel blind rivets (P/N 700-0042-001) to secure the back rest to the seat back.

Completed: Left [ ] Right [ ]

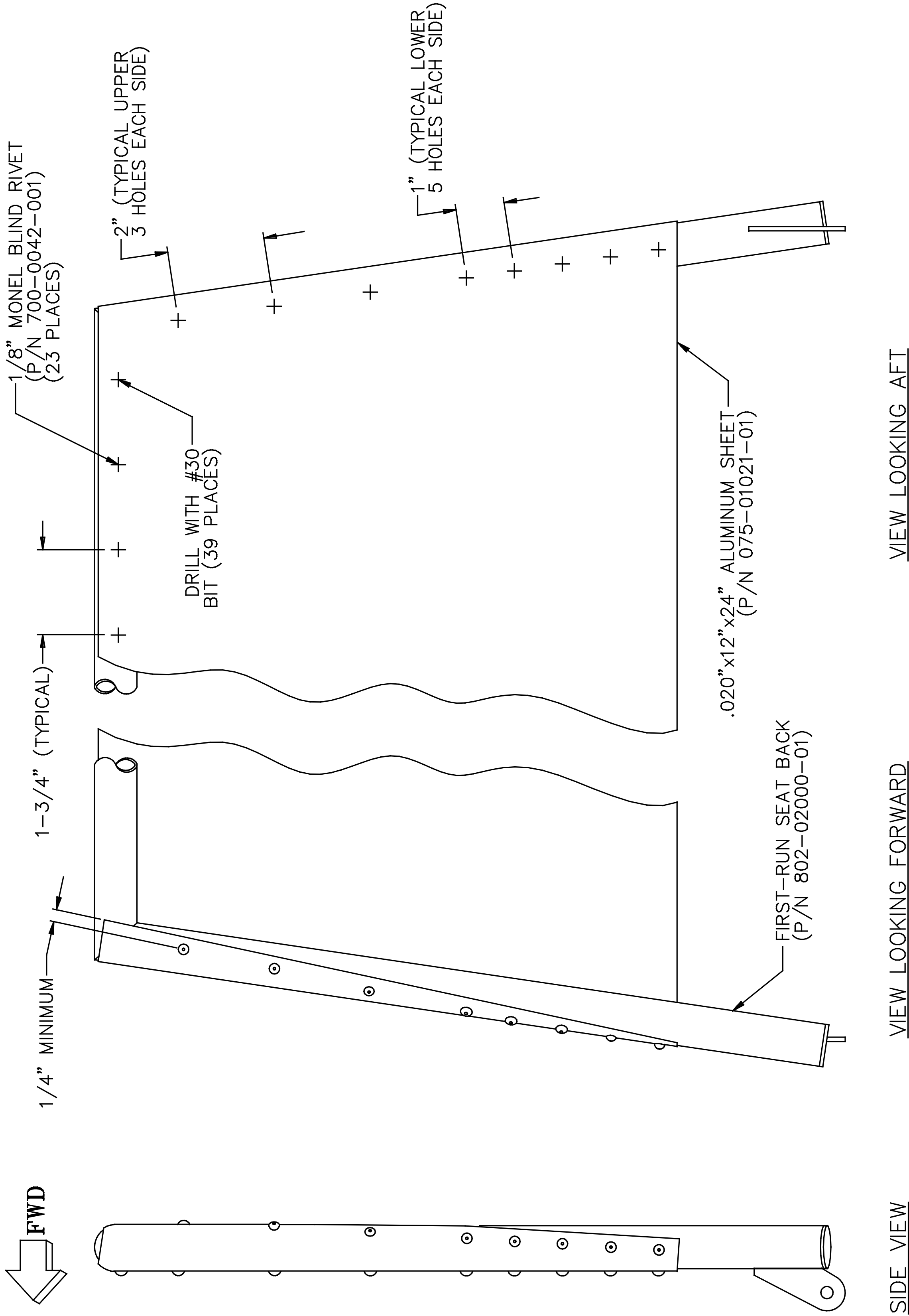
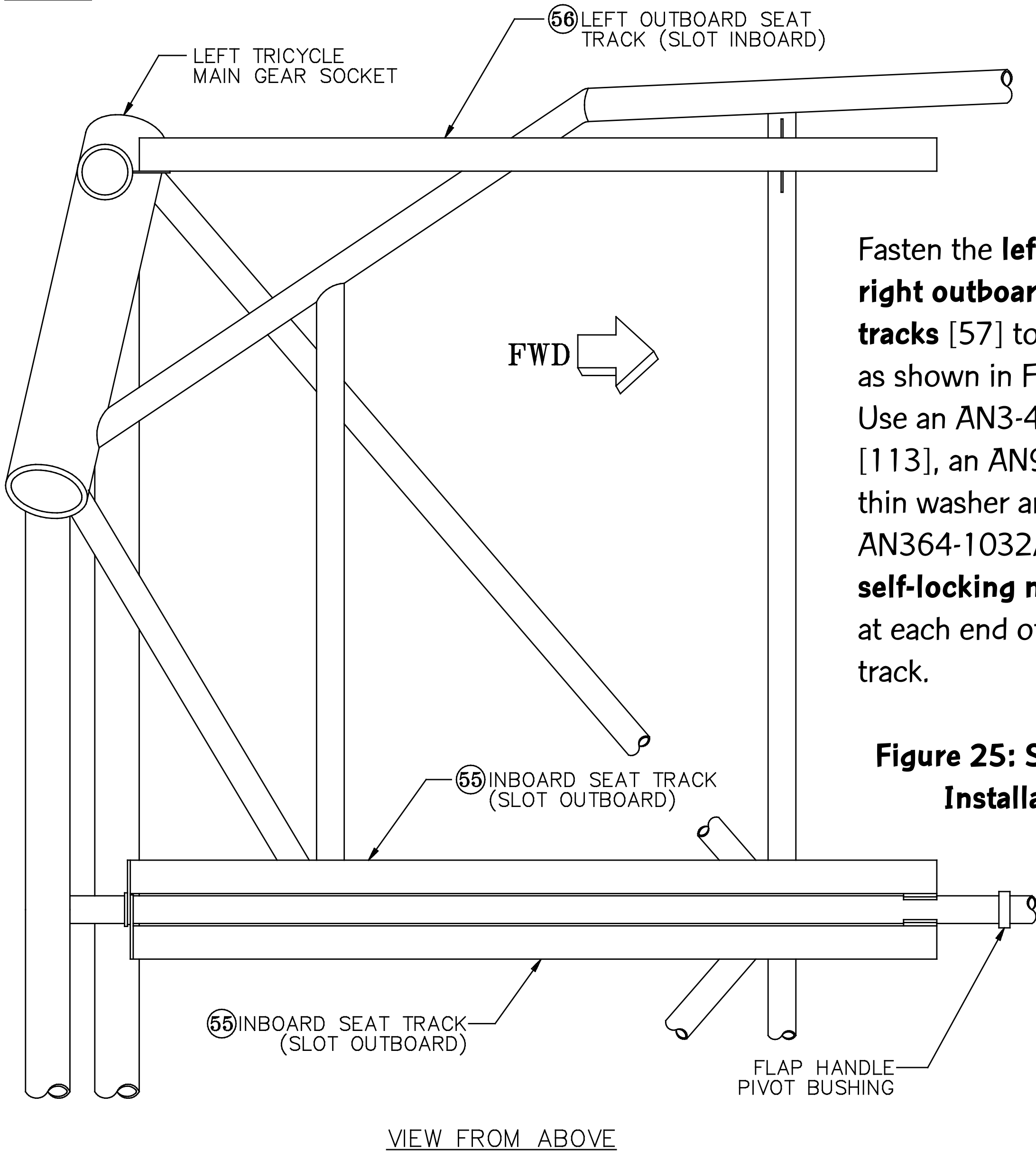


Figure 24: Back Rest Installation (First-Run Seat Backs Only)

Step 22: Mount the Seat Tracks on the Cage

Note The seat pans should be in place during this step.



Fasten the **left** [56] and **right outboard seat tracks** [57] to the cage, as shown in Figure 26. Use an AN3-4A **bolt** [113], an AN960-10L thin washer and an AN364-1032A **nylon self-locking nut** [120] at each end of each track.

Figure 25: Seat Track Installation

Note The tabs on the **aft** ends of the outboard seat tracks go on the **inboard** sides of the tabs on the cage, while the tabs on the **forward** ends of the tracks go on the **aft** sides of the tabs on the cage. The slots in both tracks should be **inboard**.

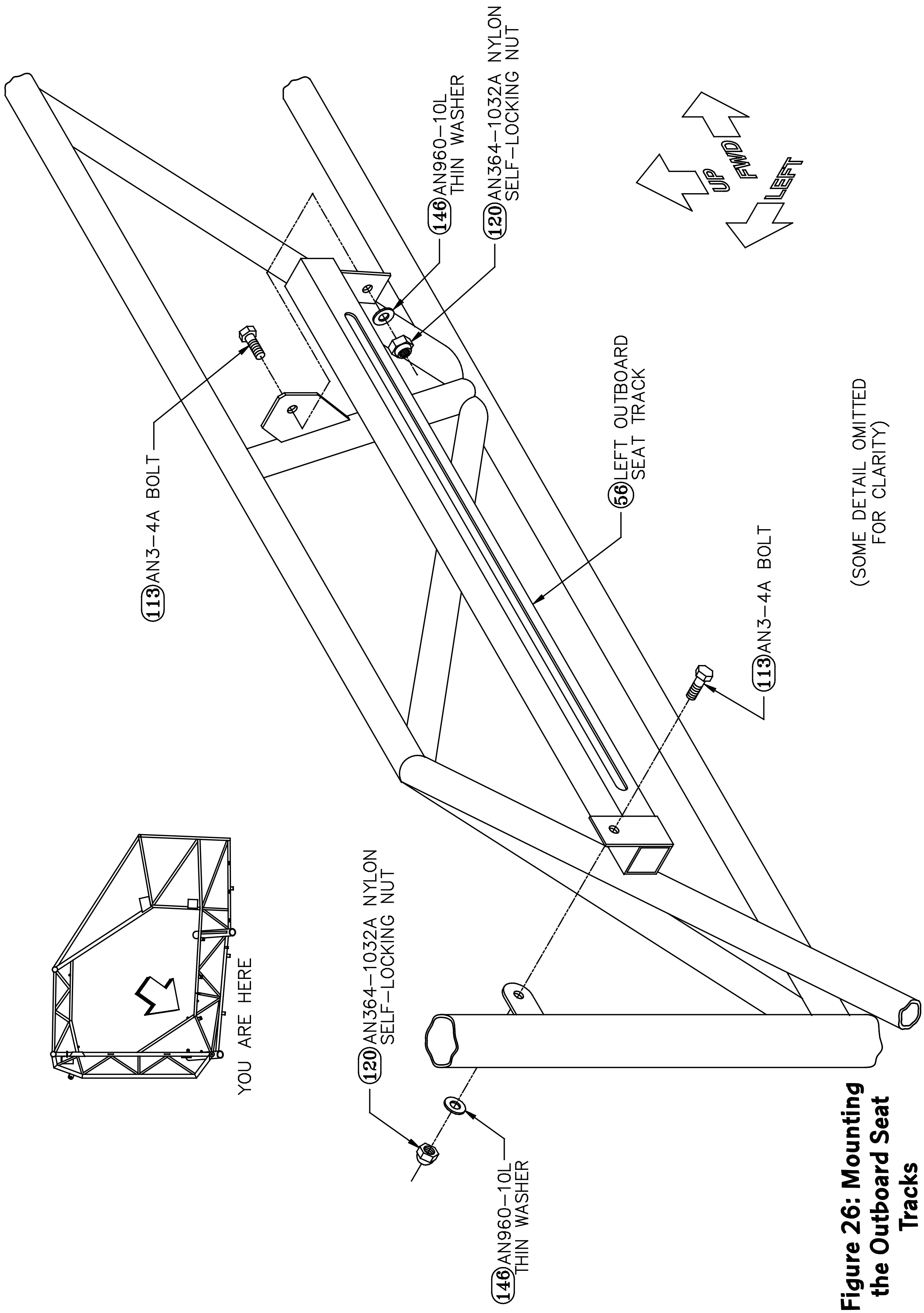


Figure 26: Mounting the Outboard Seat Tracks

Next, butt the **aft** end of the left **inboard seat track** [55] up against its attach tab, which is located on the center tube of the cage between the tricycle main gear sockets. Pin this track in place temporarily by inserting an AN3-5A **bolt** [114] through the holes in the track and cage tabs (see Figure 27). Then use a small C-clamp to clamp the **forward** end of the track to the **outboard** side of its mounting tab. From the right side of the airplane, sight across the left inboard and left outboard seat tracks and adjust the inboard track up or down until the two tracks are parallel. (Alternatively, use a digital level placed across the two tracks to check them. Move the forward end of the inboard track up or down until the inboard track is at the same angle relative to the outboard track at both ends.) When satisfied that the inboard track is parallel to the outboard track, use the holes in the two forward mounting tabs on the cage as a guide to drill a **1/4"** hole through both sides of the inboard track. Remove the inboard track and deburr the just-drilled hole.

Repeat these procedures for the right-side inboard track.

Note The tabs at the aft ends of the inboard tracks overlap, as shown in Figure 27, so the left track must be in place when fitting the right track; otherwise, the forward hole in the right track will be drilled too far forward. Thus, when you drill the forward hole through the right track your drill bit will pass through the entire assembly—left track, cage tabs and right track.

When all the mounting holes have been drilled and deburred, bolt the tracks in place, using the hardware shown in Figure 27: at the **aft** ends, an AN3-5A bolt, AN960-10 **washer** [145] and AN364-1032A nylon self-locking nut; and at the **forward** ends, an AN4-32A **bolt** [128], two AN970-4 **large washers** [157], two NAS43HT4-12 **steel spacers** [167] and an AN365-428A **nylon self-locking nut** [123]. The head of the aft bolt should be forward; the head of the forward bolt can be on either side.

Note The large washers and steel spacers will be used later to accommodate the inboard seat belt attach tabs. For now, the seat tracks must be securely bolted for a subsequent step in which the seat-back adjustment holes will be drilled in the tracks.

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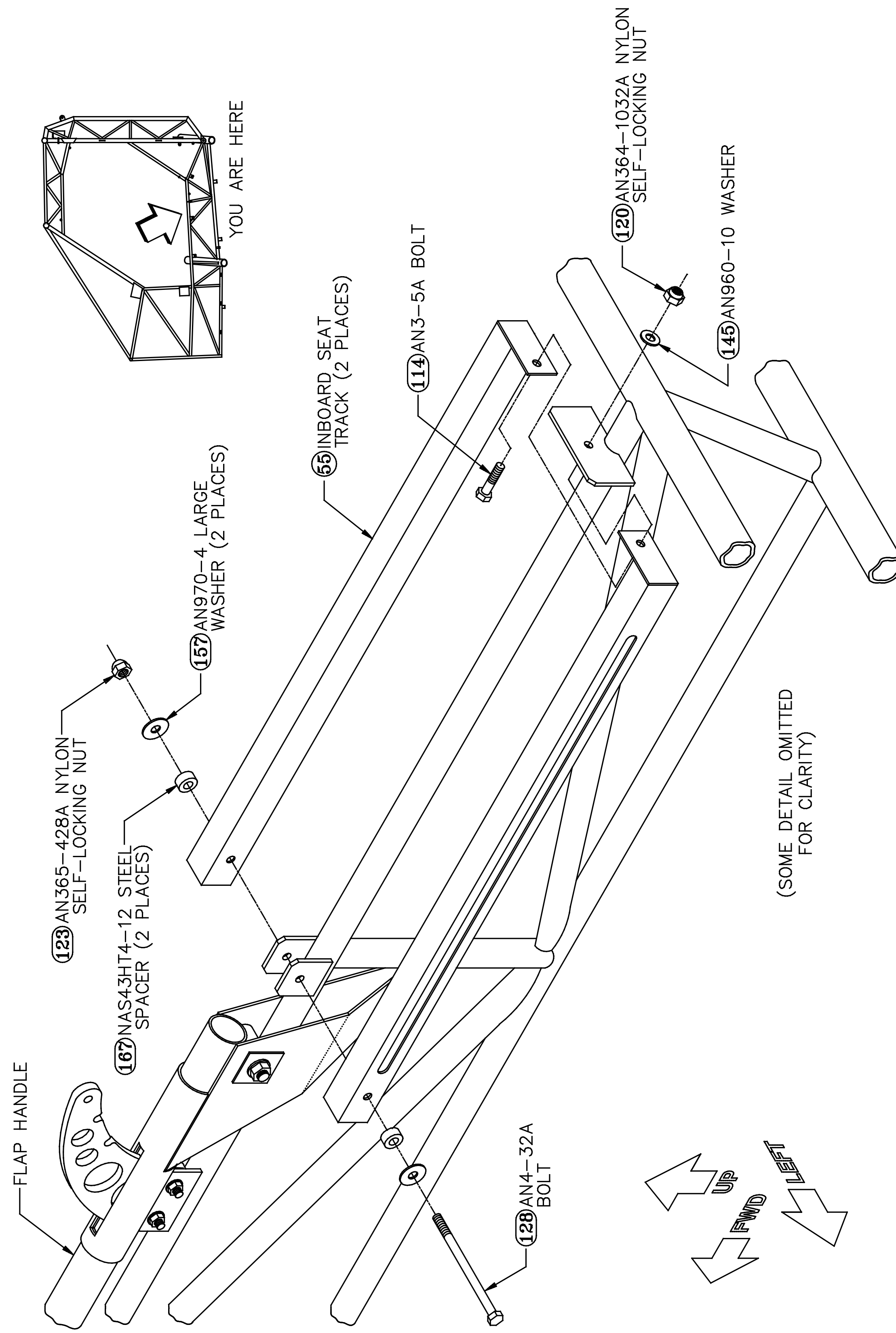
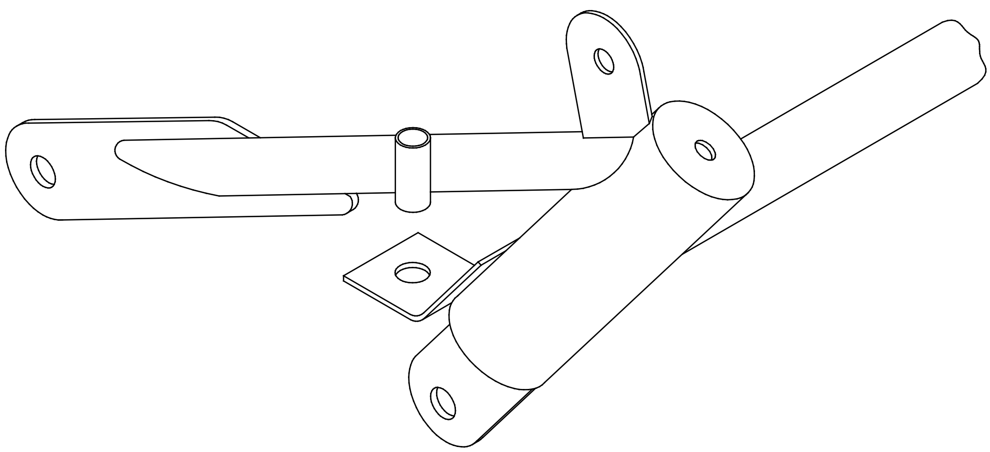
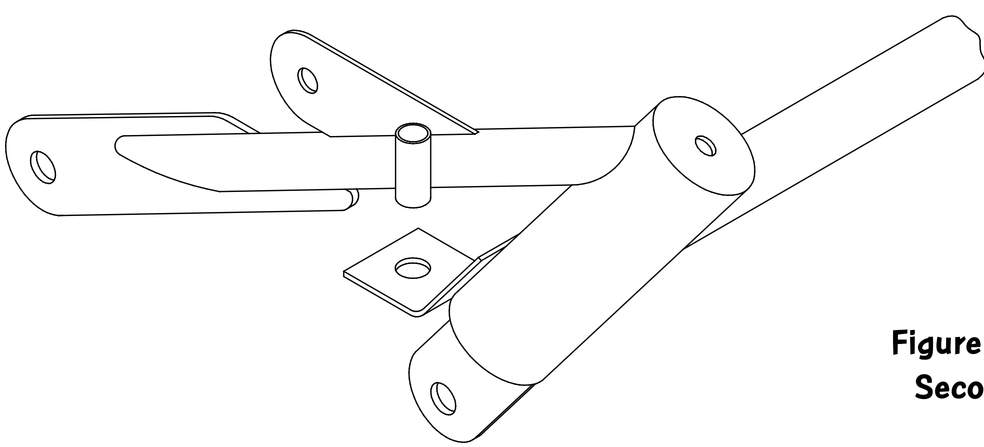


Figure 27: Mounting the Inboard Seat Tracks

Note Steps 23–26 all deal with the **seat bases** [54]. As with the seat backs, the design of these was changed slightly between the first and second runs of parts. First-run bases (P/N 802-03000-**01**) must be paired with first-run backs, and second-run bases (P/N 802-03000-**03**) must be paired with second-run backs, but otherwise, both types of bases are functionally equivalent. Because they are more common, second-run seat bases are depicted in the illustrations accompanying Steps 23–26 (Figures 29–32). However, Figure 28 shows both types of bases for reference. The assembly procedures are **completely identical** for both types.



FIRST–RUN SEAT BASE (P/N 802–03000–01)



SECOND–RUN SEAT BASE (P/N 802–03000–03)

Figure 28: First- and Second-Run Seat Bases

Step 23: Bolt the Seat Back to the Seat Base

Use AN4-5A **bolts** [129], **.032" nylon washers** [78], AN960-416L **thin washers** [148] and AN364-428A **nylon self-locking nuts** [121] to fasten each seat back to a seat base, as shown in Figure 29. Tighten the nuts until a fair bit of friction exists between the back and the base.

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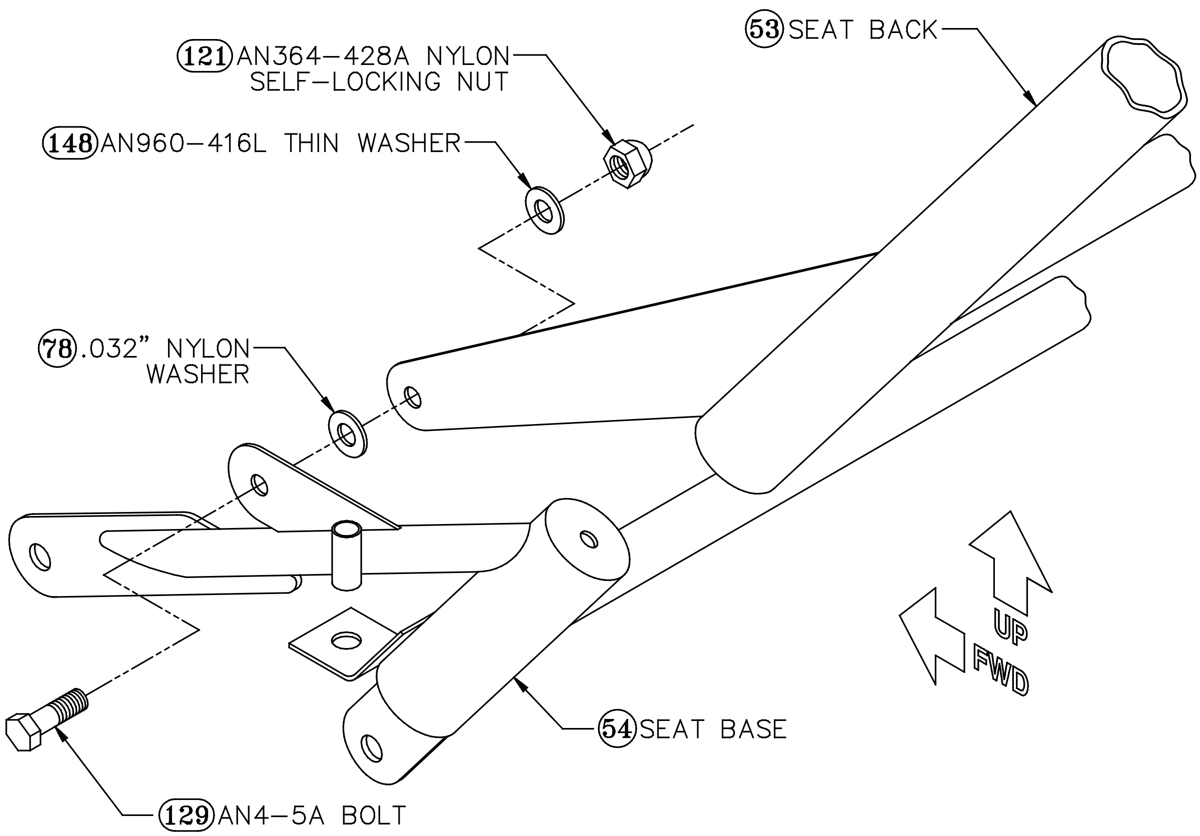

Figure 29: Bolting the Seat Back to the Seat Base

Step 24: Fasten the Seat Assemblies to the Tracks

Insert the seat track sliders into the seat tracks with the undrilled flanges up and the nutplates adjacent to the slots in the tracks, as shown in Figure 30. (Figure 30 shows the right outboard seat track and the corresponding corner of the right seat assembly, but the installation is identical in all cases.) Position the seat base between the seat tracks and thread AN3-5A bolts into the nutplates on the slider angles to secure it, as shown. Insert .032" and/or **.064" nylon washers** [79] between the tracks and the tabs on the seat base as necessary to take up slack and reduce friction. Tighten the bolts just until the heads contact the seat base tabs; over-tightening will clamp the seat base in place, making it difficult to slide.

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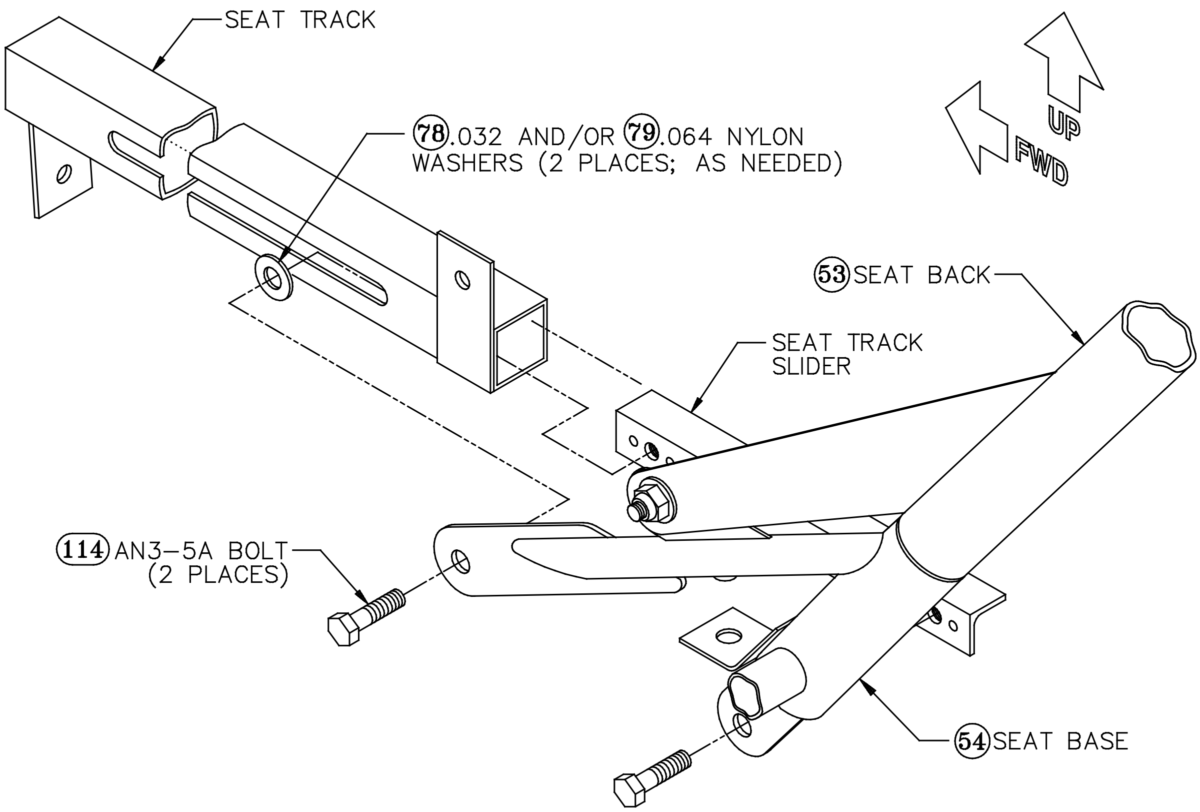

Figure 30: Mounting the Seat Assembly on the Tracks

Step 25: Drill the Seat-Back Adjustment Holes

With the seat assembly bolted to the tracks, you will now use the locking pin bushings on the seat base as guides to drill locking pin holes through the **tops** of the seat tracks on both sides, as shown in Figure 31. Begin by sliding the seat as far forward in the seat-track slots as it will go. With a letter "**F**" bit, drill the forward-most adjustment holes with the seat in this position. Then, using the same procedures, drill additional pairs of holes at equal intervals as you slide the seat aft; intervals of about **1-1/4"** will allow good flexibility in seat-back positioning. (The seat back contacting the cage serves as the limit for drilling the aft-most holes.)

Make sure the seat is square to the tracks before drilling each pair of holes (a framing square may be useful to check this) and pin the first hole of each pair with one of the 1/4" stainless steel locking pins to maintain alignment while drilling the second hole. When finished drilling, deburr all the holes and use an air hose to blow all the loose chips and shavings out of the tracks.

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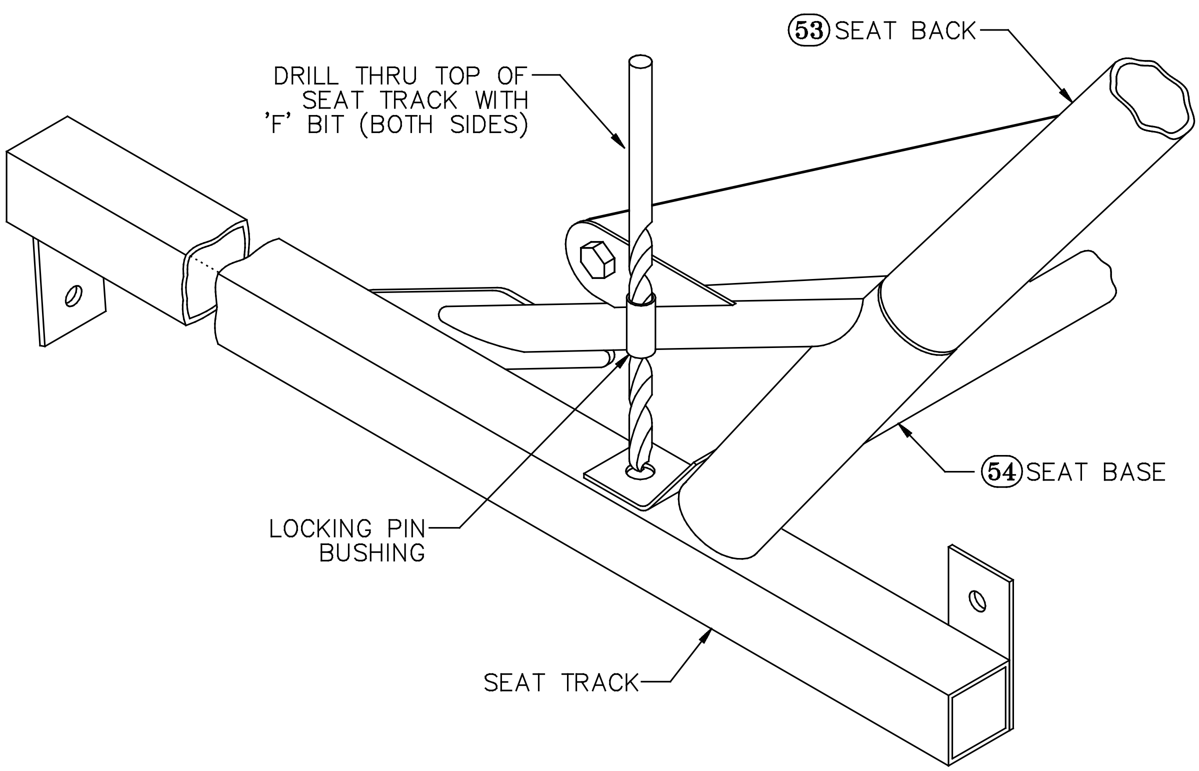

Figure 31: Drilling the Seat-Back Adjustment Holes

Step 26: Assemble the Locking Pins

Insert a locking pin through each bushing on each seat base, as shown in Figure 32. On the lower end of each pin, install an AN960-416 **washer** [147], a **seat-back adjustment locking pin spring** [76] and another AN960-416 washer, in that order. Compressing the spring out of the way, drive a **3/32" X 1/2" roll pin** [100] through the hole you drilled earlier to retain the spring. Use a light hammer or a large pair of channel-lock pliers to drive the roll pin. Repeat at all four locking pin locations.

Hint It will probably be worthwhile to remove the seat assemblies from the tracks temporarily in order to assemble the locking pins more easily. While you have them out, apply a light coat of grease to the bearing surfaces of all the sliders.

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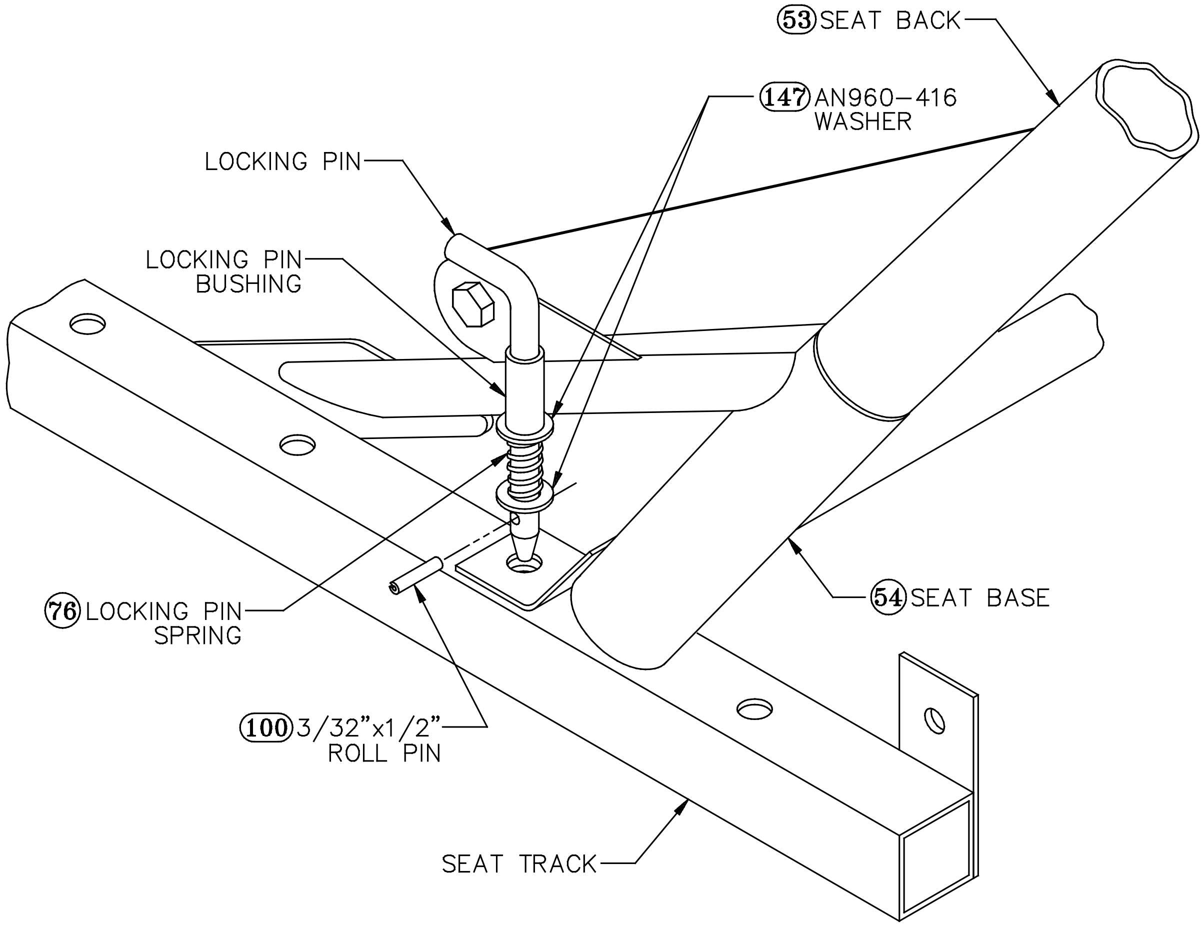

Figure 32: Assembling the Seat-Back Adjustment Locking Pins

Step 27: Install the Control Sticks

We know you've been doing it all along, but now that you're **really** ready to sit in your GlaStar and make airplane noises, you might as well position the **control sticks** [50] to your liking and drill the mounting holes!

Slide the control sticks into the tubes on the control stick pivot brackets, as shown in Figure 18 of "SECTION IX: SYSTEMS INSTALLATION." Pad the seat pan and the seat back to the approximate thickness of the upholstery you'll be using and try out the seating position. Adjust the seat back forward or aft to enable you to actuate the rudder pedals and brakes comfortably. Adjust the seat pads to position yourself at your preferred height. When satisfied with your seating position, slide the control stick forward or aft in the pivot bracket tube to the position you prefer. When you're happy with the stick position in a fore-and-aft direction, measure the straight-line distance from the top of the stick to the cage cross-tube along the bottom of the instrument panel area. Make a note of this distance, and then remove the stick from the pivot bracket.

> **Note** In most airplanes, the left and right stick are positioned identically, but if you have a taller or shorter co-pilot to please, there's no reason you can't position them separately and take separate measurements for each.

Now remove the seat assemblies and seat pans. Set the control stick pivot brackets in their neutral positions—i.e., such that the interconnect rod is centered on the control yoke. (Refer back to Step 45 in "SECTION IX: SYSTEMS INSTALLATION.") Slide the two sticks back into the pivot brackets and re-establish their positions relative to the cage cross-tube using the measurement(s) you took earlier. Use a plumb bob to position the sticks vertical relative to the fuselage and parallel with each other. Drill two **#10** holes through each pivot bracket/control stick assembly, as shown in Figure 33. Position the holes **3/8"** from the ends of the pivot bracket tubes and at approximately **90°** to each other, as shown.

> **Note** If, for any reason, your wings are installed and control cables connected at this point, then neutralize the pivot brackets by setting the ailerons to their neutral positions—with their trailing edges even with the flap trailing edges—rather than by reference to the interconnect rod.

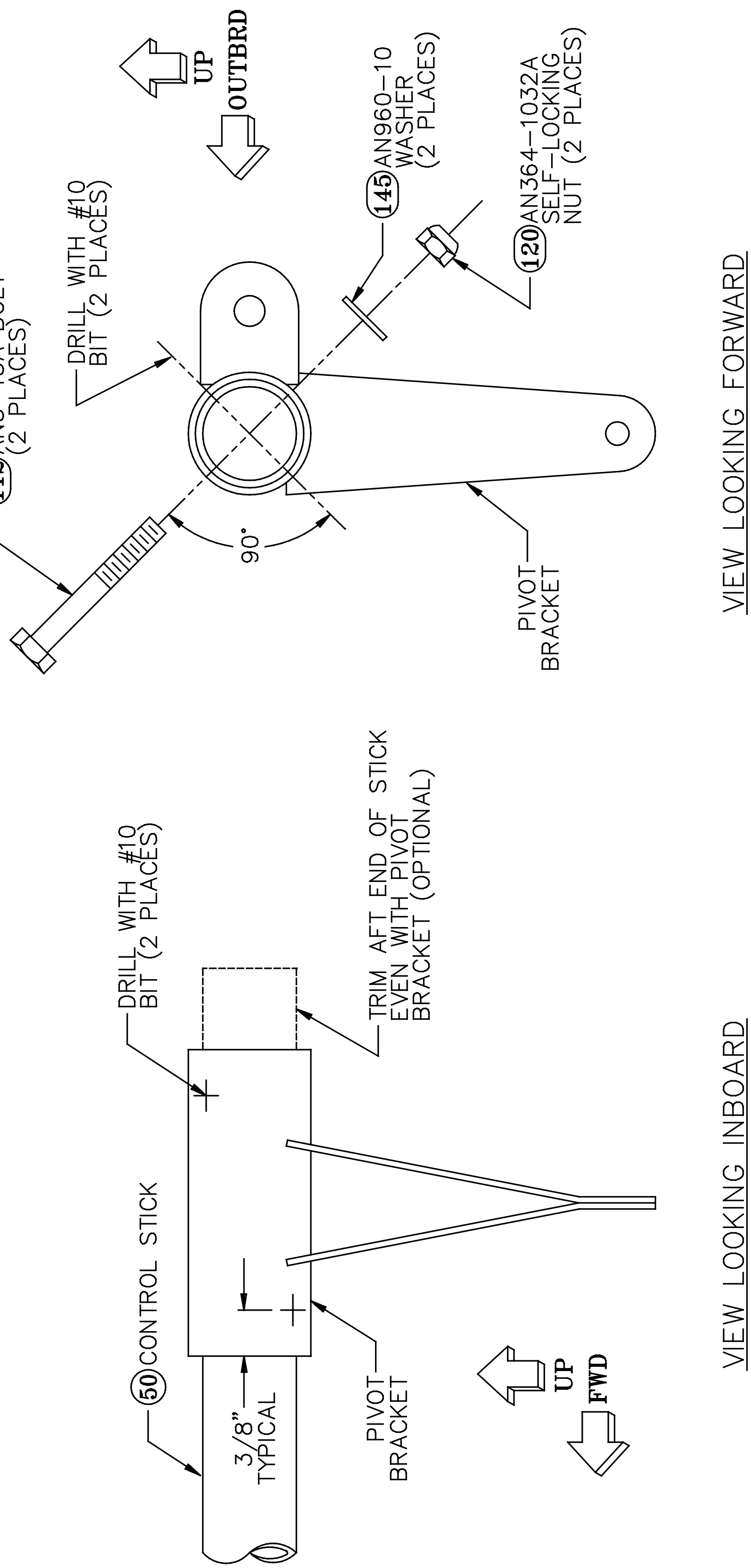

Figure 33: Drilling and Installing the Control Sticks

As an optional (but recommended) weight-saving measure, you may want to trim the lower aft ends of the control sticks where they emerge from the pivot bracket tubes. Mark the aft ends of the pivot bracket tubes onto the sticks, as shown in Figure 31; remove the sticks and trim them to the marks with a hacksaw. Smooth the cut edges with a fine-toothed file.

Regardless of whether you trim the sticks, remove them from the pivot brackets and deburr all the holes in both the sticks and brackets. Touch up any anti-corrosion protection as necessary. Then bolt the sticks to the pivot brackets with the hardware shown in Figure 31: AN3-13A **bolts** [112], AN960-10 washers and AN364-1032A nylon self-locking nuts.

> **Hint** If you are installing any switches on your sticks such as push-to-talk or electric trim switches, don't forget to run the wires through the sticks before you bolt them in place. Also, be careful when inserting the bolts not to abrade or pinch any wiring that runs there.

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Step 28: Install the Cabin Air Vents (Optional)

Cabin Air Vent Option Stoddard-Hamilton's Cabin Air Vent Kit includes pre-molded air boxes with integral NACA scoops and fully adjustable eyeball vents for both sides of the cabin, as well as all necessary installation hardware and detailed instructions. These vents provide ample air flow for comfortable operations in extremely hot conditions. Order P/N 938-02000-01.

If you're installing the Cabin Air Vent Option, **turn to the option instructions now**. Return to Step 29 in this *Assembly Manual* when the specified option steps have been completed.

☞

Note Figure 34 was deleted by Revision C.

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FUSELAGE FAIRING INSTALLATION

In this sub-section, you will install the horizontal stabilizer strakes, the rudder base fairing, the tailcone and the rudder tip fairing; the wheel pants and gear leg fairings will be installed in the next sub-section, and the horizontal stabilizer and elevator tip fairings will be installed in the "CONTROL SURFACE BALANCING AND FAIRING INSTALLATION" sub-section toward the end of the *Manual*. Before installing any of the fuselage fairings, be sure your horizontal stabilizer and elevator are in place on the fuselage.

Step 29: Mark the Centerlines of the Horizontal Stabilizer Strakes on the Fuselage

The horizontal stabilizer strakes—which enhance the slow-speed handling and stall-recovery characteristics of the GlaStar by preventing the stabilizer from stalling at high angles of attack—extend forward from the horizontal stabilizer along the fuselage sides. In order to work properly, the centerline of each strake must be aligned with the chord line of the stabilizer. In this step, you will mark an extension of this chord line onto the sides of the fuselage.

Begin by arranging a long straightedge on top of the stabilizer along one side of the fuselage, as shown in Figure 35. (As the figure shows, a carpenter's level works well for this task.) Place a scrap wood block about **3/4"** thick under the straightedge . Position the block so that it's aligned on the trailing edge of the stabilizer. Holding the straightedge firmly in position, mark along its lower edge from about **18"** to about **24"** forward of the stabilizer, as shown in the figure.

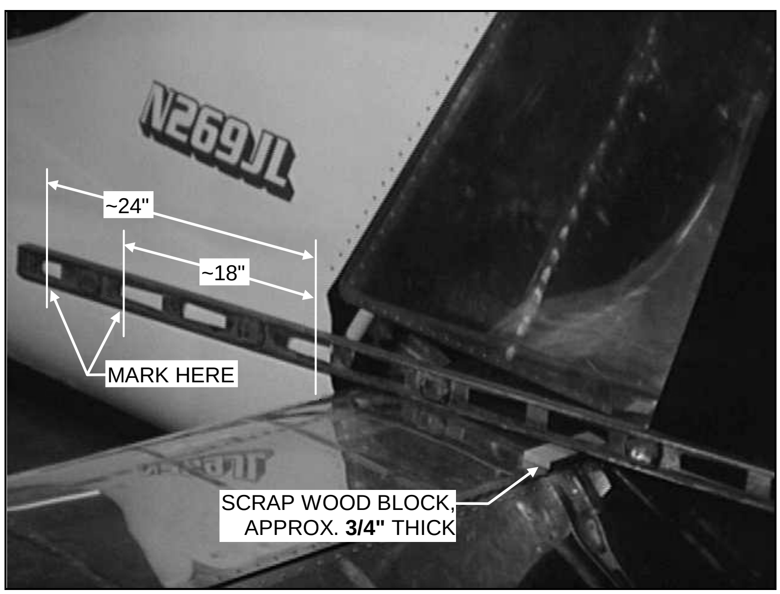

Figure 35: Marking the Stabilizer Chord Reference Lines

After marking both sides of the fuselage in this manner, repeat the process on the underside of the stabilizer. For this procedure, you'll need an assistant to help hold the straightedge and scrap wood block tightly against the stabilizer while you mark along the **upper** edge of the straightedge. Once again, the wood block should be aligned with the trailing edge of the stabilizer.

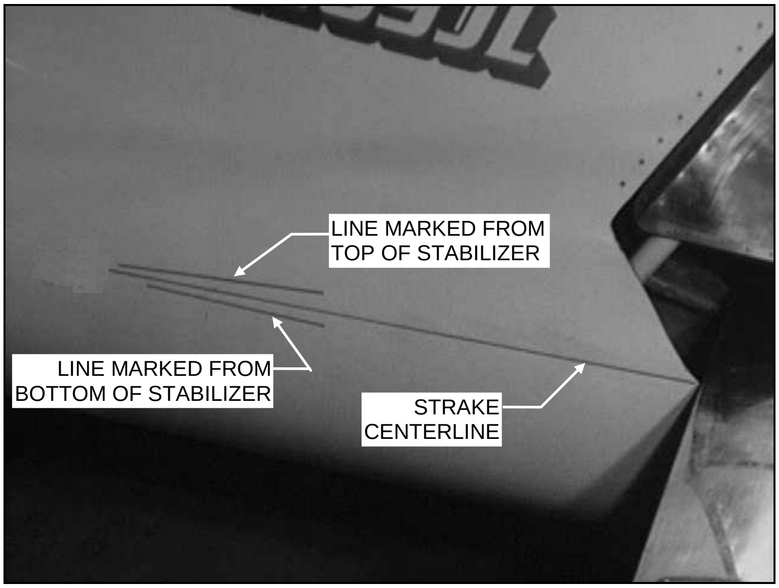

Figure 36: Marking the Strake Centerline

The result of these marking procedures is a pair of lines on each side of the fuselage that converge toward their forward ends, as shown in Figure 36. A third line drawn halfway between these lines represents the chord line of the stabilizer, which is also the centerline of the strake. Mark this third line by holding one end of a straightedge on the center of the leading edge of the stabilizer and adjusting the other end until it is midway between the two angled lines. Mark this line the full 24" or so from the stabilizer leading edge, as shown.

The chord lines just marked bring you into the ballpark. However, there's a decent chance that the lines on each side of the fuselage will not be perfectly parallel due to the inexact nature of the marking method. This is unacceptable; it's OK for the strake leading edges to be slightly lower or slightly higher than the stabilizer chord line, but it's essential that they be the same on both sides. Therefore, to check the chord lines you just marked, measure the vertical distance to each one from the fuselage waterline at a given distance forward of the stabilizer—say, **20"**. If these distances are different from left to right, split the difference, adjusting one strake centerline upward and the other downward to make them parallel.

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Step 30: Fit the Strake Halves to the Fuselage and Stabilizer and Tape Them Together

Each strake consists of an upper and a lower half that you will bond together. Now that the strake centerlines have been established, you can use the contours of the fuselage and stabilizer to help align the halves and then temporarily tape them together for bonding. As a preparatory step, apply **eight–ten** layers of wide masking tape to the leading edge of the stabilizer on each side from the fuselage shell outboard about **14"**. The tape should wrap aft from the leading edge at least **2"** on both the top and bottom surfaces. This tape serves to simulate the thickness of the protective plastic tape you will apply later between the strakes and the stabilizer.

Next, pair the strake halves off in left-hand and right-hand sets—the **upper left half** [11] with the **lower left half** [9] and the **upper right half** [12] with the **lower right half** [10]. Each of the four halves is different; to help distinguish them, keep in mind that the "fuselage flange" (that is, the longer flange that goes against the fuselage shell) of each **upper** half is at an **obtuse** angle to the surface of the strake, while the fuselage flange of each **lower** half is at an **acute** angle to the surface of the strake. Figure 37 illustrates this.

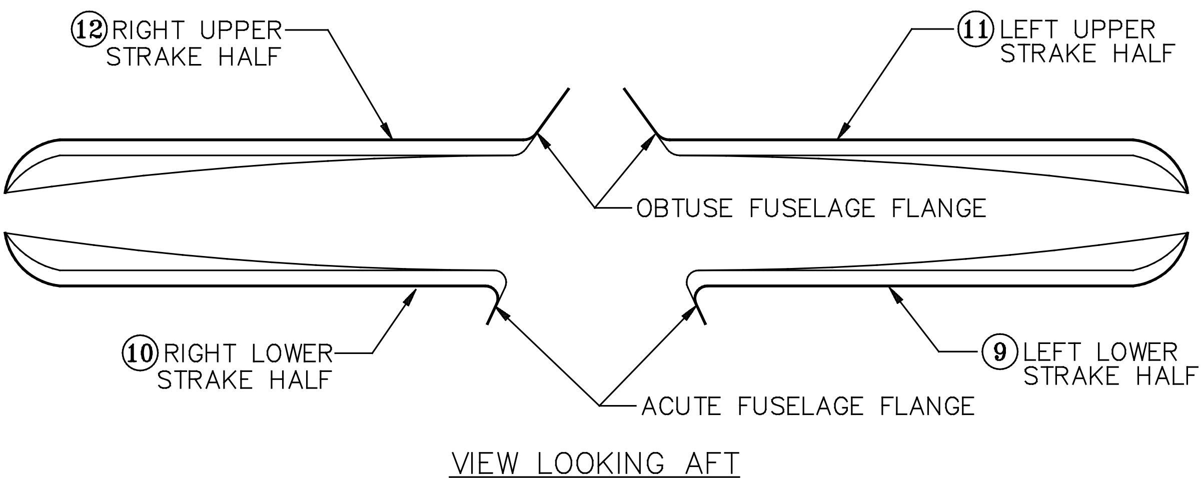
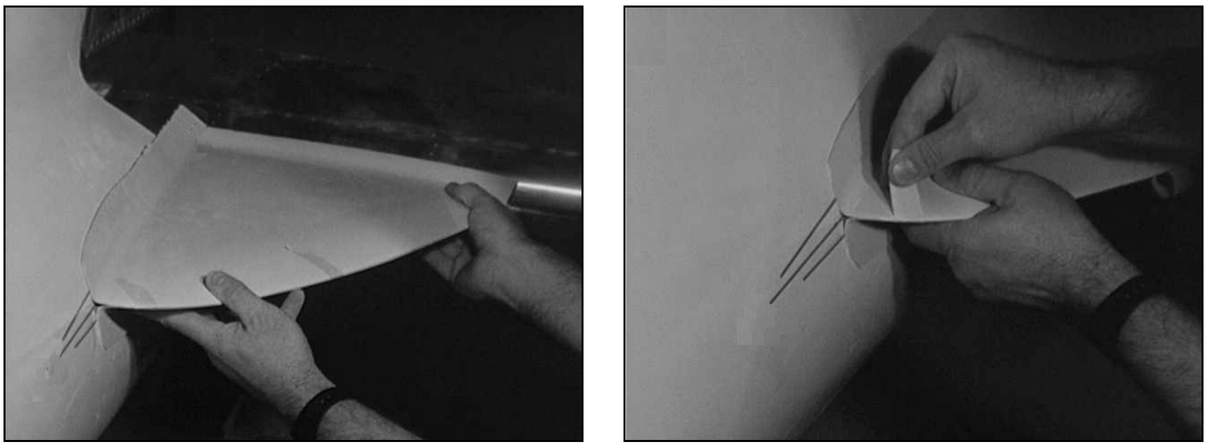


Figure 37: Identifying the Strake Halves

With the strake halves paired off, use a few strips of masking to tape to bind each pair together, aligning the leading edges of each half reasonably well. Then position each pair against the fuselage shell and the horizontal stabilizer, as shown in Figure 38a, aligning the seam between the halves with the marked strake centerline. If necessary, readjust the tape strips, as shown in Figure 38b, in order to get the fuselage flanges of each half to lie flat against the shell and the "stabilizer flanges" (that is, the shorter flanges that lie against the stabilizer) to fit snugly against the taped stabilizer leading edge.



(a) (b)

Figure 38: Fitting the Strakes to the Fuselage and Stabilizer

Step 31: Seam the Strake Halves Together

The strake halves are joined with two layers of **bi-directional cloth** [86]. Cut four strips of this cloth on the 45° bias, each **1"** wide by **24"** long. Also, prepare an extended resin brush at least **14"** long to allow you to reach the seam at all points. As shown in Figure 39, a simple way to do this is to tape a pair of tongue depressors on either side of a standard brush handle. The figure also shows how the strake halves (taped securely together) can be supported in a vertical position for seaming using our favorite high-tech jigging system—masking tape.

Catalyze a small batch of **vinyl ester resin** [95] and pre-saturate the cloth strips. Then, as shown in the Figure 39, use the extension brush to poke them down tightly into the acute angle between the two halves. Use a stippling motion to thoroughly saturate the cloth and to remove air bubbles. Allow the seam to cure completely.

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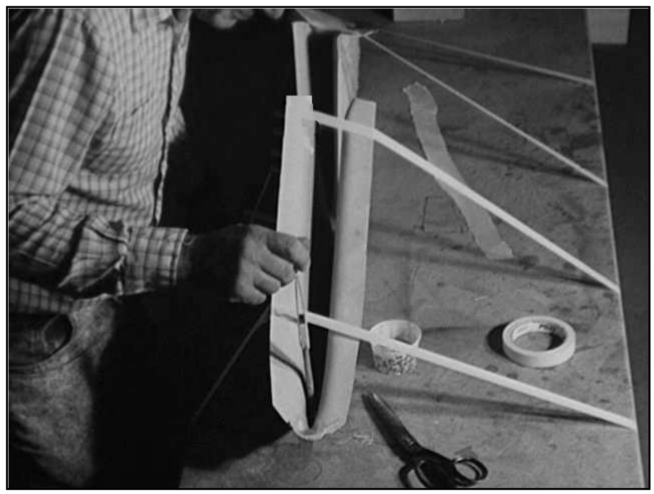

Figure 39: Seaming the Strake Halves Together

Step 32: Cut Out the Strake Ribs

Each strake is reinforced with four internal ribs, which are cut out of one of the **12" X 12" sheets of 1/2", 5-lb. density foam** [88]. Full-sized templates for these ribs are given in Figure 40. Pin the templates to the foam and cut out **two of each** with a scroll saw or a utility knife.

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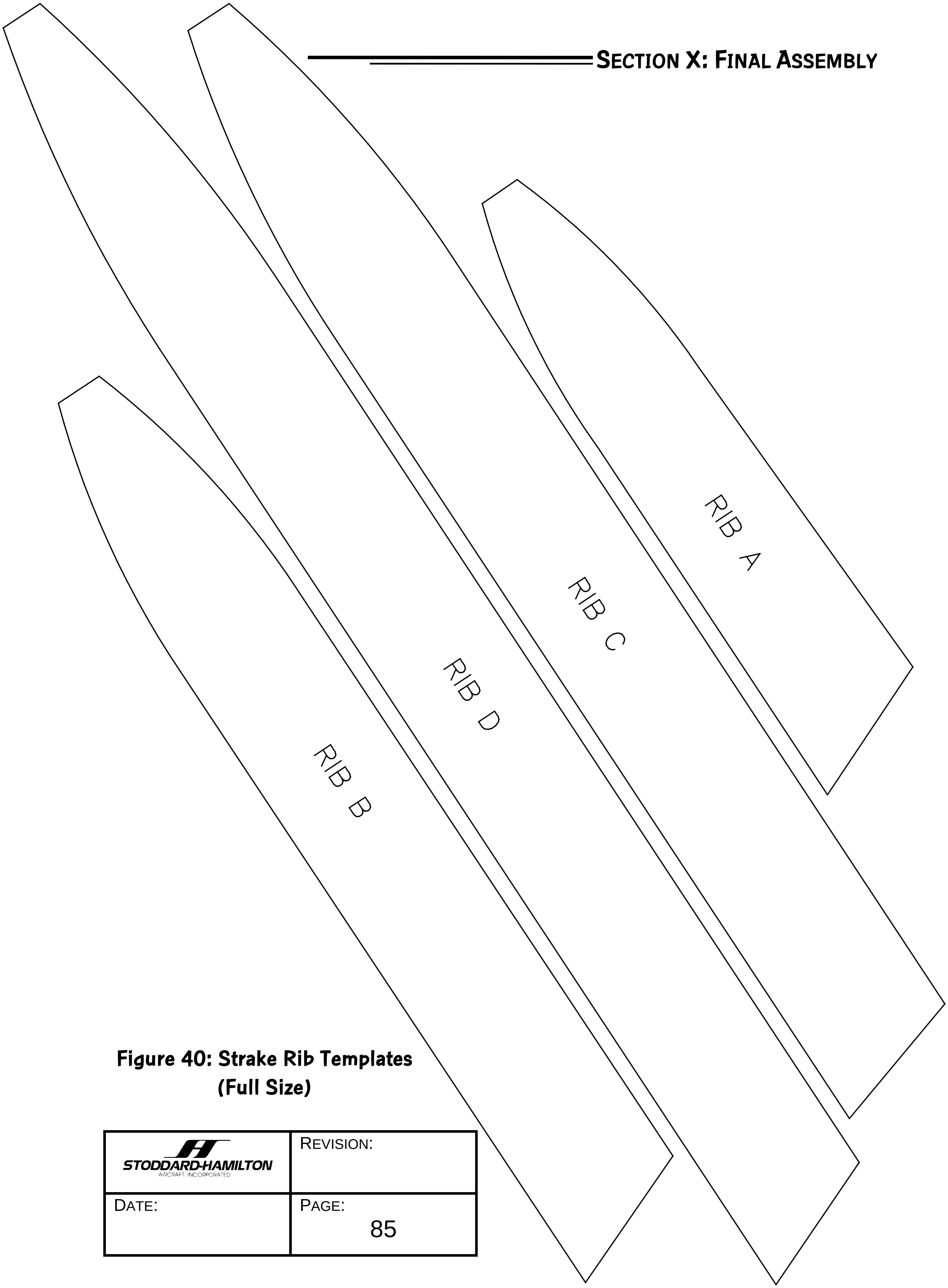

Figure 40: Strake Rib Templates (Full Size)

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Step 33: Install the Strake Ribs

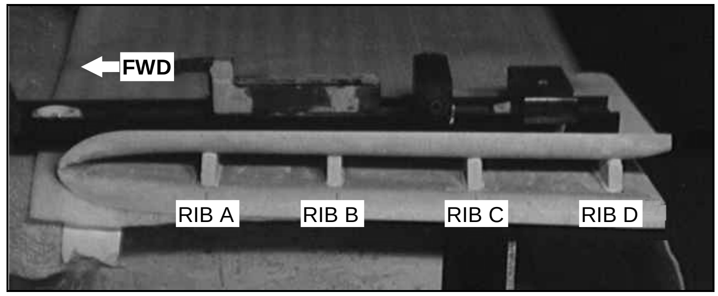


Figure 41: Placement of the Strake Ribs

As Figure 41 shows, the four strake ribs run laterally across the strake and are spaced at roughly equal intervals. The exact placement of Ribs A, B and C is very non-critical—they are essentially positioned wherever they fit best between the skins of the strake. Rib D must be placed with a bit more precision to ensure that it clears the leading edge of the stabilizer.

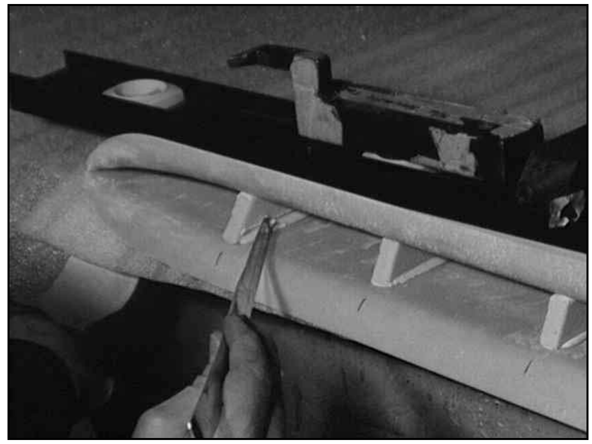
The templates for all four ribs were sized a bit over-wide so that they could be sanded to fit. Do so now, removing just enough foam from the **bottom** edge of each rib to achieve a snug fit between the skins at the approximate locations shown in Figure 41.

Note The ribs should not fit so tightly that they distend the skins.

With the ribs friction-fitted between the skins, mark the centerlines of Ribs A, B and C on the fuselage flanges of the strake. Then hold the strake in position against the fuselage and stabilizer, carefully aligning its leading edge on the strake centerline marked on the fuselage side. Reach inside the strake from the inboard side and push Rib D aft until it's tight up against the leading edge of the stabilizer. (You may find this easier to accomplish with the help of an assistant.) Then remove the strake (with Rib D still in place) and mark the location of the **forward edge** of Rib D on the strake's fuselage flanges. When you bond the ribs in place, **center** Rib D on this mark; this will have the effect of moving the rib **1/4"** forward, providing necessary clearance between the rib and the stabilizer leading edge.

Note Rib D must be fit fairly precisely in order to ensure that the strakes meet the stabilizer cleanly. With the rib in position, press the halves of the strake tightly together against it and re-check the fit of the entire assembly against the stabilizer. Re-shape Rib D as necessary to get a good fit.

(a)



(b)

Figure 42: Installing the Strake Ribs

Figure 42 shows the procedure for bonding the strake ribs in place. Begin by catalyzing a thick batch of **Q-cell** [94] and resin mixture. Use a mixing stick to spread a layer of the mixture approximately **1/8"** thick on the upper and lower edges of a rib, as shown in Figure 42a. Use your fingers to spread the strake skins slightly so you can slide the rib into position, centering it on the appropriate line.

When the rib is in place, use a "radius tool," as shown in Figure 42b, to leave a smooth fillet all the way around it and to remove the excess Q-cell. Such a tool can be either a simple length of **1/4"** dowel or can be made from any old scrap of sheet metal, plastic or thin wood. Make it **12"–14"** long and **1/2"** wide, tapering to a point with a radius of approximately **1/8"**.

For best results, begin with Rib A and proceed aft from there. After all the ribs are in place, set some weights—two or three pounds is ample—on the upper skin to hold everything down. Use a board or some comparable surface between the weights and the skins to spread the load among the ribs, although more weight will be required on Rib D than the others. (The spirit level shown in Figure 42b does the job, but we don't necessarily recommend that you treat **your** tools this way!)

When the Q-cell has cured, laminate a single **12"**-long, **2"**-wide strip of bi-directional cloth cut on the 45° bias over the **aft** face of Rib D, as shown in Figure 43. After the laminate has cured, trim and sand it down where it overhangs the ends of Rib D.

Note A gap at the **outboard** end of each rib is essential to allow any water that gets into the strake to drain. This is why all the ribs are sized to end short of the junction between the upper and lower strake halves. After installing the close-out laminate over Rib D, be sure this gap isn't sealed. If necessary, use a **1/4"** bit to drill a drain hole through the laminate in this location.

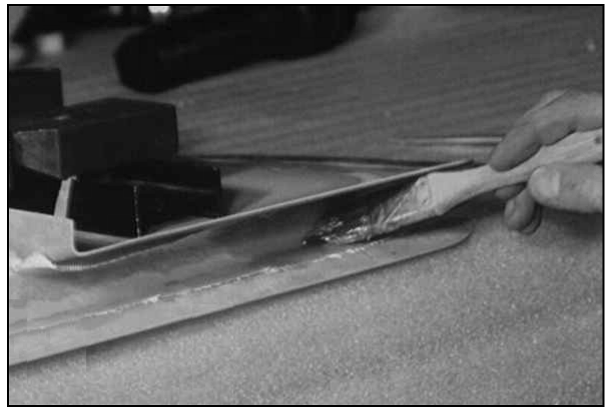


Figure 43: Rib D Close-Out Laminate

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Step 34: Adjust the Strakes and Mark Their Outlines on the Fuselage

Now that the strakes are fully assembled, you can trim and adjust them for the best fit against the fuselage and stabilizer. Use files, sandpaper and/or a rotary cutter in a die grinder to trim the fuselage and stabilizer flanges of the strakes down to the scribe lines provided. This will result in fuselage flanges about **3/4"** wide and stabilizer flanges about **1"** wide. After the flanges have all been trimmed, sand and trim the laminates you applied over the "D" ribs to allow the strakes to fit cleanly over the leading edge of the stabilizer.

After the strakes are completely sanded and trimmed, hold them in position against the fuselage and stabilizer and check the fit of the flanges. Ideally, the flanges should lie flat against the fuselage and flush with the stabilizer all along their lengths.

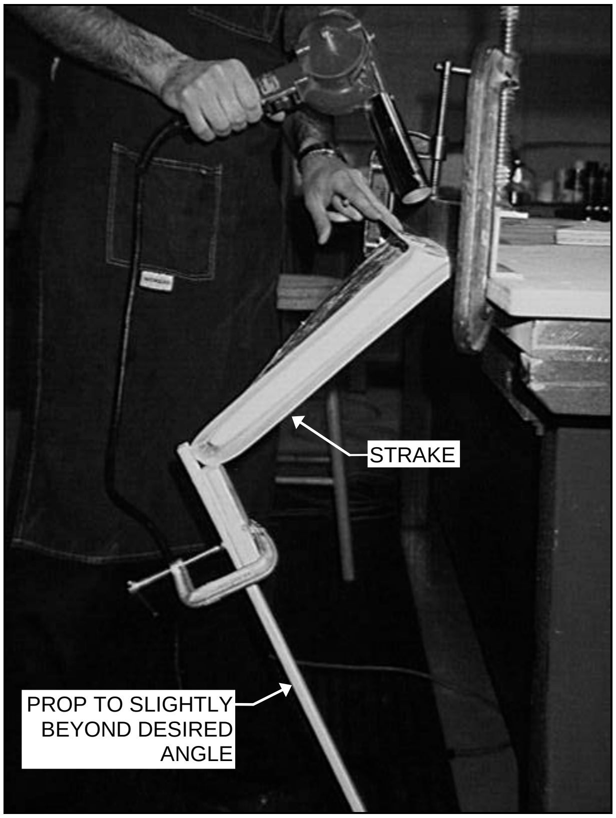


Figure 44: Adjusting the Strake Flanges with a Heat Gun

It's possible, however, that you may need to adjust the angle of one or more of the flanges to achieve a better fit. If this is necessary, use the method shown in Figure 44: clamp the offending flange flat to the bench top with a board or piece of scrap metal, bend it in the desired direction with the help of a scrap wood prop, and then use a heat gun to heat the backside of the flange radius. Bend the flange just a bit further than you want it to set in order to allow for spring-back. Run the heat gun back and forth along the radius just until it becomes too hot for you to hold your hand on the side of the flange opposite the gun. Let the strake cool completely, remove the clamps and recheck the fit.

Once you're satisfied with the fit of the strake flanges against the fuselage and stabilizer, trace the edges of the fuselage flanges onto the fuselage with a marking pen. Be sure to mark all the way from the stabilizer to the leading edge of each strake.

Completed: Left [ ] Right [ ]

Step 35: Prep the Fuselage and the Strakes for Bonding

The strakes are bonded to the fuselage with resin/**mill fiber** [90] mixture. In order for this bond to achieve sufficient strength, it's necessary to remove the gel coat from the fuselage in the bonding area. As shown in Figure 45, this area extends about **1/2"** on either side of the strake outline you marked in the last step. Mark inside and outside perimeters of this area with a marking pen.

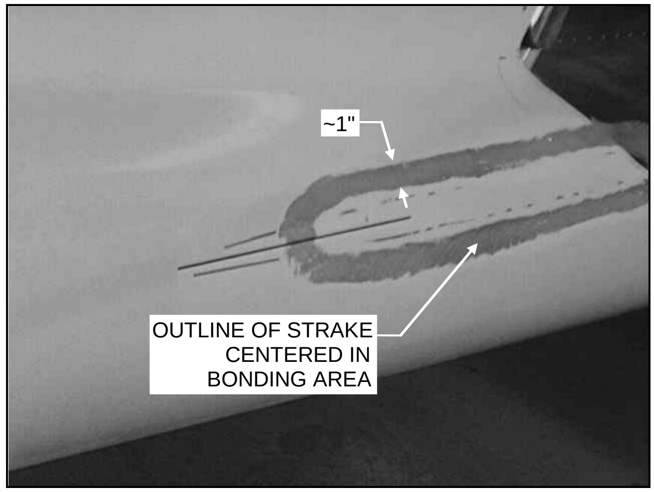


Figure 45: Removing the Gel Coat in the Strake Bonding Area

> **Warning** Hand sanding with coarse sandpaper is the best method for removing the gel coat because it offers the most control. Your goal here is to remove almost all the gel coat **without damaging the underlying laminates**. (Don't worry about small specks of gel coat that remain in the pores of the laminate.) Turn an electric or pneumatic sander loose on this task and you'll find it very hard to avoid sanding into the glass fibers of the outer fuselage laminate. **This is unacceptable**. **Any damage to the underlying fibers of the fuselage shell laminate results in loss of structural strength in one of the most critical areas of the GlaStar**. If you're nevertheless addicted to power tools, start **carefully** with a sander but stop the instant you begin to discern the tan-colored laminate through the white gel coat. Finish the job with **gentle** use of a Scotch Brite wheel in a die grinder. (Even Scotch Brite can damage the laminate, so take it easy!)

Regardless of what you use to removed the gel coat, finish by roughening the area thoroughly with 60- or 80-grit sandpaper. Also, roughen the **insides** of the strake flanges. Finally, using your favorite technique, remove the gel coat from a **1/2"**-wide strip on the **outside** of the strake fuselage flanges, as shown in Figure 46.

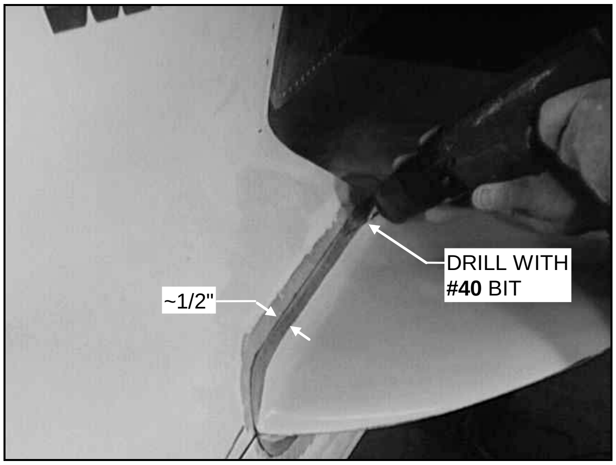


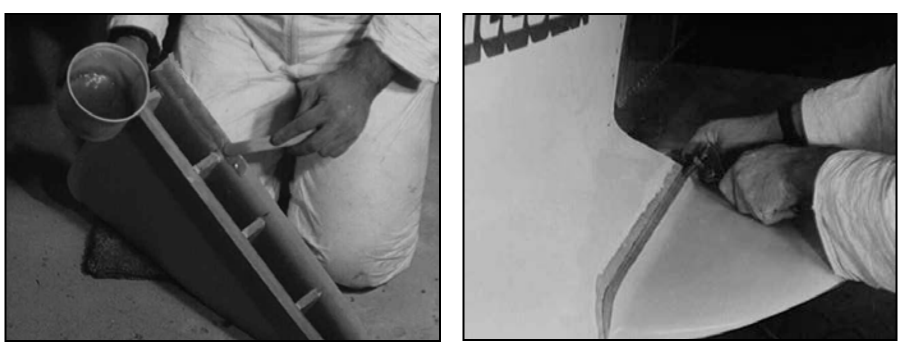
Figure 46: Drilling Cleco Holes in the Strake Flanges

Clecos work well for holding the strakes tight against the fuselage while the resin/mill fiber mixture is curing, and it's easiest to drill the Cleco holes now rather than waiting until later. Have an assistant hold the strakes firmly in position against the stabilizer and fuselage while you drill three or four **#40** holes through each flange (upper and lower) and the underlying fuselage shell. The location of the holes is not at all critical, as they will all be glassed over in any case. Simply center them by eye in the 1/2"-wide area of the flange from which you removed the gel coat and space them evenly over the length of the flange. If there are any areas where the flanges pucker away from firm contact with the fuselage shell, you can put extra Clecos there to pull the flange down tight.

Completed: Left [ ] Right [ ]

Step 36: Bond the Strakes to the Fuselage

Mix a small batch of thick resin/mill fiber mixture. Aim for a consistency roughly similar to household epoxy. Use a tongue depressor or squeegee to spread this mixture over the strake flanges to an even depth of about **1/16"**, as shown in Figure 47a. Place the strake in position against the stabilizer, and then carefully press it inward against the fuselage, being careful not to smear the resin on the shell. Cleco the strake in place as shown in Figure 47b.



(a) **(b)**

Figure 47: Bonding the Strakes to the Fuselage

Hint You may want to dip the tips of your Clecos in mold-release wax before inserting them. They'll pull out of the cured resin/mill fiber mixture in any case, but this will make it a bit easier.

Double-check that both strake flanges firmly contact the fuselage along their entire lengths, and drill and install more Clecos if necessary. Wipe up the excess resin/mill fiber mixture squeezed out by the flanges and let what remains cure completely. Remove the Clecos.

Completed: Left [ ] Right [ ]

Step 37: Fair the Strake Flanges into the Fuselage

To prepare the strakes for painting, sand both fuselage flanges to a feathered edge, as shown in Figure 48. Then apply a single **1"**-wide strip of bi-directional cloth cut on the 45° bias the length of each flange. The strip should lap equally onto both strake and fuselage. This strip is purely cosmetic: without it, over time, it's likely that small surface cracks would appear in the paint around the strake/fuselage junction. This strip will prevent those. After the strips cure, sand them to achieve a smooth fillet between the strake and the fuselage.

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Right [ ]

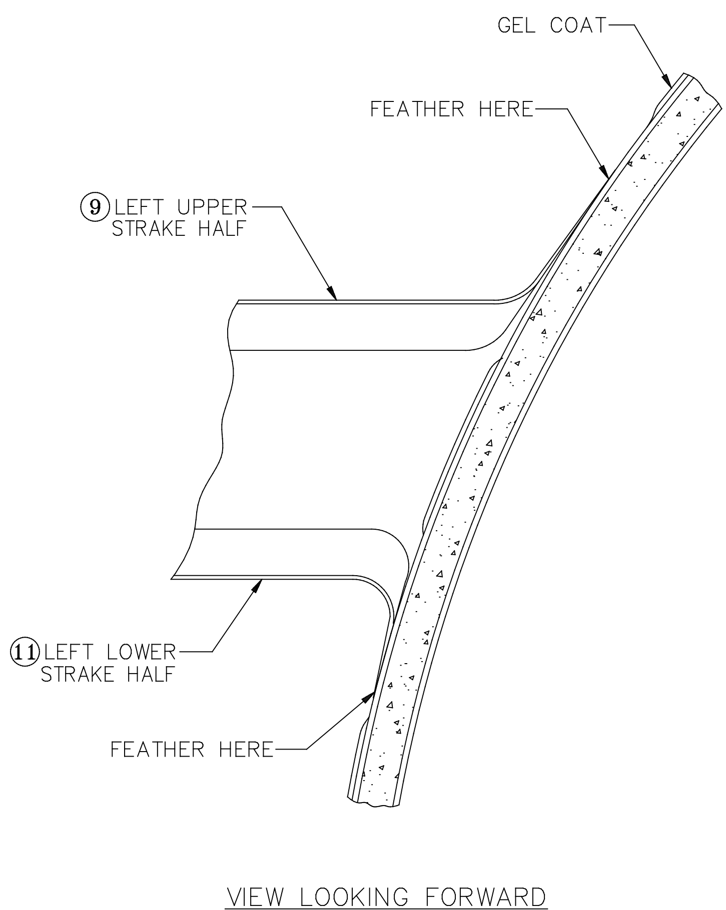

Figure 48: Feathering the Edges of the Strake Flanges

Step 38: Prep the Strakes and Fuselage/Strake Junctions for Painting

Use a lightweight body filler to fill any low spots or holes along the leading edges of the strakes and along the junctions between the strakes and the fuselage. Sand smooth.

> **Note** The strakes function best with a relatively sharp leading edge. This doesn't mean an F-104 style knife-edge, but avoid overly blunting or rounding the leading edge while filling and sanding.

Completed: Left [ ] Right [ ]

Step 39: Apply Anti-Chafe Protection to the Horizontal Stabilizer

Now it's time to replace the layers of masking tape around the leading edge of the stabilizer with something a little more permanent. Anti-chafe protection between the strakes and the stabilizer is **extremely** important. Fiberglass is very abrasive, and the normal in-flight flexing of the strakes and stabilizer could easily result in the strakes wearing right through the stabilizer skins in short order. Clearly, that's not acceptable!

We recommend the use of the same UHMW plastic tape specified for the fuel tank installation in "SECTION IX: SYSTEMS INSTALLATION." Order P/N 033-01001-01 direct from Stoddard-Hamilton.

> **Warning** If you intend to paint your aluminum stabilizer but wish to wait to do so until after flight testing is completed (which is a wise strategy, by the way), you might be tempted to forego application of anti-chafe tape until after the stabilizer is painted. **Don't do it!** It's much easier to remove the protective tape, paint and re-tape than it is to replace your stabilizer skins because they've been worn through.

Trim the tape to follow the curvature of the strake's stabilizer flanges, but be sure that the tape extends at least **1/4"** or so beyond the strake flanges. Remember, what you're concerned about here is movement of the two parts relative to each other, so don't assume that they'll stay put in flight precisely the way they fit on the ground.

Once installed, the anti-chafe tape should not simply be forgotten; during the first several hours of flight, be sure to keep a close check on the tape for signs of abrasion. Add more layers if necessary. Subsequently, this should be a checklist item for every annual condition inspection of your GlaStar.

Completed: Left [ ] Right [ ]

Step 40: Placard the Strakes

Although the strakes are plenty strong for the flight loads they will experience, they are **not** designed to be used as handles for maneuvering the GlaStar on the ground. Particularly on taildraggers, it will be very tempting to use the strakes to lift the tail. For this reason, we recommend affixing a "NO LIFT" placard to the leading edge of each strake, just as a reminder to you and a caution to others.

Completed: Left [ ] Right [ ]

Step 41: Trim the Rudder Base Fairing to Fit

The **rudder base fairing** [8] closes out the gap between the bottom of the rudder and the upper surface of the horizontal stabilizer. It also covers up the inboard aft corners of the stabilizer strakes. Figure 49 shows the fairing installed on the airframe.

Figure 49: Rudder Base Fairing

The fairing comes from the factory with scribe lines indicating the exterior contours of the fairing all the way around, as well as the typical shape of the cutout in the upper surface for the rudder yoke torque tube. However, keep in mind that these scribe lines are intended to provide only general guidance. Every GlaStar will be a little different, especially in this area, and so as they say—your results may vary!

Before test-fitting the fairing, apply three or four layers of masking tape to the upper surface of the stabilizer where the fairing will contact it. As with the strakes, this tape simulates the plastic protective tape you'll install once the fairing is trimmed to size. On this tape, mark the longitudinal centerline of the aircraft from the stabilizer leading edge to the elevator hingeline.

Note Like the **tailcone** [7], the rudder base fairing is made of fiberglass in early kits and ABS plastic in later ones. Installation of the fairing is identical in either case. From the builder's point of view, the only significant difference between the parts is the Part Number: the early, fiberglass fairing is P/N 101-01006**-01**, while the later, ABS fairing is **-03**.

Fit the fairing by trial and error, first sanding or cutting to **near** the scribe lines and then removing more material as necessary to achieve a good fit. Begin with the torque tube cutout, and then move to the outboard edges of the fairing. Trim these to achieve a consistent gap of **3/16"–1/4"** between the bottom of the rudder and the top of the fairing, as shown in Figure 50. Also, notch the lower edges of the fairing to fit neatly over the aft edges of the strakes. Throughout the fitting, be sure to keep the aft end of the fairing aligned with the marked aircraft centerline.

With the fairing's lower edges trimmed to your satisfaction, you can trim it to length. As Figure 50 shows, there will typically be more fairing than necessary at the forward end; you only need an overlap onto the fuselage shell of about **1"**. Trim off the excess beyond that. Similarly, at the aft end, trim the fairing so that its upper aft corner is even with the lower aft corner of the rudder and its lower aft corners are even with the elevator hingeline (see Figure 51).

Completed: [ ]

Step 42: Drill the Rudder Base Fairing

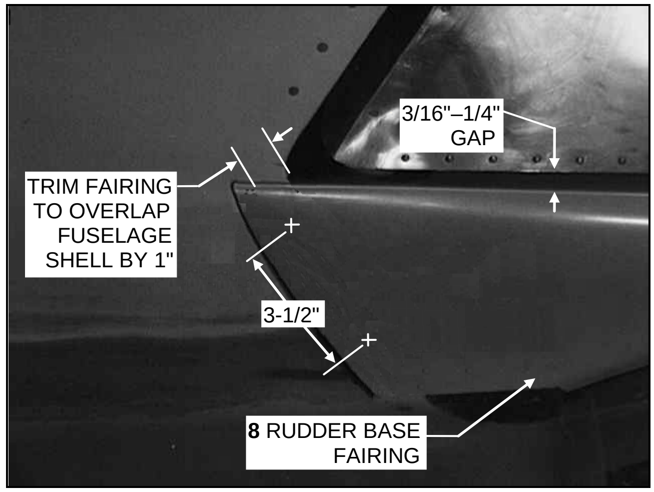

Figure 50: Trimming and Drilling the Under-Rudder Fairing

Figure 50 also shows the locations of the two mounting screw holes along the forward edge of the fairing on each side. These locations should be marked about **1/2"** forward of the aft edge of the fuselage shell. The upper location should be about **1-1/4"** below the upper edge of the fairing, and, as shown in the figure, the lower one should be marked about **3-1/2"** below the first. As these instructions imply, these locations are not overly critical, but try to place them the same way on both sides. With the hole locations marked and the fairing held tightly in place, drill through the fairing and fuselage shell at each mark with a **#19** bit. Insert AN526-8R8 round-head machine screws in these holes temporarily just to pin the fairing in place.

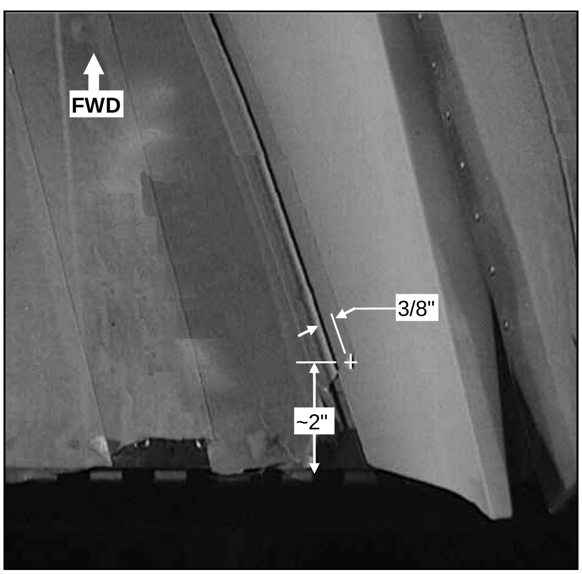

Figure 51: Drilling the Aft Mounting Screw Holes

Figure 51 shows the location of the third and final mounting screw hole on each side of the fairing. Mark this location **3/8"** inboard of the lower edge of the fairing and about **2"** forward of the trailing edge of the stabilizer. Drill through the fairing and the upper surface of the stabilizer skin at each mark with a **#19** bit.

Completed: [ ]

Step 43: Install the Nutplates and Rivnuts for the Rudder Base Fairing

The four screws at the forward end of the rudder base fairing are secured with conventional K1000-08 nutplates. Position these nutplates inside the fuselage shell and drill **#40** rivet holes. Countersink these holes on the outside of the shell to accommodate 3/32" AN426AD3 flush-head rivets. Rivet the nutplates in place, using a rivet squeezer if you have one.

For obvious reasons, nutplates can't be used for the two aft screws through the stabilizer skin. Nutplates could, of course, have been installed before the stabilizer was closed, but it would've been extremely tough to insure that they ended up in exactly the right spots. The solution to this problem is to use **Rivnuts** [65]. These consist of a female-threaded collar that can be installed like a blind rivet. As with a blind rivet, the interior portion of the collar is mushroomed against the interior surface of the skin by the installation tool, locking the collar securely in place.

> **Note** The Rivnuts supplied with the kit are specifically designed to grip thin aluminum skins securely. However, they are not optimized for use in fiberglass or steel, and so we do not recommend their use anywhere in the GlaStar not specified in this *Assembly Manual*.

The Rivnuts require a **1/4"** hole in the aluminum stabilizer skins. Use a 1/4" bit to ream the #19 holes up to final size. Deburr these holes carefully and install a Rivnut in each according to the instructions supplied with the installation tool.

> **Rivnut Installation Tool Option** Rivnuts can be installed with a special tool much like a blind rivet puller. This tool is widely available from aircraft tool supply sources and can typically be used to install a variety of different Rivnut sizes. However, this tool is a bit pricey if you only need—as in the GlaStar kit—to install a couple Rivnuts. Stoddard-Hamilton offers another, much cheaper installation tool sized specifically for the 8-32 Rivnuts specified here. Order P/N 081-01001-01. (If you use this tool, **ignore** the instruction to drill 17/64" installation holes; **1/4"** is the correct size.)

Completed: [ ]

Step 44: Fit and Drill the Tailcone

Dust off the tailcone, which you used very briefly while installing Bulkhead E back in "SECTION VIII: FUSELAGE ASSEMBLY." If you did a good job of sizing the bulkhead then, you should have very little work to do now in fitting the tailcone.

In any case, the first step is to cut slots in the tailcone for the elevator control horns and the horizontal stabilizer aft attach bracket. As shown in Figure 52, the horn slot should be approximately **1-5/8"** wide and **5-3/4"** long. Mark a centerline down the top of the cone and then lay out the trim lines as shown. Also, mark the perpendicular trim lines **3/8"** aft of the forward edge of the cone for the attach bracket slot. Use a rotary cutting tool or a saber saw with a carbide grit blade to cut close to the lines, and then finish the slot with files and sandpaper, leaving smoothly radiused corners.

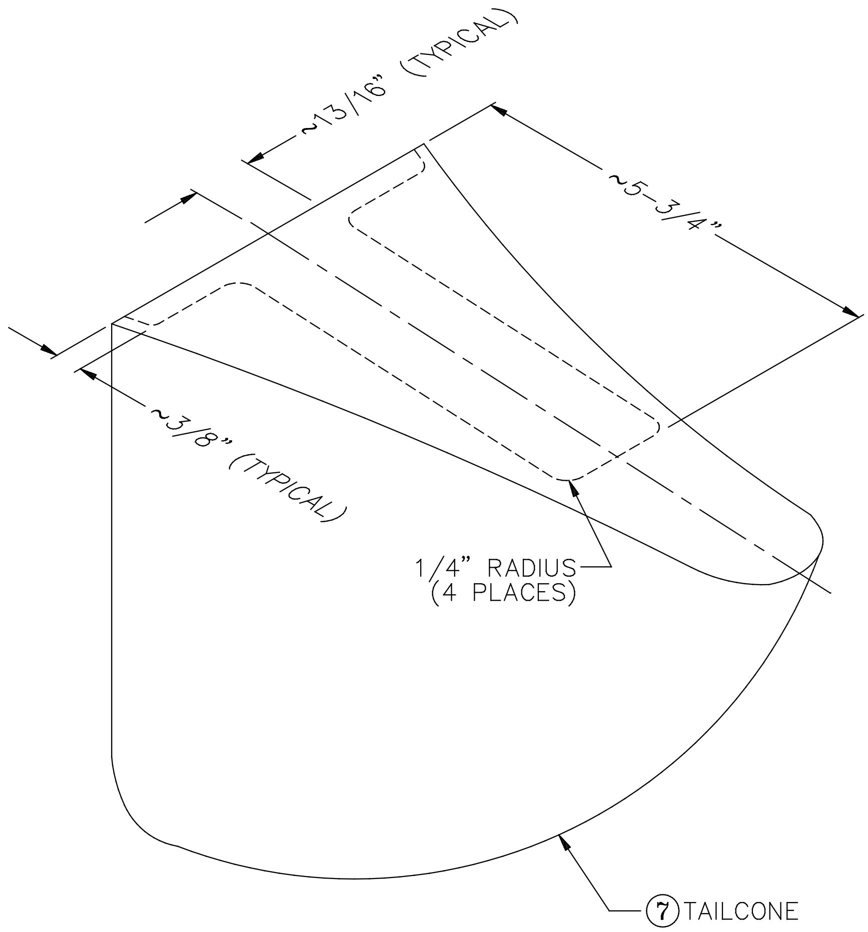

Figure 52: Cutting the Control Horn Slot in the Tailcone

Next, slide the tailcone into position over the tailcone flange of the fuselage. Trim the aft end of the fuselage as necessary to get a good fit, and then tape the tailcone securely in place with masking or duct tape.

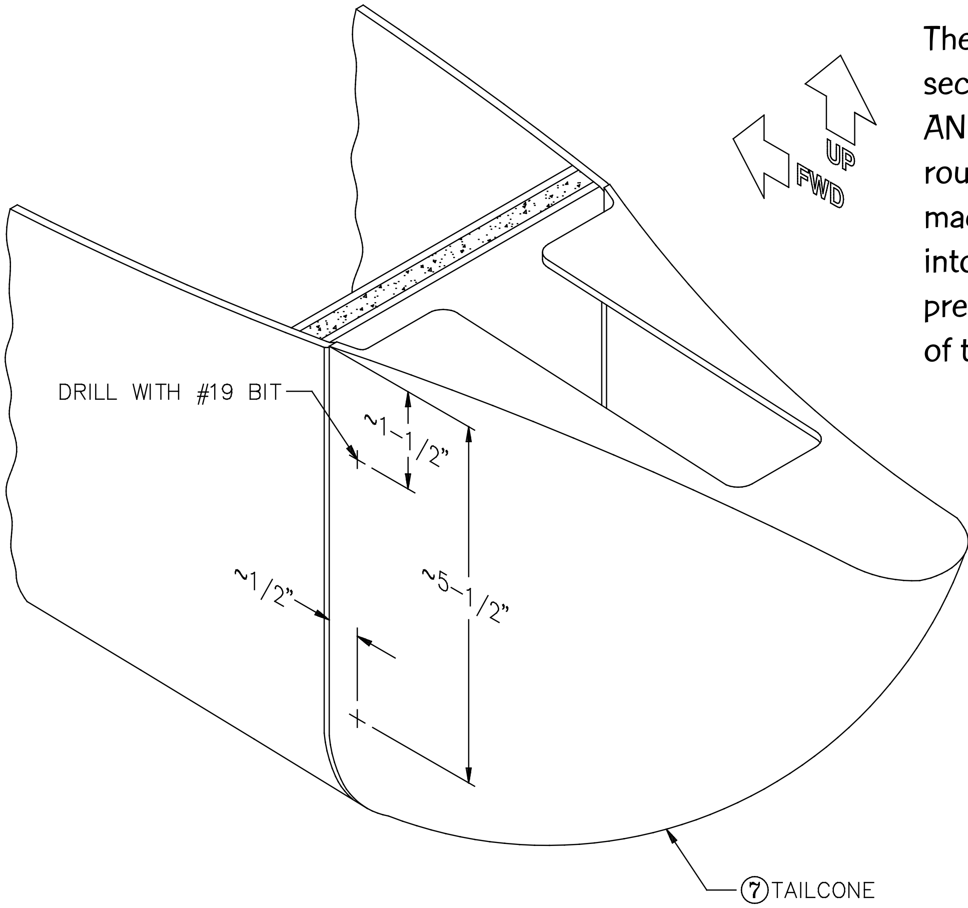

Figure 53: Drilling the Tailcone Mounting Screw Holes

The tailcone is secured with four AN526-8R8 round-head machine screws into nutplates. The precise positioning of these screws and nutplates isn't critical, but the spacing shown in Figure 53 is ideal. Mark the hole locations on the outside of the tailcone and drill through both the tailcone and the underlying flange at each mark with a **#19** bit. Then enlarge the holes **in the fuselage flange only** up to **#10** size.

After all four holes have been drilled, use standard procedures to drill **#40** rivet holes in the fuselage flange for MF5000-08 **floating nutplates** [162]. Center the screw holes in the nutplate bases on the #10 holes in the flange. Countersink the rivet holes on the outside of the flange to accommodate AN426AD3 flush-head rivets. Rivet the nutplates in place, using a rivet squeezer if you have one.

You can install the tailcone with four AN526-8R8 round-head machine screws now if you wish, but we'd recommend just setting it aside, as it will have to be removed for final inspection anyway.

Completed: [ ]

Step 45: Seam the Rudder Tip Fairing Together
(Fiberglass Fairings Only)

> **Note** In early GlaStar kits, the fiberglass rudder tip fairing consists of **left** and **right halves** (P/N 301-00015**-01** and **-02**, respectively) that the builder must seam together. Later kits include a one-piece **rudder tip fairing** [47] (P/N 301-00015**-03**) made of ABS plastic. If you have a one-piece tip, **skip this step**.

Remove the mold lip from the edges of the left and right rudder tip fairing halves.

To simplify fitting the fairing to the rudder, the two halves will be seamed together only at the forward end and along the top. The fairing halves will not be joined at their aft ends; instead, the aft end will be left open and will be trimmed off even with the trailing edge of the rudder skin. To permit this, sand inside the aft end of each half in the area where the thickness increases (about the last 1/2"), as shown in Figure 54a, until the aft end is approximately the same thickness as the rest of the laminate. After sanding, the trailing edges of the halves will not meet when placed together, but will form an elongated inverted "U" shape, as shown in Figure 54b.

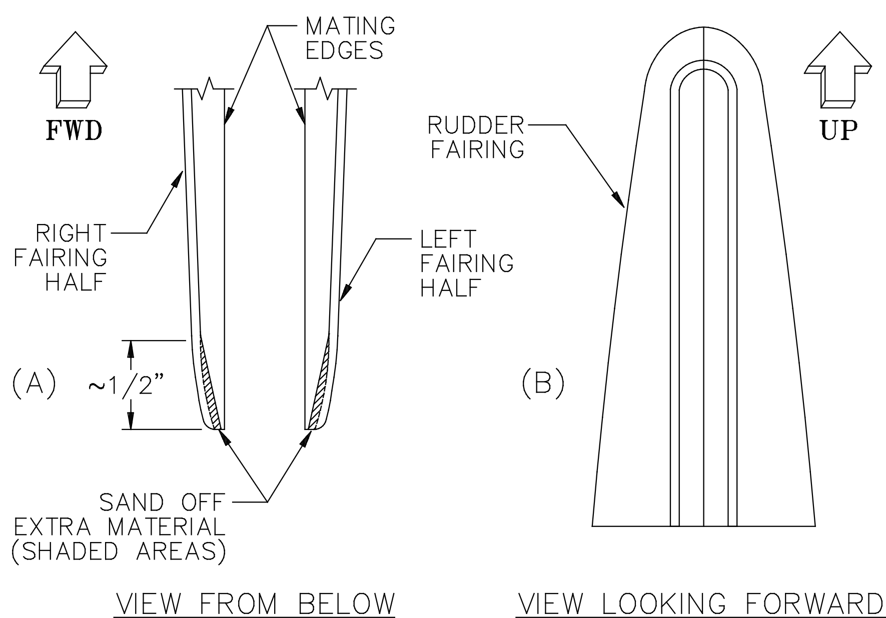

Figure 54: Trim the Rudder Tip Fairing Halves

After all the trimming and sanding has been completed, use masking tape (applied on the outside) to tape the two fairing halves tightly together.

Cut two **1" X 21"** strips of bi-directional cloth on the 45° bias. Use these, with a small amount of vinyl ester resin, to seam the fairing halves together on the inside. When the resin reaches the green cure state, use a sharp knife to trim the ends of the fiberglass strips where they protrude past the fairing halves. Let the seam laminates cure completely, and then use sandpaper to clean up any remaining roughness. Remove the tape that was used to hold the halves together.

If you wish, you can use body filler to fill any gaps along the seam and sand it to your satisfaction.

Completed [ ]

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Step 46: Secure the Tip Fairing to the Rudder

> **Note** The following instructions apply equally regardless of whether your rudder tip fairing is a seamed-together fiberglass unit or a one-piece ABS fairing.

In "SECTION III: RUDDER ASSEMBLY," you drilled three #19 holes on each side of the rudder at the tip and mounted nutplates centered on these holes for securing the tip fairing. On both sides of the rudder, use a fine-point felt-tip pen to mark lines parallel to the top of the rudder skin and **3/8"** below the **centers** of the #19 fairing-mounting holes, as shown in Figure 55. These lines mark the position of the lower edges of the tip fairing.

You now need to transfer the locations of the fairing mounting holes in the rudder to the tip fairing. This is complicated by the fact that the mounting holes in the rudder are hidden by the fairing when it is installed. One way to mark the hole locations on the fairing is shown in Figure 55. First, use a straightedge and a fine-point felt-tip pen to mark two lines at an angle to each other centered on each hole, extending the lines several inches below the fairing lower-edge line, as shown in Figure 55a. Then slip the fairing over the top of the rudder and tape it into place with its lower edge even with the horizontal lines marked previously. Position a flexible straightedge with one end along each of the angled hole location lines and the other end resting on the fairing; use a felt-tip pen to mark the continuation of the lines onto the fairing. As shown in Figure 55b, the point on the fairing where each pair of angled lines crosses marks the center of the underlying mounting hole.

After marking all six hole locations on the fairing, remove it and drill a **#19** hole at each location. Secure the fairing to the rudder with AN526-8R7 round-head machine screws.

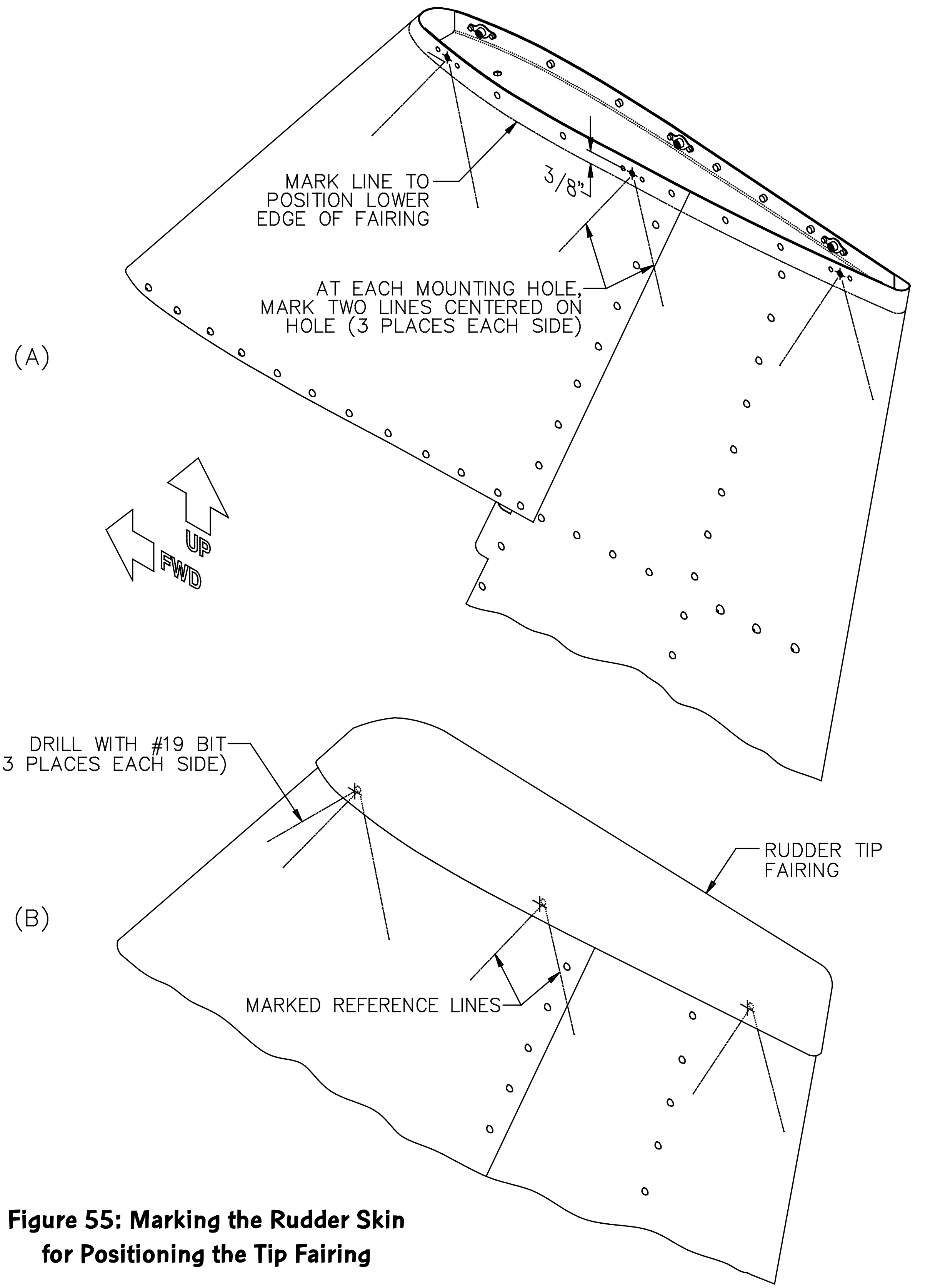

Figure 55: Marking the Rudder Skin for Positioning the Tip Fairing

> **Note** The rudder tip fairing halves in the very earliest GlaStar kits had three dimples on each side to locate the fairing mounting holes. These dimples are left over from an early mounting procedure that is no longer recommended. Therefore, you should ignore them, as they probably won't coincide with the actual locations of the mounting holes in the rudder. If you wish, you can fill the dimples with gelcoat or body putty and then paint to match.

With the fairing in place on the rudder, mark its aft end for trimming even with the skin trailing edge, if you wish. Remove the fairing, trim it, and then reinstall it.

Completed: [ ]

GEAR FAIRING INSTALLATION

This sub-section covers installation of main and nose gear wheel pants and main and nose gear leg fairings. Although the standard GlaStar kit includes all the necessary parts for these installations, they all can be considered optional, as the airplane flies fine without any of these fairings in place. Of course, there is a speed penalty to leaving them off, but if you anticipate frequent operation from rough or unimproved strips, you may prefer to pay this price.

6.00 X 6 and 8.00 X 6 Taildragger Options The next several steps cover the installation of main gear wheel pants over standard-sized, 5.00 X 5 main wheels for **either** tricycle- or taildragger-configured GlaStars. The large-tired 6.00 X 6 and 8.00 X 6 taildragger options do not include wheel pants; if you are installing 6.00 X 6 or 8.00 X 6 taildragger gear, **skip to Step 56**.

Note Each main gear wheel pant consists of two symmetrical molded fiberglass halves—the **main wheel pant left half** [170] and **right half** [171]. In the instructions for the following steps, we will use the terminology **inboard** and **outboard** halves. Just keep in mind that the **inboard** half will be a **right** half on the **left** side of the aircraft and a **left** half on the **right** side of the aircraft, and vice versa.

The text and illustrations that follow refer to the left-side wheel pant unless otherwise specified. Procedures for the right-side pant are identical.

Step 47: Prep Sand the Wheel Pant Halves

Just as you did on the fuselage shell halves in "SECTION VIII: FUSELAGE ASSEMBLY," use a long sanding block to remove any mold lip from the inside edges of the wheel pant halves. Also, sand the mating edges of the halves until they're straight, but don't remove any more material than necessary.

Completed: Left [ ] Right [ ]

Step 48: Cut Out the Wheel Pant Bulkheads

Each wheel pant has a close-out bulkhead just aft of the tire cutout, the purpose of which is to prevent mud, gravel, snow or other ground debris from being deposited in the aft portion of the wheel pant by the spinning tire. These bulkheads should be cut from one of the **12" X 12" sheets of 1/4", 5-lb. density foam** [172] using the full-size template given in Figure 56. Cut each bulkhead slightly oversized; you can fit it more precisely after the pant halves are seamed together.

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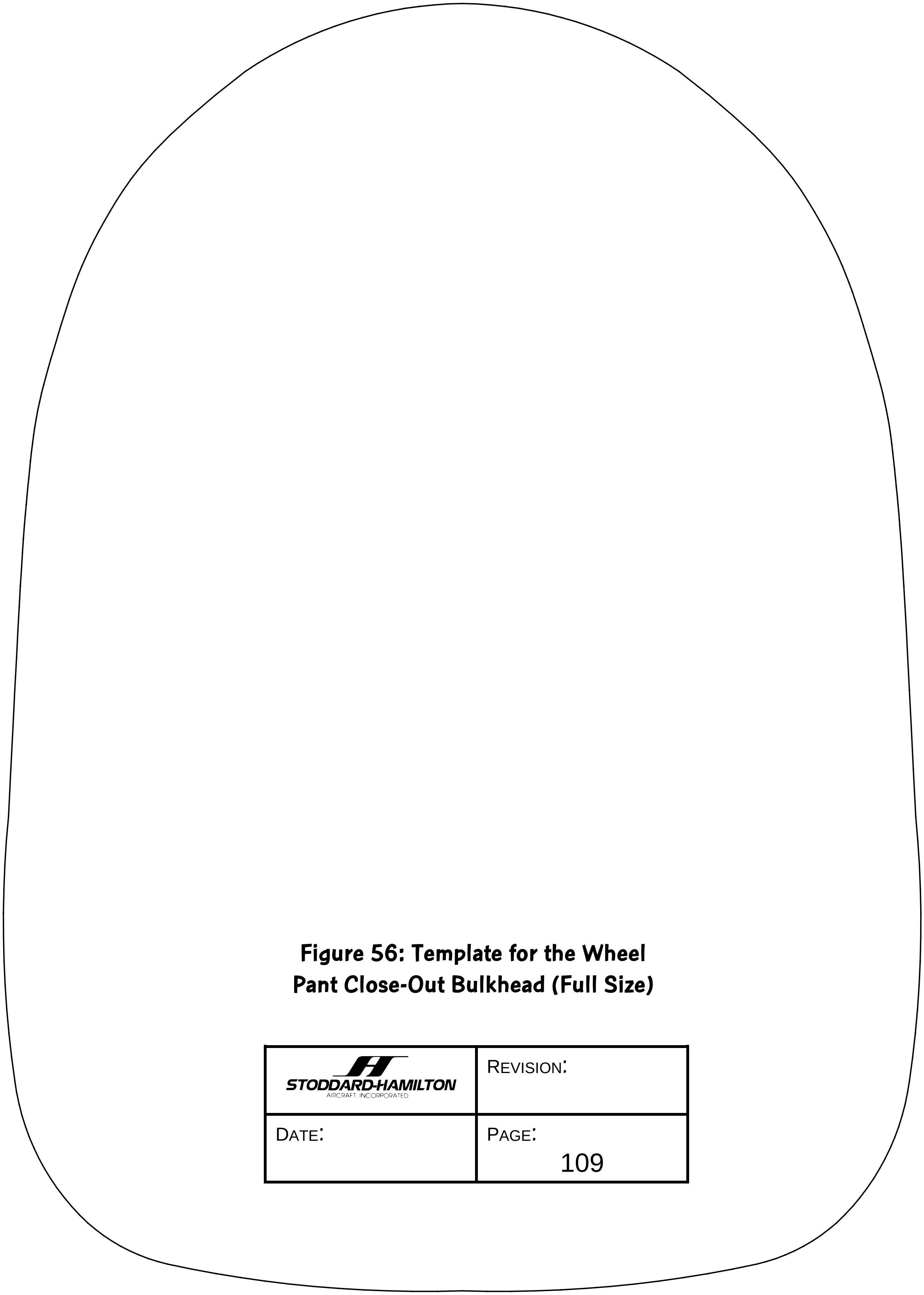

Figure 56: Template for the Wheel Pant Close-Out Bulkhead (Full Size)

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Step 49: Seam the Pant Halves Together

Prepare the wheel pant halves for seaming by taping them tightly together with masking tape. Just as you did with the fuselage shells earlier, apply short strips of tape **across** the seam and apply **lots** of them!

Next, cut enough **2"**-wide strips of bi-directional cloth on the 45° bias to apply two layers to the seam of each wheel pant. Roughly **72"** of cloth is required for each layer. Use whatever scraps you have lying around; within reason, shorter strips will be easier to work with. When your cloth is ready, catalyze a small batch of resin.

> **Hint** Before you get up to your elbows in resin, think about how you'll support the wheel pant upside down when you're seaming the upper half of the pant. Either have an extra pair of hands standing by or else arrange some shot bags or cut some supports out of scrap wood.

Starting at either end of the tire cutout, apply a layer of cloth all the way around the seam, turning the pant as you go so you don't have to laminate from below. Pre-saturating the strips will make this much easier. Overlap each strip equally onto both halves of the pant, and overlap adjacent strips by at least **1"**.

> **Hint** Getting all the air bubbles out at the aft end of the pant will require an extension brush and a flashlight.

After one layer has been applied, go ahead and apply the second one right on top of the first—no need to wait for the first layer to cure. When both layers have reached green cure, use a utility knife to trim the cloth even with the forward and aft edges of the tire cutout. Let the laminates cure fully and remove the masking tape.

Completed: Left [ ] Right [ ]

Step 50: Fit and Install the Wheel Pant Bulkhead

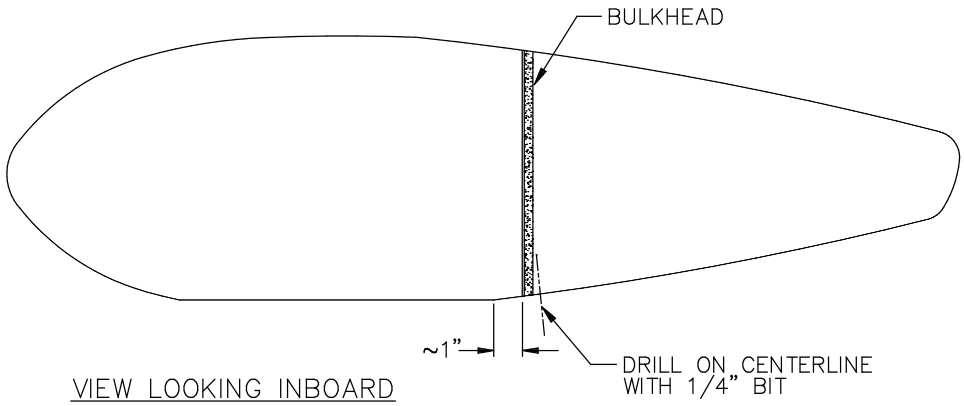

Figure 57: Positioning the Wheel Pant Bulkhead

As shown in Figure 57, the bulkhead you cut out previously is installed approximately **1"** aft of the tire cutout, perpendicular to the longitudinal axis of the pant. Trial-fit the bulkhead at this location and sand the foam as necessary to achieve a tight fit. Neither the distance aft of the cutout nor the perpendicularity is overly critical—just eyeball it.

> **Note** By a "tight" fit, we mean a friction fit that will hold the bulkhead in place for bonding. However, isolated gaps between the bulkhead and the pant wall of up to **1/8"** are perfectly tolerable, so don't spend hours on this! If necessary, you can always use a little hot-melt glue to tack the bulkhead in place.

When the bulkhead is shaped to your satisfaction, cut two pieces of bi-directional cloth on the 45° bias that are **1"** larger than the bulkhead all the way around. Next, mix a small batch of thin resin/Q-cell mixture and seal the forward face of the bulkhead. Then position the bulkhead in the pant and bond it in place just like you did the fuselage bulkheads—with a finger's-width fillet of thick-mix Q-cell all the way around the perimeter. Finally, wet the bi-directional cloth with resin and apply both layers to the forward face of the bulkhead, lapping them over onto the walls of the pant.

Let everything cure fully, and then drill a **1/4"** drain/vent hole on the bottom centerline of the pant just aft of the bulkhead, as shown in Figure 57.

Completed: Left [ ] Right [ ]

Step 51: Drill the Outboard Mounting Screw Hole and Install the Foam Spacer

The wheel pants will be secured to the wheel assembly with five screws apiece—four on the inboard side through the wheel pant backing plate and one on the outboard side through the strap on the axle nut. It's useful to drill this latter hole first so it can be used to index the location of the entire wheel pant.

As shown in Figure 58, mark this hole **7"** aft of the forward end and **2-1/4"** above the lower edge of the tire cutout. Before drilling the hole, reinforce the area for sufficient countersink depth by laminating either **four** pieces of bi-directional cloth or **two** pieces of DBM onto the **inside** of the pant. Each piece should be about **2" square** and centered on the marked hole location.

After the reinforcement laminates have cured, drill through the pant at the marked location with a **#30** bit.

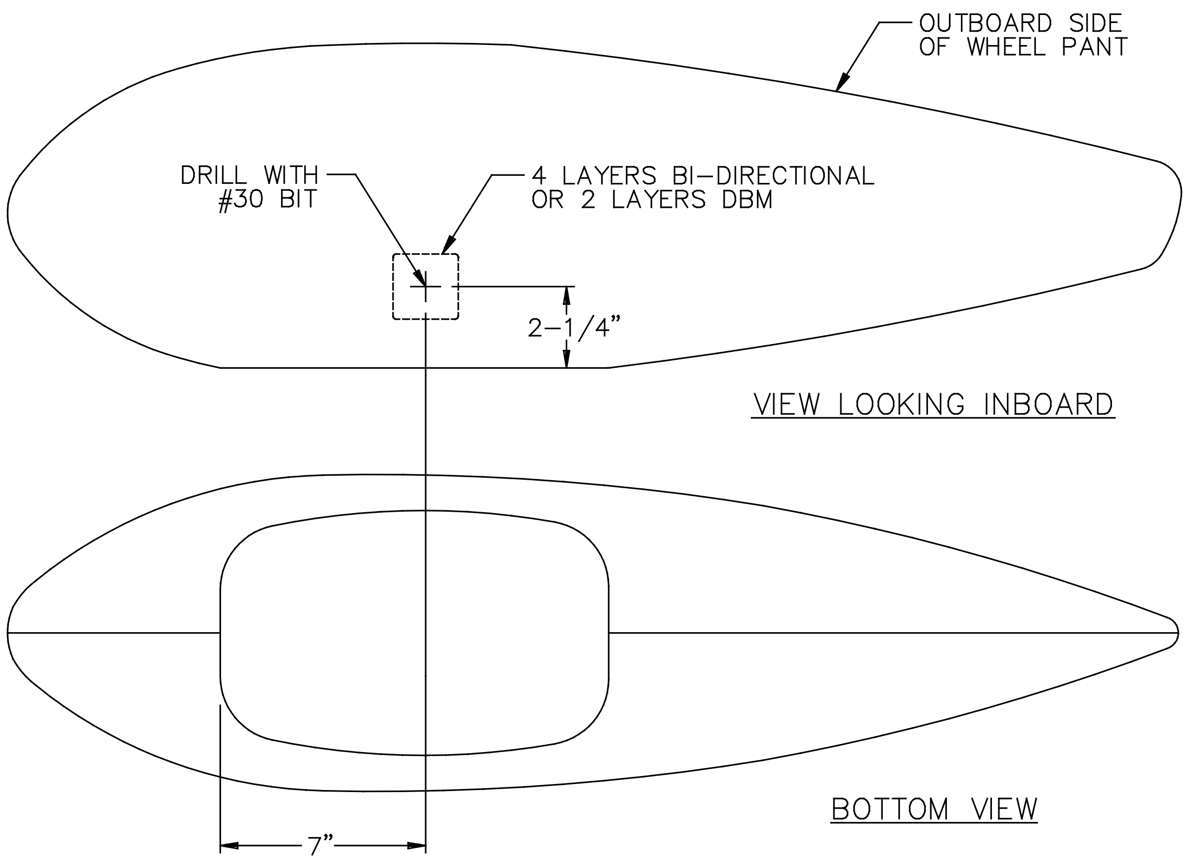

Figure 58: Drilling the Outboard Wheel Pant Mounting Screw Hole

A **1"-square** hard-foam spacer must be installed between the wheel pant and the axle nut strap to keep the wheel pant properly centered over the tire. Cut this spacer from the **1/4" X 2" X 4" 20-lb. foam sheet** [173]. The spacer will be bonded to the inside of the wheel pant with a resin/mill fiber mixture. To make this bond stronger, it's helpful to slightly "dish out" the bonding face of the spacer, as shown in Figure 59. Use a small sanding drum or rotary cutter to remove a small amount of foam from the face of the spacer, but don't reduce the thickness of the block around the edges or in an area in the center of the block approximately **3/8"** in diameter.

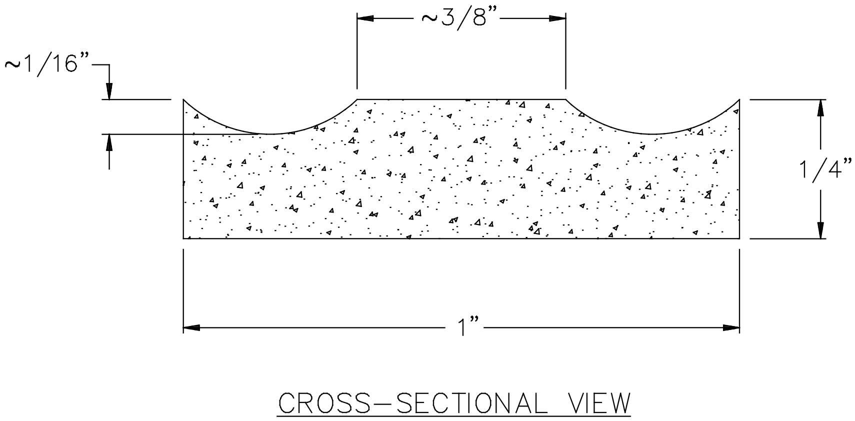

Figure 59: "Dishing Out" the Outboard Wheel Pant Spacer

Next, mark the center of the full-thickness area in the middle of the spacer's bonding face and drill a shallow **#30** hole there. Mix a very small batch of thick resin/mill fiber mixture and apply it liberally to the entire bonding face, filling the dished out areas completely. Bond the spacer to the **inside** of the outboard side of the wheel pant over the reinforcement laminates; insert a long, waxed 1/8" AN470AD4 universal-head rivet through the #30 mounting screw hole in the pant into the #30 hole in the spacer to align the two parts. Use weights or duct tape to hold the spacer in place while the resin cures. Also, wipe up any excess resin/mill fiber that is squeezed out through the hole in the pant.

After the resin has cured, withdraw the alignment rivet and use the #30 hole in the pant as a guide to drill through both the pant and the spacer with a **1/4"** bit. Keep the bit perpendicular to the outside surface of the pant. Finish the hole up by countersinking the outside surface of the wheel pant to accommodate a 1/4" countersunk **Tinnerman washer** [176].

Completed: Left [ ] Right [ ]

Step 52: Make the Brake Caliper Cutout

A cutout must be made in the inboard side of the pant to accommodate the gear axle, brake caliper assembly and brake line. This is a very irregularly shaped cutout, and it can best be made by trial and error.

As shown in Figure 60, the cutout begins approximately **6"** aft of the forward end of the tire cutout and extends aft for about **4-1/4"**. The figure doesn't specify the vertical height or the shape of the cutout because both these attributes can vary slightly from GlaStar to GlaStar and even from side to side on the same airplane. For this reason, employ a cautious trial-and-error approach—cutting away a little bit of material, trial fitting the pant, cutting away a little more, and so on.

Note When fitting the pant, you'll have to stretch the lower edges of the two halves apart to get it over the brake rotor and the strap on the axle nut. This is normal; you don't want to remove so much material that the pant fits over the strap and rotor without having to be expanded at all.

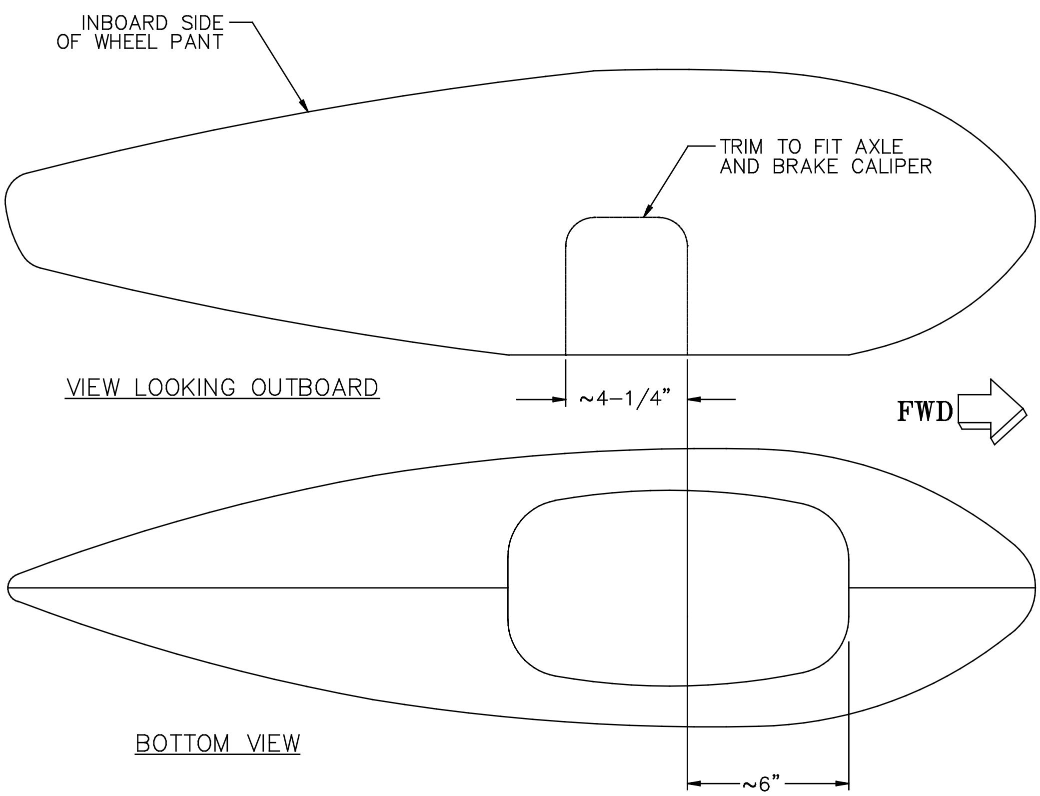

Figure 60: Initial Brake Caliper Cutout Dimensions

When fitting the pants, keep the 1/4"-thick foam spacer tight against the strap on the axle nut. Also, keep the lower edge of the tire cutout parallel with the waterline of the aircraft. To accomplish this you can either use a digital level to make the angles of the waterline and the pant the same relative to the horizontal, or you can use a spirit level to bring the entire aircraft level and then level the pants.

So, how do you know when the cutout is tall enough (i.e., when the wheel pant is low enough)? This is where the outboard mounting screw hole comes in. Keep extending the cutout until you can align the hole in the pant with the hole in the axle nut strap. When you're done, the cutout should clear the brake line and elbow, all parts of the brake caliper assembly and the axle by at least **1/8"**.

Hint If you're building a tricycle-geared GlaStar, an easy method for aligning the pants with the waterline is to fold the wings and/or place weights on the horizontal stabilizer so that the airplane sits back on its tail. With the plane in this position and the outboard mounting screw hole in the wheel pant aligned with the nutplate on the axle nut strap, rotate the pant until there is **1"** of space between the aft end of the pant and the floor. This turns out to put the pant right on the waterline.

Completed: Left [   ] Right [   ]

Step 53: Install the Inboard Foam Spacers and Drill the Mounting Screw Holes

Now you can attend to the inboard mounting screws. Figures 61 and 62 show the locations of the holes for these screws relative to the tire cutout. Measure and mark these on the **inboard** side of the wheel pant and reinforce the areas behind them on the inside of the pant just as you did for the outboard hole—with either four layers of bi-directional cloth or two layers of DBM applied in 2" squares centered on the hole locations.

After the reinforcement laminates have cured, drill through the pant at each marked location with a **#30** bit.

Note Since the initial release of the GlaStar kit, the design of the wheel pant backing plates has changed somewhat. Early kits were supplied with .063" X 12" X 12" aluminum sheet (P/N 750-0240-002), while later kits have an .090" X 12 X 12" sheet (P/N 075-01091-01). The shape of the plates, as described in "SECTION IX: SYSTEMS INSTALLATION" of the *Assembly Manual* also changed, as did the number of fasteners specified for attaching the wheel pants to the plates. The early design proved to be perfectly serviceable on our GlaStar prototype for several hundred hours of hard service, but we anticipate that the new design will be even more durable. Builders who received parts for the early design can easily upgrade by ordering the following parts:

P/N:	Part:	Qty.:
075-01091-01	Sheet aluminum 2024-T3 .090" X 12" X 12"	1
AN4-13A	Bolt	2
NAS43DD4-39	Spacer	2

The procedures that follow for drilling the inboard mounting holes and installing the foam spacers are identical regardless of which backing plate design you are using. However, Figure 61 shows the hole locations for the early design and Figure 62 shows them for the later design. Be sure to mark and drill the holes appropriate to your backing plates.

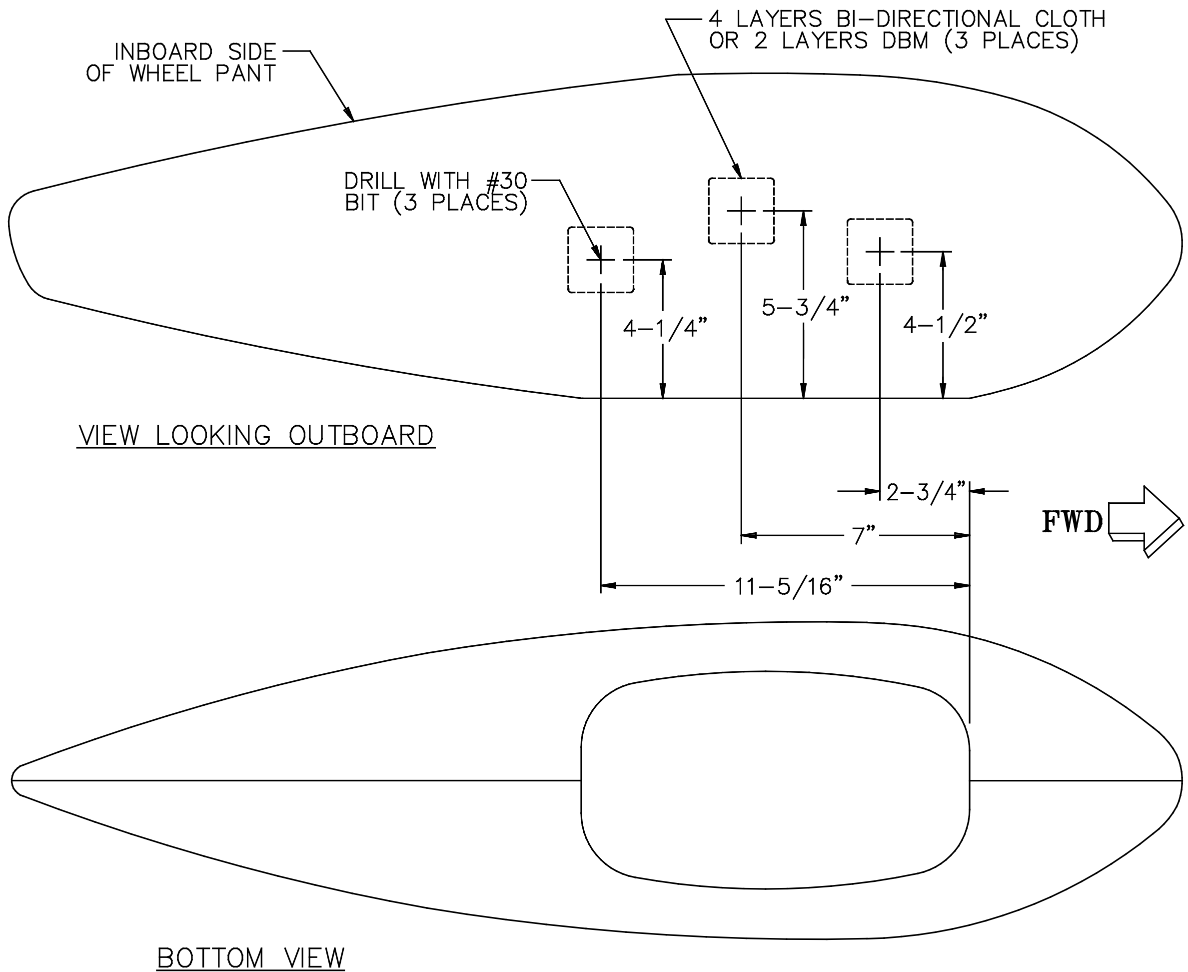

Figure 61: Drilling the Inboard Wheel Pant Mounting Screw Holes (Original Backing Plate Design)

Next, you need to bond a spacer inside the inboard side of the wheel pant at each hole just as you did for the outboard screw hole. The **1"-square** inboard spacers are cut from the **1/2" X 3" X 3" 20-lb. foam sheet** [174]. Dish out the bonding face, mark the full-thickness centerpoint and drill a shallow #30 alignment hole, just as you did before. Align the spacer under the #30 hole in the pant with a waxed 1/8" rivet and bond it in place with thick-mix resin/mill fiber.

> **Note** If you use a bandsaw or scroll saw to cut out the spacers, they will turn out to be slightly less than 1" square, given the size of the 3" X 3" piece of foam. Don't worry about this; the size is not at all critical.

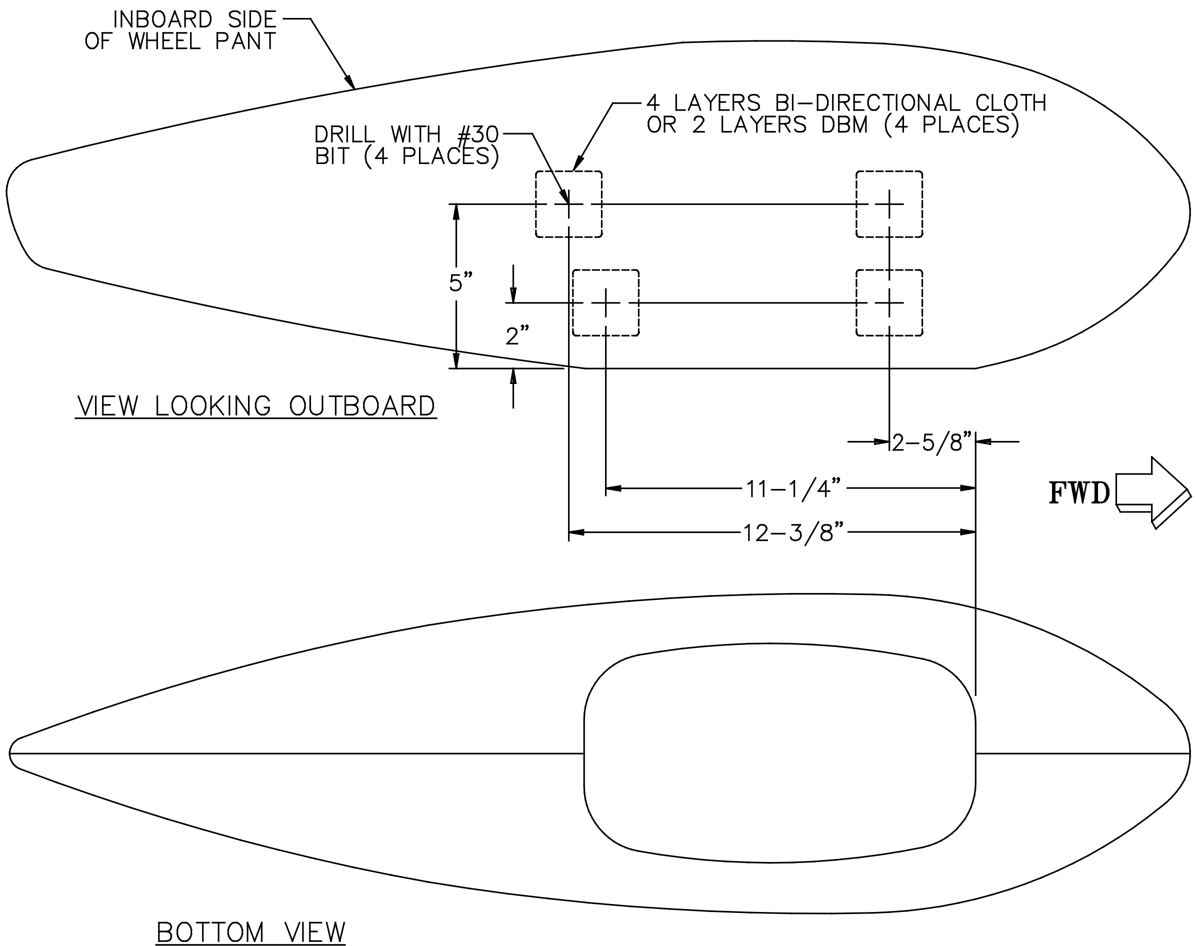

Figure 62: Drilling the Inboard Wheel Pant Mounting Screw Holes (Revised Backing Plate Design)

When the spacers have cured, try to position the wheel pant over the wheel assembly once again as you did when you made the brake caliper cutout. You may find that the side-to-side distance between the foam spacers is too small to allow the pant to be positioned properly. If so, use a small sanding block to shave the spacers as necessary until the proper fit is achieved.

> **Note** Decide which spacers to sand by observing whether the pant is skewed to the inboard or outboard relative to the tire. When the outboard spacer is tight against the axle nut strap, the inboard spacers are tight against the backing plate, and the pant is centered on the tire, then you've got it just right.

Now you're ready to drill the inboard mounting screw holes. Begin by positioning the pant over the tire and securing it with an AN509-416R12 **flush-head machine screw** [178] through the 1/4" Tinnerman washer and the outboard screw hole into the nutplate on the axle nut strap. With the pant secured on its outboard side, it will still be free to rotate around the screw, of course. Have an assistant hold the pant so that the lower edge of the wheel cutout is parallel with the aircraft waterline and so that the pant is level relative to the axle—that is, so that an imaginary line between the lower edges of the tire cutout is parallel to the axle. With the pant supported in this way, use one of the #30 holes in the inboard side of the pant as a guide to drill through the pant and the spacer with a **#10** bit, keeping the bit perpendicular to the outside surface of the pant. As you break through the spacer, the bit will contact the aluminum backing plate. Drill **only** until the tip of the bit has marked the surface of the plate; **don't** continue drilling all the way through the plate.

Note Obviously, you will eventually drill all the way through the backing plate, but there are two reasons not to do so now. First, the plate is somewhat flexible, and since it's unsupported from behind, it could bend out of the way of the bit, resulting in misaligned holes. Second, don't forget that you've got that vulnerable black rubber thing sitting back there! How would you explain **that** to your EAA buddies?!

Once you've marked the plate, remove the wheel pant and drill all the way through the plate at the marked location, taking care to keep the bit perpendicular to the plate. To ensure that you don't damage the tire or wheel, hold a scrap wood block behind the plate while drilling. Because you will install MF5000-3 **floating nutplates** [179] behind all the inboard holes, these holes should be slightly oversized. Therefore, use either a **15/64"** fractional bit, a **#1** bit, or an "A" or "B" letter bit. These are all within a few thousandths of an inch of the size you want. However, these are also all kind of exotic sizes, and an equally workable alternative is simply to drill the hole with a **#10** or a **3/16"** bit, and then ream it up a bit with a narrow rat-tail file. Your choice.

In any case, once you've provided the hole, use it to position and drill one of the MF5000-3 nutplates. The orientation of the nutplate is unimportant. After drilling the **#40** rivet holes, countersink them on the **inboard** side of the plate to accommodate 3/32" AN426AD3 flush-head rivets. Use these to rivet the nutplate in place.

Now countersink the inboard #10 hole in the wheel pant to accommodate a 3/16" countersunk **Tinnerman washer** [175]. Then reinstall the AN509-416R12 screw through the outboard hole and install an AN507-10R14 **flush-head machine screw** [177] through the Tinnerman and the drilled inboard hole. With the pant secured at these two locations, repeat the procedures you just undertook for each of the **undrilled** inboard holes:

A) Drill through the pant and each spacer to mark the backing plate with a **#10** bit;

B) Drill through the backing plate at each marked location with a bit of approximately **15/64"** and position, drill and install an MF5000-3 floating nutplate at each hole;

C) Countersink each #10 hole in the pant to accommodate a 3/16" Tinnerman washer;

D) Install an AN507-10R14 screw in each hole.

Completed: Left [ ] Right [ ]

Step 54: Trim the Tire Cutout as Necessary

Once the pant is installed, check the clearance between the tire and the cutout all the way around. To allow the tire to bulge during hard landings and to swell as it heats up during high-speed taxiing, you need to provide at least **1/2"** of clearance all the way around the tire. If necessary, remove the pant and use files and sandpaper to provide this margin of clearance.

Completed: Left [ ] Right [ ]

Step 55: Sand and Fill the Wheel Pant Seam

The pants are now ready for final finishing. Sand the seams as necessary to eliminate any rough or uneven edges, as well as to eliminate any high spots caused by resin that seeped out from between the halves. If necessary, fill any gaps or depressions with body filler before sanding.

Completed: Left [ ] Right [ ]

Step 56: Cut Out, Bend and Fit the Main Gear Leg Fairings

The main gear leg fairings (for all gear configurations) are simple, bent sheet-metal parts. Each fairing consists of an upper half overlapping a lower half. The joint between the halves allows the gear leg to flex without kinking the fairing. Lengths of piano hinge riveted along the trailing edges of the fairing halves hold them together around the leg, and the hinge pin also holds the fairing in position relative to the fuselage and gear leg.

The first step in fabricating the fairings is to cut the flat patterns out of the supplied **.020" X 12" X 36" aluminum sheets** [68]. Figure 63 shows the dimensions for the upper and lower halves; the flat patterns are identical for the left and right sides. Lay these dimensions out on the sheet with a fine-point marking pen and cut the four pieces out with snips. Thoroughly deburr all the cut edges.

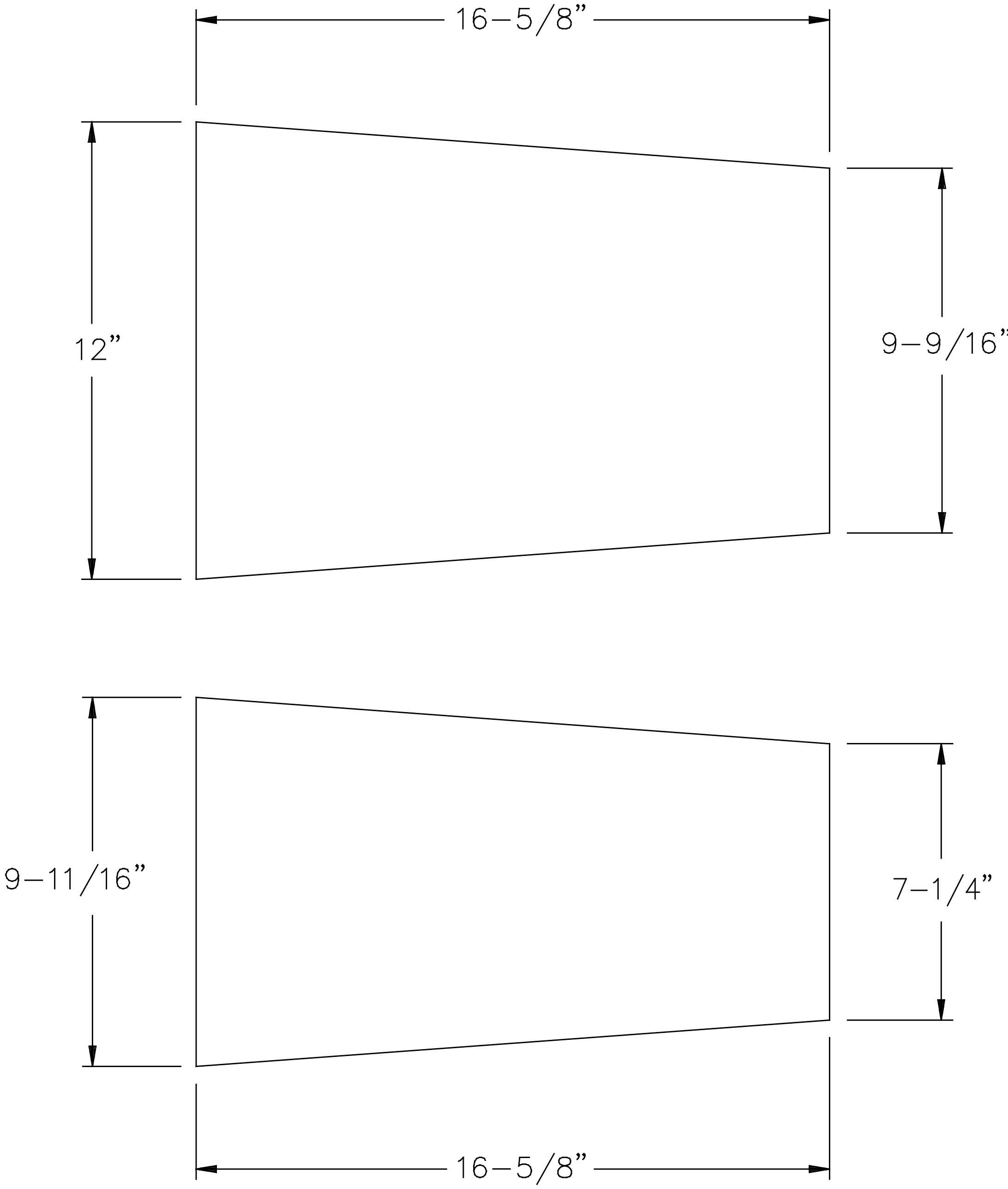

Figure 63: Flat Patterns for the Main Gear Leg Fairing Halves

The next step is to bend the flat pieces to create the aerodynamic shape of the fairing halves. There are all kinds of complicated ways to accomplish this, but we recommend a simple one: bending the metal around a broomstick.

First, mark a longitudinal centerline down each piece. Then find a broom handle or any comparable cylindrical object—a wooden dowel, a piece of pipe, etc.—with a diameter of between **3/4"** and **1-1/8"**. The piece should be at least **20"** long so that it hangs beyond both ends of the fairing by at least a couple inches. Clamp the fairing piece between the broom handle and the bench top with the broom handle aligned about **3/4"** to one side of the fairing centerline. The centerline itself should be aligned with the edge of the bench. See Figure 64a.

Hint If you're using an actual broom handle or wooden dowel, simply sand a flat spot at each end to accommodate C-clamps. If you use a metal pipe, you'll have to devise some type of cleat to clamp each end down.

Next, as shown in Figure 64b, position a **20"**-long 1 X 4 under the overhanging half of the fairing. Push the 1 X 4 up from below to bend the sheet around the broomstick, taking care to keep the board parallel to the broomstick (and thus to the centerline of the fairing). As the bend progresses, move the board in as close to the broomstick as possible to keep the bend relatively tight.

Hint The bending may go easier if you have an assistant to help you manage the 1 X 4. Also, you may find it useful to secure the edges of the fairing piece to the bench top on the other side of the broomstick with duct tape just to make it less likely that the sheet will try to slide around during the bending.

Keep folding the metal over until the outside edges of the piece touch. Then remove the pressure and measure the distance between these edges after the metal springs back open. Ideally, as shown in Figure 65, you'd like about a **5-1/2"** opening at the wide end of the upper fairing and about a **3"** opening at the narrow end of the lower fairing; the gap where the two halves meet should be about **4-1/4"**. If necessary, reposition the fairing, broomstick and 1 X 4 and bend the metal further.

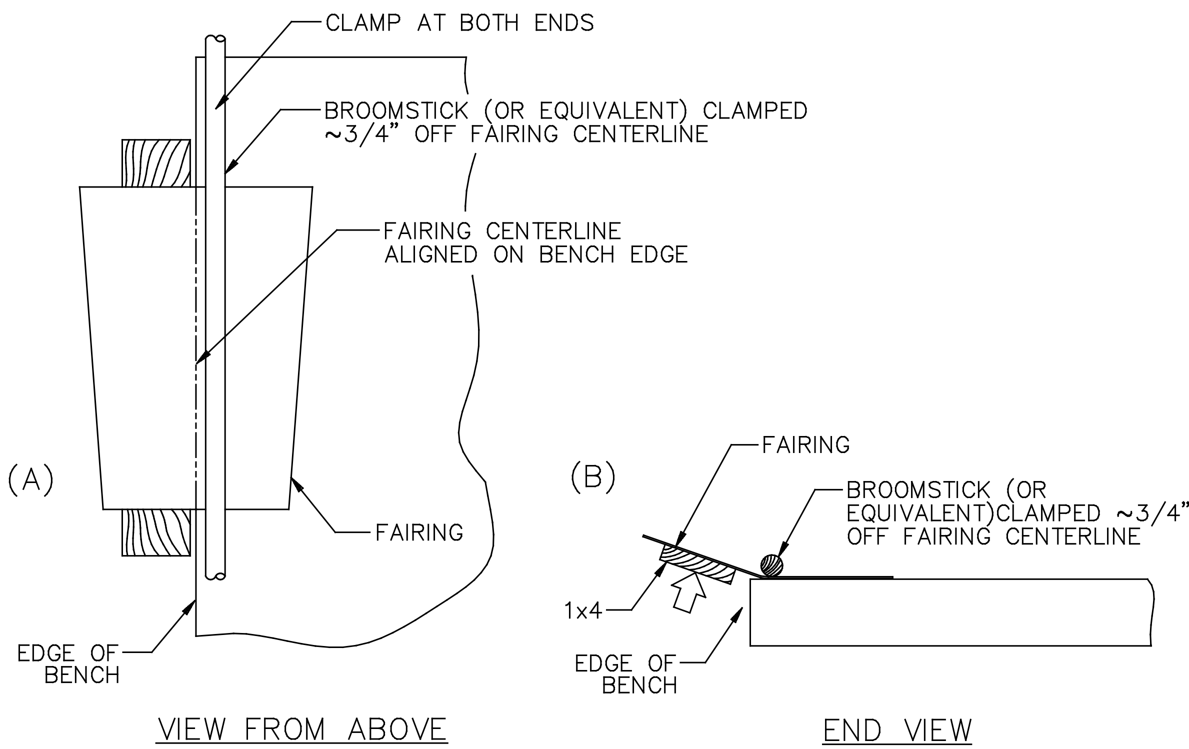

Figure 64: Bending the Gear Leg Fairing Halves

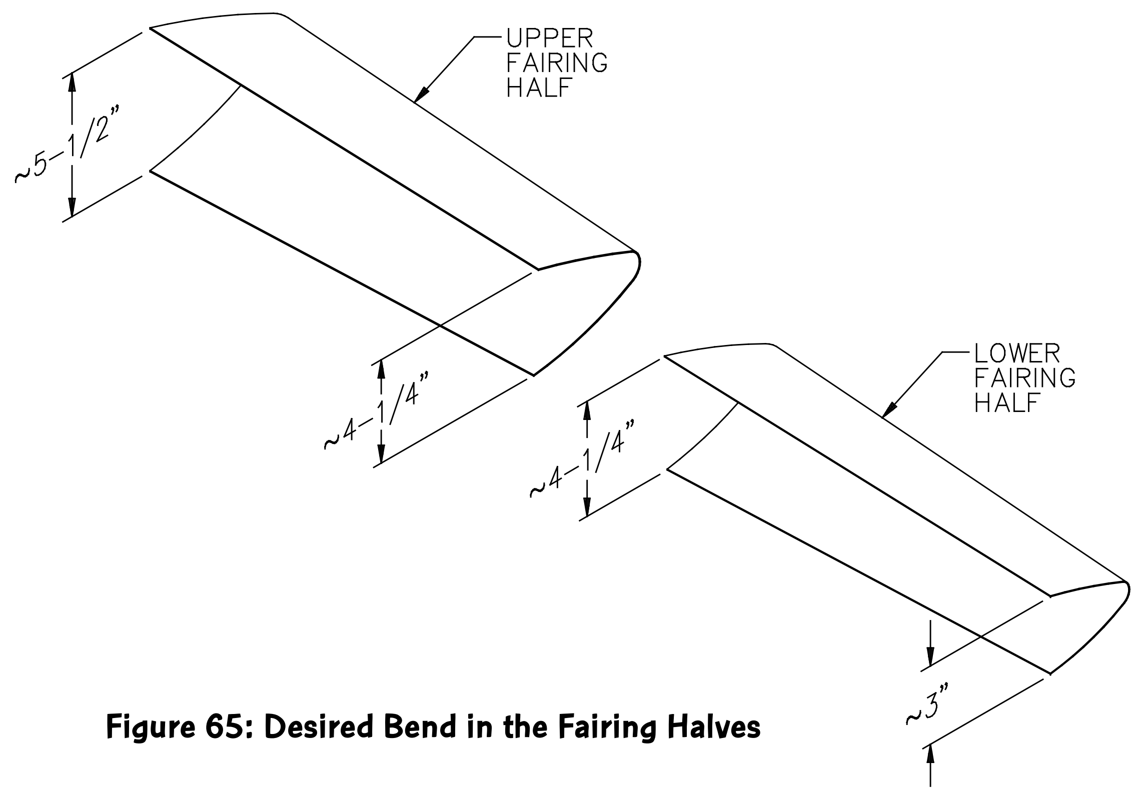

Figure 65: Desired Bend in the Fairing Halves

Finally, the ends of the fairing halves must be trimmed to fit. This is best accomplished through trial and error. Begin by taping the upper and lower halves together to form one long, tapering fairing. Lap the upper fairing half over the lower one by **5/8"**. Then slide the taped fairing over its gear leg from the **forward** side and trim the upper end to fit tightly against the curvature of the fuselage and the lower end to clear the axle and brake line. Use offset snips to trim just a bit at a time off the fairing until it fits to your satisfaction.

Note Be sure to assess the fit of the fairings with their trailing edges held tightly together.

Landing Gear Options Builders intending to convert back and forth between tricycle and taildragger landing gear should be aware that the fairings will fit for **only one configuration or the other**, primarily because the tricycle and taildragger gear legs exit the fuselage at different angles. Since they are glued to the landing gear struts, the foam stiffener blocks (described in Step 58, below) will be reused as will the sheet metal screws at the overlaps of the fairing halves. Additional sheet metal and hinge stock for the extra set of fairings are included in the gear conversion kits available from Stoddard-Hamilton.

Thoroughly deburr the trimmed edges, leaving the halves taped securely together.

Completed: Left [ ] Right [ ]

Step 57: Install Piano Hinge Along the Trailing Edges of the Fairing Halves

Piano hinges are used to hold the trailing edges of the gear leg fairings together. Remove the pin from the **72" length of rolled hinge stock** [164] and set it aside. Then put the hinge halves back together and cut **four 16"** lengths of hinge. The location of the cuts relative to the hinge knuckles is unimportant in this case. Also, cut the hinge pin into **two 36"** pieces and, if you wish, bevel an end of each piece with a bench grinder.

Mark the hinge halves so they can be reunited with their mates, and then separate them. On one half of each pair, mark and center punch a row of rivet hole locations, as shown in Figure 66. These holes should be centered on the tab of the hinge half and should be spaced roughly on **1-1/2"** centers. The uppermost and lowermost holes should each be about **1/2"** from the ends of the hinge half. All told, each hinge half should accommodate about **eleven** hole locations, but neither the number nor the spacing is particularly critical.

With the upper and lower fairing halves still taped securely together with a **5/8"** overlap, arrange marked hinge halves from two pairs along the inside of one trailing edge of the fairing. As shown in Figure 66, the pin holes of each hinge half should be located **3/8"** forward of the fairing trailing edge. Vertically, the hinge halves should each be positioned about **1/2"** from the ends of the fairing halves, which means that their other ends will fall right on the edges of the 5/8" overlap between the two fairing halves, as shown.

With the hinge halves held in position (tape may help), drill through the hinges and the fairing at each of the marked locations with a **#40** bit. Cleco as you go.

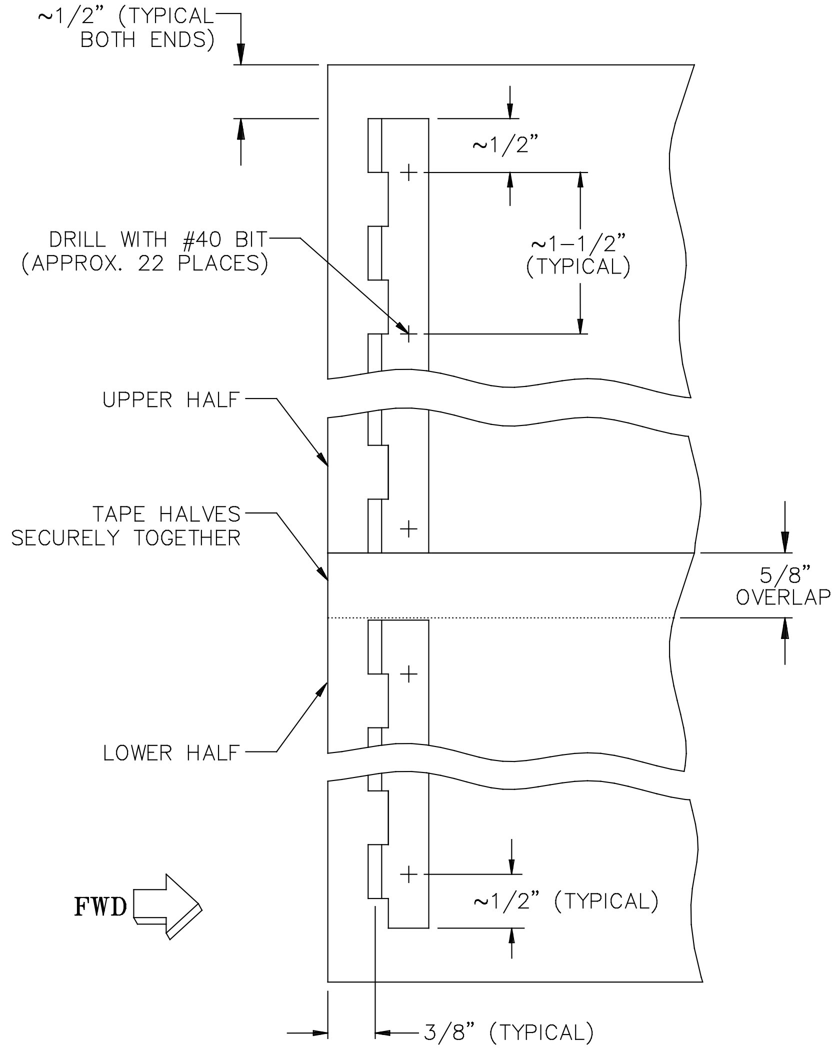

Figure 66: Positioning and Drilling the Fairing Trailing Edge Hinges

Hint It's imperative that the pin holes of both hinge halves line up with one another, so insert one of the 36"-long hinge pin through both halves prior to drilling.

Now, with one pair of hinge halves Clecoed to one trailing edge, pin the matching halves back in place with one of the 36"-long hinge pins. Draw the trailing edges of the fairing together and tape them securely, as shown in Figure 67. Next, lay out a row of rivet holes to match the drilled row but mark these locations on the **outside** of the undrilled fairing trailing edge. Then lay a strip of scrap wood or a dowel a couple inches longer than the fairing into the vee formed by the two hinge halves of each pair. Pressing this piece of wood down into the vee will hold the undrilled hinge halves flat against the undrilled fairing trailing edge for drilling. Use a **#40** bit just as you did for the other side, and Cleco as you go.

Note Given the tight clearances, you will probably have to remove the opposite Cleco for each hole you drill to avoid drilling into the Cleco. Likewise, you will probably be unable to Cleco opposing holes on both sides. Just alternate every other hole.

After the drilling is complete, remove all the Clecos and tape, and deburr all the holes. In order to accommodate 3/32" AN426AD3 flush-head rivets, the holes in the fairing must be dimpled, and then the holes in the hinge halves must be countersunk to accommodate the dimples. (If necessary, refer back to "SECTION VI: WING ASSEMBLY" to refresh your memory on this procedure; you used it on the leading edge skins and forward spars.)

After all the holes have been dimpled or countersunk, as appropriate, corrosion-proof the parts to your satisfaction and then rivet the hinge halves in place.

Completed: Left [ ] Right [ ]

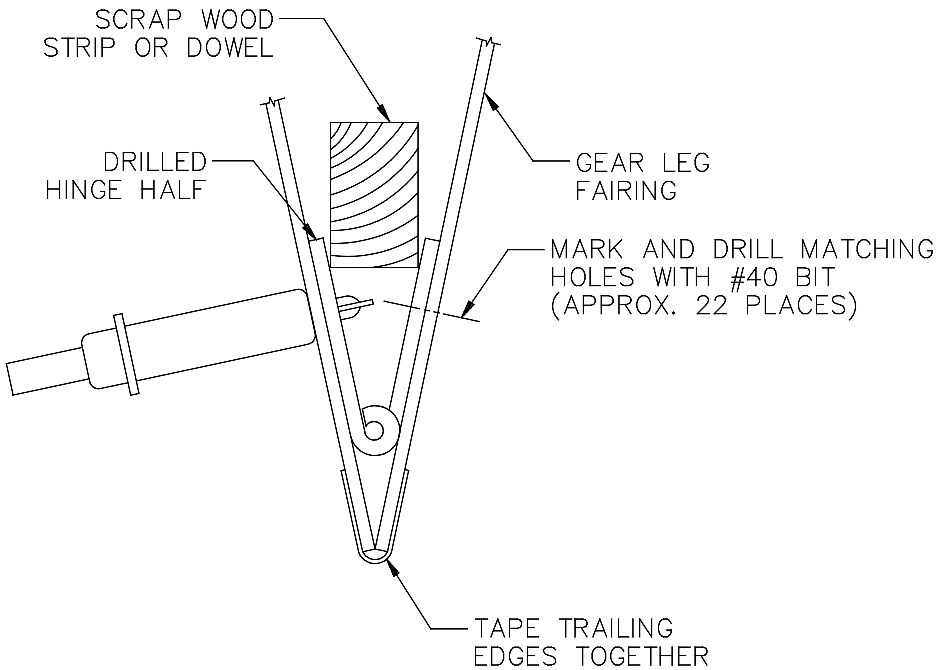

Figure 67: Aligning the Undrilled Hinge Half

Step 58: Install the Main Gear Leg Fairings

Installation of the fairings consists of little more than pulling them over the gear leg and pinning the hinge halves together. Try it once, however, and you'll realize (if you haven't already) that there's no room to insert the hinge pin! The fuselage is in the way if you try it from above and the wheel and brake are in the way if you try it from below. The solution for the **tricycle gear** GlaStar is to drill a small hole in the fuselage shell and insert the pin from inside the airplane. This method offers the added benefit of serving as a way of securing the upper end of the fairing fore-and-aft, because the upper end of the pin will remain inside the fuselage. For the **taildragger** GlaStar, the hinge pin cannot be inserted from inside the fuselage because a cage tube is in the way; instead, the taildragger's wheel and brake must be removed to insert the pin from below.

Position the fairing around the leg and temporarily tape the trailing edges tightly together. Rotate the fairing around the leg until the airfoil shape of the fairing is oriented in the direction of flight, and then make a small mark on the fuselage where the upper, trailing edge corner of the fairing falls. Remove the fairing and, for the **tricycle** gear GlaStar, make a second mark approximately **3/8" forward** of the first mark and drill a **#40** hole through the fuselage shell at this location.

Note On our tricycle-geared GlaStar prototype, this hole came out just outboard of the aft shell attach fitting. Before drilling, eyeball your hole location relative to the aft attach bracket screw heads on the outside of the shell to assure yourself that you won't be coming up under the fitting. Adjust your hole location as necessary.

Now replace the gear fairing. Pull the trailing edges together so that the hinge halves mesh and, for the **tricycle** gear GlaStar, insert one of the hinge pins through the hole from inside the fuselage. (You can do the left side yourself with one arm through the baggage door, but you'll need an assistant for the right side.) For the **taildragger**, insert the pins from below.

Hint A very light coating of WD-40 or other lubricant will make insertion of the pin much easier.

When the hinge pin reaches the other end of the hinge, there should still be several inches protruding from the insertion end of the hinge (the upper end for the tricycle gear GlaStar, and the lower end for the taildragger). For the **tricycle gear** GlaStar, mark the location on the pin where it disappears through the fuselage floor. For the **taildragger**, mark where the pin disappears into the lower end of the hinge. For both gear types, put a right-angle bend in the pin at the marked point and, then, cut off the excess pin so that your right-angle hook is about **1"** long. For the **tricycle gear** GlaStar, this end can be left loose under carpeting, as in our prototype, or you can devise some simple way of retaining it against the fuselage floor. Secure the **taildragger** hinge pin to the inside of the fairing with a retainer like the ones used to secure the elevator hinge pins, as described in Step 176 of this section. In any case, be sure to make the pin easy to remove, because you will need to remove the gear fairing periodically for brake line inspections and so on.

The final step in installing the gear leg fairings is to fabricate and install a foam stiffener block around the gear leg where the fairing halves overlap. Prepare to make this block by removing the hinge pin, separating the upper and lower fairing halves, and then pinning the upper half only back in place. Use a little tape to hold it in position against the fuselage shell, aligning it with the mark made previously.

Next, as shown in Figure 68, fit a pair of cardboard scraps (each about **2" X 6"**) around the gear leg and the brake line just below the bottom of the upper fairing half. Use snips and trial and error to cut out the mating edges of the scraps until they fit tightly around the leg and brake line as shown. Then tape the two pieces together, slide them up tight against the bottom of the fairing, and trace the outline of the fairing onto the cardboard.

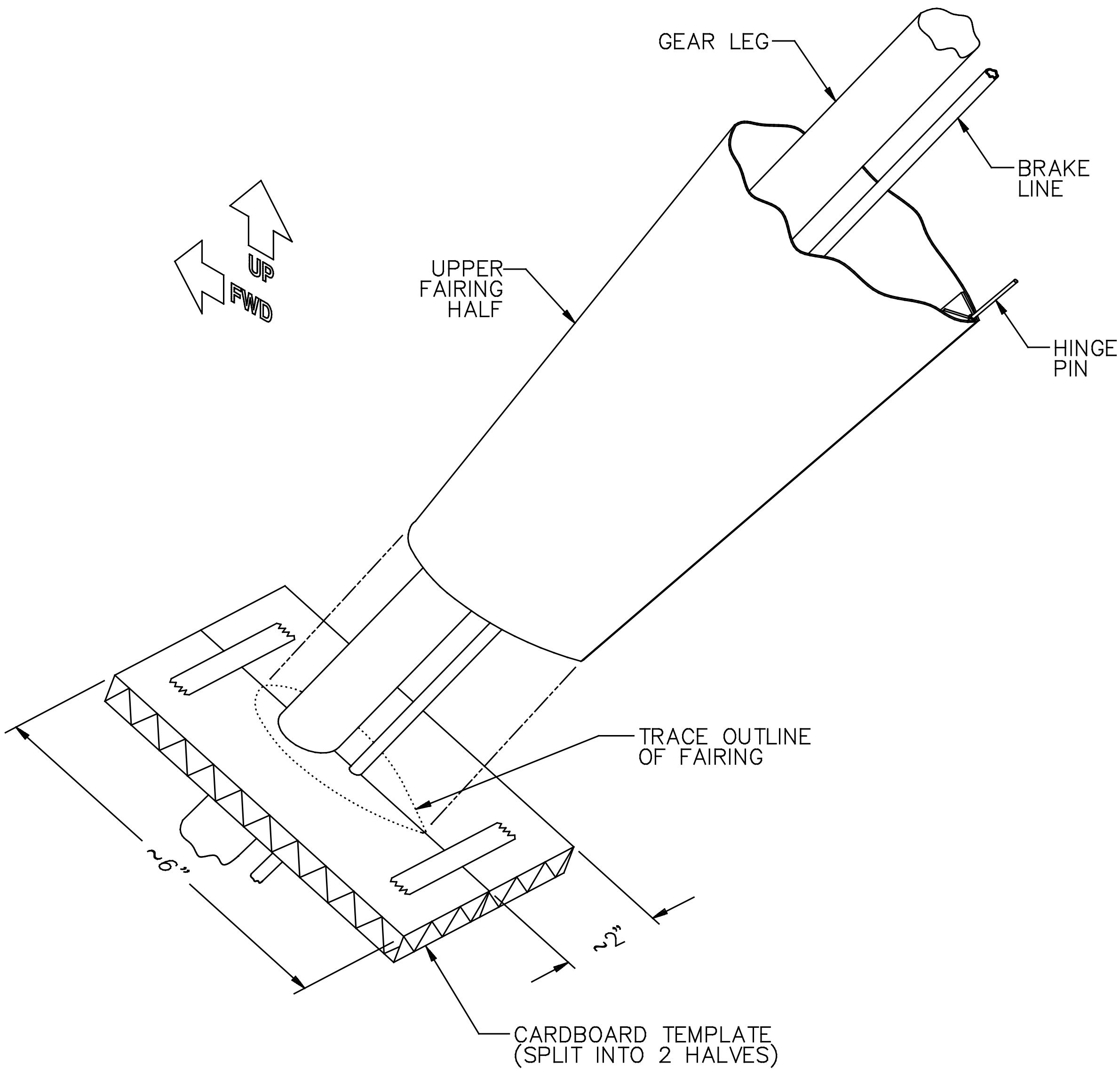

Figure 68: Making Cardboard Templates for the Foam Stiffener Blocks

Next, separate the two cardboard pieces and cut out the fairing airfoil shape you just traced. Use the resulting templates to mark the shapes onto the **3" X 4" sheet of 1/2", 40-lb. foam** [89]; use a bandsaw or scroll saw to cut them out.

> **Note** It's possible that your cardboard templates will be a bit longer than the 4"-long foam, but this is not a problem. Simply let the **aft** ends of the templates hang over the end of the foam.

Once you have the foam stiffeners cut out, use regular household epoxy to glue the pair of blocks opposite each other on either side of the gear leg and brake line, as shown in Figure 69. The blocks should be located vertically such that their **lower** faces are even with the **bottom** end of the **upper** fairing half. When gluing the blocks in place, take care to keep the split line between them aligned with the direction of flight. Let the epoxy cure thoroughly before proceeding.

When the epoxy has cured, trial fit the gear leg fairing (both the upper and lower halves) over the blocks. Use coarse sandpaper to reshape and resize the blocks as necessary to allow the fairing halves to close tightly around the blocks with the hinge pin in place.

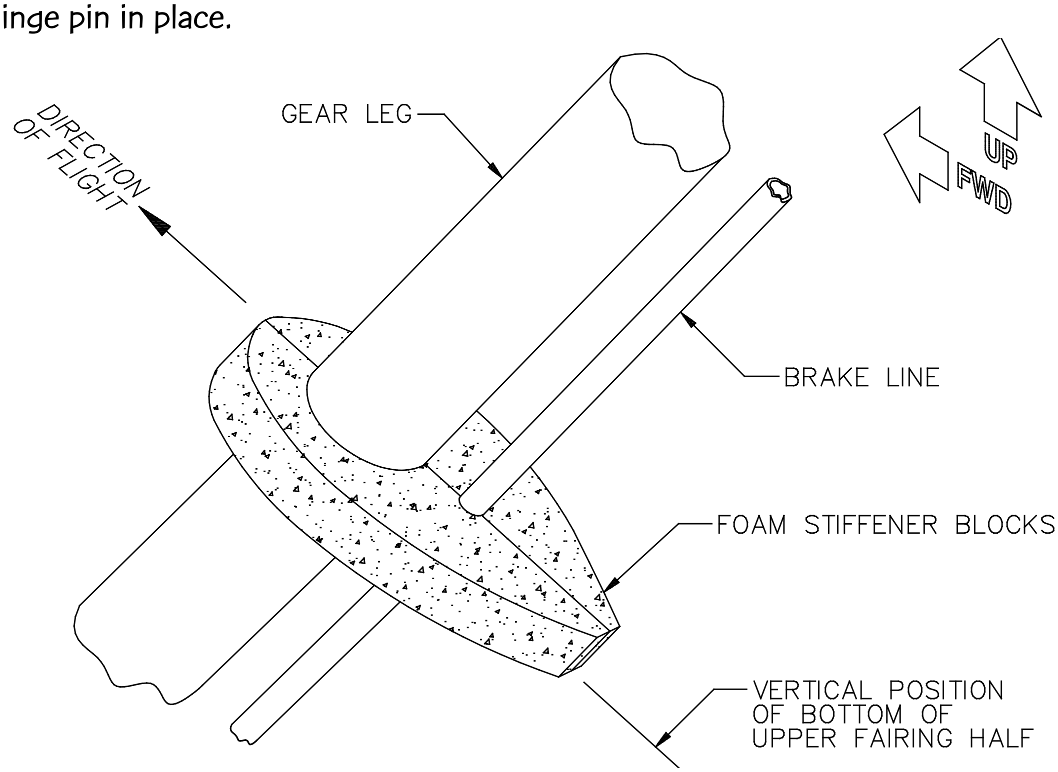

Figure 69: Gluing the Stiffener Blocks to the Gear Leg

Finally, with the fairing halves pinned in position around the blocks, drill a **#40** hole through both fairing halves and into the **inboard** stiffener block. Use a drill stop to set the depth of cut at about **5/16"**. The hole should be centered fore-and-aft on the gear leg and should be located vertically about **1/4"** above the bottom edge of the upper fairing half. After drilling, install a **#6 X 3/8" self-tapping screw** [107] in the hole. See Figure 70.

Completed: Left [ ] Right [ ]

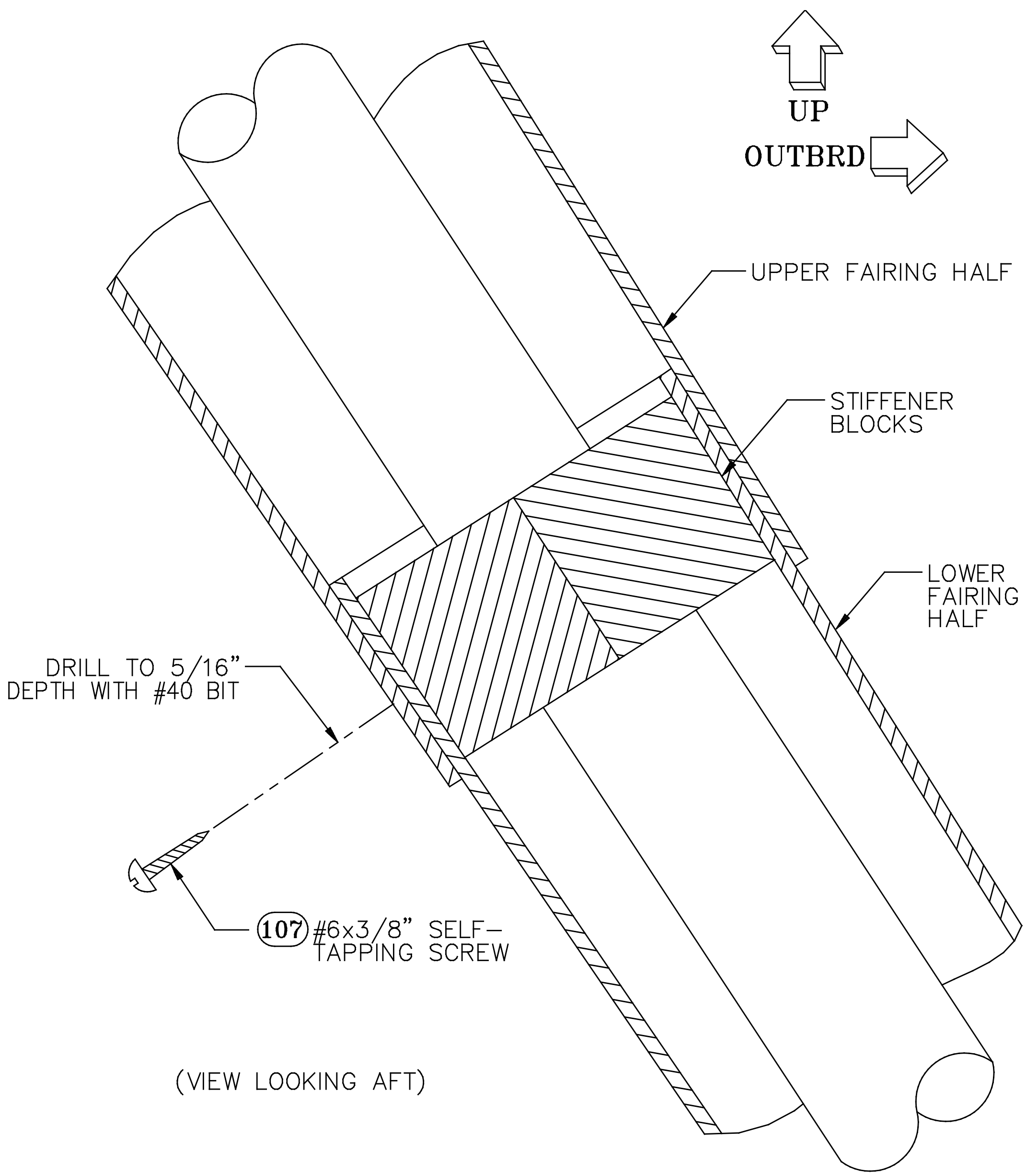

Figure 70: Installing the Stiffener Block Screw

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Step 59: Prep Sand the Nose Wheel Pant Halves (Tricycle Gear Only)

Taildragger Options If you're installing 5.00 X 5, 6.00 X 6 or 8.00 X 6 taildragger landing gear, **skip to Step 74**.

☟

Use a sanding block to remove the mold lip and to square up the edges of the **left** [182] and **right nose wheel pant halves** [183]. Trial fit the two halves together, paying special attention to how the two halves mate at their aft ends. The right-hand pant half is likely to require some extra sanding or filing in this area to allow a good, close fit.

Completed: [ ]

Step 60: Reinforce the Mating Edge of the Left Wheel Pant Half (Tricycle Gear Only)

The nose wheel pant halves will eventually be held together by flush-head machine screws. In order to provide sufficient thickness for countersinking, the inside mating edge of the **left** pant half must be reinforced with a two-layer laminate of bi-directional cloth. Cut enough **1"**-wide strips of cloth on the 45° bias to provide two layers all the way around the perimeter of the part, with the exception of the very aft end of the pant; that area does not need to be reinforced.

Laminate these strips in place. Both layers can be applied in one operation. Once the laminates have reached green cure, use a utility knife to trim their inboard edges even with the edge of the pant half.

Completed: [ ]

Step 61: Mark and Drill the Screw Holes in the Wheel Pant Halves (Tricycle Gear Only)

Join the left and right pant halves securely together with masking tape, just as you did the main gear pant halves. Try to keep the fit as close as possible all the way around.

Next, mark **eleven** hole locations around the perimeter of the pant. Figure 71a shows the fore-and-aft locations of five of these holes; space the locations for the remaining holes evenly between the ones that are specified. As shown in Figure 71b, all the holes should be **1/4" outboard** of the **inboard** edge of the **left** pant half.

With the halves still taped securely together, drill through both halves with a **#30** bit at each marked location. Insert Clecos after drilling to help maintain alignment. After the drilling is complete, separate the halves and countersink the holes on the outside of the left-hand half to accommodate AN507-6R7 **flush-head machine screws** [186].

Completed: [ ]

Step 62: Install the Nutplates on the Right Wheel Pant Half (Tricycle Gear Only)

Position MF5000-06 **floating nutplates** [189] at each of the screw holes in the **right-hand** pant half and drill the **#40** rivet holes. Countersink these holes on the outside of the pant flange to accommodate 3/32" AN426AD3 flush-head rivets, and use these rivets to install a nutplate at each hole.

Completed: [ ]

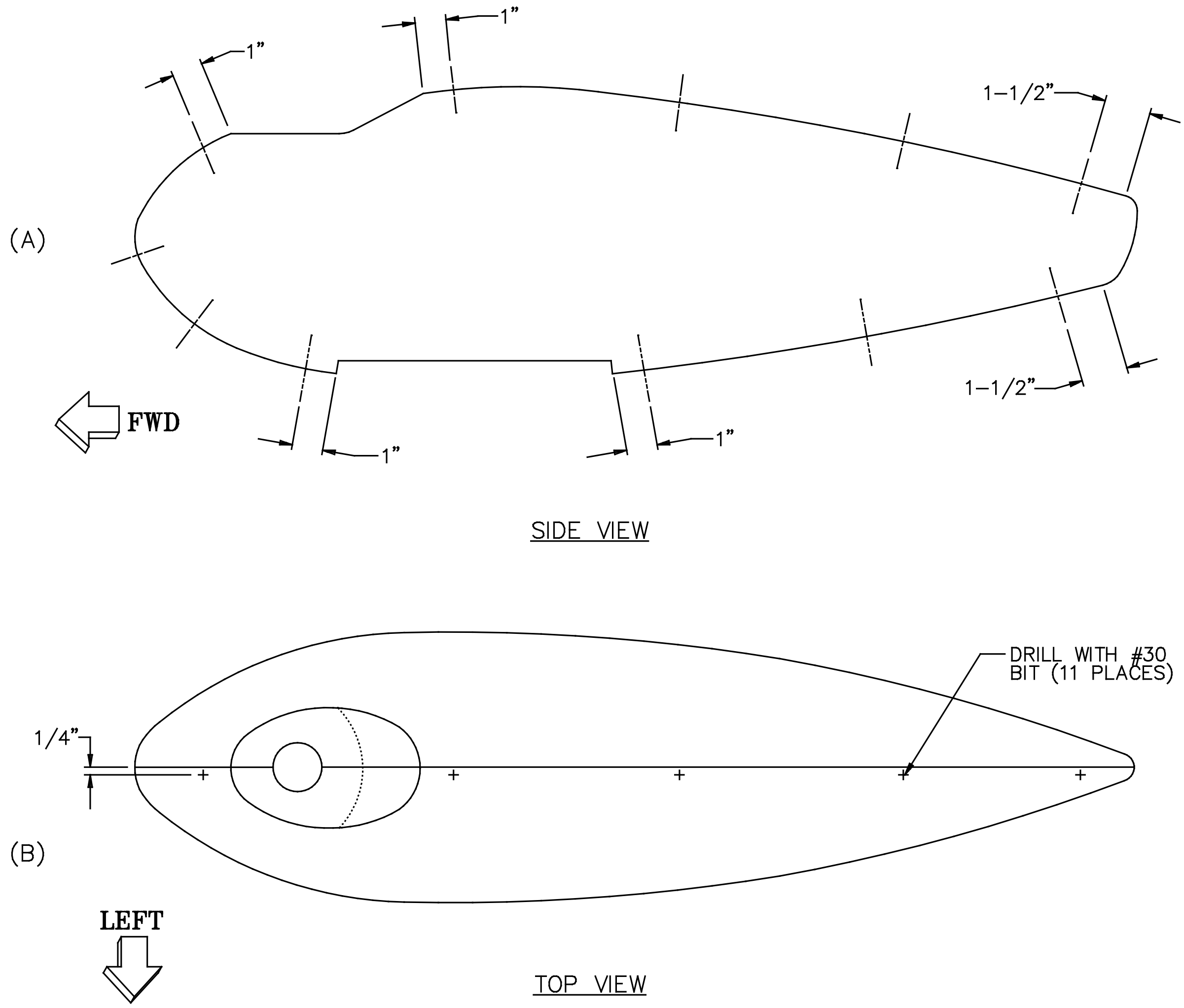

Figure 71: Drilling the Screw Holes in the Nose Wheel Pant

Step 63: Drill the Forward Mounting Screw Hole in the Right-Hand Pant Half (Tricycle Gear Only)

Position the right-hand wheel pant half against the towbar tube bracket in the front and against the aft mounting bracket in back. As shown in Figure 72, the flat pivot plane at the forward end of the pant half should be perpendicular to the fork axle and **1-1/8"** above the top of the nose gear stop assembly. In the fore-and-aft direction, the tire cutout in the pant half should be centered around the tire.

Note Positioning the wheel pant half as described will require that you cut out a half circle on the inboard edge of the pivot plane to provide clearance for the gear leg. Use a rotary file in a die grinder or a half-round hand file to make this cutout. Provide about **1/8"** of clearance all the way around the leg.

With the pant half held in position, mark around the perimeter of the towbar tube bracket on the inside of the pant half, as indicated in Figure 72. You will probably find it difficult to mark all the way around the bracket, but this isn't really necessary; just be sure to mark the forward edge and a bit of the top edge, as shown in Figure 73.

Next, remove the pant half from the wheel assembly and lay it inside-up on a bench. You will now use the outline of the towbar tube bracket you just marked as a reference for laying out hole locations for the forward pant mounting screw and the towbar pin engagement hole. As shown in Figure 73 the mounting screw hole is located **1-1/16" aft** of the forward edge of the towbar tube bracket and **3/8" below** the top edge of the bracket. Mark this location and drill it with a **#10** bit. The towbar pin engagement hole is located **3/8" aft** of the forward edge of the towbar tube bracket and **3/8" below** the top edge of the bracket. Mark this location and drill it with a **1/2"** hole cutter.

Towbar Option Stoddard-Hamilton's custom towbar (P/N 471-0645-101) makes single-handed ground handling of the GlaStar a breeze. Of lightweight aluminum construction, the towbar is anodized bright red for visibility.

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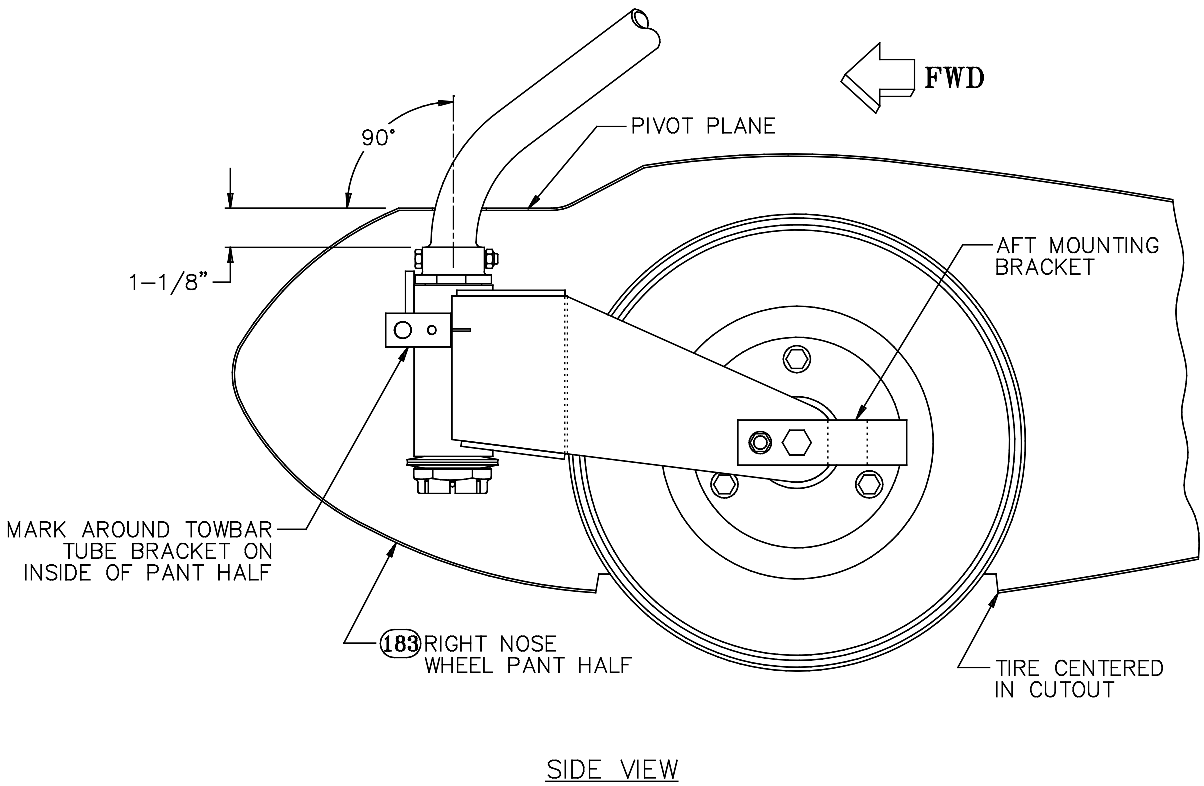

Figure 72: Positioning the Right Wheel Pant Half

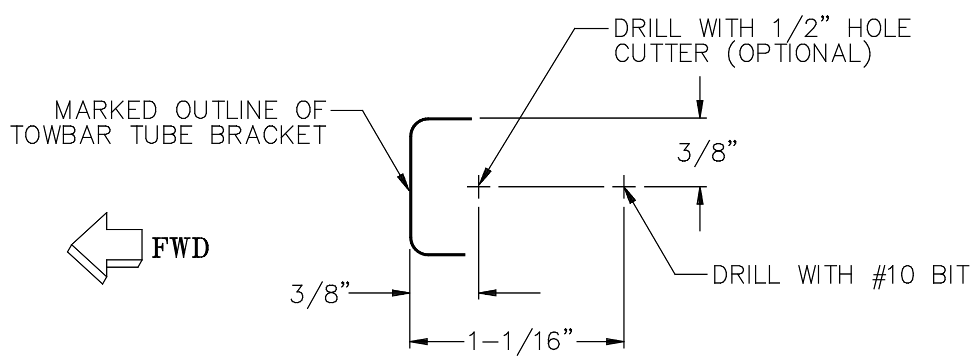

Figure 73: Laying Out the Forward Mounting Screw and Towbar Engagement Pin Holes

Step 64: Drill the Aft Mounting Screw Hole in the Right-Hand Pant Half *(Tricycle Gear Only)*

The aft mounting screw hole must be located over the aft mounting bracket using the modeling clay trick you used earlier in the fuel tank installation (see "SECTION IX: SYSTEMS INSTALLATION," Step 54). In positioning the pant half against the bracket, you can now take advantage of one firm index point—the forward mounting screw hole.

Hold the right-hand pant half up against the forward and aft mounting brackets as you did in the last step and get a general idea of where the aft mounting bracket contacts the inside of the pant half. Apply a thin layer of modeling clay over this area of the pant. Then bring the pant half into position around the nosewheel assembly again but don't press it up against the aft bracket tab yet. Insert an AN509-10R7 **flush-head machine screw** [187] through the forward mounting screw hole you drilled in the last step and thread it into the nutplate on the towbar tube bracket. There's no need to tighten this screw; it simply serves to pin the pant half in place.

Rotate the pant half around the screw until the pivot plane is perpendicular to the fork axle and the tire is centered in the cutout. Then press the pant half firmly against the aft mounting bracket to make an impression of the bracket in the clay.

Remove the pant half and drill a **#40** pilot hole through the pant half at the very center of the rectangular bracket tab imprint. Remove the modeling clay. Then use a fine-point marking pen to mark a **longitudinal** centerline on the face of the aft mounting bracket tab, as shown in Figure 74.

Replace the pant half against the forward and aft mounting brackets, and once again pin it in place with the AN509-10R7 screw through the forward hole. Rotate the pant half around the screw until the centerline on the aft bracket tab appears centered under the #40 hole you just drilled, as shown in Figure 74. Holding the pant half firmly in this position, drill a **#10** hole through the pant half and the bracket tab, using the pilot hole as a guide.

Caution Be careful when drilling the tab not to plunge the bit through into your nosewheel!

Completed: [ ]

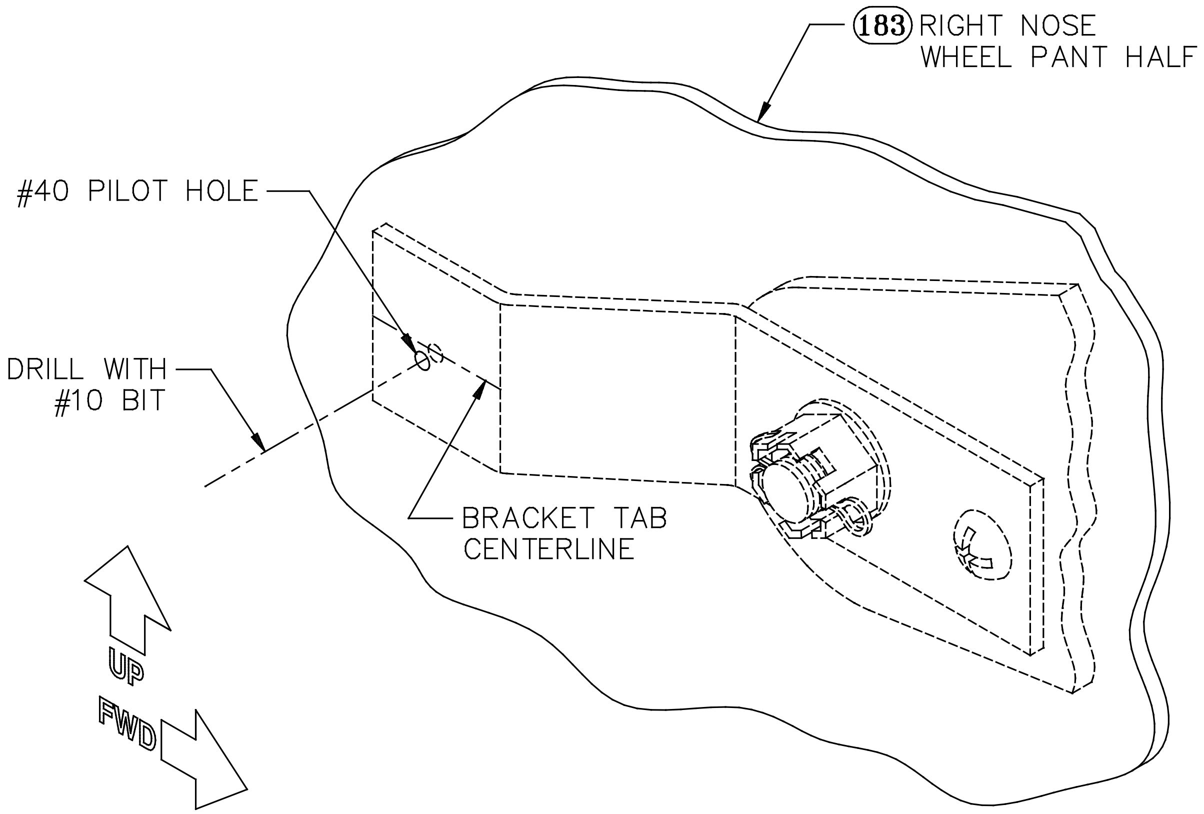

Figure 74: Aligning and Drilling the Aft Wheel Pant Mounting Hole

Step 65: Install the Nutplate on the Right-Hand Aft Mounting Bracket (Tricycle Gear Only)

Using standard procedures, position and drill an MF5000-3 **floating nutplate** [191] at the #10 hole in the right-hand aft mounting bracket tab. Countersink the tab on the outboard side to accommodate 3/32" AN426AD3 flush-head rivets, and use these to rivet the nutplate in place on the inboard side of the tab.

Completed: [ ]

Step 66: Reinforce and Countersink the Right-Hand Mounting Screw Holes *(Tricycle Gear Only)*

With both mounting screw holes now drilled in the right-hand pant half, you need to reinforce the areas around these holes in order to make the laminate thick enough for countersinking. For **each** hole, cut **six** squares of bi-directional cloth on the 45° bias **or three** squares of DBM, each about **2"** on a side.

Use acetone to thoroughly clean the areas on the inside of the pant half around each hole (especially the aft one, where you need to get rid of all modeling clay residue), and then laminate the cloth squares over each hole. After the laminates have cured fully, redrill the **#10** holes and then countersink them on the **outside** of the pant half to accommodate AN509-10R7 screws.

Completed: [ ]

Step 67: Fit and Install the Left-Hand Pant Half *(Tricycle Gear Only)*

With the right-hand pant half now completed, you can use it to position the left-hand half. Mount the right-hand half on the nose wheel fork, using AN509-10R7 flush-head screws front and back. Go ahead and tighten the screws down now.

Next, apply thin layers of modeling clay to the areas inside the left-hand wheel pant half that will contact the forward and aft mounting brackets. Then press the pant half into position against the brackets, using the right-hand half as an alignment guide. Thread a couple of AN507-6R7 screws into the nutplates along the pant seam to lock in the alignment of the two halves. Then press the left-hand pant firmly against the brackets to make good impressions of them in the clay.

Remove the left-hand half and drill **#10** holes at each mounting bracket location, as marked by the clay imprints. Also, drill a **1/2"** hole at the towbar tube location. Remove the clay, thoroughly clean the areas, and then laminate **six 2"-square** pieces of bi-directional cloth cut on the 45° bias **or three 2"-square** pieces of DBM over each #10 screw hole, just as you did on the right-hand half. Redrill the #10 holes and countersink them to accommodate AN509-10R7 screws.

Finally, reposition the left-hand half and use the aft mounting hole as a guide to drill a matching **#10** hole in the aft mounting bracket. Install an MF5000-3 floating nutplate on the bracket. Then install the wheel pant with AN509-10R7s into the brackets and AN507-6R7s along the seams. Leave the pant in place at least until after the nose gear leg fairing has been installed.

Completed: [ ]

Step 68: Reinforce the Trailing Edges of the Nose Gear Leg Fairing Halves (Tricycle Gear Only)

The fiberglass **nose gear leg fairing** consists of a **left** [180] and a **right** [181] half. Lengths of piano hinge will be riveted inside the trailing edges of these halves to join them, just as the main gear fairing trailing edges were joined. To insure that the rivets securing the hinge halves have plenty of material to grab, it's necessary to reinforce the trailing edges of the fairing halves with a single-layer laminate of bi-directional cloth.

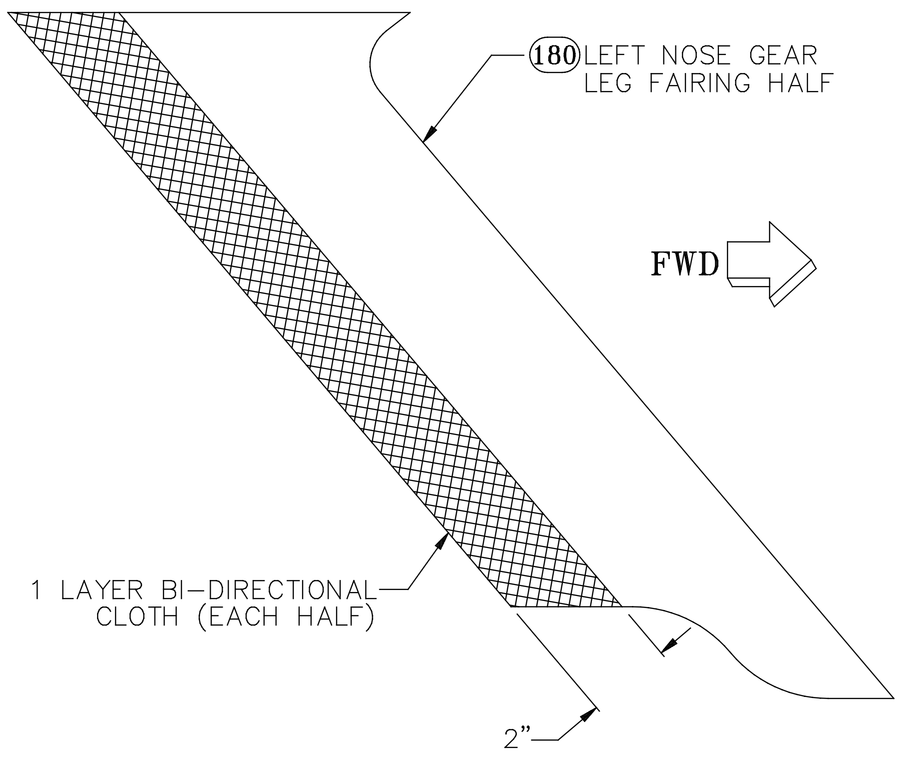

Figure 75: Reinforcing the Nose Gear Leg Fairing Halves

Cut two **2" X approximately 20"** strips of cloth on the 45° bias and laminate one in place on each fairing half, as shown in Figure 75. At green cure, use a sharp utility knife to trim the laminates where they overlap the edges of the fairing halves.

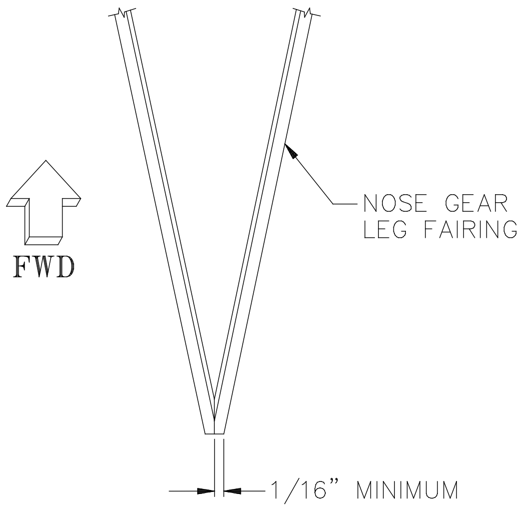

Figure 76: Beveling the Trailing Edges

After the reinforcement laminates have cured fully, use a long sanding block to taper the trailing edges of the halves so that they fit together flushly. However, you don't want to sand these down to a real knife-edge. As shown in Figure 76, leave a blunt edge on **each** trailing edge at least **1/16"** thick.

Also, sand the leading edges of the fairing halves to remove any mold lip, leaving straight, smooth mating edges.

Completed: Left [ ] Right [ ]

Step 69: Install Piano Hinge Along the Trailing Edges of the Fairing Halves (Tricycle Gear Only)

Tape the left and right fairing halves tightly together with masking tape or duct tape along both the leading and trailing edge seams. Hold the assembled fairing with its trailing edge flat on a bench and slide the **18" length of rolled hinge stock** [192] into the vee of the trailing edge, as shown in Figure 77. Insert the hinge into the fairing until it is even with the end of the fairing at one end. Don't push the hinge down into the trailing edge vee; just let the hinge find its own best vertical location. Then tape both hinge halves to their respective fairing halves with small pieces of tape at each end.

Now pull the hinge pin and separate the two fairing halves, being very careful not to disturb the hinge halves. Use a marking pen to mark a line on each fairing half along the entire **forward** edge (i.e., the straight edge) of each hinge half. Then untape the hinge halves from the fairing halves.

Put the hinge halves together **without** the pin and cut them to a final length of **17"**. Cut the hinge pin to a length of **17-1/2"** and put a 90° bend in the last **1/2"** of one end. Bevel the opposite end of the pin, if you wish.

Next, use lots of tape to secure one of the hinge halves to each fairing half, using the line you marked as a fore-and-aft reference. In the vertical direction, Figure 78 shows that each hinge half should begin **even** with the lower, aft corner of the fairing half. Using a try square, mark a reference line from this point on each fairing half, as indicated in the figure, and position the hinge halves as shown.

Note Be as precise as possible in marking the vertical reference line and in positioning the hinge halves on the lines. Inaccuracies in either of these operations will cause trailing edge misalignment in the finished fairing.

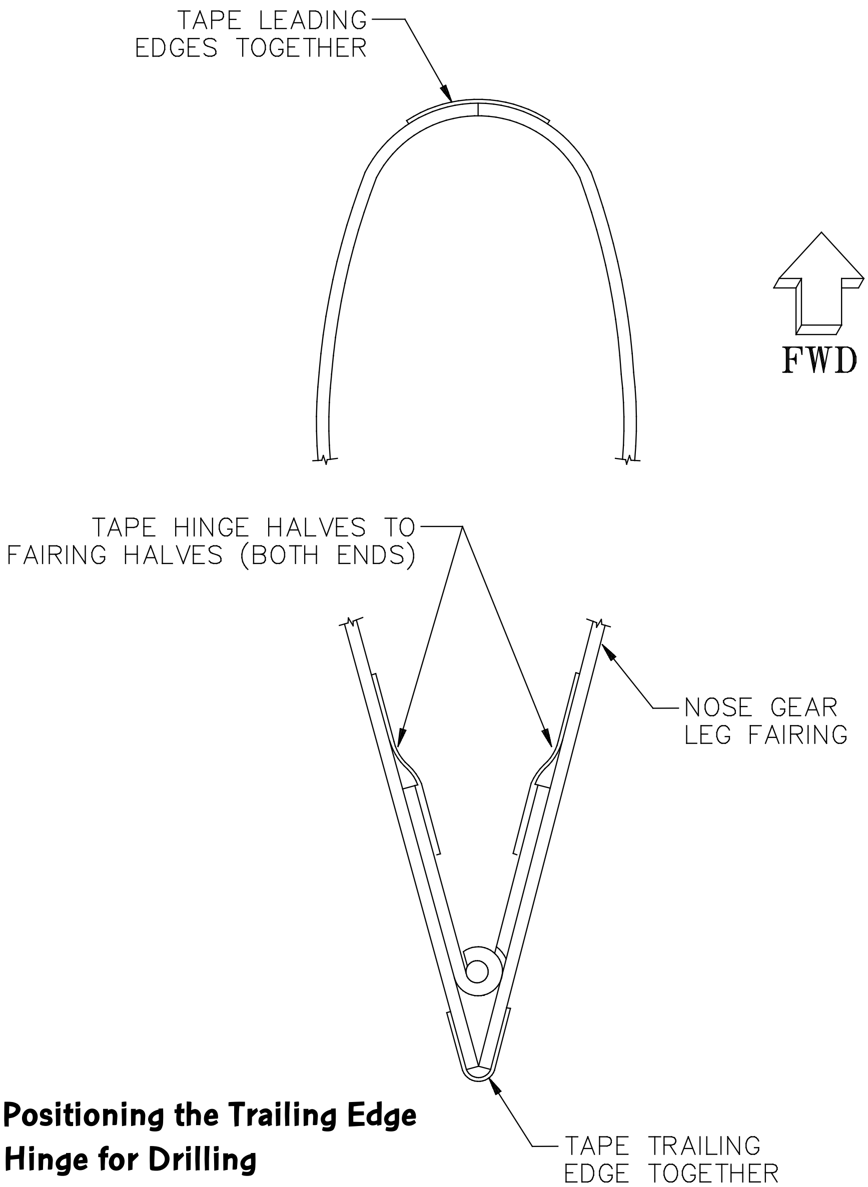

Figure 77: Positioning the Trailing Edge Hinge for Drilling

With the hinge halves taped securely in place, mark and drill **eleven** rivet holes in each according to the dimensions given in Figure 78: The holes at each end should be **1/2"** from the end of the hinge, and the intervening holes should be equally spaced roughly on **1-1/2"** centers. All the holes should be centered fore-and-aft on the hinge flange and should be drilled with a **#40** bit. Cleco as you go.

After the drilling is complete, untape the hinge halves, and then deburr them. Countersink the holes on the outside of each fairing half to accommodate 3/32" AN426AD3 flush-head rivets.

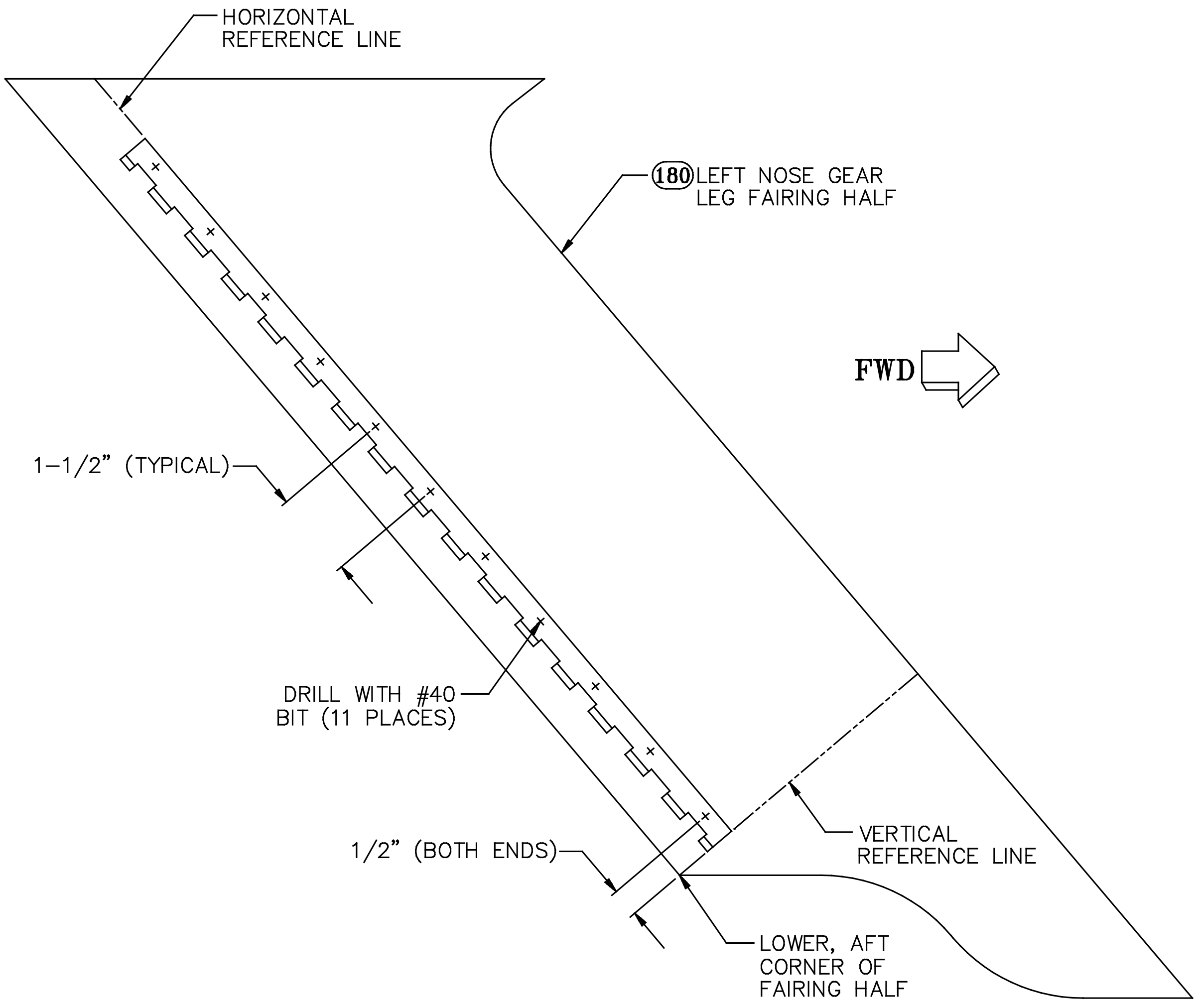

Figure 78: Marking and Drilling the Hinge Halves

When the fairing is installed on the nose gear leg for the final time, the hinge pin will have to be safety-wired in place. To facilitate this, fabricate a clip according to the dimensions shown in Figure 79. The clip can be made out of any scrap of **.020"** aluminum—you should have plenty of that left over from the main gear leg fairings.

After bending the **3/8"** tab at one end of the clip, position it over the lower end of one of the hinge halves so that the bent tab is roughly **1/4"** beyond the end of the hinge. Then use the lowest two rivet holes in the hinge as guides to drill matching **#40** holes through the clip. Finally, drill a pair of closely spaced **1/16"** holes in the tab to complete the clip. Deburr all the holes.

With the safety wire clip finished, you're now ready to rivet the hinge halves to their respective fairing halves. Use 3/32" AN426AD3 flush-heads. Remember to switch to a longer rivet for the two holes through the safety wire clip.

Completed: Left [ ] Right [ ]

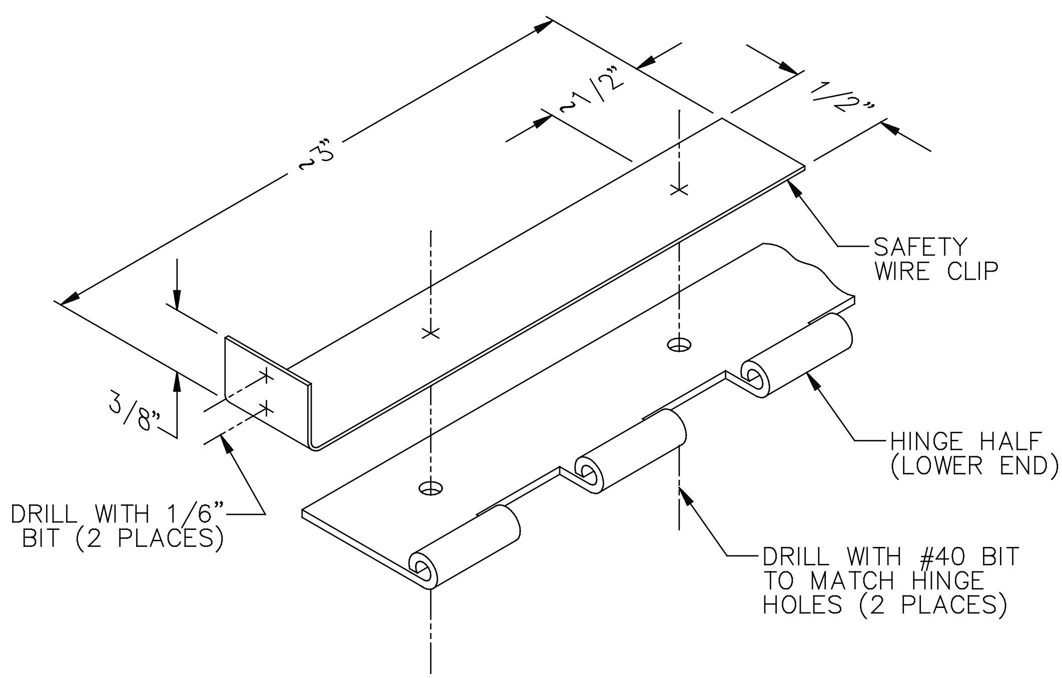

Figure 79: Fabricating the Hinge Pin Safety Wire Clip

Step 70: Reinforce the Mounting Hole Locations in the Fairing Halves *(Tricycle Gear Only)*

The nose gear leg fairing will be secured to the leg with four screws—two per side. The areas where these screws penetrate the fairing must be reinforced with extra laminates on the inside of the fairing halves.

Begin by cutting **twenty-four 2"-square** pieces of bi-directional cloth on the 45° bias **or twelve 2"-square** pieces of DBM. Figure 80 shows where these pieces should be applied. Prepare the inside of the fairing halves in these locations with an acetone wipe-down and laminate **six** bi-directional **or three** DBM cloth squares at each location.

Let the laminates cure fully, and then mark the exact middle of each reinforced area. Drill through the fairing halves at these four locations with a **#40** bit. These holes will serve as pilot holes for the drilling of the fairing mounting brackets.

Completed: Left [ ] Right [ ]

Step 71: Seam the Fairing Halves Together *(Tricycle Gear Only)*

Assemble the two fairing halves by mating the hinge halves and inserting the pin temporarily. Tape the leading edges of the fairing halves tightly together with masking tape or duct tape, and then remove the hinge pin. Insert a couple scrap wood blocks between the trailing edges of the fairing halves to hold the fairing open between **1-1/2"** and **2"**. This gap provides access for the application of the leading edge seam laminate.

Cut two **2"**-wide strips of bi-directional cloth on the 45° bias. Each strip should be in the neighborhood of **25"** long. Lay these strips **inside** the fairing over the leading edge seam, lapping equally onto the left and right halves. Let the laminates cure with the wood blocks still holding the fairing open. This will make the fairing easier to install.

When the laminates reach green cure, trim them even with the upper and lower edges of the fairing with a utility knife.

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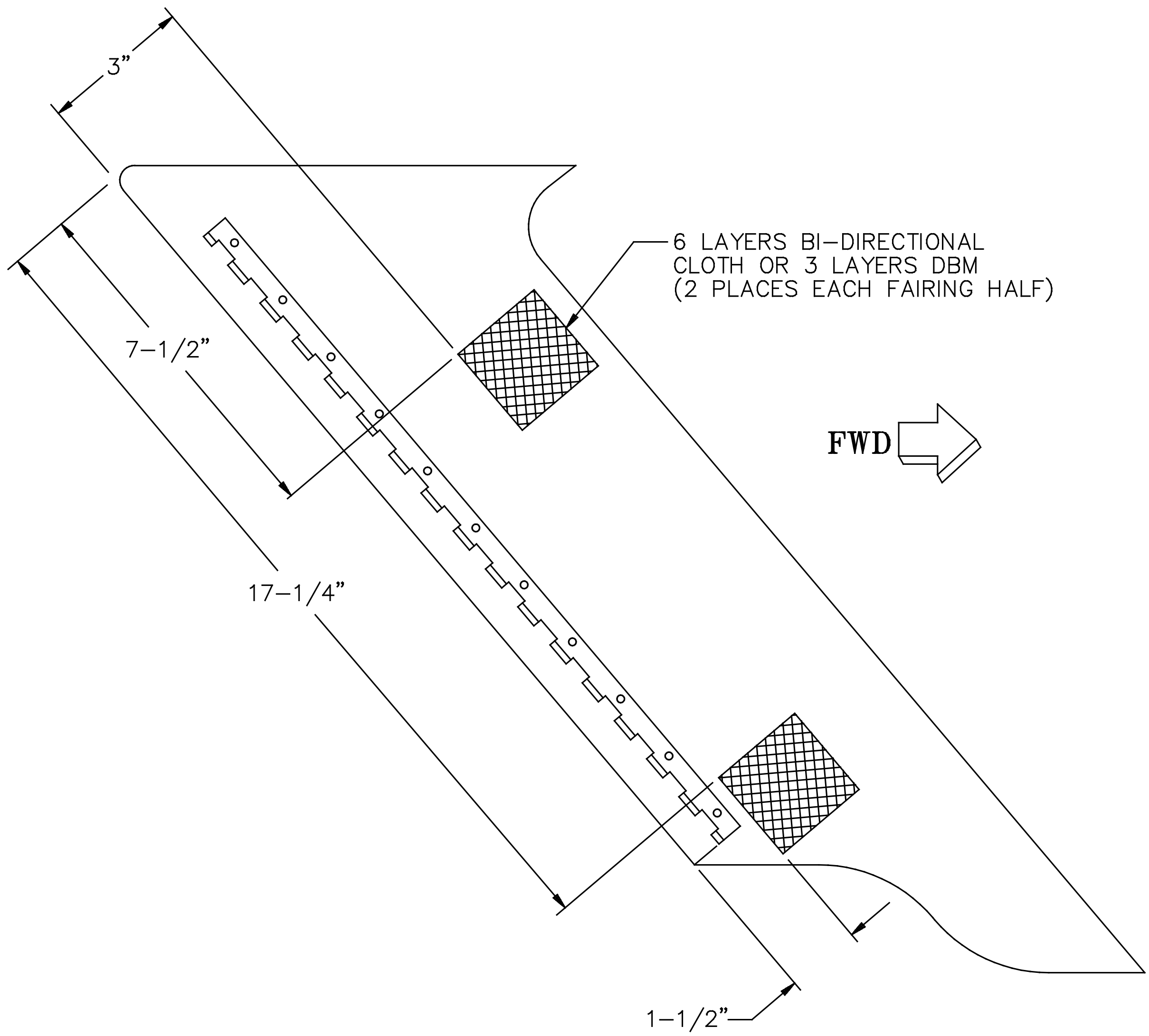

Figure 80: Reinforcing the Mounting Screw Locations

Step 72: Fabricate the Fairing Mounting Brackets
(Tricycle Gear Only)

Each mounting bracket for the nose gear leg fairing consists of a simple "U"-shaped aluminum strap secured to the leg with a stainless steel hose clamp. As shown in Figure 81, each bracket comes from a flat blank **1-1/2" X 6"** in size. The brackets should be fabricated from **.063" aluminum sheet** [184]; there should be enough material remaining from the sheet from which you cut the forward shell attach fittings and the rudder pedals. Cut out the basic rectangular shape with a hacksaw or bandsaw, smooth the cut edges and radius the corners. Then lay out four hole locations according to the dimensions given on the left-hand side of Figure 81.

As indicated on the right-hand side of the figure, drill all four holes with a **1/4"** bit. Then use a scroll saw or a rat-tail file to remove the material between the holes, leaving two 1/4"-wide slots across the width of the bracket.

Next, the brackets must be bent into a "U." This can be done either over a **1"**-diameter pipe or dowel in a vise or over the nose gear leg itself. In either case, begin by marking a centerline across the width of the bracket between the two slots. Align this centerline over your bending die, whatever it may be, and bend the two ends of the bracket around it by hand. If necessary, a rubber mallet or lead body hammer can be used to tighten up the radius of the bend, but this isn't too critical. The ends of the brackets should be bent until they are nearly parallel with one another.

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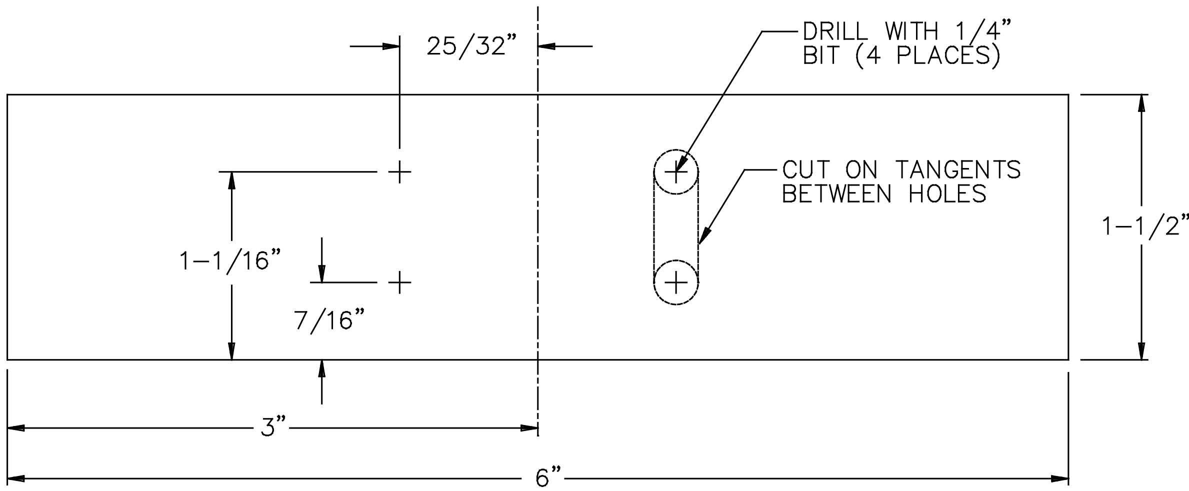

Figure 81: Cutting and Drilling the Nose Gear Leg Fairing Mounting Brackets

Step 73: Fit and Install the Nose Gear Leg Fairing

(Tricycle Gear Only)

Figure 82 shows how the fairing mounting brackets are installed on the nose gear leg. Loosen the screw of an **11/16"—1-1/4" hose clamp** [185] until the strap comes free. Position a "U"-shaped bracket around the gear leg, and then insert the loose end of the clamp strap through the slots in the bracket. Reinsert the strap into the clamp and tighten the screw.

The **lower** bracket should be positioned initially about **19-3/4"** below the bottom of the fuselage shell, and the open end of the "U" should be aft, as shown in Figure 82. The **upper** bracket should be positioned about **8-1/2"** below the shell, but it should open **forward**. (Both dimensions are measured along the gear leg, not vertically.) These locations are "initial" because the brackets may need vertical adjustment to coincide with the reinforced mounting screw areas on the fairing.

To determine whether such adjustment is necessary, first mark a longitudinal centerline on each outboard face of both brackets, as shown in Figure 82. Then position the fairing over the gear leg with its seamed edge forward. Adjust the fairing so that **A)** it is centered on the gear leg fore-and-aft; so that **B)** the lower, forward corner of the fairing is even with the upper, forward corner of the wheel pant pivot plane; and so that **C)** there is a gap of roughly **1/8"** between the bottom of the fairing and the wheel pant pivot plane. The gap between the upper end of the fairing and the fuselage shell and cowling is much less critical; ideally it should be between **1/8"** and **1/4"**. The fairing should **not** contact the fuselage shell or the cowling. Trim and sand the fairing as necessary to achieve a good fit.

Note Trial-fit the fairing with its trailing edges squeezed together, as this will change the shape of the fairing. Also, if you have not yet mounted your engine cowling, you may want to postpone this step to ensure that you get a nice fit at the top of the fairing.

When the fairing fits to your satisfaction, hold it in position and check the bracket locations by inserting a marking pen through each of the #40 pilot holes in the fairing to mark the underlying mounting bracket. Also note whether the arms of the brackets are spread widely enough to contact the fairing firmly when its trailing edges are squeezed closed. Then remove the fairing.

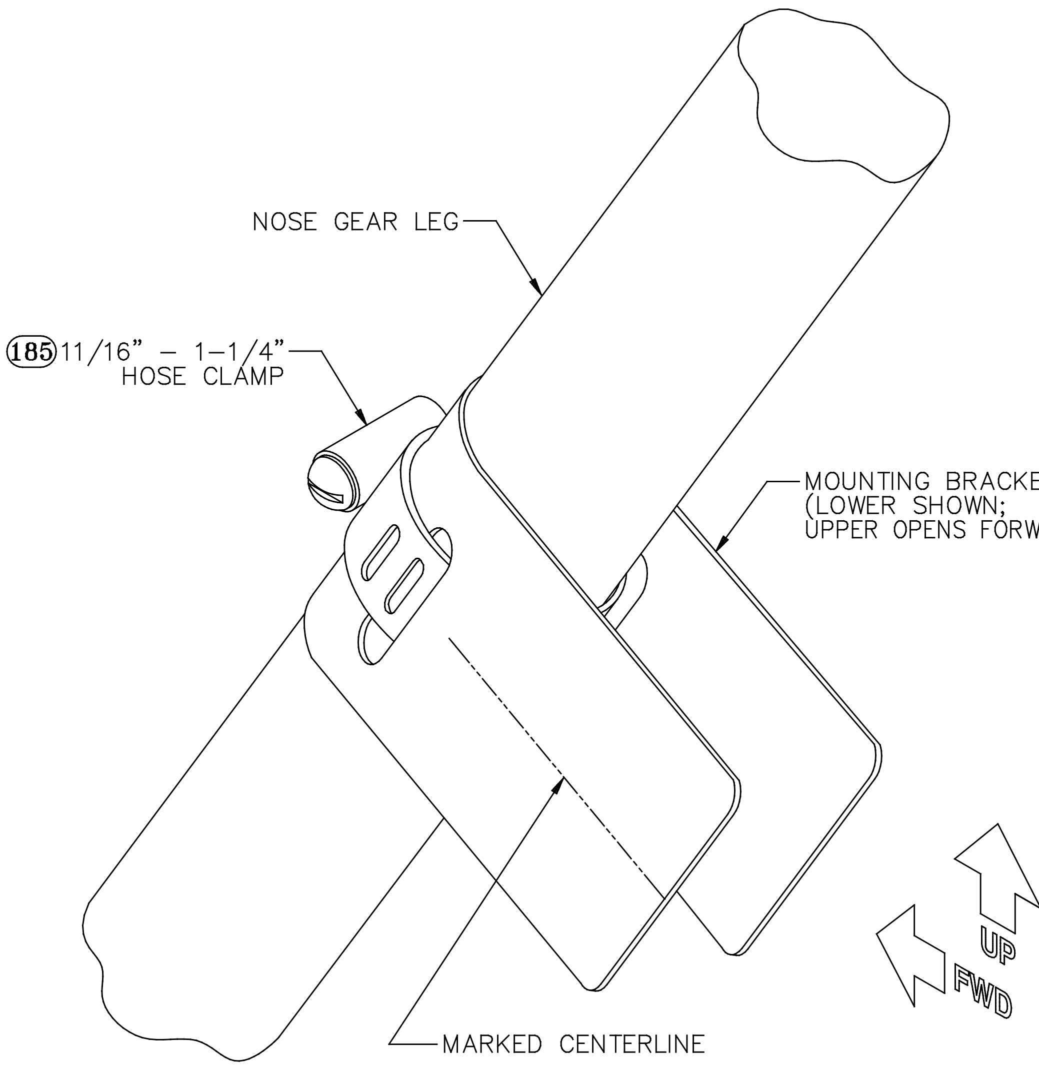

Figure 82: Installing the Fairing Mounting Brackets

If either of the brackets appeared to be too tightly bent to contact the fairing, loosen its hose clamp and bend its arms outward a bit. Then check the locations of the marks you made through the fairing pilot holes. If the marks on both sides of a bracket appear **above** the arm centerlines, then move that bracket **up** the leg an equivalent amount. Similarly, if the marks appear **below** the centerlines, move the bracket **down**. If the mark is above the centerline on one side and below it on the other, then split the difference.

Note Don't spend too much time on this procedure; the **exact** vertical positions of the brackets aren't overly critical.

After the brackets have been adjusted as necessary, replace the fairing and insert the hinge pin to hold the trailing edges together. You'll have to pivot the nose wheel to one side to gain access for the pin.

Insert some shims between the lower end of the fairing and the wheel pant pivot plane to maintain the proper gap there, and then, while holding the fairing firmly in position, drill through the fairing and the bracket arms with a **#19** bit at each of the four #40 pilot holes.

Remove the fairing and countersink all four holes on the outside to accommodate AN509-8R8 **flush-head machine screws** [188]. Then mark the locations of the mounting brackets on the gear leg, remove the brackets and drill rivet holes in each bracket arm for an MF5000-08 **floating nutplate** [190]. You may also want to ream the center screw hole in each arm up to **11/64"** so the nutplate has room to float. Finally, countersink the nutplate rivet holes on the **outboard** face of each arm to accommodate 3/32" AN426AD3 flush-head rivets. Corrosion-proof the brackets as you see fit, and then use AN426AD3s to rivet the nutplates to the inboard face of each arm.

Finally, return the brackets to the gear leg and tighten the hose clamps securely. Position the fairing over the brackets and secure it with AN509-8R8 screws. Insert the hinge pin from below with the right-angle bend at the end of the pin pointing forward. Insert the pin until the bend is just below the bent tab of the safety wire clip, as shown in Figure 83. (You may have to shorten the pin a bit to achieve this.) With the pin in place, loop a piece of safety wire through the two small holes in the clip tab. Twist the wire around the bent pin end to secure the pin.

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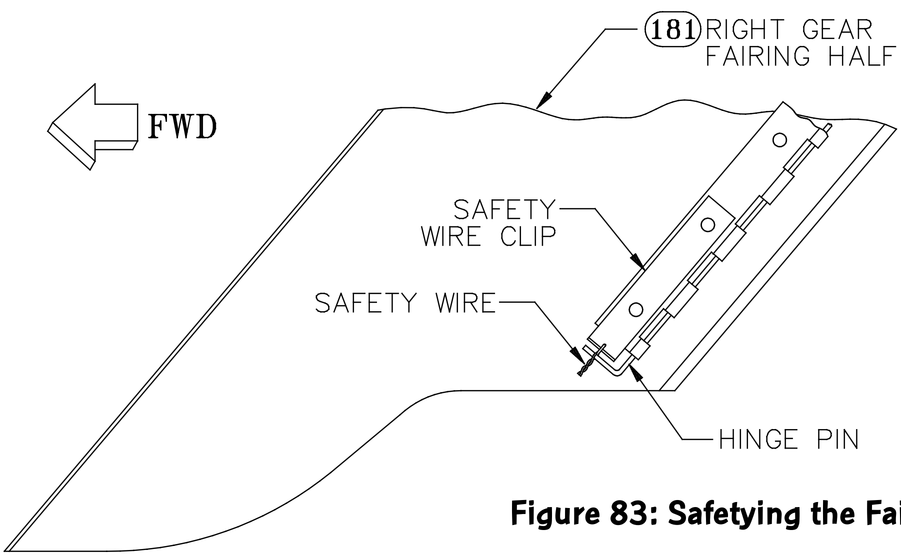


Figure 83: Safetying the Fairing Hinge Pin

FINAL WING ASSEMBLY

In this sub-section, you will complete construction of the wing, including final riveting of all remaining skins, installation of the fuel tanks, installation of the wingtip fairings, etc. To accomplish most of these tasks, you'll need to return your wings to the jig (one at a time, of course!). Check that the jig uprights are still plumb and true. Make sure that all fuel tank vent lines, the pitot line and any optional electrical wiring are installed and securely fastened to the airframe as specified in "SECTION IX: SYSTEMS INSTALLATION." Check that the aileron and flap bellcranks, pushrods and cables are secure and properly safetied. Check for free movement of all control system components and for lack of interference with the wing structure. Make a final check of all the rivets securing the lower wing skins, the lower hat section stiffeners, the wing ribs, and the flap and aileron control system components; remove and replace any unsatisfactory rivets. When satisfied, return the wing to the jig.

Hint This would be an excellent time to have your local EAA technical counselor inspect your project. Such an inspection not only brings an experienced, knowledgeable pair of eyes to bear on your project at a critical stage but may also qualify you for lower aircraft insurance rates. Contact EAA for the names of counselors in your area.

Step 74: Cleco the Upper-Surface Hat Section Stiffeners to the Spars

Cleco the upper surface hat section stiffeners between the forward and aft spar flanges. Be careful to install each stiffener in the correct location as marked in Step 37 of "SECTION VI: WING ASSEMBLY."

Make a final check that everything is in readiness for riveting the wing skins. If you have not already done so, apply the fuel tank anti-chafe tape to the upper hat sections in the area of the fuel tank(s).

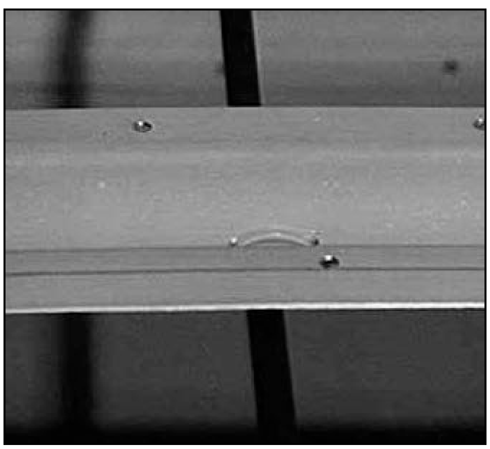
Completed: Left [ ] Right [ ]

Step 75: Connect the Fuel Tank Vent Lines and Secure Them to the Upper Hat Sections

With the upper surface hat sections Clecoed in place for the final time before being riveted, you can now secure the fuel tank vent lines to them.

The method for securing the lines is shown in Figure 84. As shown in Figure 84a, drill a **#30** or **1/8"** hole through the bottom of the hat section on either side of the vent line; the holes should be about **3/8"** apart. Deburr these holes, and then insert a **4" cable tie** [83] through them and cinch it tightly around the vent line, as shown in Figure 84b. You could probably get by with securing the lines only to every other hat section, but we recommend using every one.

Completed: [ ]



(a) **(b)**

Figure 84: Securing the Fuel Tank Vent Lines to the Hat Sections

Step 76: Drill the Flap Track Rib Rivet Holes

Back in "SECTION VI: WING ASSEMBLY," you drilled all the upper-surface skin holes with the exception of the holes over the **flap track ribs**—the short ribs on either side of the inboard and outboard flap tracks. These were omitted because it's vitally important that the flap tracks themselves be perpendicular to the aft wing spar to prevent binding in the flap roller bearings, and at the time you were drilling the other cove rib rivet holes, the flap tracks hadn't been positioned yet. Later, when you installed the flap track reinforcement angles in Step 65 of SECTION VI, you squared the tracks and locked them into position.

Now, Cleco the center and inboard upper main skins in place on the wing structure. Make a final check for squareness between the flap tracks and the aft spar, focusing your attention on the top of the tracks. While the bottoms are held square by the reinforcement angles, it's still possible that the tops might be slightly out of square, and this is your last chance to correct them. If a track is found to be out of square, bring it into position by inserting an appropriately sized piece of scrap wood between the flap track rib and the adjacent flap cove rib.

When you're satisfied that everything is properly aligned, drill through the skin and the flap track rib flange with a **#40** bit at each of the pre-punched skin holes. There are five holes per rib. When the drilling is complete, remove the skins and deburr the holes in both skins and all four flap track ribs.

Completed: Left [ ] Right [ ]

Step 77: Rivet the Upper Wing Skins

Use the following sequence to rivet the upper wing skins and hat sections:

A) Use 1/8" AN426AD4 flush-head rivets to rivet the **outboard** skin and the forward ends of its hat sections to the forward spar flange, **except** for the rivet hole at the overlap between the outboard and center skin. Use the procedures described in "SECTION II: TOOLS AND TECHNIQUES" to choose the correct length rivet for each location, being aware that you will need a half-size longer rivet where both the hat sections and the skins attach to the spar flange. Also, follow standard procedures for installing a line of rivets: rivet at the ends and the center of the line first, and then install rivets halfway between existing rivets, continuing in this manner until the entire line is filled.

> **Note** You'll have to lift up the trailing edge of the upper skin to gain access to the inside of the wing for your bucking bar. You can use lengths of wide masking tape or duct tape to hold the skin up out of the way. It might be a good idea to Cleco or clamp a length of 1/4" plywood or aluminum angle to the trailing edge of the skin to reinforce it and keep it from buckling. At least be aware of the possibility of kinking the skin, and exercise appropriate care.

Rivet the outboard skin to its hat section stiffeners and to Main Rib 5 with 3/32" AN470AD3 universal-head rivets; rivet it to Main Rib 6 with 3/32" AN426AD3 flush-head rivets. Work back and forth across the skin in a spanwise direction, starting at the leading edge and gradually laying the skin down onto the wing as you proceed toward the aft spar. As you approach the aft spar, the gap between the aft spar and the skin will decrease, so you will have to gain access for your bucking bar through the lightening holes in the aft spar or from the ends of the skin through the rib lightening holes. **Do NOT** rivet the outboard skin to the aft spar flange yet; just Cleco the skin to the aft spar for the time being. Also, do not rivet to Main Rib 4; the outboard skin will be riveted to Main Rib 4 with the center skin later.

B) Now Cleco the **center** skin in place and rivet it and the forward ends of its hat sections to the forward spar flange using 1/8" AN426AD4 flush-head rivets, **except** for the rivet hole at the inboard end where the center and inboard skins overlap. (However, you **should** rivet the overlap between the center and outboard skins at this time). A couple of the rivets in the area of the strut beam assembly are inaccessible for bucking; use 1/8" AAPQ-44 structural blind rivets in these locations.

> **Note** We have had difficulty obtaining the long AAPQ-44 rivets necessary for these few holes. Thus, you kit may contain Cherrymax CR3212-4-8 blind rivets instead; these are entirely equivalent.

Rivet the center skin to its hat sections and to Main Ribs 3 and 4, using the same procedures as you used in Step A for the outboard skin: work back and forth in the spanwise direction starting at the front, moving aft and laying the skin down as you go. Use 3/32" AN470AD3 universal-head rivets. Rivet the outboard skin to Main Rib 4 at the same time, of course. As you near the aft spar, you will not have as many lightening holes for access as you did for the outboard skin; gain access for bucking through the inspection holes in the lower wing skin. **Do NOT** rivet to Main Rib 2 or to the aft spar yet. The center skin will be riveted to Main Rib 2 with the inboard skin; all the skins will be riveted to the aft spar after all the wing skins have been riveted to the ribs and hat sections.

C) Cleco the **inboard** skin in place and rivet it to the forward spar flange and the forward ends of the hat sections using the same procedures as described in Step A for the outboard skin and in Step B for the center skin. **Do NOT** rivet the hole at the inboard end that lies over the root rib (Main Rib 1) location. Use 1/8" AN426AD4 flush-head rivets.

Rivet the inboard skin and the inboard end of the center skin, to Main Rib 2 and to the hat sections aft of the forward spar, using the same procedures as described in Steps A and B. Use 1/8" AN470AD4 universal-head rivets in Main Rib 2; use 3/32" AN470AD3 universal-head rivets in the hat sections. **Do NOT** rivet Main Rib 1 (the root rib) yet; it will be riveted after the fuel tanks have been installed.

D) Make a final check to verify that the wing jig is straight and true and that the wing is untwisted; this is important because any twist remaining in the wing will be locked in once the wing skins have been riveted to the aft spar. When you are satisfied that the wing is straight, proceed to rivet the upper skins and the aft ends of their hat sections to the aft spar flange. (Rivet the aileron and flap bellcrank bracket/spar flange attach angles at the same time.) Use 1/8" AN470AD4 universal-head rivets. Follow standard procedures for installing a line of rivets. In areas that are absolutely inaccessible for bucking (above the flap bellcrank bracket, for example), use 1/8" AAPQ-4 structural blind rivets.

E) Finally, use 3/32" AN470AD3 universal-head rivets to rivet the upper skins to the flap and aileron cove ribs and the flap track ribs.

Completed: Left [ ] Right [ ]

Step 78: Install the Fuel Tank and Rivet the Root Ribs to the Spars and Skins

Prepare the fuel tank for installation by removing the plugs and/or sealing tape from the vent line boss at the outboard end of the tank and the filler opening on the top of the tank. Then slide the tank into the wing all the way to the main rib at the outboard end (Main Rib 2). Cleco the root main rib (Main Rib 1) in place with a pair of Clecos through the forward spar and the root nose rib (Nose Rib 1). Then Cleco the root cove rib (Flap Cove Rib 1) in place with a pair of Clecos through the aft spar and the root main rib. Finally, add additional Clecos through the upper and lower skins into the main rib.

Rivet the root ribs in place according to the following schedule.

A) Rivet the root main and nose ribs to the forward spar with 1/8" AN470AD4 universal-head rivets. The rivet heads should be forward for easiest access with the rivet gun, although you may be able to squeeze some of these rivets if your squeezer has a deep enough yoke.

B) Rivet the root main and cove ribs to the aft spar with 1/8" AN470AD4 universal-head rivets. In this case, the heads should be aft.

C) Rivet the lower inboard main skin and doubler to the lower flange of the forward spar and the root main rib with a pair of 1/8" AN426AD4 flush-head rivets. The forward rivet of this pair will also pick up the aft, inner corner of the inboard leading edge skin; adjust your rivet length accordingly. Then use the same type and diameter of rivet to rivet the upper inboard main skin and the aft, upper corner of the inboard leading edge skin to the upper flange of the forward spar and root main rib. All four of these holes should have been dimpled (in the skins) and countersunk (in the spar) earlier. These rivets (as well as those to follow in Steps D–F) can easily be squeezed.

> **Note** When you riveted the inboard leading edge skin to the forward spar, you should have left the **innermost** hole in the upper and lower flanges unriveted. However, if you accomplished that step using the initial, unrevised version of the *Assembly Manual*, you probably went ahead and installed these two rivets as instructed. They will have to be drilled out and replaced now.

D) Rivet the root main rib aft of the forward spar to the lower inboard main skin and doubler with 1/8" AN470AD4 universal-head rivets. (This row of rivets includes the rivet through the lower flange of the aft spar.)

E) Rivet the root main rib aft of the forward spar to the upper inboard main skin with 1/8" AN470AD4 universal-head rivets. (This row of rivets includes the rivet through the upper flange of the aft spar.)

F) Rivet the lower inboard main skin to the root cove rib with 3/32" AN470AD3 universal-head rivets.

G) Rivet the upper inboard main skin to the root cove rib with 3/32" AN470AD3 universal-head rivets.

H) Use 1/8" AN426AD3 flush-head rivets to rivet the root rib doublers to the upper and lower flanges of the forward and aft spars at the eight holes inboard of the wing skins.

> **Note** These eight holes should have been countersunk on the upper side of the upper spar flanges and the lower side of the lower spar flanges to accommodate the flush-head rivets. However, if you drilled these holes according to the instructions given in the unrevised version of the *Assembly Manual*, then you were never told to do so. Countersink the eight holes at this time and touch up your anti-corrosion protection as you see fit.

Completed: Left [ ] Right [ ]

Step 79: Install the Filler Necks and Fuel Caps

Using an appropriate thread sealant (Our mechanics favor Permatex High Tack Adhesive Sealant for its resistance to avgas.), install a **fuel tank filler neck** [46] into the filler opening of each tank. Thread these in until they're good and snug. Then install a **fuel cap** [45] on each neck.

Completed: Left [ ] Right [ ]

Step 80: Connect the Fuel Tank Vent Lines to the Tanks

Reaching in through the inspection holes, tighten the male connector nut at the end of each vent line onto the connector body threaded into the outboard end of each tank.

> **Note** Use of thread sealant is **not** recommended for nylon fittings.

Completed: Left [ ] Right [ ]

Step 81: Rivet the Inspection Hole Doublers to the Wing

In "SECTION IX: SYSTEMS INSTALLATION," you riveted nutplates to the inspection hole doublers and taped them inside the wing. Untape them now and Cleco them in place for final riveting, making sure they're oriented the same way they were when they were drilled. Rivet the doublers to the skins with 3/32" AN470AD3 universal-head rivets.

Completed: Left [ ] Right [ ]

> **Note** The following several steps can be accomplished with the wing in or out of the jig, at your convenience. Our experience is that most of these procedures are probably a bit easier if the wing is lying flat on a bench, but be sure to take extra care with the left wing to avoid damaging the pitot tube, if you have installed one.

Step 82: Cut the Cove Skins to Length

The flap and aileron cove skins fit between the trailing edges of the upper and lower main skins to close out the aft end of the wing. The cove skins are made of thin aluminum sheet with an angled flange bent along one edge; the flange rivets to the lower wing skin aft of the cove ribs. From the lower wing skin, the cove skins wrap up and aft along the aft ends of the cove ribs. The center areas of the cove skins are riveted to tabs on the aft ends of the cove ribs; the upper edges of the cove skins are riveted, along with a trailing edge doubler, to the upper wing skins.

From an **inboard/outboard flap cove skin** [32], cut one piece **21-3/4"** long for the inboard section of each wing and one piece **22-1/4"** long for the outboard section, as shown in Figure 85. From a **center flap cove skin** [33], cut two pieces **31-1/2"** long for the center sections of each wing. Use offset sheet-metal snips to cut the cove skins.

From an **aileron cove skin** [34], cut one piece **12-1/2"** long for the inboard section, one piece **42-1/4"** long for the center section and one piece **11-1/4"** long for the outboard section of each wing, as shown in Figure 86.

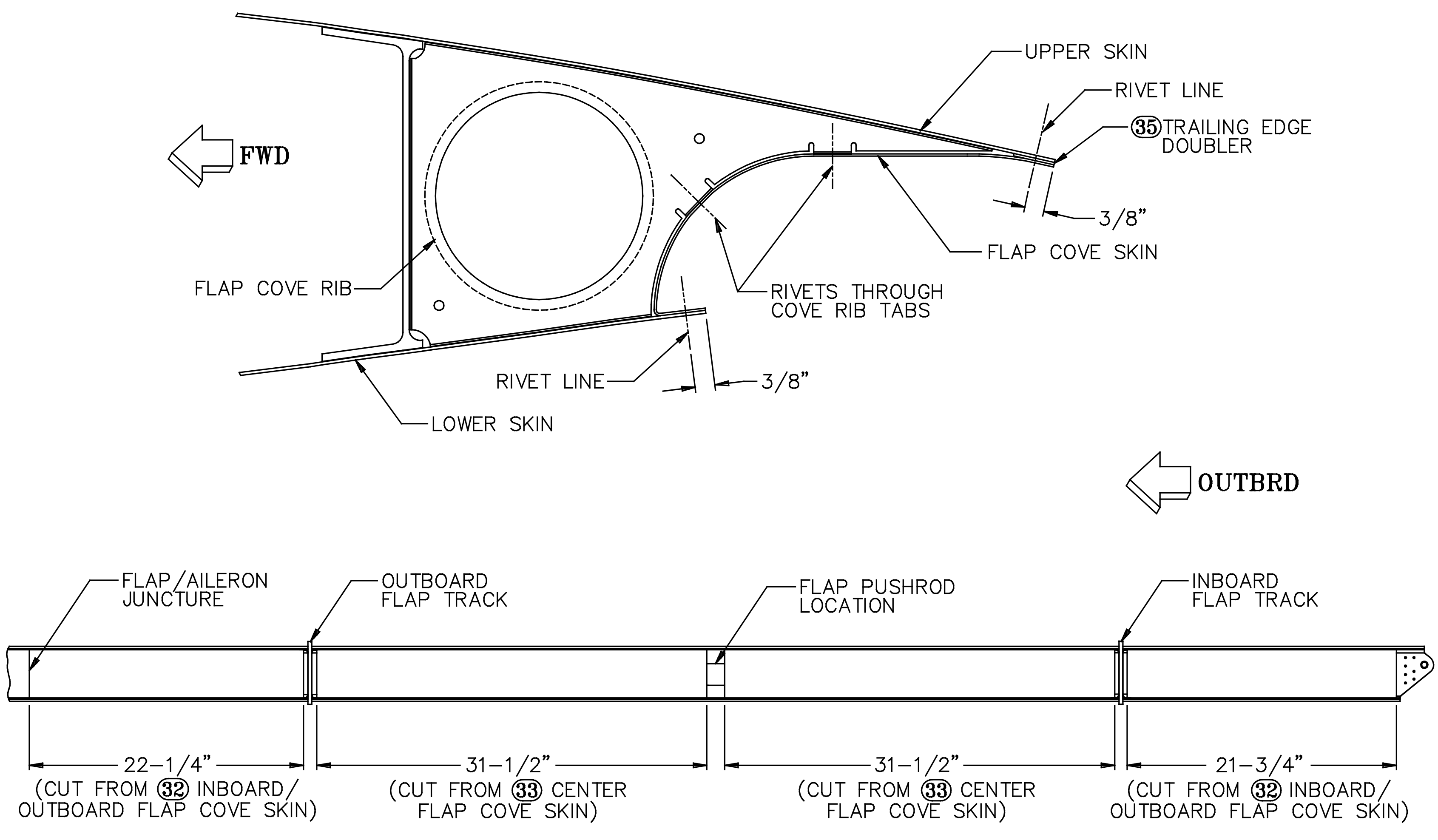


Figure 85: Cutting the Flap Cove Skins

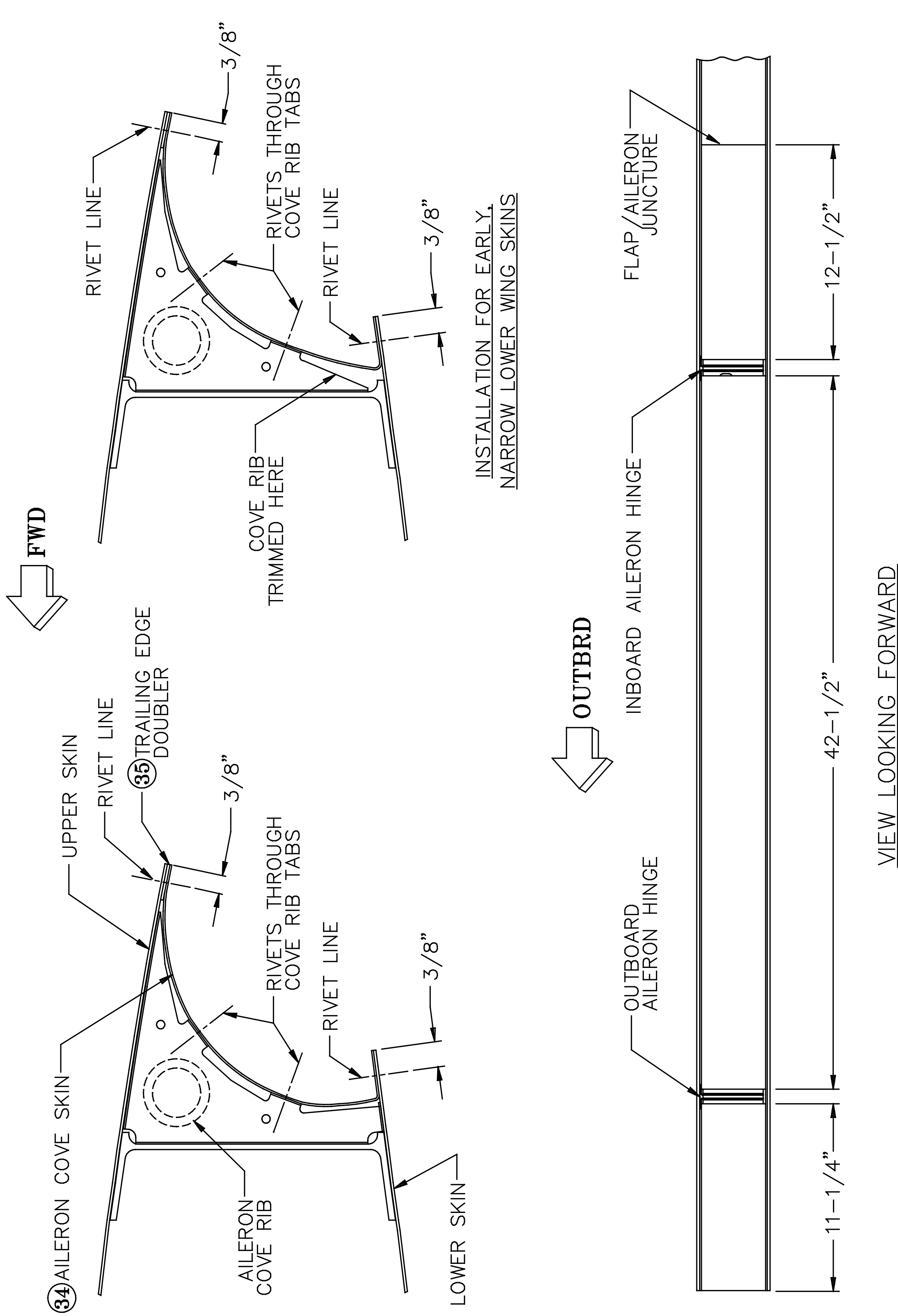


Figure 86: Cutting the Aileron Cove Skins

Check the fit of all the cove skin pieces in their respective locations. Make sure that none of them interferes with the flap track guide arms, the aileron hinges or the flap or aileron pushrods. Adjust the lengths of the pieces as necessary and then deburr all the cut ends.

Note Don't be concerned if the edges of the cove skins are not even with the edges of either the upper or the lower wing skins. At each joint, the longer skin will be trimmed to match later (in Step 84) after the rivet holes have been drilled. If you have the narrower lower outboard and lower center skins described in Step 30.1 of "SECTION VI: WING ASSEMBLY," you will have trimmed the aileron cove ribs to accommodate the cove skins, as shown in Figure 86. For these kits, force the aileron cove skin flanges forward to align them as closely as possible with the edges of the lower wing skins.

Completed: Left [ ] Right [ ]

Step 83: Fit the Trailing Edge Doublers

The wing skin **trailing edge doublers** [35] are .032" X 3/4" X 48" aluminum strips. These will be riveted between the upper wing skins and the flap and aileron cove skins the full length of the wing trailing edge. The doublers will simply be butted end-to-end rather than overlapped in any way.

The flap section of the wing trailing edge is just under 111" long, so it will take **two** of the **full-length**, **48"**-long doublers plus **one** section just under **15"** long. Lay two full-length doublers along the wing trailing edge and trim a short length from a third one to fit. It doesn't matter where the joints between the doublers are located; position them anywhere you choose.

The aileron section of the wing is about 67-1/2" long. Use **one full-length** strip, and **one** strip about **19-1/2"** long. Trim the short strip to fit your wing, using the remainder of the strip you trimmed for the flap section.

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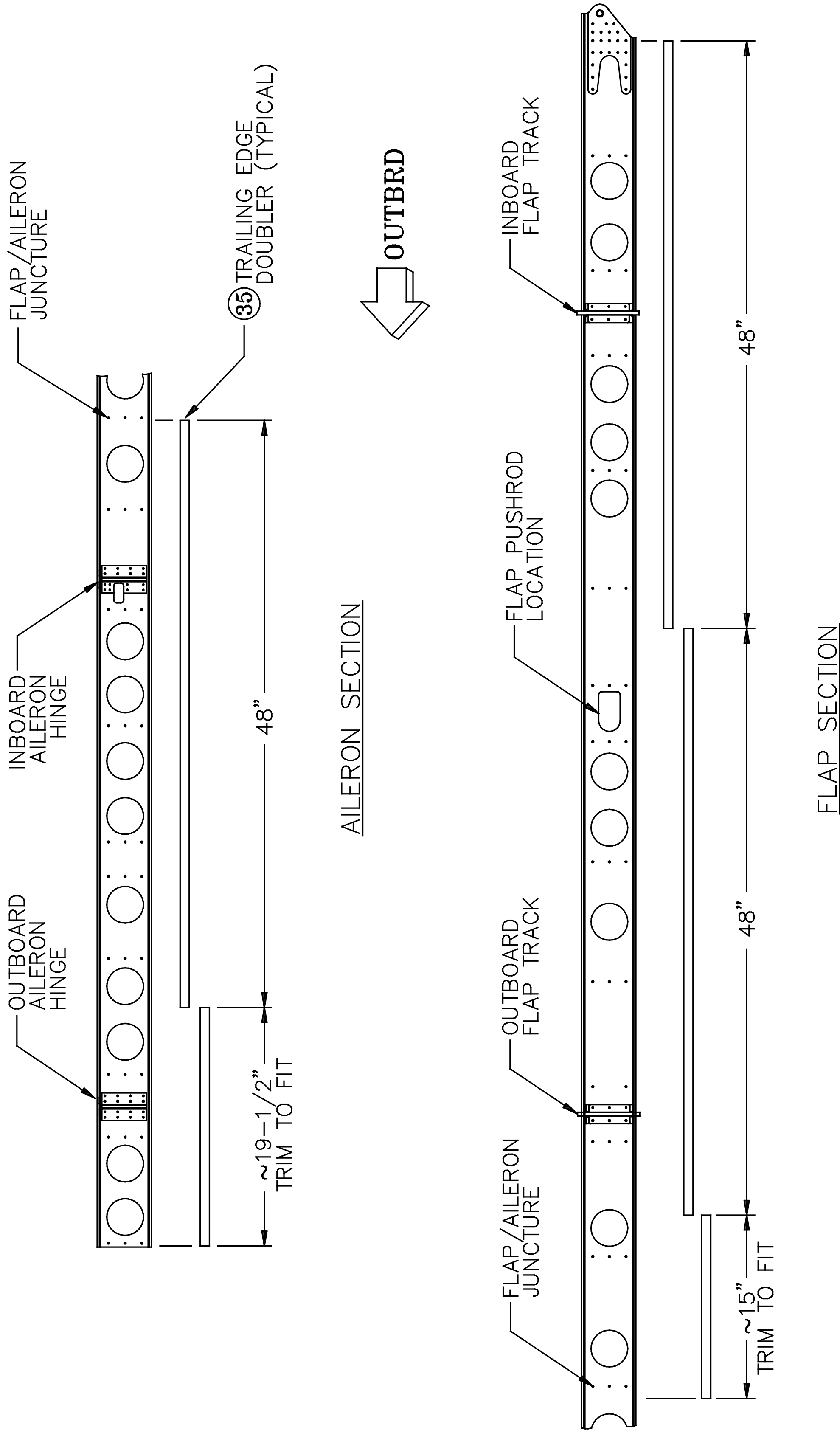

Figure 87: Cutting the Trailing Edge Doublers

Step 84: Fit and Drill the Cove Skins

You now need to transfer the locations of the rivet tabs on the cove ribs to the cove skins. Hold each cove skin in its correct spanwise position with the straight (un-flanged) edge just below the tabs on the aft sides of the cove ribs, as shown in Figure 88a. Mark the spanwise centers of the tabs onto the edges of the cove skins, and then use a try square to continue these marks down across the surfaces of the cove skins.

> **Note** Figure 88 shows the innermost flap cove skin, but the marking procedure is identical for all the skins.

Next, you must mark the vertical locations of the cove rib tabs. Place the inboard flap cove skin in position and lightly clamp it to both the upper and lower wing skins, as shown in Figure 88b. Sight from the inboard end of the wing to mark the vertical centers of the cove rib tabs onto the end of the cove skin. Remove the cove skin and measure from the edges of the cove skin to the marks; use these measurements to mark the rivet hole centers at the spanwise cove rib tab locations of all the flap cove skins.

> **Note** To facilitate positioning the cove skin, pre-bend the curved portion around a pipe, a broomstick or a cardboard shipping tube.

Follow similar procedures to transfer the locations of the centers of the aileron cove rib tabs to the aileron cove skins; work from the outboard end of the wing for the aileron skins. After all the holes have been marked, clamp the cove skins and the trailing edge doublers into position at the trailing edge of the wing.

> **Note** All of the sheet metal pieces involved here are quite thin and easily deformed. We recommend clamping strips of wood to the assembly to help keep the skins from rippling under the pressure of the drill when drilling rivet holes. Also, you will probably have to notch the trailing edge doublers in the aileron area to fit around the aileron cove ribs and the aileron hinge ribs. Without such notches, you will be unable to position the doublers far enough forward to match the trailing edges of the upper skins and cove skins.

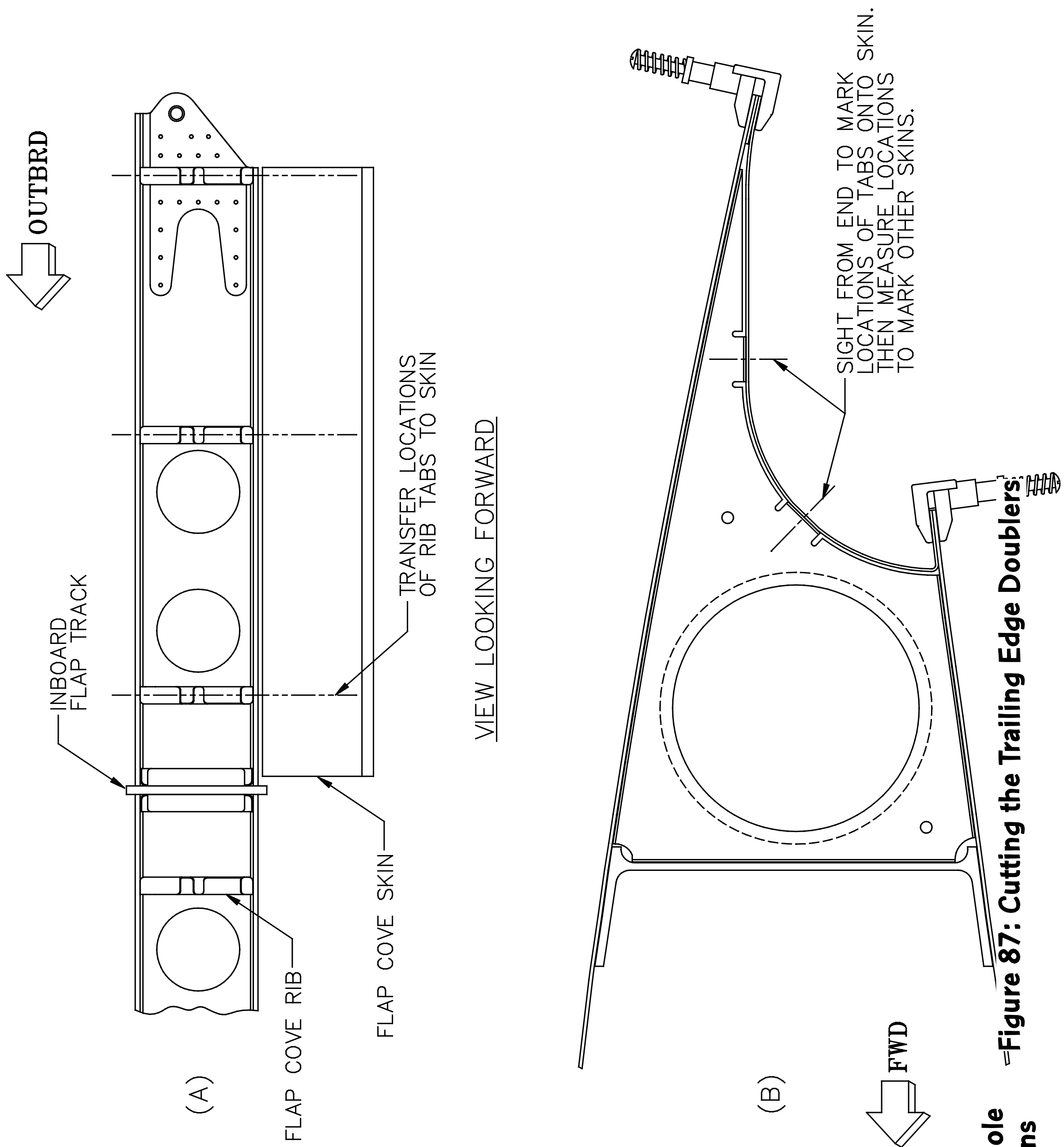

Figure 87: Cutting the Trailing Edge Doublers

Figure 88: Marking Rivet Hole Locations on the Cove Skins

Use the marked hole locations to drill **#40** rivet holes through the cove skins and the tabs on the aileron and flap cove ribs, as shown in Figure 89a. Insert Clecos into these holes as you go.

Next, as shown in Figure 89b, lay out rivet holes along the trailing edge of the upper skins every **2"** along the length of the wing and **3/8"** forward of the trailing edge. Drill through the upper skin trailing edges, the trailing edge doublers, and the flap and aileron cove skins at each of these locations with a **#40** bit. Insert Clecos into every third-to-fifth hole after drilling. Similarly, lay out hole locations on the lower skins. These should also be on a line **3/8"** forward of the trailing edge but on **1-7/8"** centers. Drill **#40** rivet holes through the lower wing skins and flap and aileron cove skins at these locations, Clecoing as you go.

Note Figure 89 shows the innermost flap cove skin, but the drilling procedures are identical for all the skins.

If the edges of the wing and cove skins are not even (i.e., one of them extends aft of the other), mark the longer skin for trimming even with the edge of the shorter skin. Do this for both the upper and the lower skins. Remove the cove skins and trim the longer skin to the mark. Deburr the cut edges and also deburr the rivet holes.

In order to prevent interference with the wing control surfaces, the **upper** wing skins will be riveted to the cove skins and trailing edge doubler with **flush rivets** installed with the **heads down** toward the control surfaces. Therefore, the cove skins, trailing edge doublers and upper wing skins must all be dimpled on the lower sides, as indicated in Figure 83a, to allow installation of the rivets. Use your **3/32"** dimple dies to dimple all the rivet holes for the upper wing skins.

Note Make sure you dimple the cove skins, the trailing edge doublers and the wing skins from the **lower** sides so that the rivets can properly be installed with the heads down (see Figure 90). The cove skins will be riveted to the **lower** wing skins with **universal-head** rivets, so no dimpling is required for these.

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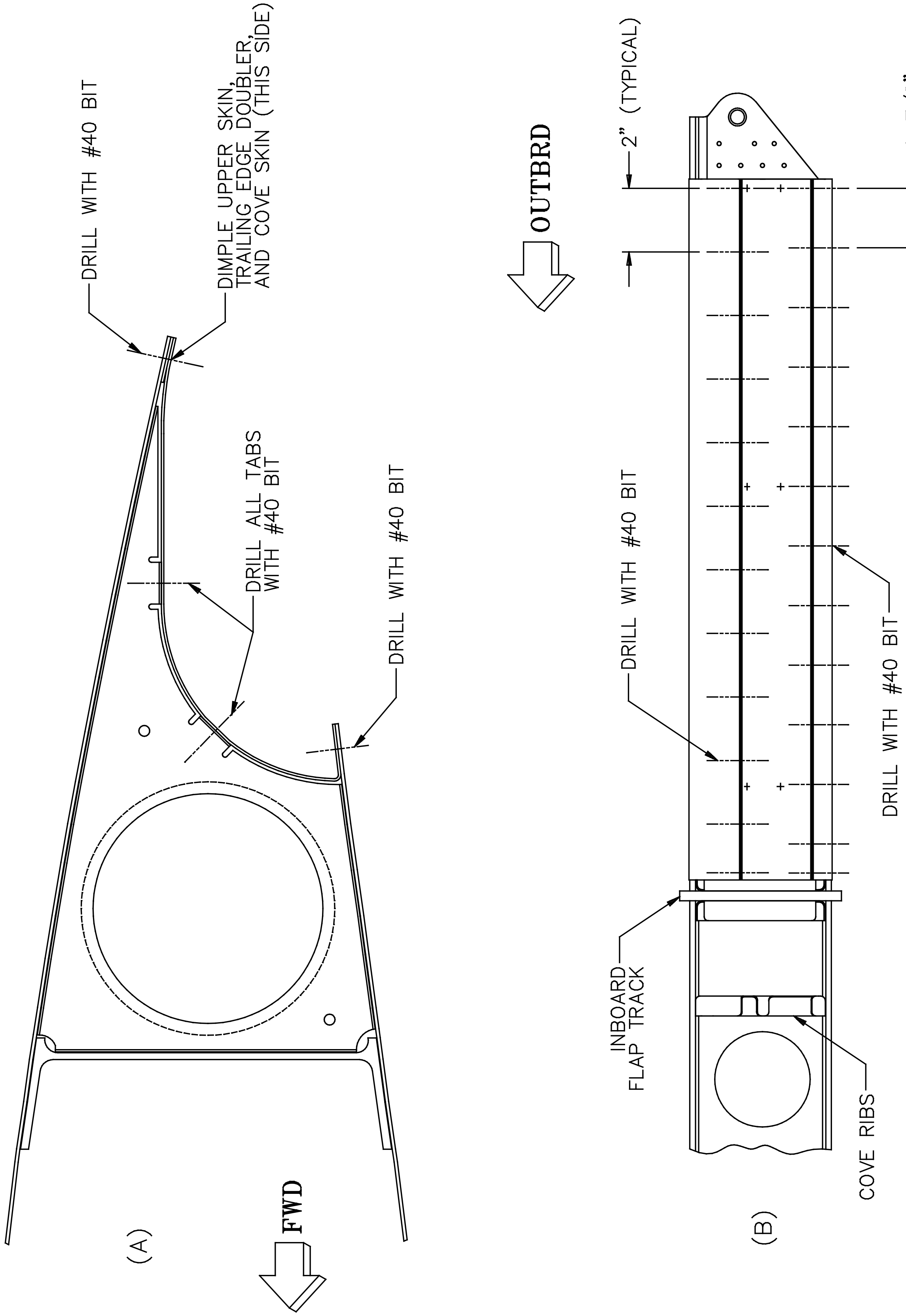

Figure 89: Drilling the Cove Skins and Trailing Edge Doublers

Step 85: Rivet the Cove Skins and Trailing Edge Doublers

Note Before riveting the cove skins, make sure that all the control cables, cable pulleys, cable guards, cable guides, electrical wiring, pitot/static lines and other equipment and hardware that occupy space aft of the aft spar are properly installed and safetied and that none of the systems interferes with the control cables. Verify that the control cables are untwisted and are free to move without interference. We recommend devising some kind of support for the control cables where they exit the inboard end of the wing to hold them in an untwisted condition until the wing is remounted to the fuselage and the final cable connections can be made. This support could consist of a couple of tongue depressors (with notches cut into them for the cables) duct-taped together and then temporarily fastened to the wing structure.

Alternatively, wait until the wings have been mounted to the fuselage for the final time and all the cable connections have been finalized before riveting the cove skins.

Cleco the cove skins and trailing edge doublers in place on the wing. Rivet the cove skins to the tabs on the aft ends of the cove ribs with **3/32" aluminum blind rivets** [104], as shown in Figure 90. Then rivet the cove skins to the lower wing skins with 3/32" AN470AD3 universal-head rivets, installed with the heads on the lower side (outside) of the lower wing skins. Finally, rivet the cove skins and the trailing edge doublers to the upper wing skins with 1/8" AN426AD3 flush-head rivets, installed with the heads down. Be sure to observe proper sequencing while driving these long rows of rivets.

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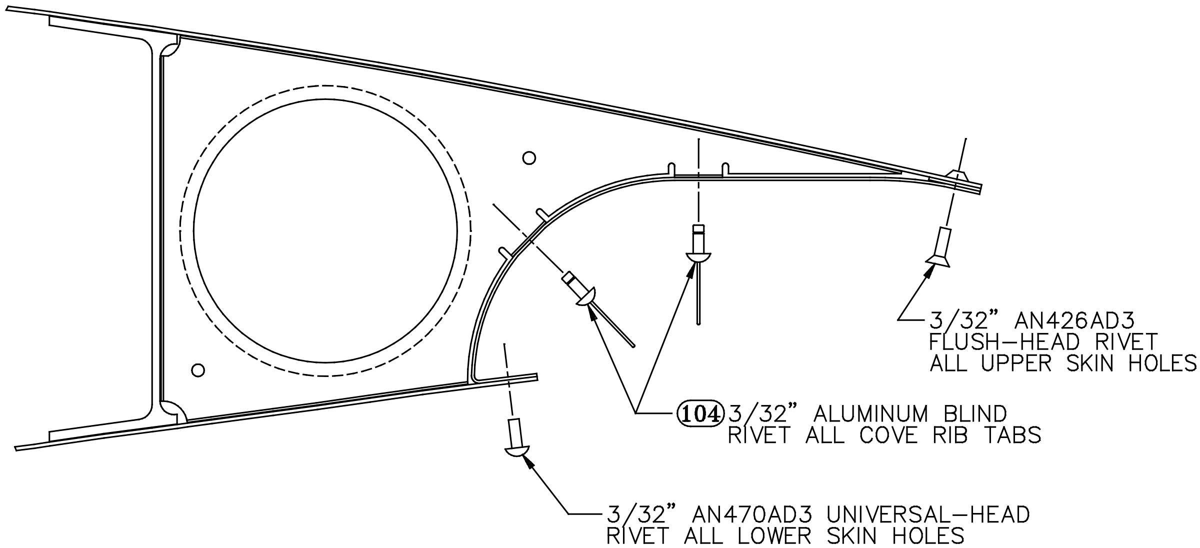

Figure 90: Riveting the Cove Skins and Trailing Edge Doublers

Step 86: Install the Main Fuel Line Fittings and Hose

Rigid tubing fuel lines will be installed inside the cabin of the GlaStar, but to accommodate the folding wing feature, the lines from the tanks into the cabin must be of flexible hose. In this step, you will install the tank fittings and this short length of hose.

Begin, as shown in Figure 91, by threading a **finger screen** [97] into the main fuel line boss of the tank. This screen will ensure that no major junk ever gets into your fuel line from the tank. Next thread an AN844-6D **45° aluminum elbow** [142] into the screen. Thread the elbow into the screen fitting until it's good and snug, with the unthreaded nipple of the elbow **pointing aft**, as shown in Figure 91. We recommend the use of a thread sealant on both the screen and the elbow.

Next, use a utility knife to cut a length of the **5/8" rubber hose** [77] 12" long. Slide a **7/32"–5/8" hose clamp** [99] over one end of this hose, and then push the hose over the elbow nipple as far as it will go (i.e., all the way to the shoulder of the fitting, as shown in the cross-sectional view of Figure 91). Position the hose clamp roughly **5/8"** from the end of the hose and tighten it.

Note It's just as bad to overtighten a hose clamp as to undertighten it. As the clamp tightens, it will tend to push the rubber out from underneath it, and this movement will be easily visible at the end of the hose. You should tighten the clamp until the end of the hose **just begins** to move.

Hint To ease installation of the hose, very lightly grease the fitting first.

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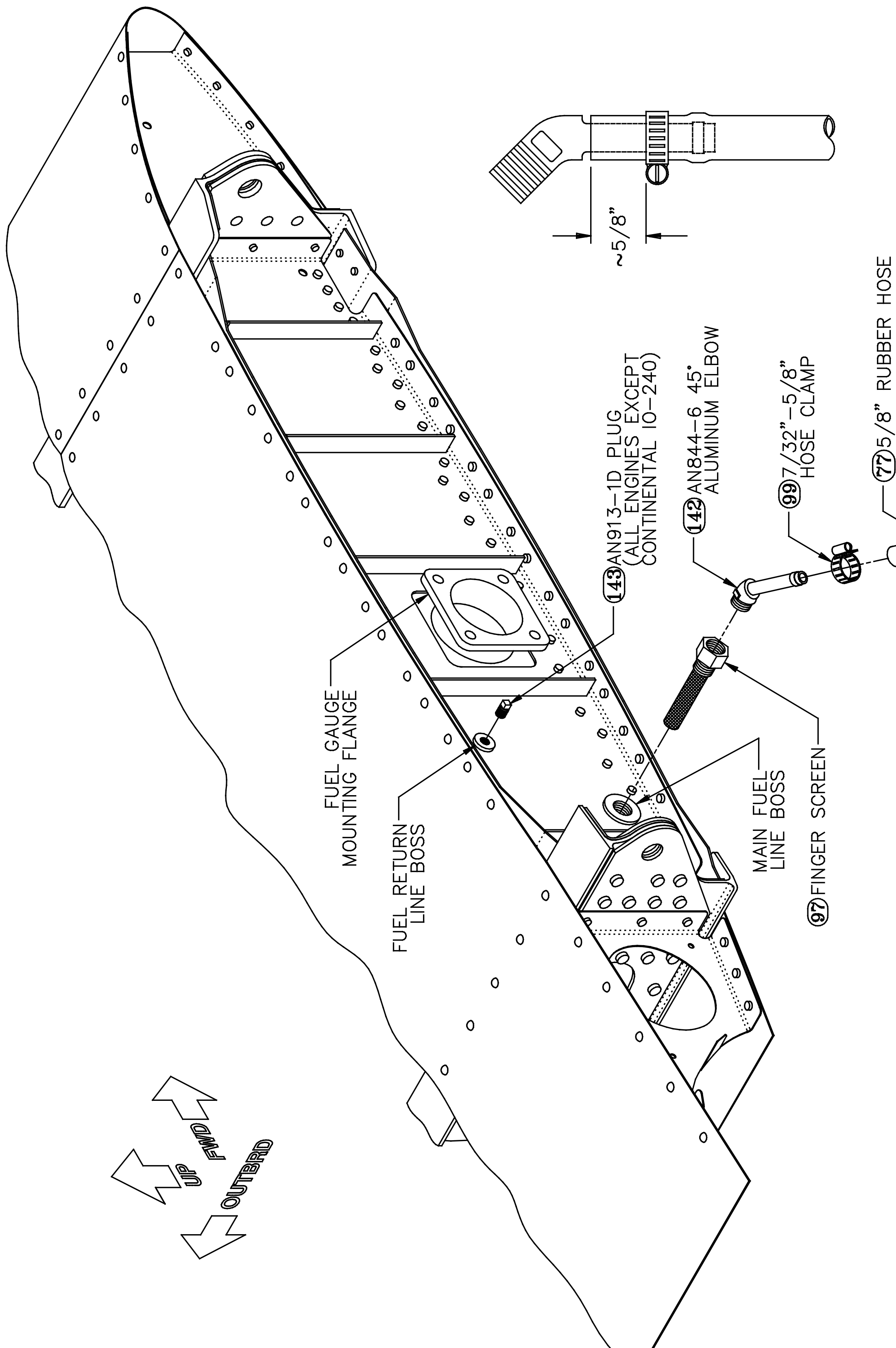

Figure 91: Installing the Inboard-End Fuel Tank Fittings

Step 87: Install a Plug in the Fuel Return Line Boss (All Engines Except the Continental IO-240)

The Continental IO-240 engine requires a return line from the engine to the fuel tanks, but such a line is unnecessary for most engines—including all the Lycoming O-320s. Therefore, for all engines except the IO-240 the return line boss on the inboard end of the tank **must** be plugged, as shown in Figure 91. An AN913-1D **plug** [143] is provided for this purpose. As with the other metal fittings, use of a thread sealant is recommended.

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Step 88: Install the Fuel Tank Sump Drain Valve

Install a **drain valve** [96] in the sump drain boss at the bottom of each tank. Remove the plug from the boss and use a wrench to thread the valve all the way into the boss, but be careful not to over-torque the relatively fine threads. As with the other metal fittings, use of a thread sealant is recommended.

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Step 89: Cut Out the Components of the Delta Wings

Small delta wing-shaped vortex generators are installed on the upper surfaces of the GlaStar wing leading edges to enhance the aircraft's handling characteristics during extreme aft-loaded, high angle-of-attack, power-on stalls. These delta wings are of simple bent sheet-metal construction. Each wing consists of a triangular cap and a support piece.

Full-sized templates for the caps, the outboard supports and the inboard supports, respectively, are given in Figures 92, 93 and 94. Use these templates to lay out **four** caps, **two** outboard supports and **two** inboard supports on the supplied **.032" X 16" X 16" aluminum sheet** [69]. We recommend laying out all eight parts before cutting any of them, since the 16" X 16" sheet leaves very little excess material.

Use a bandsaw, scroll saw and/or snips to cut the parts out. On the supports, first cut the basic shapes (as indicated by the solid lines on the templates) and then drill at each of the marked locations with a **#10** or **3/16"** bit. Finally, cut tangent to each hole (as indicated by the dashed lines on the templates) to complete the parts.

Sand all the cut edges smooth and radius all sharp corners.

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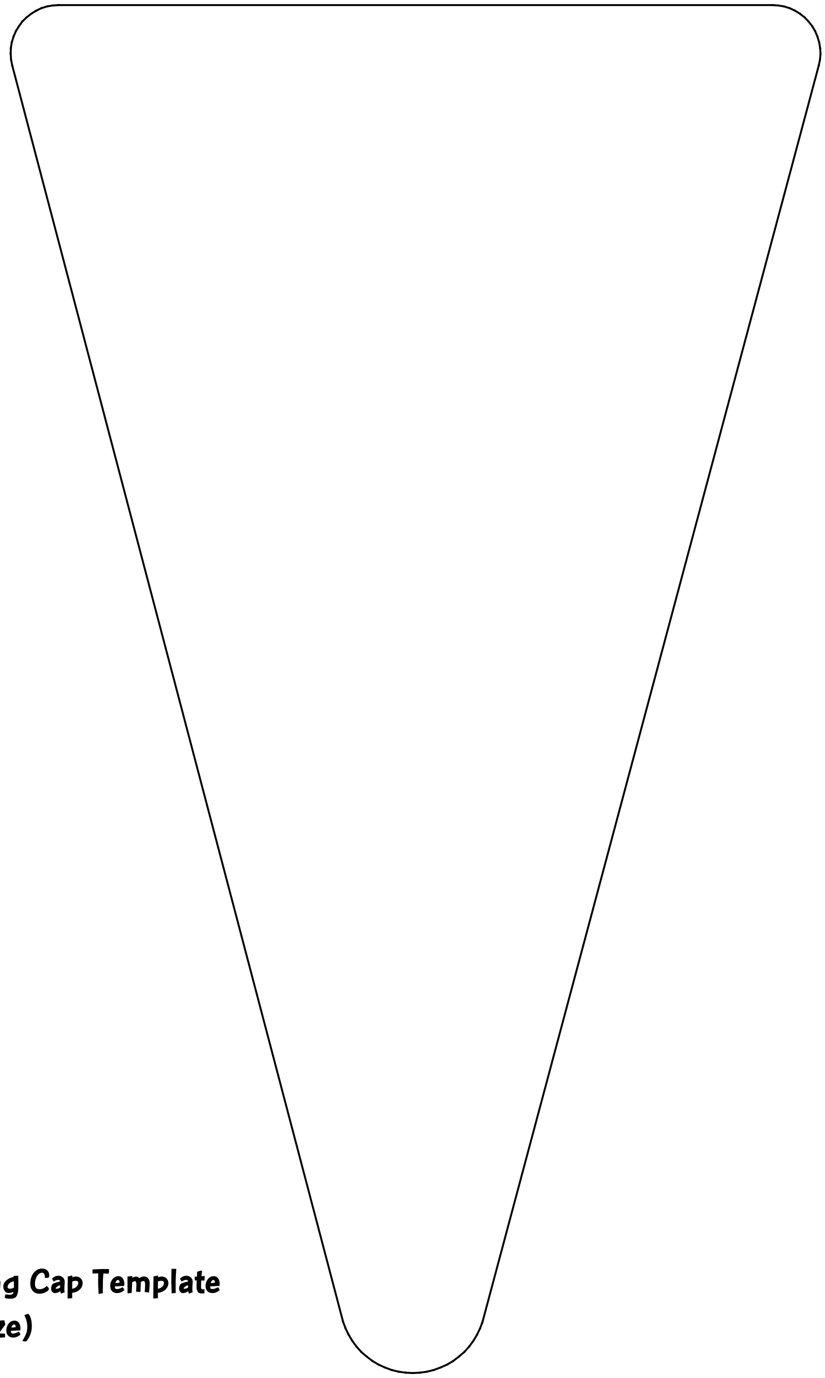

Figure 92: Delta Wing Cap Template (Full Size)

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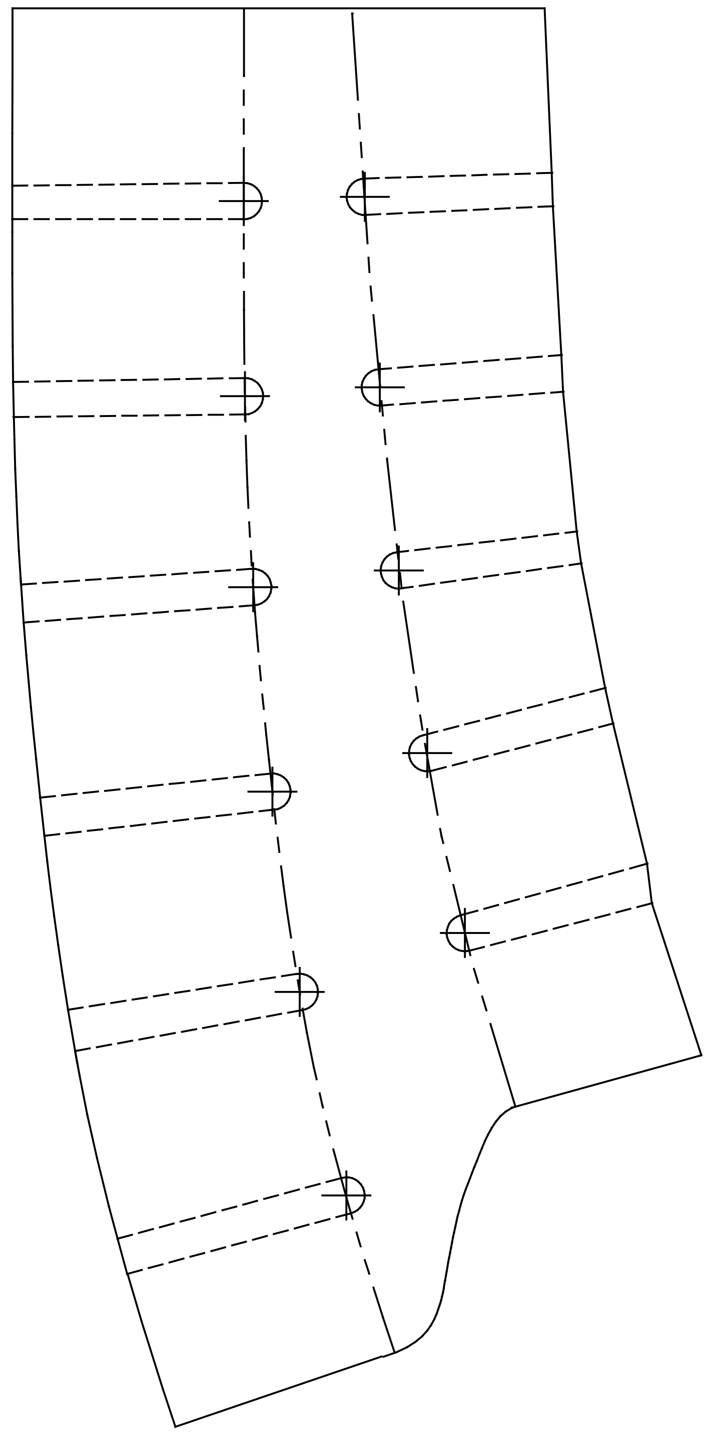

Figure 93: Outboard Delta Wing Support Template (Full Size)

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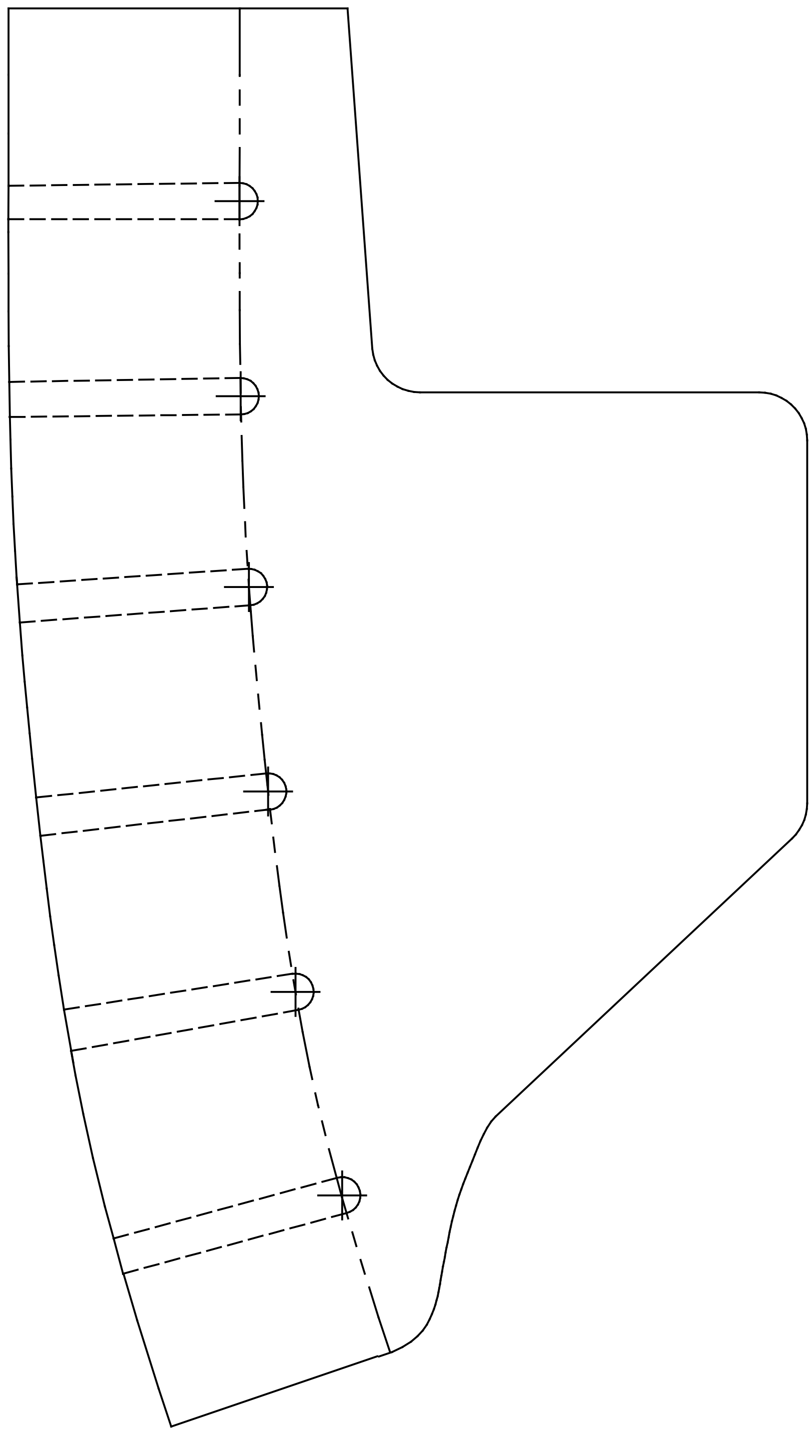

Figure 94: Inboard Delta Wing Support Template (Full Size)

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Step 90: Bend the Outboard Delta Wing Supports

The flat shape of the outboard delta wing supports consists of a central vane with rows of tabs along the upper and lower edges. When bent at right angles to the vane, these tabs become mounting tabs. The lower tabs are riveted to the leading edge skin of the wing and the upper tabs are riveted to the delta wing cap. The two panels of Figure 95 show how the tabs should be bent.

As Figure 95a shows, alternate tabs are bent in opposite directions, with the centerline of the bend going through the center of the hole at the base of each slot. These bends can be made with a pair of duckbill pliers. Try to keep the radius of the bend in the neighborhood of **1/8"**, but don't worry too much about this—it's not critical.

Figure 95b illustrates the completed support.

Note For simplicity's sake, we recommend bending both supports according to the directions on the tabs in Figure 95a. Two identical supports will result, and they will be perfectly functional. However, if you prefer perfect symmetry, you can bend one support according to the bend directions shown and the other with the tabs bent in the **opposite** directions.

Completed: [ ]

Step 91: Bend the Inboard Delta Wing Supports

The inboard supports function just the same way, except that because they are placed at the fuselage/wing junction, they can be riveted directly to the vertical wing-root area of the fuselage shell (as illustrated in Figure 97). Thus, they only need bent mounting tabs on the top where they attach to the delta wing caps. Use the same procedures you just used on the outboard supports to bend these upper tabs.

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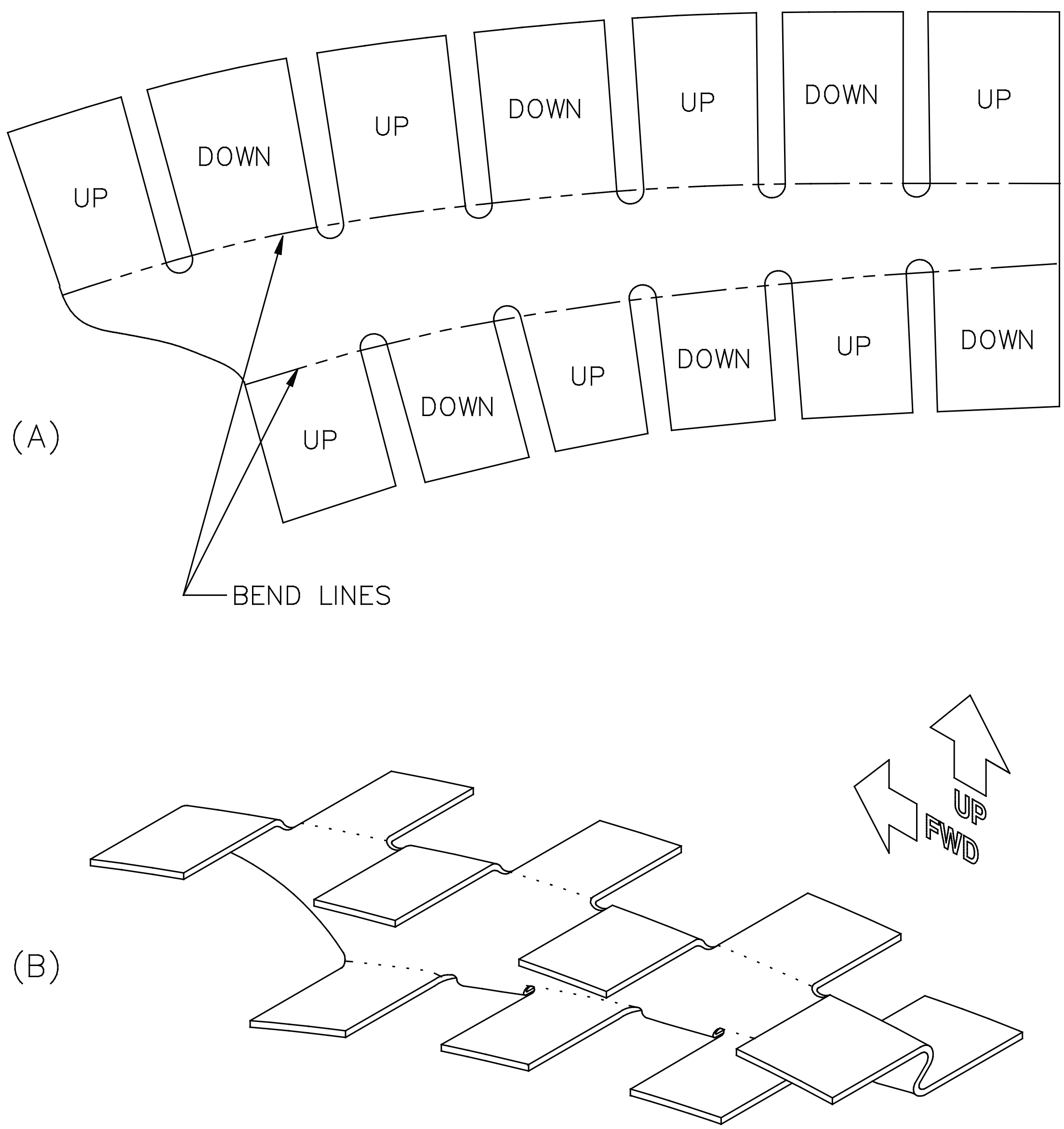

Figure 95: Bending the Outboard Delta Wing Supports

Step 92: Drill the Delta Wing Caps and Upper Support Tabs

Now that you have all four delta wing supports bent to shape, you can drill the holes for the rivets that will attach the caps to the upper tabs of each support. Begin by marking a longitudinal centerline on one side of each cap.

Lay a cap flat on the bench with this centerline up. Position a delta wing support on top of the cap with its vertical vane centered on the centerline and its forward-most upper tab flat against the cap, as shown in Figure 96a. While holding the support in this position, drill a **#40** hole through the forward-most upper tab and the cap.

> **Note** In general, drill about **1/4"** inboard of the end of the tab or the edge of the cap, whichever is closer to the support centerline. The tabs that extend past the cap edges will be trimmed later. In a fore-and-aft direction, center the holes on each tab; eyeball accuracy is fine for judging this.

After drilling the first hole, insert a Cleco. Then, as shown in Figure 96b, rock the support backward, bending the cap to match the curvature of the support, until the second tab is flat against the cap. Drill and Cleco that tab, and proceed in this manner until all the tabs have been drilled and the cap is held tightly against the support along its entire length. Then mark each cap and support so that they can be reunited later and mark any tabs that need trimming to match the cap. Remove the Clecos, deburr all the holes and trim the tabs as necessary.

> **Note** Figure 96 shows an inboard support because it allows a clearer illustration, but the outboard supports and caps should be drilled in exactly the same way.

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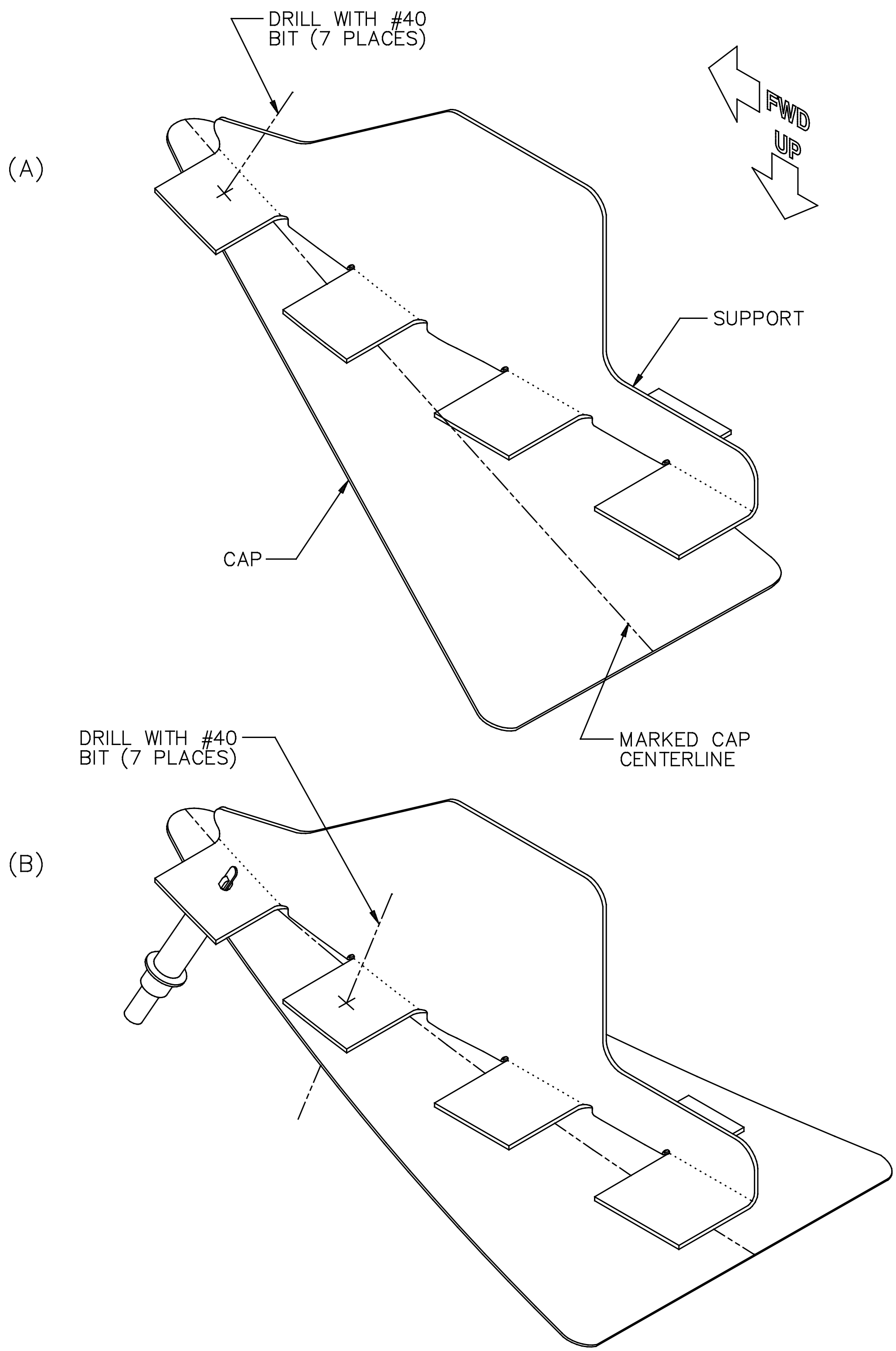


Figure 96: Drilling the Delta Wing Caps and Upper Support Tabs

Step 93: Position the Supports on the Airframe and Drill the Lower Tabs

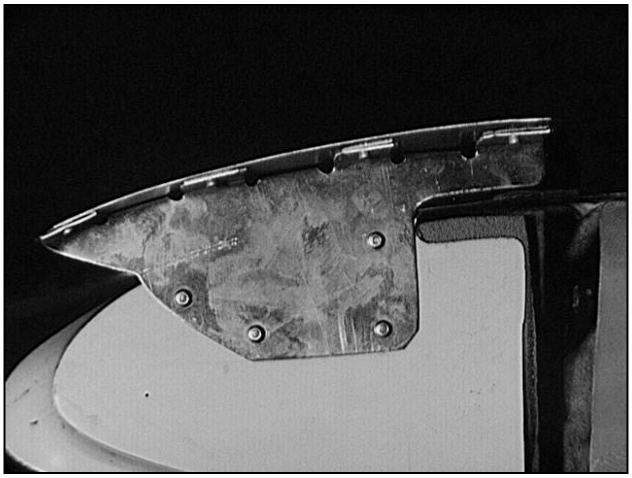


Figure 97: Inboard Delta Wing Installation

The next step is to drill the rivet holes through the lower support tabs and the underlying airframe structures to which the delta wings attach.

Begin with the inboard supports. As Figure 97 shows, these are riveted directly to the vertical portion of the fuselage shell wing-root area. Figure 98 shows how the supports should be positioned relative to the wing-root area. The leading edge of the support should be positioned even with the leading edge of the airfoil shape. Vertically, the upper support tabs should be **1-1/4"** above the airfoil surface at the forward end and **11/16"** above the surface at the aft end (both distances measured perpendicular to the surface).

With the support held in position, drill four **#30** rivet holes through the tab of the support and the fuselage shell. The location of the holes isn't critical—just follow the example of Figures 97 and 98.

Hint Because the top deck hasn't yet been installed, the fuselage wing-root areas are still quite flexible. You may find it worthwhile to have an assistant hold a scrap wood block on the inboard side of the wing root while you drill these holes.

The outboard supports are riveted directly to the leading edge wing skin. They are centered over **Nose Rib 14**, approximately **135"** outboard of the inboard edge of the inboard leading edge skin, as shown in Figure 99. Because the lower tabs fix the vertical position of the supports, you only need to make sure that, as with the inboard supports, the leading edges of the outboard supports are even with the leading edges of the wing.

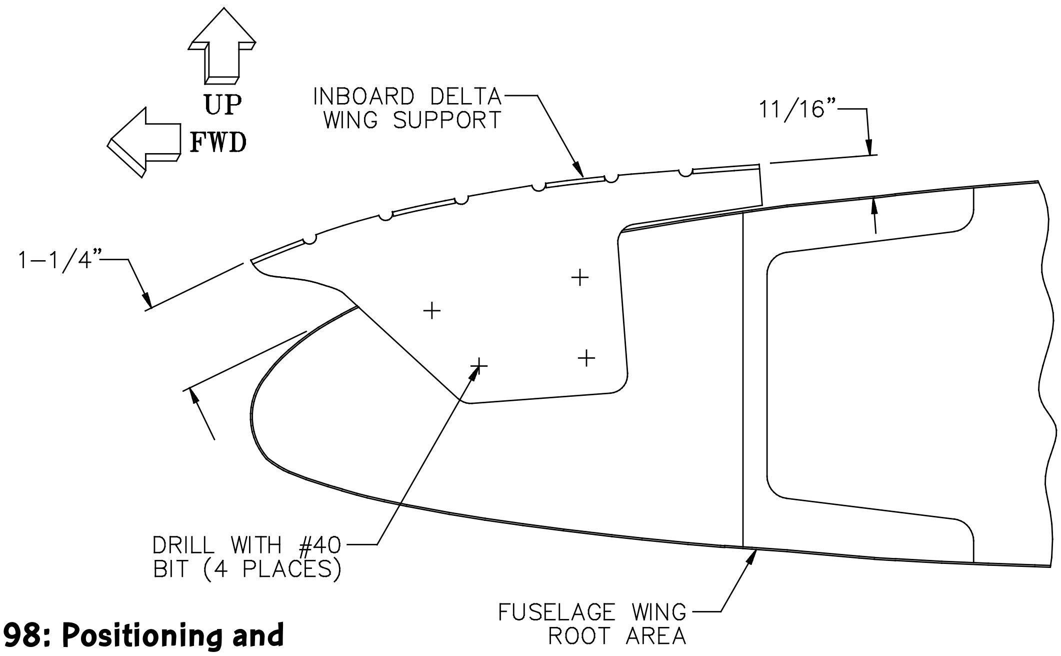


Figure 98: Positioning and Drilling the Inboard Supports

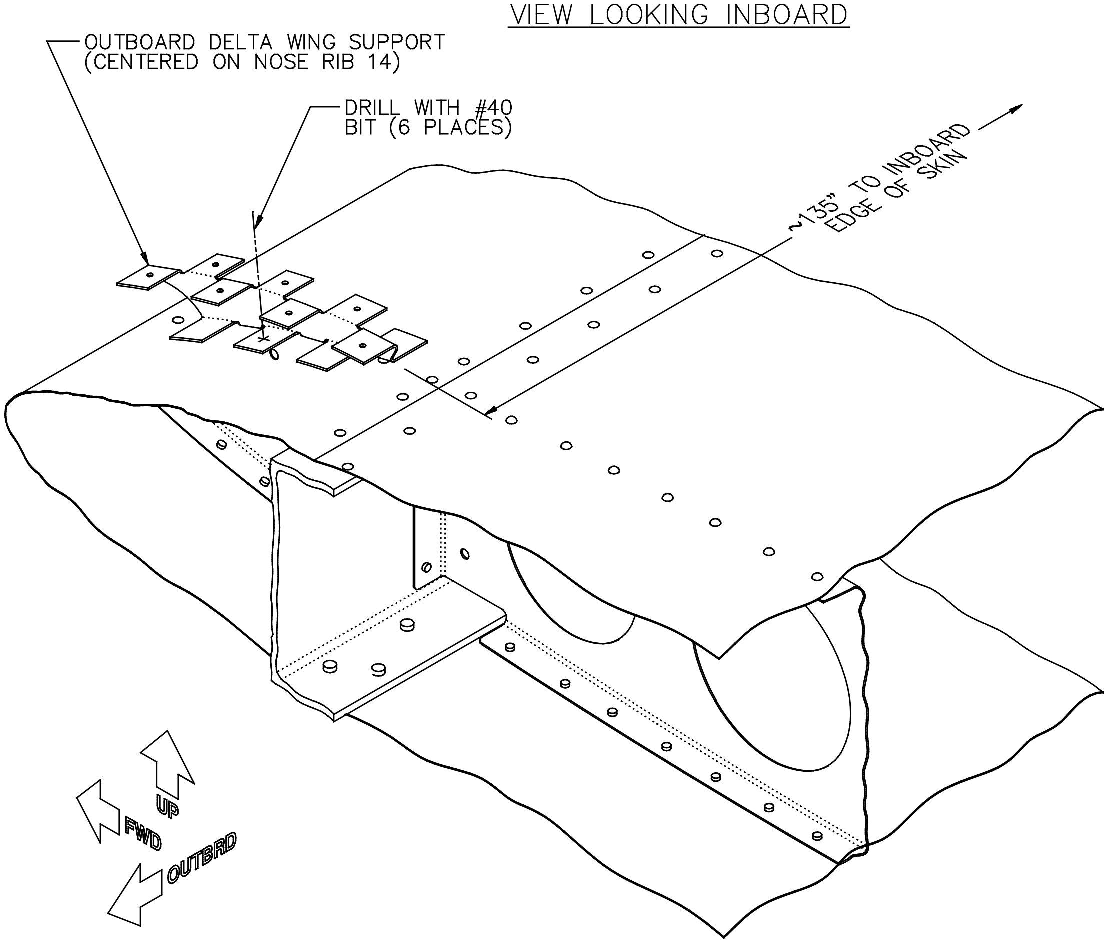


Figure 99: Positioning and Drilling the Outboard Supports

Holding the supports in position, drill a **#30** hole through the center of each tab and the underlying leading edge skin. Insert Clecos as you go. After drilling, deburr all the holes in the supports and the leading edge skins.

Completed: Left [ ] Right [ ]

Step 94: Corrosion-Proof the Delta Wing Components

The delta wings are now completed, but we recommend not riveting them together or installing them until the "Miscellaneous Final Assembly Details" sub-section below. This will give you a chance to paint your wings and fuselage without having to work around the delta wings. However, now is a good time to apply the anti-corrosion protection of your choice to the delta wing components.

Completed: [ ]

Step 95: Prepare the Wing-Root Areas of the Fuselage Shell for Final Wing Installation

It's almost time to hang the wings on the fuselage once again, but first, you have to provide a couple more cutouts in the wing-root areas of the fuselage shells—for the fuel gauge mounting flanges on the inboard ends of the fuel tanks and for the blue rubber fuel lines and fittings. For each wing root, measure the locations of the fuel gauge mounting flange and the main fuel line boss relative to the wing spar ends. Transfer these dimensions to the wing root area of the fuselage shell on each side, measuring from the wing attach lugs on the cage.

Use drills, hole cutters, files and/or a saber saw with a carbide grit blade to make cutouts in the shell matching those in the root ribs. In the case of the fuel lines/fittings, the cutout should start at the location corresponding to the main fuel line boss and extend aft as a slot all the way to the aft spar cutout.

Hint All the cutouts may have to be extended or adjusted during the process of hanging the wings, so keep your cutting tools handy as you move on to the next step.

Completed: Left [ ] Right [ ]

Step 96: Install the Wings on the Fuselage

It's time to install the wings on the fuselage for the final time! To do this, you'll want to use essentially the same procedures you used in "SECTION IX: SYSTEMS INSTALLATION," but there are a few differences.

First, you will probably find it easier to install the wing this time if the wing strut is already bolted to the strut attach arm at its outboard end before you start. Second, the fuselage is on its gear now, so of course you'll need to raise the wing higher. However, assuming that you have an adequate number of helpers (three others is probably about optimal), there's no need to arrange padded supports this time around, because the strut is already adjusted and in place.

Bring the wing into position and secure the spar roots to the cage attach lugs, using the hardware specified in SECTION IX (see Figures 61 and 62 for the forward and aft spars, respectively). Unlike the initial wing installation, go ahead and install all the specified washers and safety pins at this time.

With the spar attach points taken care of, position the fuselage wing strut attach fitting around the fuselage strut attach lug and secure it there with the hardware called out in Figure 63 of SECTION IX.

Completed: Left [ ] Right [ ]

Step 97: Complete the Fuel Tank Vent Line Installation at the Wingtip

The fuel tank vent line runs outboard from the tank through grommets in Main Ribs 3–5 and is secured to the upper hat sections. From the outermost hat section, the line curves down through the third lightening hole from the front in Main Rib 6 and through the lower wing skin just outboard of the web of Main Rib 6. Figure 100 shows the details of this installation.

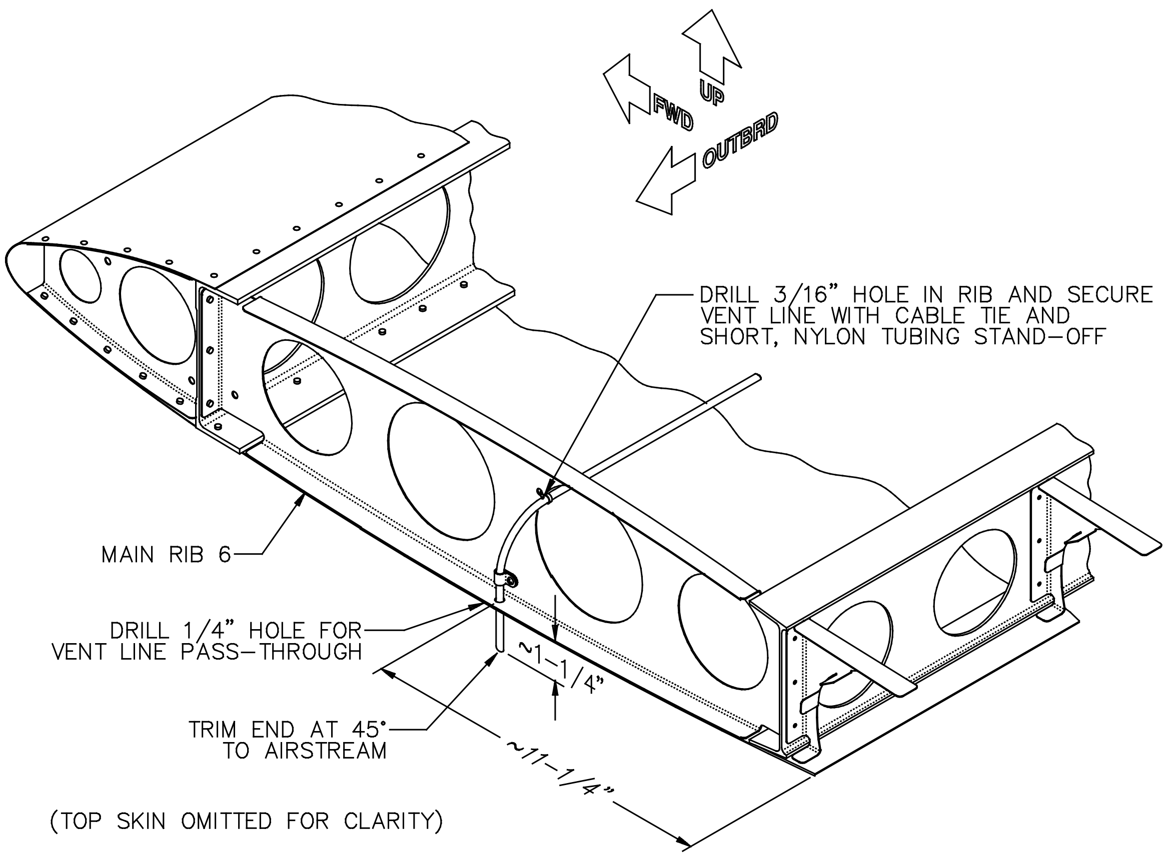
First, drill and deburr a **1/4"** hole in the lower wing skin and the lower flange of Main Rib 6 for the vent line to pass through. Drill the hole about **11-1/4"** forward of the aft end of the lower main skin and centered from side-to-side on the rib flange, as shown in Figure 100. If necessary, adjust the position of the hole fore or aft to avoid rivets and rib flutes.

Route the vent line in a gentle curve from the last hat section, through the third lightening hole from the front in Main Rib 6, and then through the hole just drilled in the lower wing skin. The line will pass very close to the forward edge of the lightening hole. Drill a **#10** or **3/16"** hole through the rib next to the lightening hole to secure the vent line with a cable tie. Stand the line off from the lightening hole flange with a short (about **3/16"**) length of 1/4" nylon tubing, using the technique described in Step 110 of "SECTION IX: SYSTEMS INSTALLATION" for securing the fuel lines to the fuselage cage. If the vent line contacts the edge of the lightening hole elsewhere, use nylon spiral wrap or RTV to prevent chafing. You can also use RTV where the vent line passes through the hole in the lower skin.

Trim the vent line off about **1-1/4"** below the wing skin at a **45°** angle to the airflow, with the opening facing **forward**. This angle prevents airflow past the vent opening from forming suction which could otherwise drain fuel through the vent.

When the vent is positioned satisfactorily, position a **1/4" nylon loop clamp** [194] around the vertical portion of the tubing near the lower flange of Main Rib 6, as shown in the detail view of Figure 100. Drill and deburr a **#19** hole through the rib web and secure the clamp with an AN526-8R6 screw, AN960D8L **thin aluminum washer** [155] and AN364-832A **nylon self-locking nut** [122]. In addition to the AN960D8L between the rib web and the nut, stack additional washers between the clamp and the rib web as necessary to stand the clamp off from the web to match the position of the vent line.

Completed: Left [ ] Right [ ]



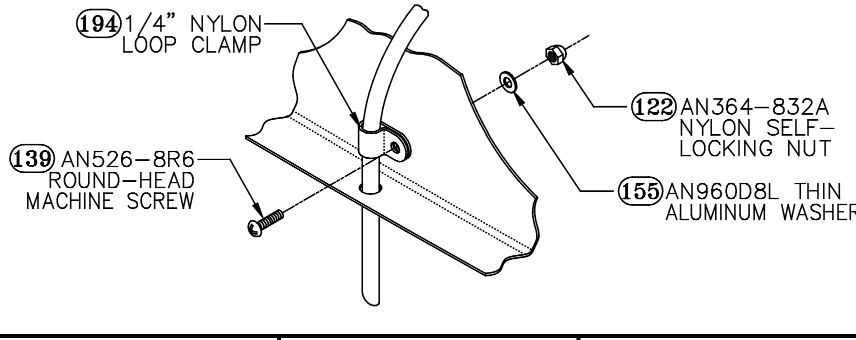


Figure 100: Wingtip Fuel Tank Vent Line Installation

Step 98: Complete the Wing-to-Fuselage Fuel System Connections

At this time, trim the inboard ends of the rubber fuel hose as necessary to meet the beaded aluminum tubing you installed in "Section IX: Systems Installation." Slip a 7/32"–5/8" hose clamp over the hose; then very lightly grease the tubing end and push the hose over the tubing until it's well past the bead. Move the hose clamp into position below the bead and tighten it.

Completed: Left [ ] Right [ ]

Step 99: Seam the Wingtip Fairing Halves Together

The fiberglass wingtip fairings consist of upper and lower halves which are seamed together with strips of fiberglass cloth. Use the procedures described in Step 1 of "SECTION VIII: FUSELAGE ASSEMBLY" to remove the mold lip along the edges of the **left** and **right upper** [40 and 41] and **left** and **right lower wingtip fairing halves** [38 and 39]. Sand just until the mold lip disappears.

Tape the upper and lower tip fairing halves of each pair together by stretching masking tape across their mating edges. Initially tape only from the trailing edges of the fairing halves to the aft end of the flat surface provided for the navigation light assembly on the upper half. To keep resin from leaking out, cover the entire length of this aft part of the seam with masking tape without leaving any gaps. **Don't apply any tape forward of the nav light mounting surface yet**. Use the masking tape as a hinge to fold the two fairing halves apart like opening a book; this will provide access for applying laminates to the narrow trailing edge portion of the seam on the inside of the fairing.

For each wingtip fairing, cut two pieces of bi-directional cloth on the 45° bias, one **1" X 54"** and one **1-1/2" X 54"**. Mix a batch of resin and laminate the 1"-wide ply first and then the 1-1/2"-wide ply in the taped area of the seam. Once the aft part of the seam has been saturated and while the laminates are still wet, carefully fold the two fairing halves closed and tape the rest of the seam with masking tape applied on the outside. Finish laminating the leading edge portion of the seam on the inside.

When the laminates reach the green cure condition, use a utility knife to trim them even with the ends of the fairing halves. Let the seam final-cure and then sand any remaining roughness at the trimmed ends.

Note Do not bond together the curved trailing edge portion at the aft end of the fairing at this time. By leaving this section unbonded, the aft end of the fairing can be adjusted up or down slightly to align with the aileron trailing edge. The fairing trailing edge will be bonded after establishing its proper position relative to the aileron.

Completed: Left [ ] Right [ ]

Step 100: Trim the Wingtip Fairings to Clear the Ailerons

As shown in Figure 101, scribe lines are molded into the tip fairing as guides for trimming clearance slots for the aileron (on both the upper and lower surfaces) and for the aileron counterweight (on the lower surface only). In this step, the fairings will be trimmed to clear the ailerons so they can be mounted on the wing. The counterweight slots will be cut in a later step.

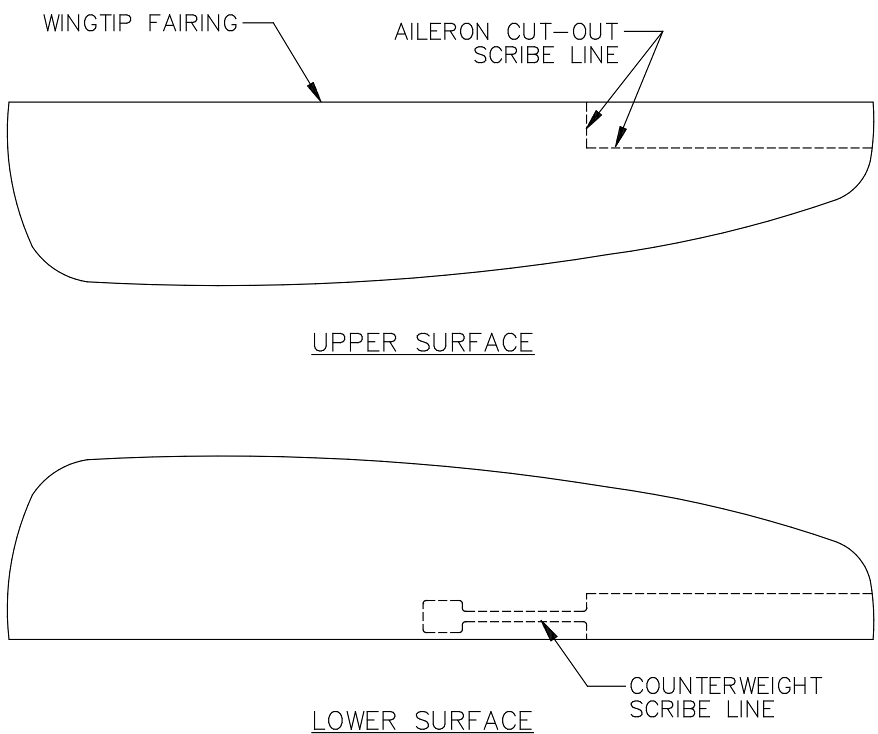


Figure 101: Wingtip Fairing Scribe Lines

As shown in Figure 102, mark lines on both the upper and lower surfaces of the wing parallel to and **13/16"** inboard of the outboard ends of the skins. Then, using the scribe lines as an initial, rough guide, open up the aileron cutouts until the fairing can be slid onto the end of the wing to the 13/16" line while maintaining a clearance from the end of the aileron of between **3/16"** and **1/4"**, as shown in Figure 102. At the same time, trim the forward ends of the cutouts until they're even with the aft edges of the wing skins on both the upper and lower surfaces, as shown. You'll also have to cut a notch in the lower inboard edge of the fairing to clear the fuel tank vent line; make the notch **3/8"** wide to provide 1/16" clearance all around the vent line. Remove the fairing when satisfied with its fit.

Completed: Left [ ] Right [ ]

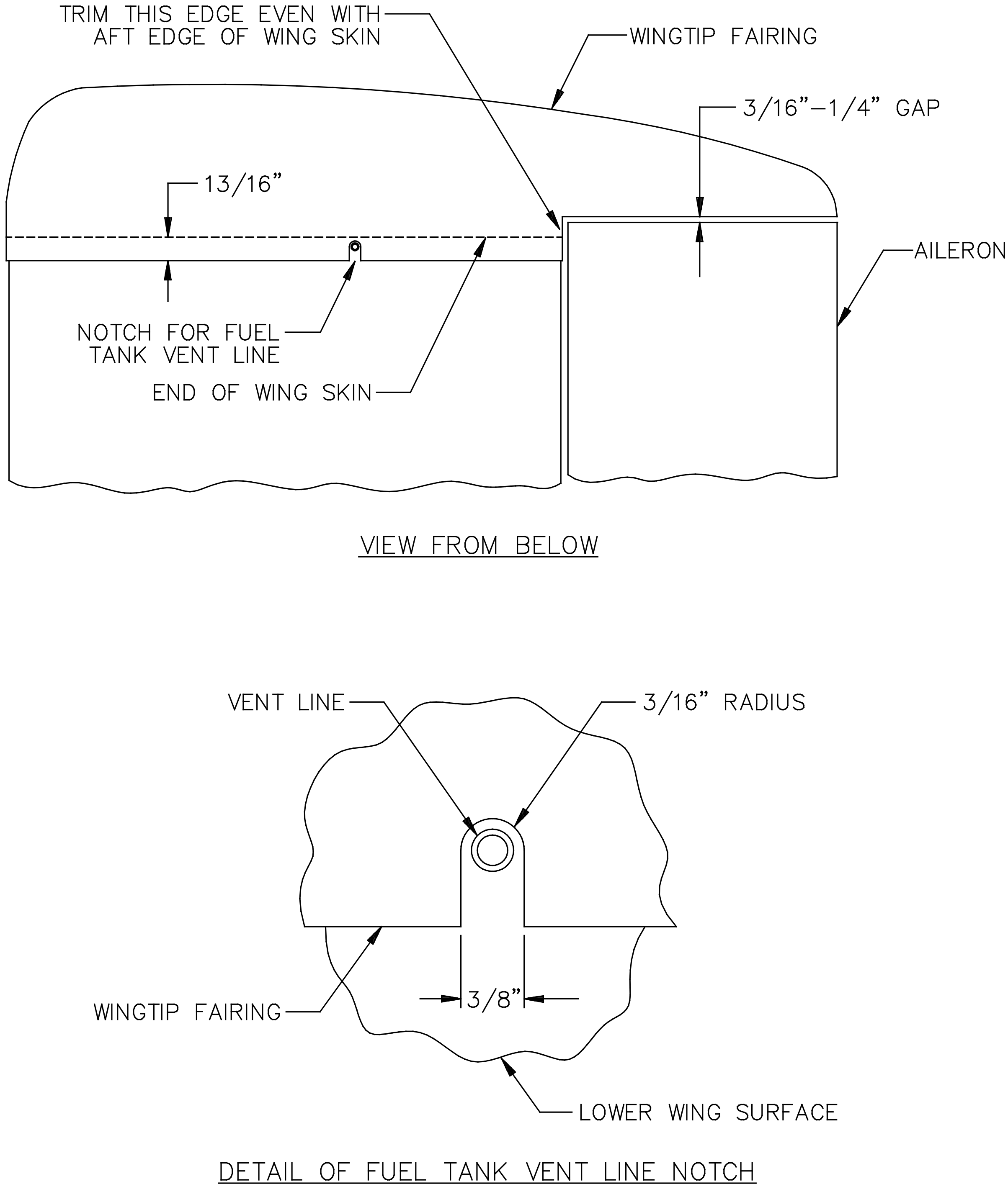


Figure 102: Trimming the Wingtip Fairing to Clear the Aileron and Fuel Tank Vent Line

Step 101: Install the Fairing Mounting Nutplates

Each wingtip fairing will be fastened to the end of the wing with ten AN526-8R7 round-head machine screws threaded into K1000-08 nutplates. Five fasteners will be used on the upper surface and five on the lower surface of each wingtip.

The holes for the fairing mounting screws will be centered on the Main Rib 6 rivet lines. Use a felt-tip pen to mark these lines on the outsides of the **wing skins**, top and bottom. Lay out five fairing mounting hole locations on each side along the lines just marked, positioned **approximately** as shown in Figure 103a: the forward-most locations are about **3"** forward of the split line between the leading edge and main skins, and the rest are spaced about **6"** apart, except for the aft-most ones, which are spaced about **4-1/2"** on the upper surface and about **3-1/2"** on the lower surface from the next ones forward. Position the hole locations so that the nutplates, when installed, will not interfere with existing wing skin rivets, rib flutes or spar flanges. (Since the nutplates are about 1" long, the hole locations must be spaced a minimum of 1/2" from any obstruction.) Make the hole location marks long enough (continuing them inboard past the 13/16" fairing edge line) so that they will be visible when the tip fairing is installed.

Next, on the **wing**, measure the distance from the 13/16" fairing edge line to the Main Rib 6 rivet line, labeled "X" in Figure 103b. Mark lines on the **tip fairing** this same distance from the inboard edge on both the top and the bottom surfaces; these lines will be the centerlines of the fastener holes. (The lines will be about 1/2" outboard of the fairing's inboard edges, but measure as instructed, just to be certain).

Install the fairing on the end of the wing with its inboard edges on the 13/16" reference lines on the wing. Push aft on the leading edge of the fairing to get a good, close fit. (You may find it necessary to grind down the seam laminates slightly at the leading edge of the fairing to help get a good fit). When satisfied, tape the fairing securely to the wing top and bottom. Transfer the hole location marks on the wing to the fastener centerlines on the fairing and drill through the fairing, wing skin and rib flange at each location with a **#19** bit. Insert 5/32" Clecos as you go to keep the fairing tight against the wing.

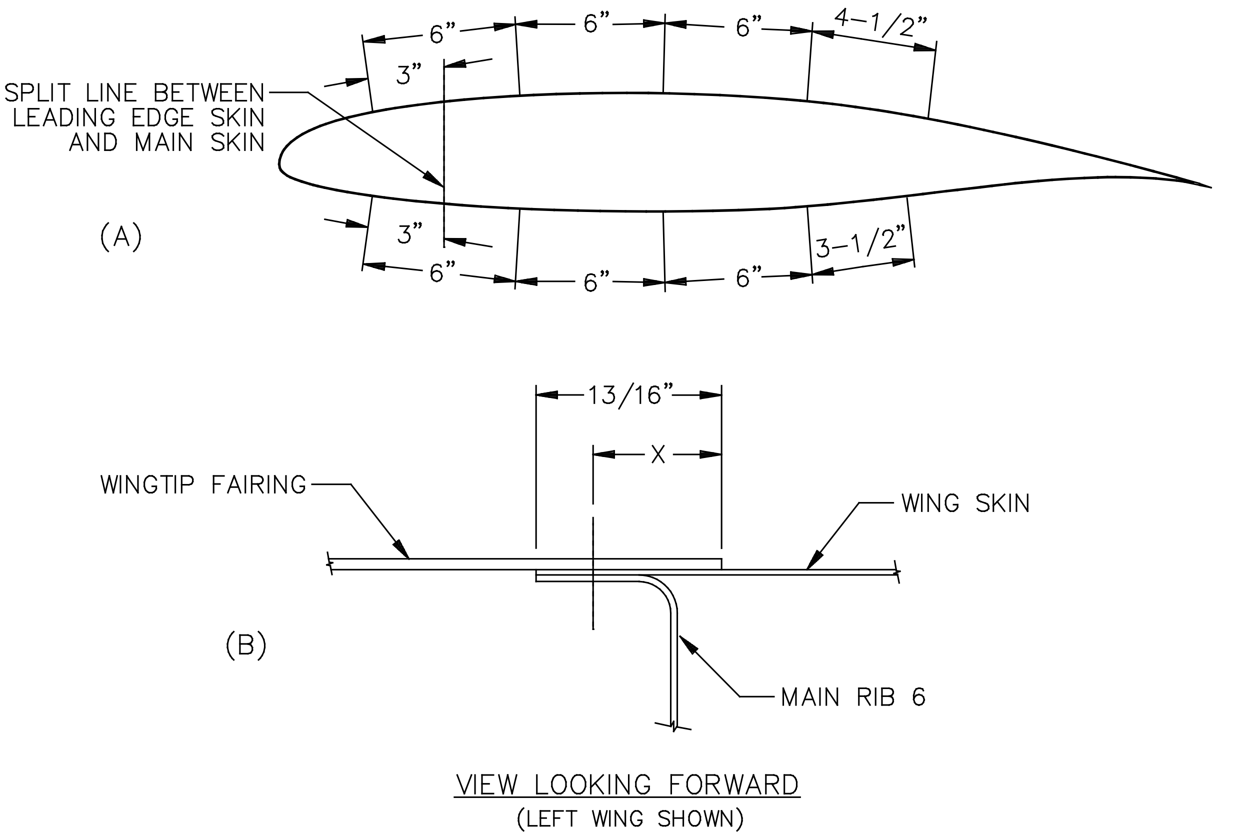


Figure 103: Marking the Fairing Mounting Screw Hole Locations

Remove the fairing and drill and deburr **#40** holes for the nutplate rivets in the wing skins and rib flanges, and then dimple the holes to accommodate 3/32" AN426AD3 flush-head rivets. The dimple die will easily dimple both the rib flange and the skin at the same time. For best results, you can also dimple the K1000-08 nutplates themselves, but you will probably have to grind one side of the female die to provide clearance for the nutplate centers.

Rivet the nutplates to the wing, and install the fairing temporarily with AN526-8R7 screws.

Completed: Left [ ] Right [ ]

Nav/Strobe Light Option Kit A mounting surface has been provided on the outboard side of the tip fairing for the Whelen 3-way wingtip light assembly supplied with Stoddard-Hamilton's Nav/Strobe Light Option Kit. If you are installing the Nav/Strobe Light Option, you can mount the light assemblies at this time and complete the routing of the wiring to the wingtip. **Turn to the option instructions now.** Return to Step 102 of this *Assembly Manual* when the specified option steps have been completed. ☞

Step 102: Bond the Trailing Edges of the Fairings Together

Now it's time to finish the wingtip fairings by bonding their trailing edges together. Prepare by setting the ailerons in their neutral position, with their trailing edges even with the flap trailing edges. Then mix a small batch of thick resin/mill fiber mixture to bond the curved portion of the tip fairing trailing edge together. Pry the trailing edge of the fairing apart (removing one or two mounting screws to permit this, if necessary) and apply a small bead of the mill fiber mixture between the surfaces at the trailing edge. Place the fairing trailing edges back together and adjust them up or down to align with the aileron trailing edge. Drill a **#40** hole or two through both fairing halves near the inboard end of the trailing edge and insert Clecos to help hold the trailing edge in position relative to the aileron. Elsewhere, use masking tape to hold the fairing trailing edge together while the mill fiber mixture cures, or use very light clamping pressure with Cleco side-grip clamps or small C-clamps.

After the trailing-edge bonds have cured, remove the wingtip fairings and set them aside. You'll further trim them for final installation in the "CONTROL SURFACE BALANCING AND FAIRING INSTALLATION" sub-section when you install the aileron counterweights. If you wish, you can fill any Cleco holes now with body filler and sand smoothe.

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DOOR INSTALLATION

In this sub-section, you will mount both the cabin doors and the baggage door. Since the fiberglass fuselage shell flexes slightly when the fuselage is under load, we recommend waiting until the engine and wings are mounted on the fuselage before fitting the doors. Otherwise, you might fit the doors precisely to the shell only to find that gaps open up around the doors or—even worse—that the doors won't close properly when the airplane is completed.

Procedures for mounting the **left** [13] and **right cabin doors** [14] are identical. Unless otherwise specified, the following text and illustrations refer to the left door.

Step 103: Mark Reference Lines on the Fuselage Shell and Cabin Door

The first step in installing the cabin door is to mark the hinge line on the fuselage shell. As shown in Figure 104, this line should be marked parallel to and about **1/8"** forward of the forward edge of the door cutout. Use a straightedge to mark the line.

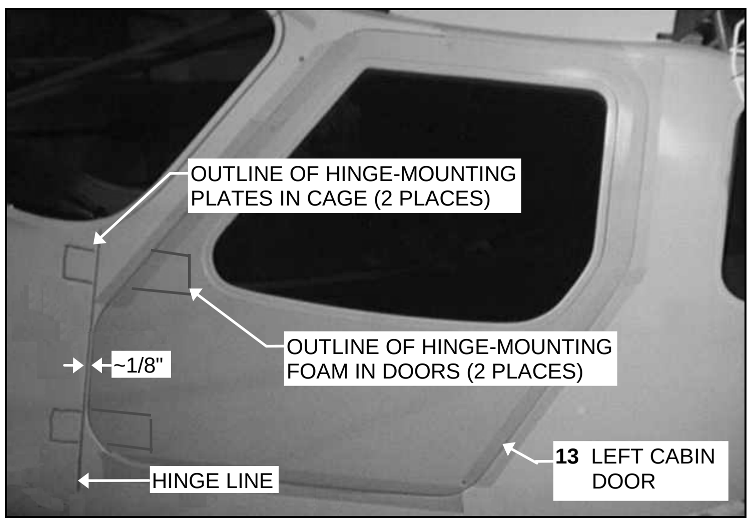

Figure 104: Marking Cabin Door Reference Lines

Also, mark on the outside of the shell the outlines of the two steel hinge-mounting plates on the fuselage cage. There's no need to take exact measurements here—just eyeball the outlines of the plates.

Finally, use the same informal technique to mark the outlines of the foam hinge-mounting hardpoints on the outside of the door.

Completed: Left [ ] Right [ ]

Step 104: Fit the Door to the Cutout and Temporarily Secure It in Place

The cabin doors are trimmed in a jig at the factory, so they should fit the door cutouts fairly closely "right out of the box." However, final sanding of the door to achieve the precision of fit you want is best left until after the hinges and latches have been installed. For now, simply sand the edges of the doors as necessary to place them into their cutouts in the fuselage shell.

Position the doors in the cutouts so that any gaps between the edges of the doors and the edges of the cutouts are equalized all the way around, and then tape them securely in place with wide masking tape. Apply the tape around the entire perimeter of the door, except for the forward edge where the hinges will be mounted.

Completed: Left [ ] Right [ ]

Step 105: Assemble the Hinges

Each door has an upper and a lower hinge consisting of a forward and an aft half. The first step in assembling the hinges is to press NAS75-3-004 **plain steel bushings** [169] into the pivot holes of **all** the **door hinge halves**: the **aft lower left** [15] and **right** [16], the **aft upper left** [17] and **right** [18], and the **forward left** [19] and **right** [20].

Next, pair the hinge halves off as shown in Figure 105. Note that the aft **upper** halves (Figure 105a) are longer than the aft **lower** halves (Figure 105b), while the two forward halves are identical. Also note that the left and right are distinguished by the off-center positions of the horizontal flanges—**high** on the **aft** halves and **low** on the **forward** halves. Take care to ensure that you have paired all the halves correctly.

Both hinges are assembled with identical hardware, which is shown in Figure 105a; insert a **small nylon washer** [80] between the halves and secure the parts with an AN3-6A **bolt** [115], an AN364-1032A nylon self-locking nut and an AN960D10L **thin aluminum washer** [152] under both the bolt head and the nut. Tighten the nut until the hinge halves snug down against the nylon washer but **not** to the point that the washer is compressed between the halves.

Note Figure 105 shows the **left-hand** upper and lower hinges; the right-hand pair is mirror-imaged.

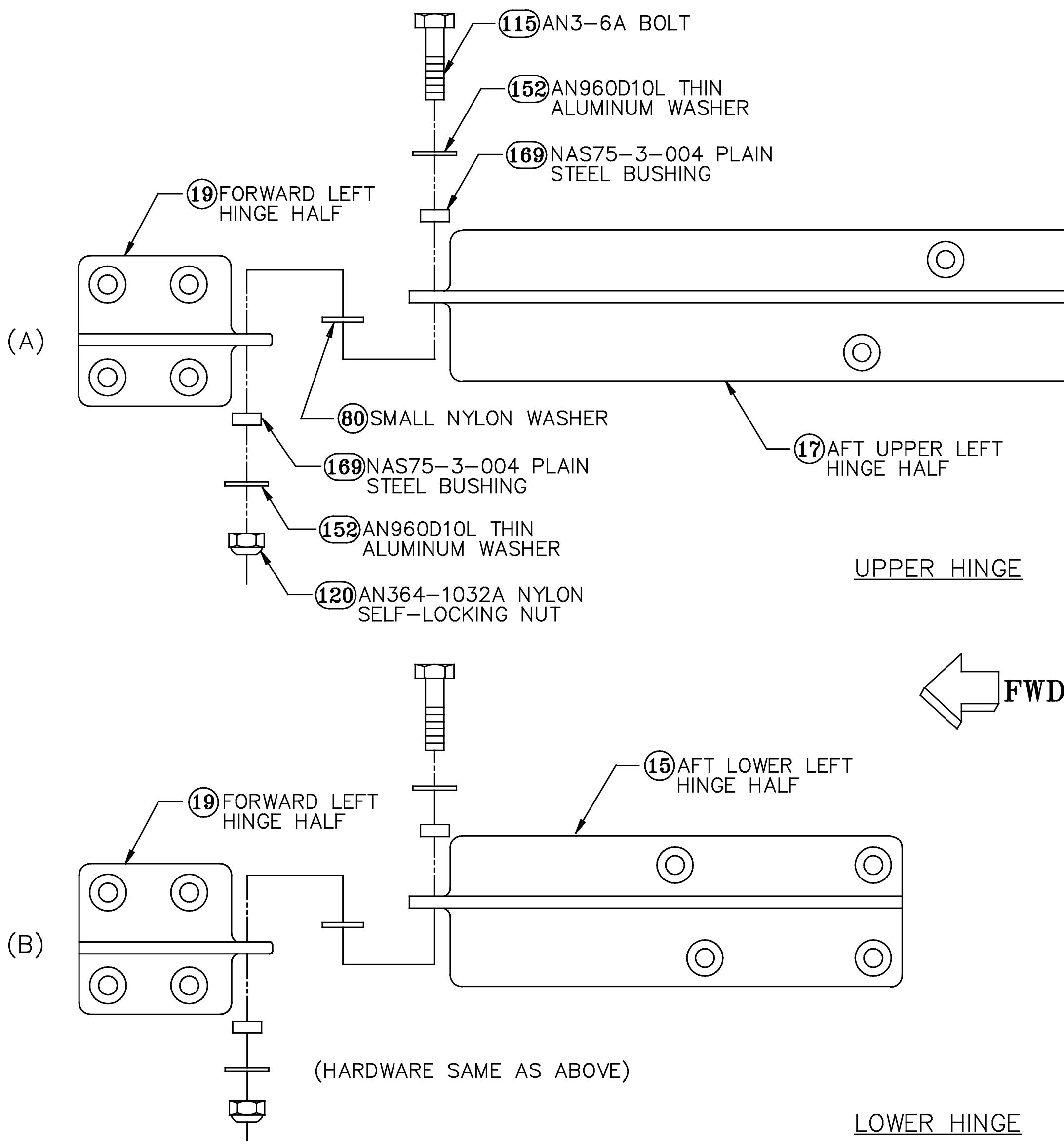

Figure 105: Assembling the Hinges

Step 106: Position and Drill the Hinges

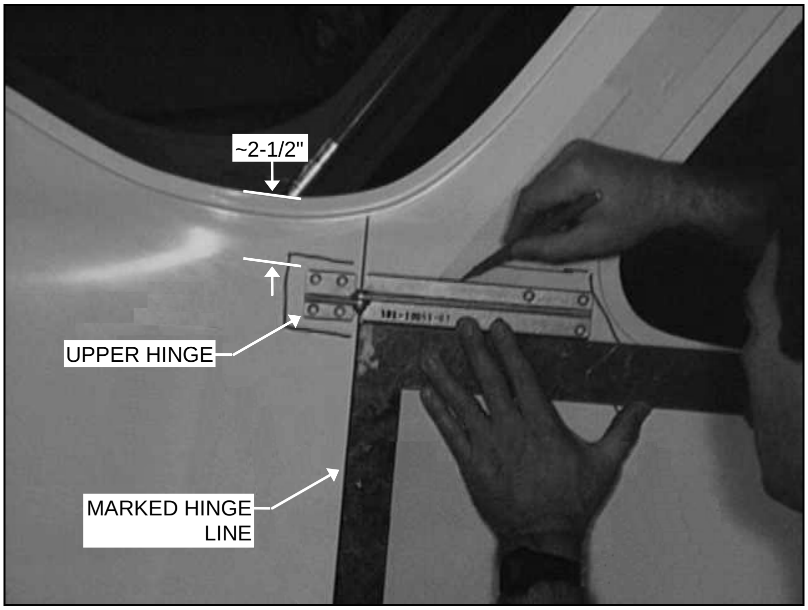

Figure 106: Positioning the Hinge

As shown in Figure 106, the hinges are positioned with reference to the marked hinge line using a framing square. Hold the upper hinge against the door and fuselage roughly centered in the mounting area outlines you marked earlier and with the hinge bolt centered over the hinge line. When properly positioned, the forward, upper corner of the hinge should be about **2-1/2"** below the edge of the windshield cutout in the shell, as shown in the figure. When you're satisfied, mark along the upper edge of the hinge assembly onto the outside of both the door and the fuselage.

Repeat the process to mark the location of the lower hinge. When the lower hinge is centered in its mounting area outlines, its horizontal flange should be about **11-3/4"** below the horizontal flange of the upper hinge. This time mark along the lower edge of the hinge assembly, being sure to mark both the fuselage and the door.

Note It may have occurred to you that the pivot axes of the two hinges will not be perfectly aligned when the hinges are mounted flat on the fuselage sides, because the sides of the fuselage aren't strictly flat. However, the misalignment involved is quite minor, and the hinges can tolerate it without any noticeable binding. Therefore, there's no need to build up or grind away the shells in order to position the bases of the hinges in precisely the same plane.

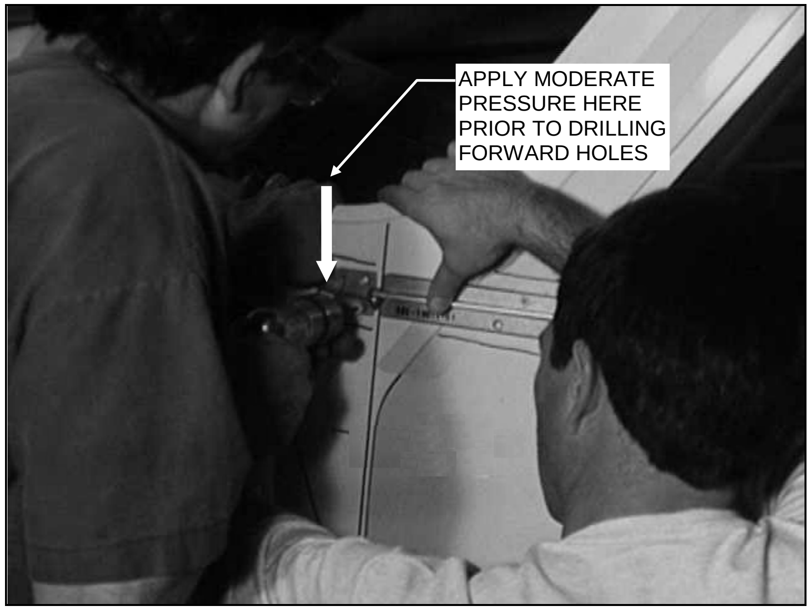

Figure 107: Drilling the Hinge Mounting Holes

As Figure 107 shows, it's a good idea to have a helper assist you in holding the hinges in position while drilling the mounting holes. Be careful, as always, to drill square to the mounting surface. For each hinge, begin with a couple holes through the **aft** hinge half into the door. Drill these holes **all the way through the door** with a **#10** bit, and then insert AN509-10R20 **flush-head machine screws** [136]. Temporarily secure these screws with AN960-10L thin washers and AN315-3R **jam nuts** [117].

Next, drill a couple **#10** holes through the forward half of each hinge, the fuselage shell and each cage mounting plate. Insert AN509-10R18 **flush-head machine screws** [135] in these holes and temporarily secure them just as you did the aft pair.

Caution When drilling these holes, take great care to hold the drill steady. It's easy to inadvertently enlarge the holes through the fiberglass while drilling through the steel mounting plates.

Hint Before drilling these holes, apply moderate **downward** pressure on the forward hinge half as indicated by the bold arrow in Figure 102. This slight "pre-load" will help offset sagging over time from the weight of the door.

Note There is a gap between the fuselage shell and the mounting plates that you will fill shortly with resin/Q-cell mixture. For now, avoid tightening the nuts on the temporary screws through the forward hinge halves more than finger tight; over-tightening them risks permanently deforming the shell.

With two holes and two screws in each half of each hinge, go ahead and drill the remaining holes in all four hinge halves.

> **Warning** When drilling the **aft** two holes through the **forward** half of the **lower** hinge, be very careful that your drill bit doesn't contact the cage tube that lies behind the mounting plate. If it is nicked, its structural integrity could be compromised. Use a drill stop or place a block of wood inside the mounting plate to prevent this.

After the holes have been drilled, label each half of both hinges so that they can be reunited with their mates after disassembly. Then remove the hinges from the fuselage and the door and separate the halves.

Completed: Left [ ] Right [ ]

Step 107: Install the Forward Hinge Halves

You can now fill the gap between the fuselage shell and the upper and lower cage mounting plates with thick-mix Q-cell. Apply masking tape across the gap along the side and bottom of each plate to help retain the mixture while it cures. Mix up a very thick batch of Q-cell and pack it into the spaces between the shell and the plates. Clean up any excess Q-cell, leaving a nice fillet along the top edge of each plate.

After the Q-cell is in place but before it starts to cure, replace the forward hinge halves, inserting their mounting screws through the Q-cell. Clean up excess Q-cell that is displaced inboard of the plates by the screws, and then secure them permanently with the washers you used before and AN364-1032A nylon self-locking nuts. Just tighten the nuts until they are snug against the plates. After the Q-cell has cured completely, tighten the nuts firmly.

Completed: Left [ ] Right [ ]

Step 108: Install the Door Seal

The rubber **door seal** [102] requires a gap all the way around the door between the flange of the fuselage door cutout and the inside edge of the door frame. You will set the gap on the exterior of the airplane later, but here we're interested in the **interior** side of the door. This gap can acceptably be anywhere from **1/8"** to **1/4"** wide, but **3/16"** is optimal, as shown in Figure 108.

With the door still taped in place, mark the door cutout flange of the fuselage shell wherever it needs trimming to provide an acceptable gap. Remove the door and trim or sand the fuselage flange to the marks, leaving a slightly rounded edge all the way around the cutout.

> **Hint** You can use a draftsman's compass to mark trim lines onto the fuselage flange. Set the legs of the compass 3/16" apart and then run the leg with the point around the perimeter of the door frame while the pencil point marks a line onto the fuselage flange.

The door seal is very flexible and can be stretched or compressed significantly during installation. The idea is to compress the seal as much as you can during installation so that a gap won't open up should the seal contract later.

Cut the supplied door seal into two **10'** lengths and one **6'** length for the cabin doors and the baggage door, respectively. Starting at the **bottom, aft corner** of the cabin door cutout, press the seal over the cutout flange, as shown in Figure 108.

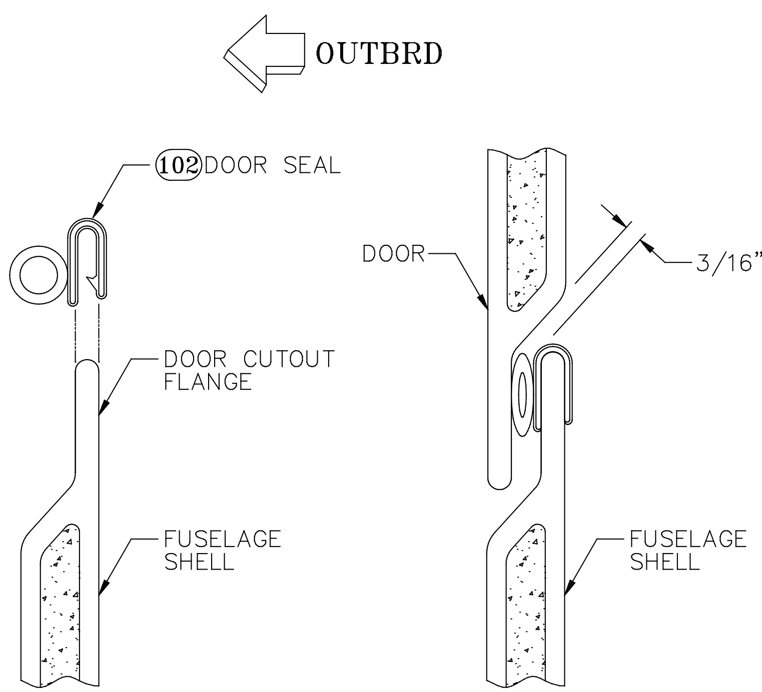

Figure 108: Door Seal

Work the seal onto the flange all the way around the cutout, all the while compressing the seal **lengthwise** as much as you can. (It doesn't matter whether you go forward or aft from your starting point.) When you've installed the seal all the way around the door, let the end hang loose inside the fuselage and trial fit the door. If there are areas where the seal interferes with the door, remove the door, pull the seal away and sand the fuselage flange as necessary until the door fits cleanly with the seal in place. If there are areas where the seal is too far from the door frame to be effective, pull the seal and build up the cutout flange with layers of tape until the seal fits the door acceptably well.

> **Note** The fuselage shells for the very latest GlaStar kits have had the door openings trimmed larger during manufacture. Builders of early kits should expect to remove about **1/8"** of material all around the opening.

When you're satisfied, you can cut off the excess seal, However, do **not** cut the seal right at the point where the ends appear to meet. Instead, cut it off about **2" longer** than seems necessary. Then, go around the perimeter of the door again, seating the seal down onto the flange and compressing it lengthwise as you did in the initial installation until the excess length is taken up and the two ends fit snugly together. Our experience has been that if this extra round of compressing is omitted, a gap will inevitably appear later between the ends of the seal, even if they seemed to fit perfectly on initial installation. Pay particular attention to the corners of the door, where it's easy to inadvertently pull the seal away from the flange. If you get to a point where you absolutely cannot compress the seal any further and some excess length remains, go ahead and trim that off, but **try hard** first!

> **Note** It is unnecessary to secure the seal to the cutout flange with any sort of adhesive.

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Step 109: Fabricate the Door Latches and Dogs

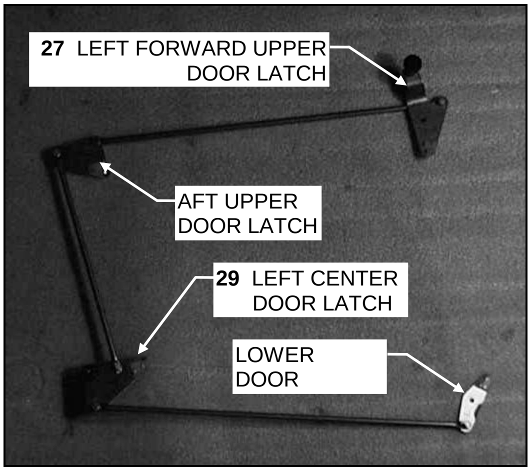

Figure 109: Door Latches and Pushrods

The door latch system in the GlaStar consists of four latch plates attached to each side of the cage. Interconnected by pushrods, these latches engage four dogs that are attached to each door. Figure 109 shows the general arrangement of the latches and pushrods.

Because they are somewhat more complex parts, the **left** [27] and **right forward upper** [28] and **left** [29] and **right center door latches** [30] have been manufactured for you. The upper aft and lower forward latches, however, are simple aluminum shapes, and are therefore left to you to fabricate. Likewise, the eight door dogs must also be cut from sheet metal—stainless steel in this case.

Full-sized templates for each of these builder-fabricated parts are given in Figure 110. Cut **two aft upper** and **two lower** door latches from the **.090" X 3" X 9" aluminum sheet** [71] and cut **eight** dogs from the **.090" X 3/4" X 24" stainless steel sheet** [74]. Although the left- and right-hand parts will be distinguished later, they are identical at this stage. Use a bandsaw or scroll saw to cut out the shapes, and then files and/or a belt sander to smooth the cut edges.

Note The stainless will require a fine-toothed, metal-cutting blade.

Using a center punch driven through the templates, mark the holes locations shown on one of the upper aft and one of the lower forward latches. Then stack the latches of each type together in pairs and drill all the holes, using the bit sizes specified on the templates. Deburr all the holes thoroughly.

The door dogs also require some holes. With a **#30** bit, drill **nine** holes in the square end of each dog. The spacing of these holes is not critical—their purpose is simply to aid in bonding the dogs to the door frame.

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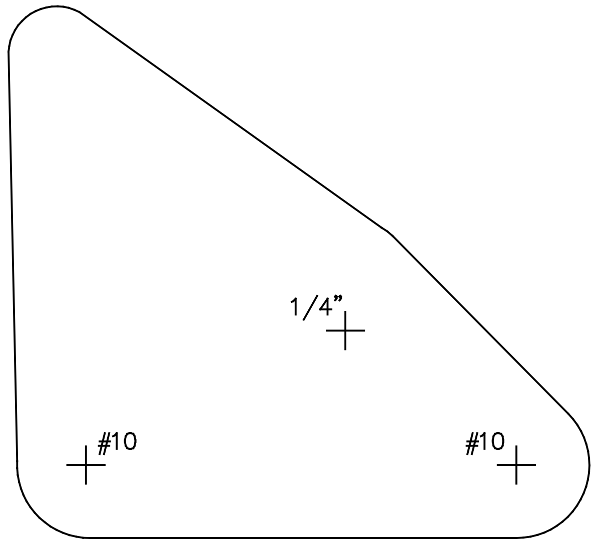
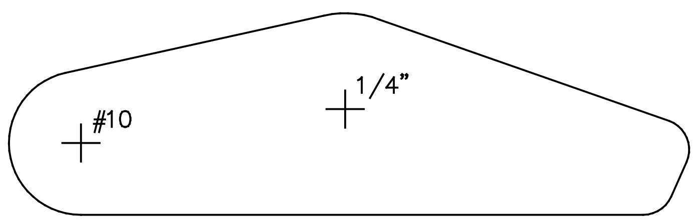
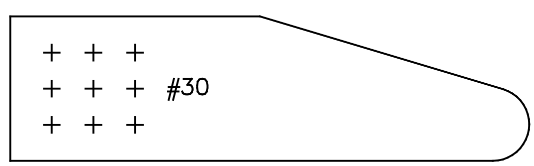


AFT UPPER DOOR LATCH
(CUT 2 FROM (71) .090"x3"x9" ALUMINUM SHEET)



LOWER DOOR LATCH
(CUT 2 FROM (71) .090"x3"x9" ALUMINUM SHEET)



DOOR DOG
(CUT 8 FROM (74) .090"x3/4"x24" STAINLESS STEEL SHEET)

Figure 110: Templates for the Builder-Fabricated Door Latches and Dogs (Full Size)

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Step 110: Install Shoes on the Ends of the Latches (Optional)

As mentioned previously, the latches engage dogs to secure the doors Three of the latches—both uppers and the lower—are aluminum, and over time, these latches will wear somewhat against the stainless steel dogs. As of this writing, our prototype GlaStar has logged 500+ hours and countless door openings and closings, and the latches, though slightly worn, are still serviceable. Nevertheless, you may wish to provide extra wear protection to these parts in the form of small shoes of a more durable material riveted onto the bearing surfaces of the latches.

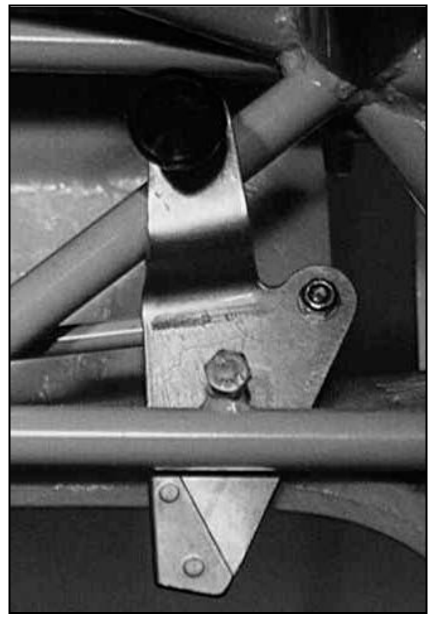

Figure 111: Door Latch Shoe

Figure 111 shows the approach to this problem employed by an early GlaStar builder. Small scraps of leftover .016"-thick stainless from the firewall were trimmed and bent to go around the engagement edge of the latch. The latch was then countersunk and the shoe dimpled **on both sides** for a pair of flush-head rivets. The double countersink allowed the rivets to be set essentially flush on both sides of the latch.

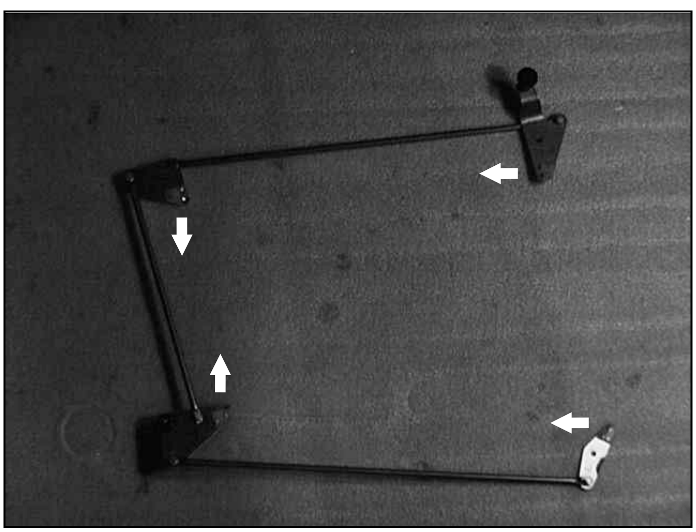

Figure 112: Direction of Engagement of the Door Latches

If you choose to install shoes on your latches, be sure to note which edge of each latch engages the dogs. Figure 112 shows the direction of engagement for the left-hand latches; the right-hand are mirror images.

Completed: Left [   ] Right [   ]

Step 111: Install the Latches on the Cage

The two upper latches and the lower latch are all installed with AN4 bolts inserted through steel bushings that are welded to the fuselage cage. Refer to Figure 113 for the locations of these bushings.

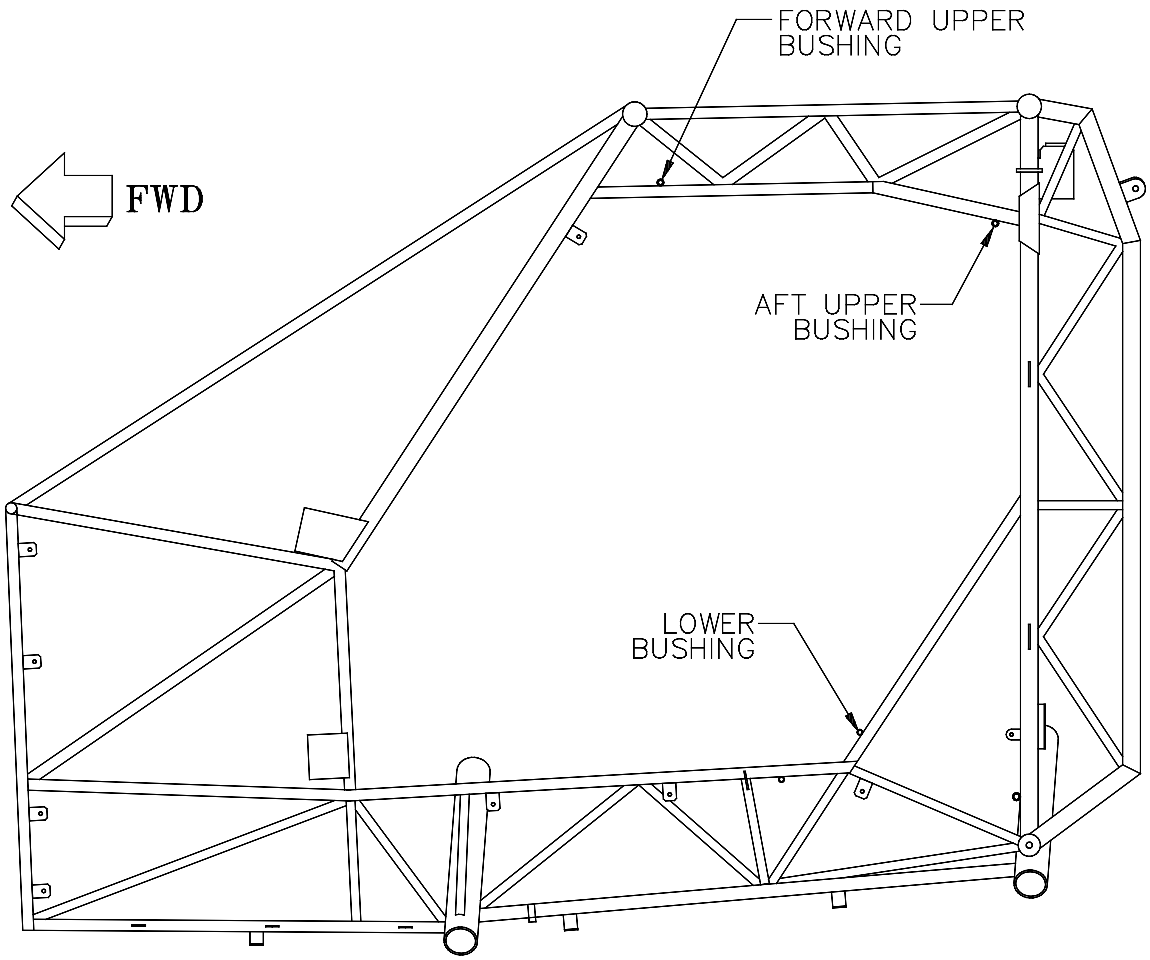

Figure 113: Locations of the Door Latch Bushings

Figure 114 shows the general installation method for all three of these latches. (The center latch is handled somewhat differently, as detailed below.) Each latch is installed **outboard** of its respective cage bushing, with the bolt inserted from the **inboard** side. One or more washers are used between the bushing and the latch to position it the proper distance from the door seal; aim for a gap of about **1/8"**, as shown in Figure 114.

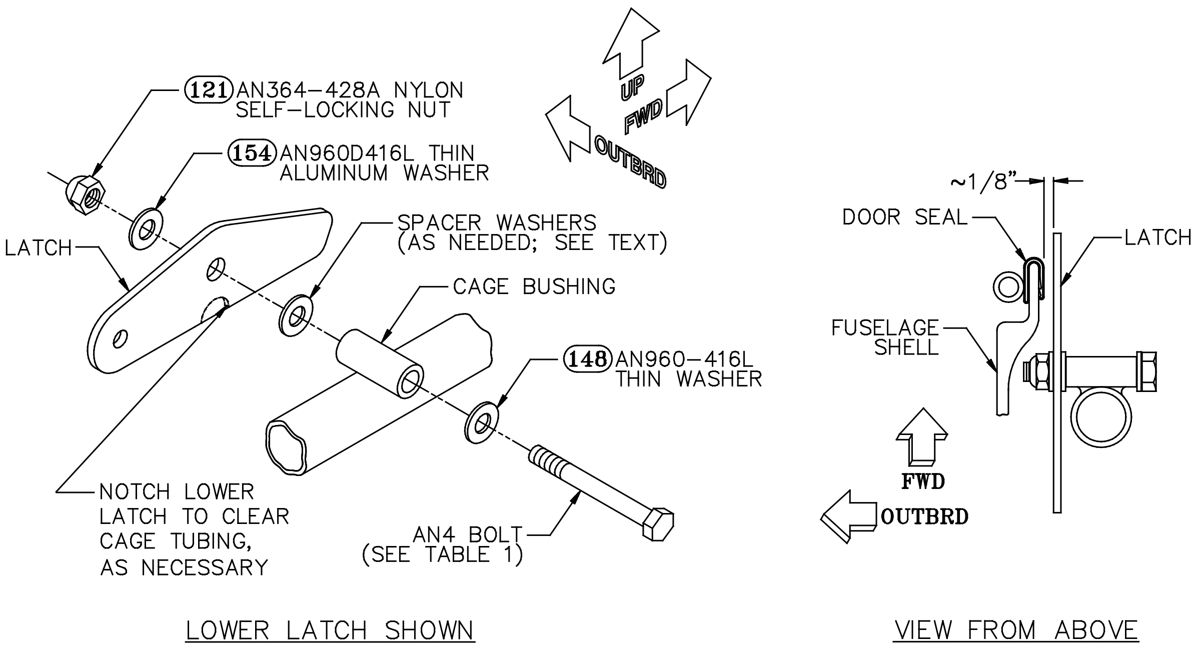

Figure 114: A Typical Latch Installation

Because of variations in the relative positions of cages and fuselage shells, it's impossible to specify the exact washer stack-up you will need between the outboard end of the bushing and the latch in order to achieve this spacing. You can use any combination of thick and thin washers, and you can use a mix of aluminum and steel washers, as necessary. However, there are a couple general principles to observe in any case. First, you must use **at least** one **steel** washer against the cage bushing, be it an AN960-416, standard-thickness washer or a -416L thin washer. Second, if you need more than one washer, it's more desirable to use **aluminum washers**—either AN960D416 standard [153] or D416L **thin** [154]—outboard of the first steel washer. Experiment with different combinations as necessary to achieve the desired 1/8" gap for each individual latch. Finally, it may be necessary in some cases to **remove** material from the outboard end of the bushing; these cases still require a steel washer between bushing and latch, however.

Before you install the **lower latch**, notch its lower edge as necessary to clear the fuselage cage tubing, as shown in Figure 114. To determine how big a notch to cut, look ahead to Figures 117 and 125, which show the latch's latched position and which way it rotates.

Because the bushings are not all the same length and because of the variations mentioned above in cage-to-shell relationships, each latch will require a different length bolt. Table 1 gives the anticipated best size for each latch; however, it's possible that you will need to use bolts a size or two longer or shorter for one or more or your latches.

LATCH POSITION	BOLT
Forward upper	AN4-14A
Aft upper	AN4-26A
Lower	AN4-12A

Table 1: Latch Bolt Lengths

When you've determined your optimal washer stack-up and bolt length, mount the latches as shown in Figure 114. Apply a modest amount of axle grease to the bolts and the bearing surfaces of the washers and latches before assembly. Use AN364-428A nylon self-locking nuts to secure all the bolts. Tighten these nuts firmly, and then back them off about a quarter-turn to allow free rotation of the latches.

Figure 115 shows the proper orientations of the (a) forward upper, (b) aft upper and (c) lower latches, respectively, relative to the door cutout and cage structure. Refer to these photographs carefully to make sure you orient your latches properly.

> **Note** Figure 115 shows the left-hand latches; the right-hand are mirror images.

Now it's time to install the final latch—the center latch. This latch comes with a shaft welded to it that penetrates the fuselage side through the bushing you pressed into the upper shell attach fitting way back in "SECTION VIII: FUSELAGE ASSEMBLY." This shaft will be drilled to accommodate the exterior door handle in a subsequent step. Figure 116 shows the orientation of the left-hand lower aft latch; the right-hand latch is mirror image.

Before proceeding, builders of **early kits only** need to drill an additional hole in each of the center latch plates to bring the latches up to current specifications. Figure 114.1 shows the current latch, which has **two** #10-diameter holes along its lower edge spaced **.95"** and **1.5"** from the lower pushrod-attach hole. Early latches had one or the other of these holes, but not both. If your latch has a hole .95" from the pushrod-attach hole, drill a **#10**-diameter hole **1.5"** from the pushrod-attach hole; if your latch has the hole at 1.5", drill a **#10**-diameter hole **.95"** from the pushrod-attach hole. Repeat for both center latches.

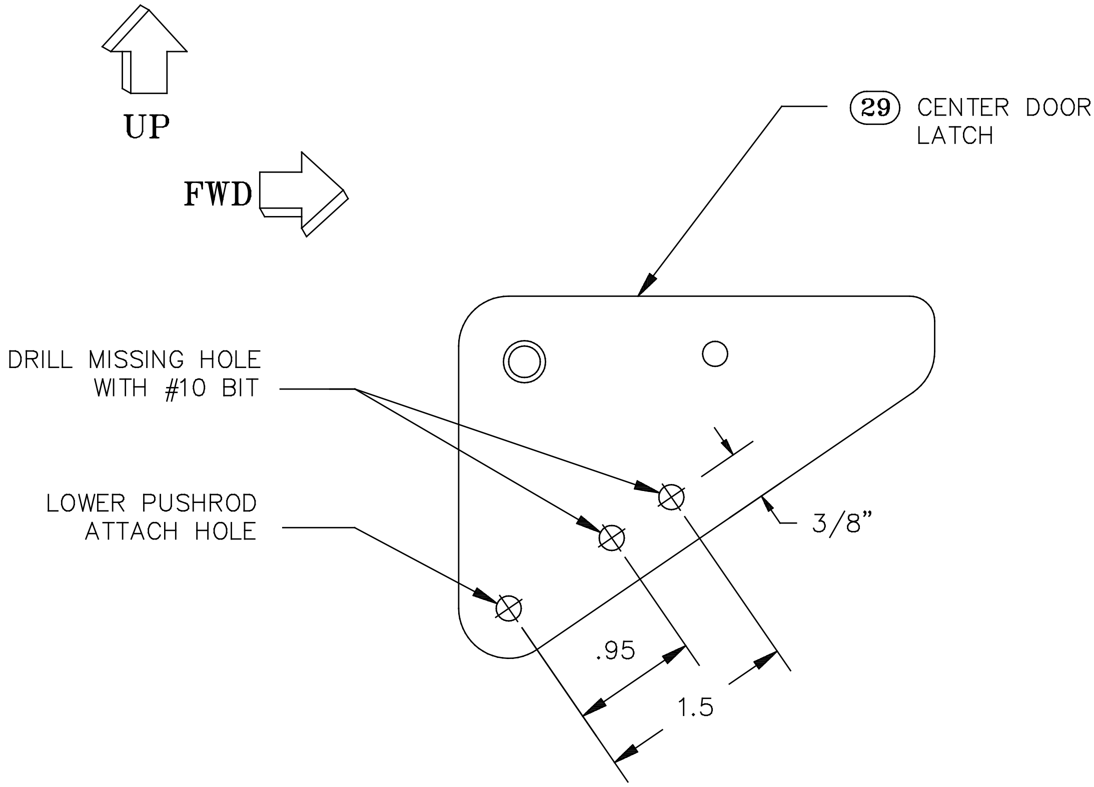

Figure 114.1: Center Latch Modification (Early Kits Only)

> **Note** The additional hole in the current center latch accommodates a second over-center spring. The second spring and its mounting hardware were not included in early kits, but they will be supplied in a Parts Addendum that will be shipped to all early builders. The Addendum includes two each of the **forward door latch over-center springs** [P/N 077-00002-02], two each **AN4-11** bolts, two each **AN3-10A** bolts and two each **AN315-3R** jam nuts. Various washers and elastic stop nuts are also needed in the assembly, but there should be enough extra of these in the original kit to satisfy your needs.

As with the other latches, shim washers must be inserted between the bushing and the latch to produce a gap of about **1/8"** between the outboard face of the latch and the door seal. In this case, however, **nylon** washers should be used. You should have an ample supply of these in both thin and thick varieties left over from shimming between the fuselage shell and the cage. In order to use these washers with the latch, you'll have to ream them with a **5/16**" drill bit.

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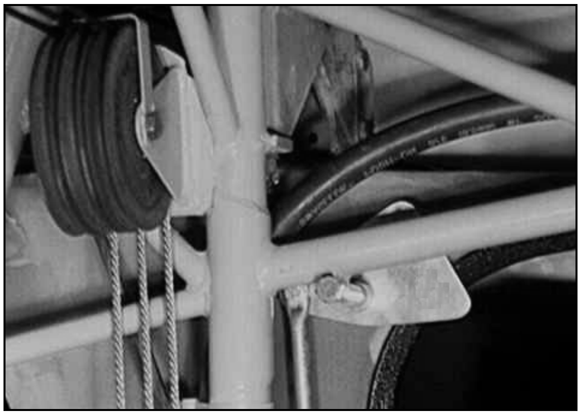
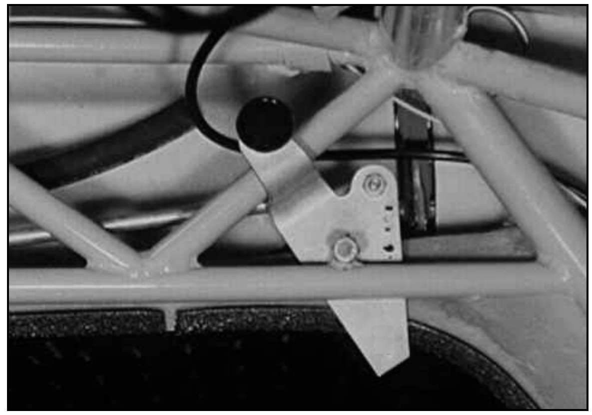
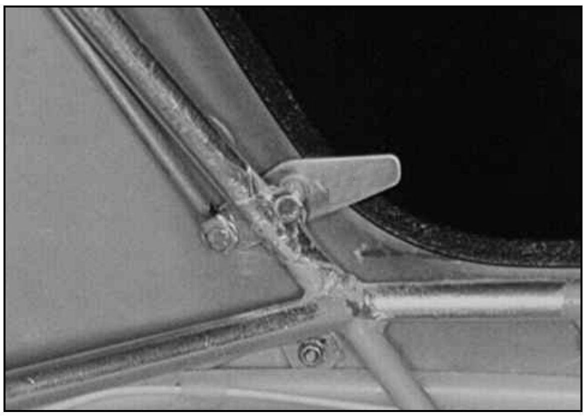


(b)



(a)



(c)

FWD ➡

Figure 115: Orientations of the Forward Upper, Aft Upper and Lower Door Latches

After you have inserted the shaft of the lower aft latch through the requisite number of washers and the upper shell attach fitting bushing, grab the end of the shaft outside the fuselage shell with a pair of vise-grip pliers to hold the latch tightly in place temporarily.

Completed: Left [ ] Right [ ]

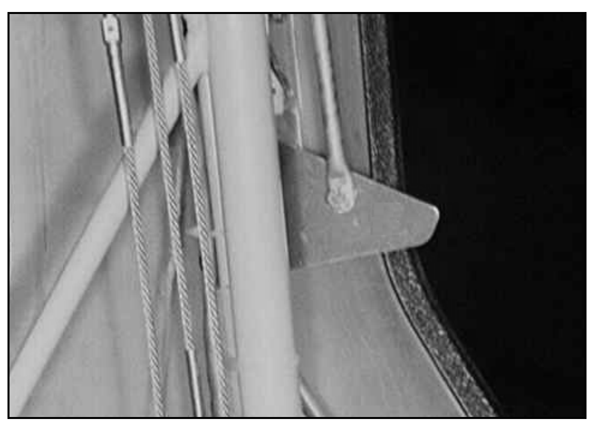


Figure 116: Orientation of the Center Door Latch

Step 112: Fabricate the Door Latch Pushrods

With all the latches in place, you can now make the pushrod linkages between them. These rods are made from **5/16" 6061-T6 aluminum tubing** [110], cut to the proper length and flattened on each end to accept a bolt. The first step, therefore is to determine the proper tubing lengths. This must be done for each pushrod individually. There are simply too many possible variations for us to successfully prescribe a rod length ahead of time, and in fact, you may find that—for instance—your left upper rod needs to be a slightly different length than your right upper rod. So don't take anything for granted; measure the required rod length for each of the six locations!

Prior to measuring, you need to position all the latches properly relative to one another. Figure 117 shows these orientations for the left-hand latches, using the edges of the door as references. There's no need to go to elaborate lengths in measuring these angles; since you'll locate the door dogs to match the latch positions, you can simply eyeball the latter with fine results. Secure the latches in position either with tape or by temporarily tightening the nuts on the pivot bolts.

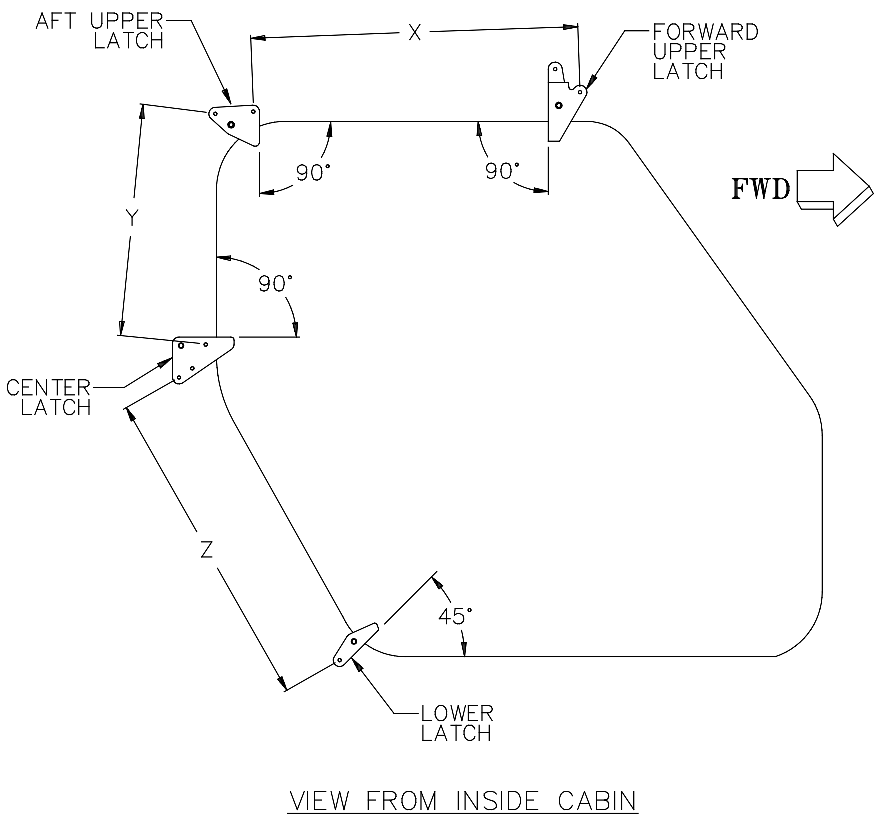


Figure 117: Measuring the Latch Pushrod Lengths

Now measure the straight-line distances between the centers of the pushrod holes on each latch, as indicated by Lines X, Y and Z in Figure 117. Take care to make sure you're using the proper holes for each rod.

Once you've determined X, Y and Z, **add 5/8" to each dimension to get the actual pushrod length**. Remember, you measured center-to-center distance; if you cut your rods to this length, you'll be embarrassed when it comes time to drill the bolt holes in the rods! (We've provided approximately 40" more tubing than is required, so you're allowed one such mistake, but not more!)

Hint Cut the longest rod first; that way, if you do make a mistake, you can still use the tubing for one of the shorter rods.

Having cut the rods to length, the next step is to flatten the ends for drilling. This is best done in a bench vise. However, if you use the square-edged jaws of a standard vise for this purpose, the jaws will bite into the tubing, perhaps to the point of cutting the end right off rather than simply flattening it as desired. To prevent this, make a pair of "soft" jaws like those shown in Figure 118. Simply sand or file a **1/8" radius** into the ends of a couple pieces of scrap aluminum angle. Tape these in place inside the jaws of your vise, and insert the tubing to be flattened into the rounded ends of the new jaws, as shown in the photograph. This will produce a nicely radiused, gradual bend in the tubing.

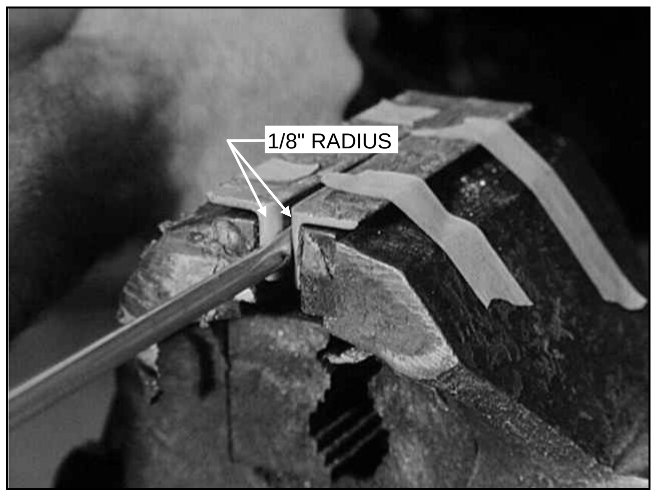


Figure 118: "Soft" Vise Jaws for Flattening Tubing

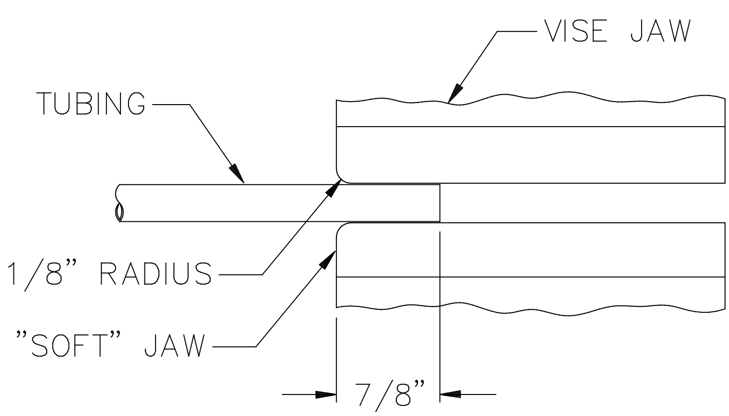


Figure 119: Flattening the Tubing

As shown in Figure 119, insert the end of a rod to be flattened **7/8"** beyond the **square** end of the jaws. This will produce a flat area about **3/4"** long. Tighten the vise until the tubing is completely collapsed.

Note Flattening the first end of each rod is easy, but be absolutely certain that you flatten the other end **in the same plane** as the first one! In other words, make sure the already flattened end is **vertical** when you place the other end in the vise.

Note When you remove the flattened end from the vise, you'll probably notice that the edges of the flattened area have cracked slightly (see Figure 120). Don't worry about this. It's unavoidable and will not affect the strength or utility of the pushrods.

Once the rod ends are flattened, chamfer the corners at about 45° and smooth the cut ends, as shown in Figure 120. Then, using a **#10** bit, drill the bolt holes the ends of the rods, using the X, Y and Z dimensions measured earlier to determine the exact placement. As Figure 120 shows, be sure place the holes so as to maintain the proper edge distance specified in the figure.

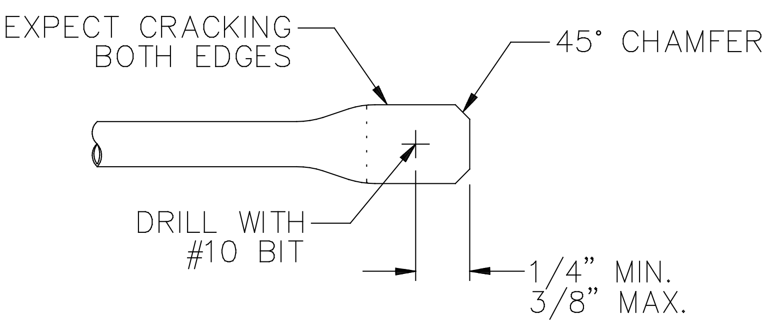


Figure 120: Finishing the Latch Pushrod Ends

Mark each pushroad as it's completed to make sure you can return it to its original position.

Completed: Left [ ]
Right [ ]

Step 113: Install the Latch Pushrods

Install the pushrods between the latches using the hardware shown in Figure 121a: AN3-4A bolts, AN960D10 [151] and D10L standard and thin **aluminum washers** and AN364-1032A nylon self-locking nuts. Be sure to use the thicker washer between the latch and the pushrod, and then check the final result to see that there is a minimum gap of about **1/16"** between the rod and the latch, as shown in Figure 121b. If necessary, use additional thin aluminum washers to shim the rod away from the latch.

As with the installation of the latches themselves, lightly grease the bearing surfaces of all the parts prior to assembly.

> **Note** All the pushrods go on the **inboard** side of the latches, as shown in Figure 121, with the exception of the upper pushrod where it attaches to the forward upper latch; **only** this end should be secured **outboard** of the latch.

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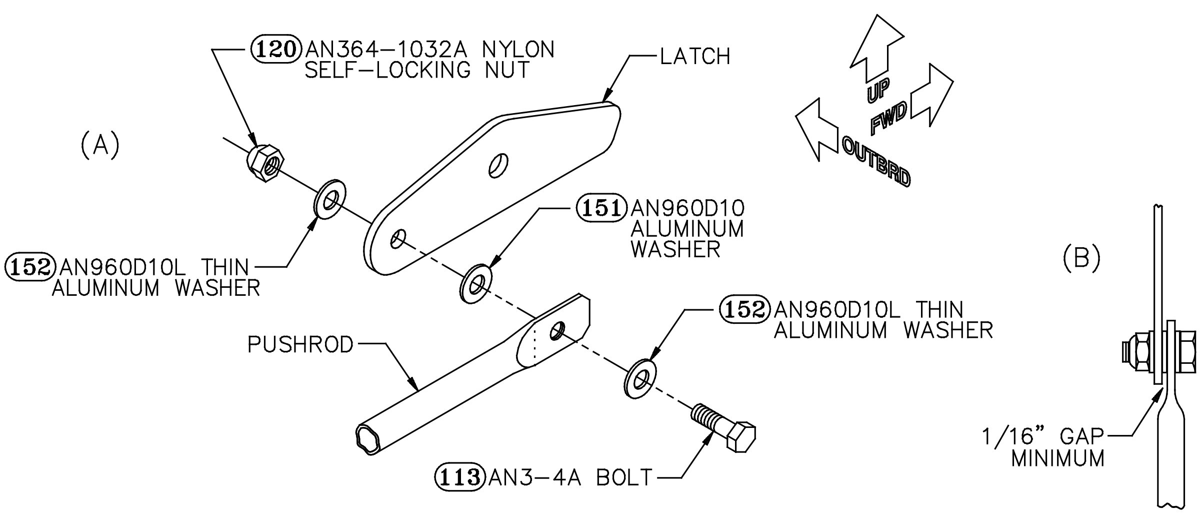

Figure 121: A Typical Pushrod Installation

Step 114: Bend the Door Dogs

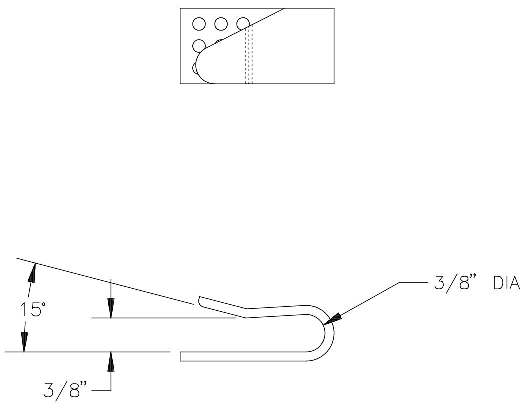

Figure 122: Dog Specifications

Now it's time to return to the stainless steel door dogs. As shown in Figure 122, the flat shapes you cut out earlier must be bent over on themselves to form catches that will capture the latches when they are rotated by the door handle. The bent dogs are then bonded to the door frame.

As shown in the figure, the dog blanks should be bent in half to a **3/16"**-radius just over **180°**. Then, the last **3/8"** or so of the narrow end should be bent back away from the square end at about a **15°** angle to provide a ramp to capture the latch.

Bending stainless—especially small, relatively thick pieces like the dogs—can be a real challenge. We recommend enlisting the help of a local sheet metal or machine shop with a leaf brake. This will allow you to bend the dogs to about 45° or so. From that point you can finish the bends by clamping the dogs in a vise around a **3/8"**-diameter rod. Don't insert the dogs too far down into the vise, or else the legs will bend into a curved shape, as shown in Figure 123a. Instead, you want to continue the 3/16"-radius bend begun in the brake. This requires putting just a bit of the part into the vise, as shown in Figure 123b. To prevent the vise from spitting the part out, apply downward pressure to the 3/8"-diameter rod while slowly tightening the vise until the desired bend is achieved. To finish the bend the last bit beyond 180°, turn the assembly over and tighten the vise, as shown in Figure 123c. Then, reposition the dog in the vise as shown in Figure 123d and use a block of wood and a hammer to bend the ramp section on the narrow leg of the dog. Make this last bend around a piece of angle with a 1/8"-radius, as shown.

> **Note** In bending the dogs, be sure to bend four in one direction and four in the other; the left and right doors require **mirror-imaged sets**.

Completed: Left [ ] Right [ ]

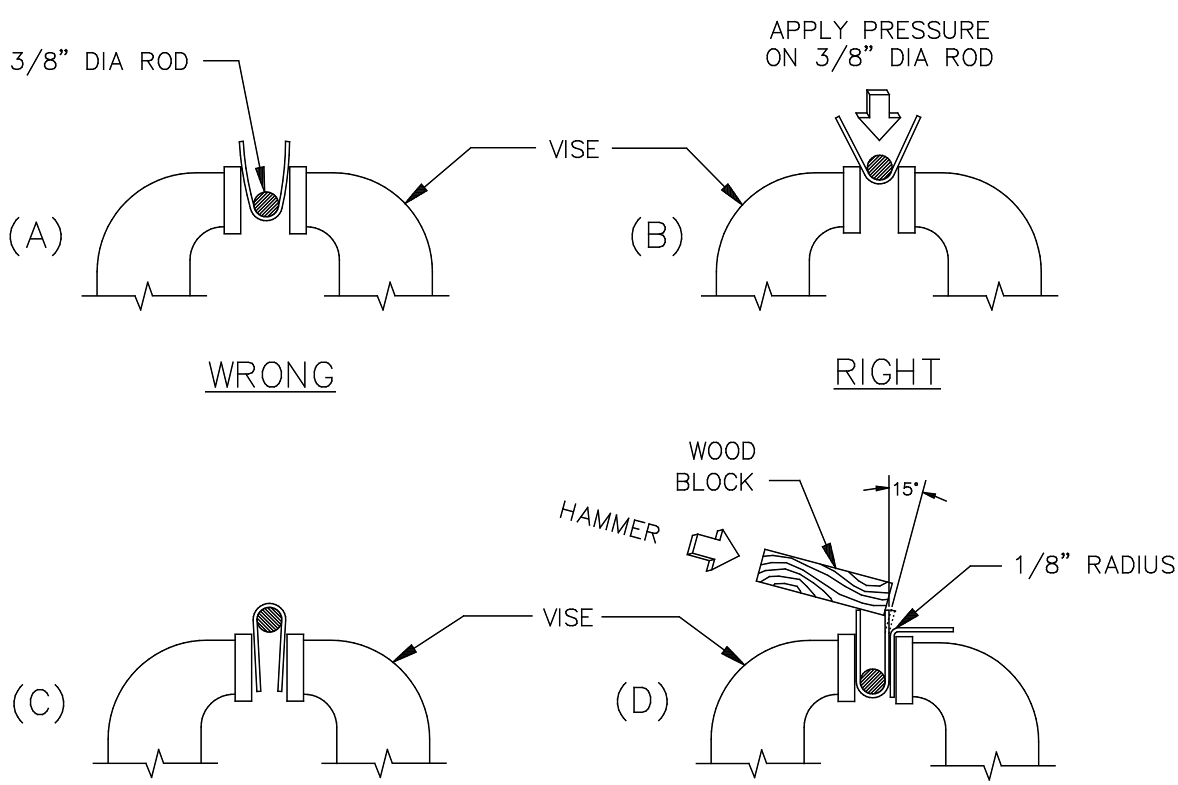

Figure 123: Bending Techniques for Finishing the Dogs

Step 115: Install the Dogs on the Doors

In order to position the dogs properly, it's necessary first to re-hang the doors. Before doing that, however, use coarse sandpaper to roughen a few square inches on the inside of each door frame where the dogs will be mounted.

Next, re-bolt the aft hinge halves to the door, again using the temporary AN315-3R jam nuts. (Ultimately, the aft hinge halves will be secured with more aesthetic **acorn nuts** [64] and AN936A10 **lock washers** [144], but this should await whatever upholstery or interior finish you intend to put on your door panels.) Then reassemble the hinges. Close the door tightly, compressing the door seal until the exterior surface of the door is flush with the exterior surface of the fuselage shell. Use tape or, if necessary, clamps through the door windows to hold the door in tightly against the seal.

Figure 125 shows how the dogs are positioned relative to the latches. Note first that the angled edge of each dog faces inward toward the center of the door. The forward upper dog opens forward, the aft upper opens forward and upward, the center opens downward and the lower opens forward and downward. The upper three dogs are all roughly centered on the width of the door frame, and the lower dog is spaced an equivalent distance inward from the edge of the door.

Check to see that all four latches are still secured in their closed positions—that is, the positions you placed them in Step 112—and then one by one, position the dogs as shown in the figure. Slide each dog against the engaging edge of its respective latch until the latch makes firm contact with the inside of the dog. **Make sure that the end of each latch protrudes slightly beyond it's dog, as shown.** Then, holding the dog in that position, trace around its base with a marking pen. After marking the position of each dog, mark the dog itself so you can be sure to return it to its original position later.

Repeat the process for all the dogs, and then remove the door from the fuselage and lay it inner side up on a bench.

The dogs are first bonded to the door frames with a mill fiber/resin mixture, and then two patches of bi-directional cloth are laminated over the bases of the dogs to provide extra strength. Begin by mixing a small batch of very thick mill fiber/resin mixture, and apply it liberally to the back of the dog. Then position the dog inside the outline on the door frame, pressing it down firmly so that the mill fiber oozes out the bonding holes. Spread this excess over the inside surface of the base, and shape a fillet around the perimeter of the base.

Note Figure 124 was deleted by Revision C.

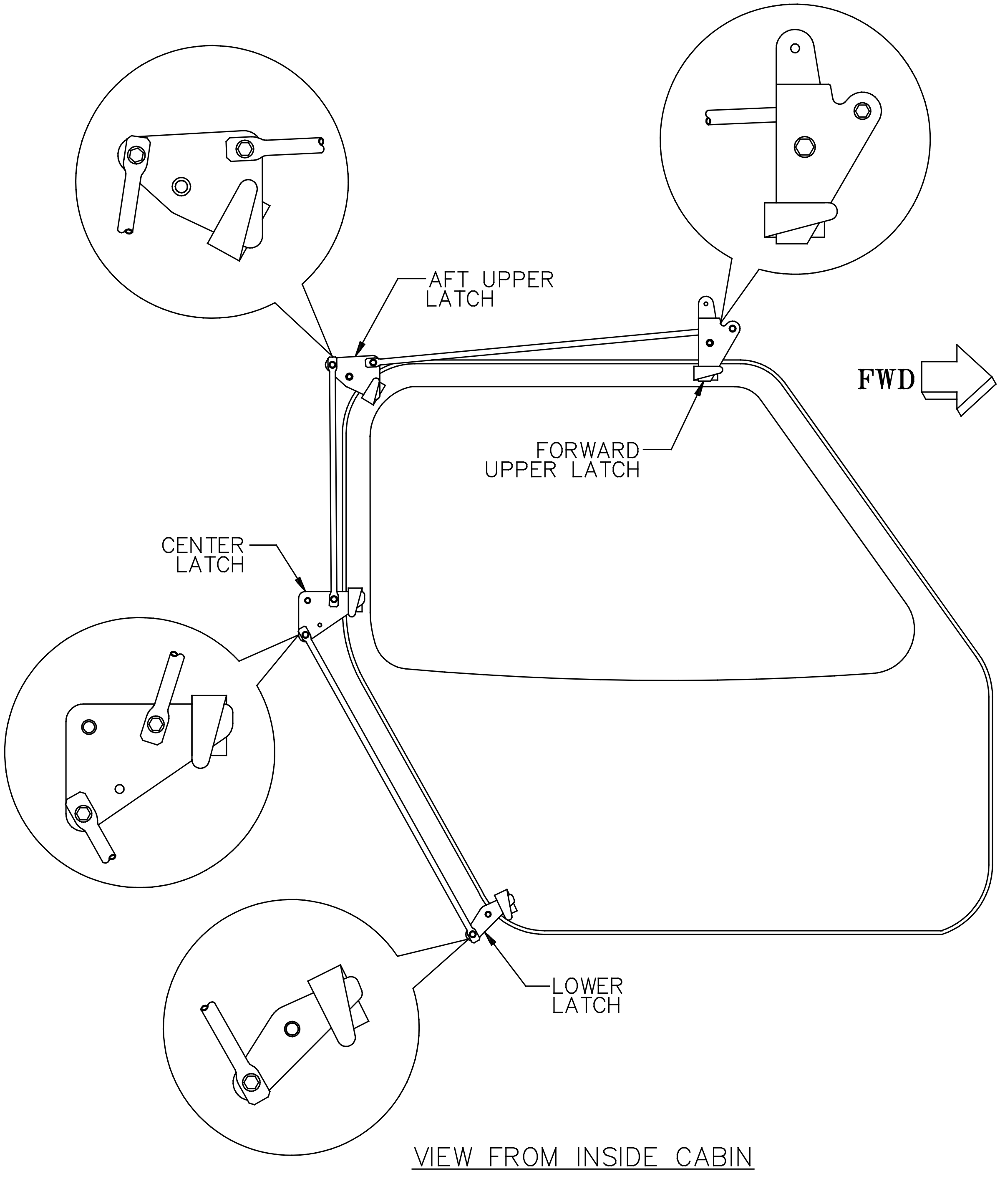

Figure 125: Positioning the Dogs

After you have smoothed down the mill fiber and removed any excess (especially where it oozes through the bonding holes), you can apply the bi-directional laminates. There's no need to wait for the mill fiber mixture to cure. For each dog, cut two **2"-square** pieces of cloth on the 45° bias. As shown in Figure 126, laminate these pieces over the base of the dog, lapping down around the door frame evenly on both sides. However, don't allow the laminates to lap over onto either the inside or outside flanges.

Let the mill fiber and the cloth laminates cure fully. Then sand any rough edges smooth. Be careful when sanding not to sand through to the cloth, especially the exterior layer of cloth on the door itself.

Completed: Left [ ] Right [ ]

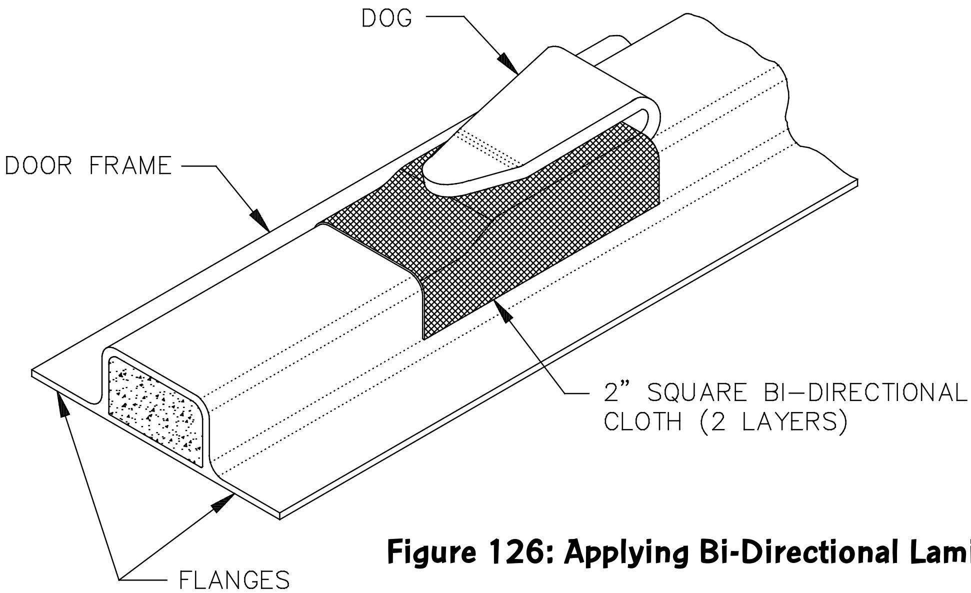

Figure 126: Applying Bi-Directional Laminates to the Dogs

Step 116: Drill the Exterior Door Handle

Re-mount the doors on their hinges, close them tightly against the door seal and move the latches to their fully closed positions. Lock them in place by torquing the nut on one of the pivot bolts. Double check the center latches for proper shimming away from the door seal. Once the **exterior door handle** [31] is drilled, there will be no possibility of adding or removing nylon washers from the latch shaft, so it's got to be right now.

You'll want to drill the exterior handle so that, when the latches are fully closed, it's in its "flying" position—that is, parallel longitudinally with the aircraft waterline. However, you'll be removing the handle and latch shaft from the airplane for drilling, so you need to reference the position of the handle to the latch plate itself. If nothing has changed since your initial set-up of the latches, the upper edge of the center latch plate should be perpendicular to the aft edge of the door cutout, and this is, for all practical purposes, parallel to the waterline (see Figures 117 and 125). Double check now to see that the latch is still in this position. If it has moved a bit, make note of the direction and amount of the change so that you can adjust the relative position of the door handle accordingly.

Next, slide the door handle over the latch shaft and assess the length of the shaft. When the shaft is bottomed out in the handle, the inboard face of the handle should ride on the outboard end of the door latch bushing. You may find it necessary to trim the end of the shaft to achieve this.

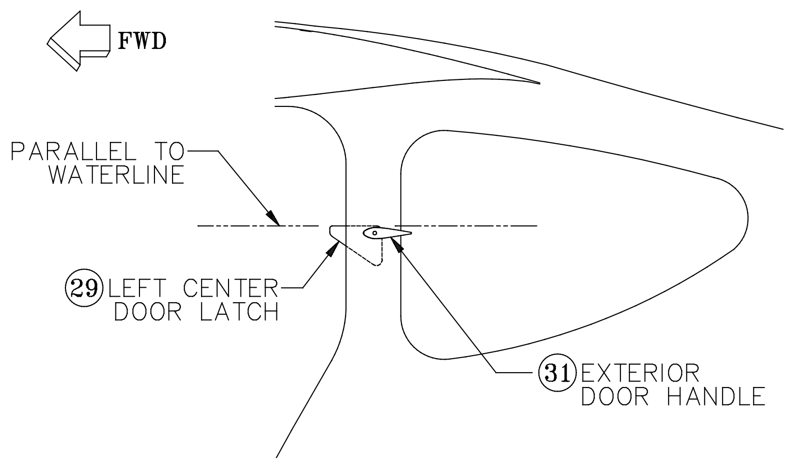

Figure 127: Aligning the Exterior Door Handle

Then have an assistant climb into the cabin and apply firm pressure in the **outboard** direction on the center latch plate. While s/he is doing that, use a sharp scriber to mark the latch shaft where it emerges from the door handle bushing. Mark around the entire circumference of the shaft.

Once the shaft has been marked, unlatch the door and remove the center latch from the fuselage. Leave all the other latches and the pushrods in place.

Figure 128 illustrates the drilling procedure. Use a stack of steel washers on the latch shaft to space the handle the proper distance from the latch plate, as determined by the scribed line indicating where the shaft emerged from the door handle bushing. Use whatever combination of washers is necessary to hold the handle on the scribed line.

Hint Actually, you may want to shim the handle about **1/64"** further **outboard** than the scribed line, just to provide a little extra clearance. Also, be sure **not** to use nylon washers in your temporary shim stack-up; they can be compressed in the vise.

Orient the latch and handle properly relative to one another, and clamp the entire assembly in a vise, as shown in the figure. The latch and handle should be **upside down** so that you'll be drilling into the bottom of the handle.

Note It's easy (but embarrassing) to mistakenly orient the handle 180° off its proper position—that is, with its sharply pointed end forward. Take one more look to make sure this doesn't happen to you!

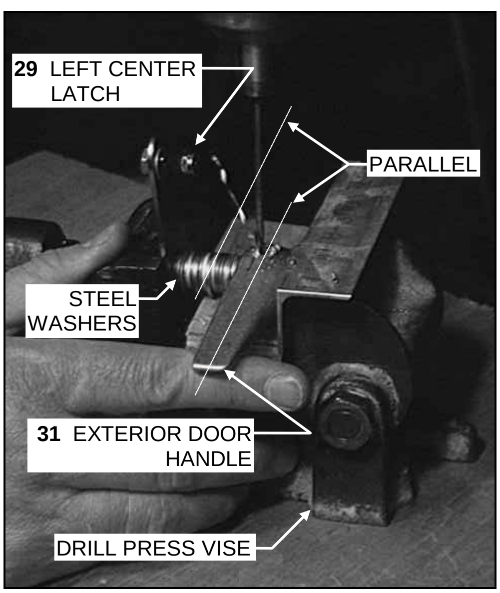

Figure 128: Drilling the Exterior Door Handle

When clamped in place, the longitudinal axes of both the handle and the shaft should be parallel to the base of the vise. And assuming that your latches stayed in their initial closed positions, the **upper** edge of the center latch should also be parallel to the handle, as shown in Figure 128. As discussed above, if there was any discrepancy in the position of your latches when you scribed the latch shaft, adjust the vise so that the same **relative position** between the handle and the latch is maintained.

The handle is secured on the shaft by means of a small roll pin. To accommodate this pin, you must drill a hole all the way through the handle and the shaft. Center punch a hole location on the bottom of the handle that is centered over the shaft and **1/4" outboard** of the **inboard** edge of the handle. Drill through the handle and shaft at this location with a sharp **1/8"** bit.

> **Note** Use of a drill press and drill press vise is **strongly** recommended for this procedure. Although it would be possible to drill the hole successfully with a hand-held drill, it would be extremely difficult, and the odds are good that you'd miss the center of the shaft and/or elongate the hole.

After the hole has been drilled, disassemble the parts and deburr the holes. Mark the handle to distinguish the left-hand one from the right. If you wish, the handles can now be polished with sandpaper of progressively finer grits or with a non-metallic buffing wheel.

> **Note** Do **not** use steel wool on the aluminum handles. Dissimilar-metals corrosion will result from the steel wool residue left on the part.

Completed: Left [ ] Right [ ]

Step 117: Install the Forward Over-Center Spring

A **forward door latch over-center spring** [75.1] installed between the center latch and the upper shell attach fitting, as shown in Figure 129, insures that the doors latch positively. The spring is inserted at its upper end through a small hole drilled in the shell attach fitting; at its lower end it is secured with a bolt. In addition, an **aft door latch over-center spring** [75] will be installed in Step 129 when the shell attach fitting is fastened to the cage tab.

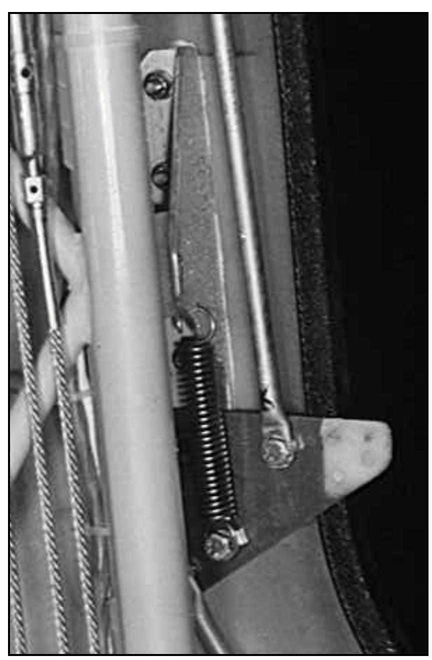

Figure 129: Forward Over-Center Spring

As Figure 130a shows, the **#40** hole for the upper end of the spring is drilled **1/4" outboard** of the **inboard** edge of the upper shell attach fitting. Vertically, the hole should be located as high as possible on the fitting flange while remaining below the cage attach tab. This will provide the maximum spring tension for the most positive over-center effect. Deburr the hole after drilling it.

Figure 130b shows the installation of an AN3-10A **bolt** [111] in the forward-most open hole in the center latch plate. The goal here is to install the bolt so that it sticks out as far inboard as possible. Insert the bolt through two AN960-10 washers, and then thread an AN315-3R jam nut onto the bolt as far as it will go. Next, insert the bolt through the latch plate from the inboard side until the jam nut contacts the plate. Secure the bolt with an AN364-1032A nylon self-locking nut and an AN960-10L thin washer on the outboard side of the latch plate. Thread the locking nut onto the bolt just until the end of the bolt emerges from the nut. Then tighten the jam nut down on the plate from the inboard side.

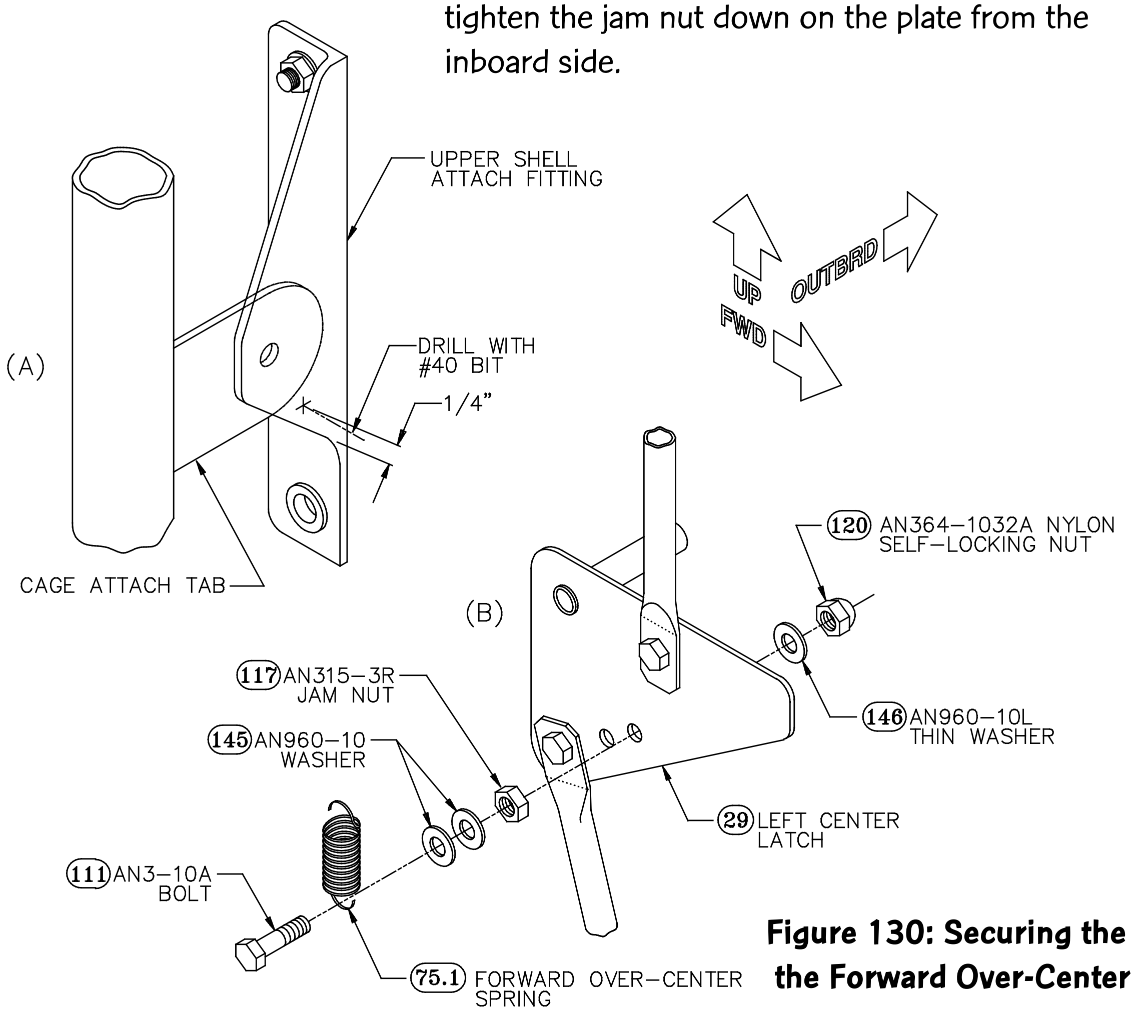

Figure 130: Securing the Ends of the Forward Over-Center Spring

Replace the center latch along with its original stack-up of nylon washers and reconnect the latch pushrods. Install the over-center spring with a pair of needle-nose pliers. At the lower end, the two spacer washers on the AN3 bolt should be **outboard** of the spring. Check to see that they are sufficient to hold the spring clear of the latch when the latch is rotated.

Completed: Left [ ] Right [ ]

Step 118: Final-Adjust the Latches

Re-mount the doors on the hinges for the final time. From inside the cabin, pull the door closed and engage the latches. Push out on the door and check each latch to see if it remains tightly engaged against its dog without tending to back off. If necessary, the latches can be adjusted slightly for better engagement by bending their tips inward or outward.

Completed: Left [ ] Right [ ]

Step 119: Install the Exterior Door Handle and Interior Knob

Slide the exterior door handle over the center latch shaft and line up the holes in the two parts. Drive a **1/8" X 5/8" roll pin** [98] into the hole. There are two methods for doing this. The easiest is probably to use a large pair of channel-lock pliers to mash the pin into the hole. Alternatively, you can use a light hammer and a bucking bar. Hold the bucking bar under the handle and use the hammer to drive the pin.

Finally, install the black plastic **knob** [103] on the inboard side of the forward upper latch. Secure it with an NAS603-7P round-head machine screw; use AN936A10 lock washers under both the screw head and the knob. You have to use either an offset or a stubby screwdriver to gain access to the outboard side of the latch.

Completed: Left [ ] Right [ ]

Step 120: Install the Cabin Door Locks (Optional)

Door Lock/Key Ignition Option Stoddard-Hamilton offers a complete door lock and keyed ignition switch option kit that includes two custom-designed cabin door locks, two baggage door locks and a standard five-position aircraft ignition switch, all of which use the same key. The kit also includes all installation hardware (excluding electrical supplies), two duplicate keys and detailed instructions. Order P/N 921-03000-01.

If you're installing the Door Lock/Key Ignition Option Kit, **turn to the *Option Instructions* now**. Return to Step 121 of this *Assembly Manual* when the specified option steps have been completed.

☞

Completed: Left [ ] Right [ ]

Step 121: Final-Fit the Cabin Doors

Now you can sand the doors as necessary to get the best possible exterior fit. Aim for a uniform gap between the door and the cutout of between **1/16"** and **1/8"** all the way around.

Completed: Left [ ] Right [ ]

Step 122: Trim the Baggage Door Hinge

The baggage compartment door is hinged on piano hinge. Remove the pin from the **19" length of rolled hinge and pin** [163] supplied with the kit, and separate the two halves. Cut one of them to **18"** with a hacksaw or bandsaw, positioning the cuts at each end roughly in the middle of a "knuckle," as shown in Figure 131. Then **invert** the other half of the hinge, as shown in the figure, and cut it to a matching length. Sand or file the cut ends smooth.

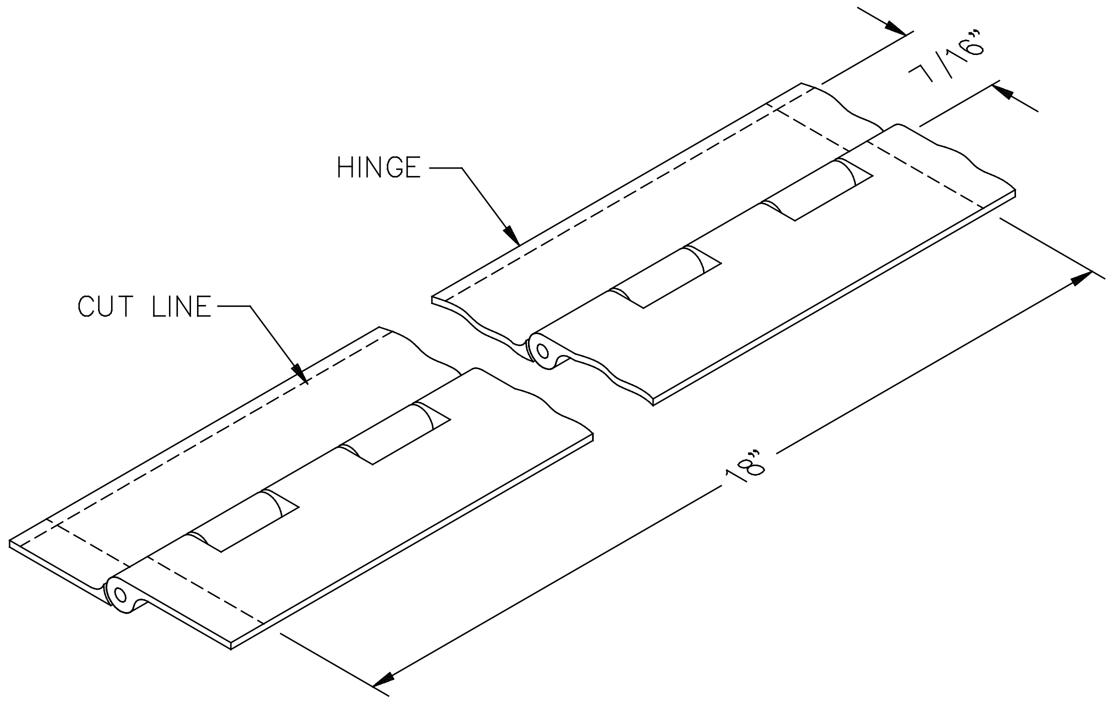

Figure 131: Trimming the Baggage Door Hinge

One of the hinge halves must also be trimmed to a narrower width. As shown in Figure 131, cut the hinge half down to a width of **7/16"**, measured from the center of the pin hole. You can use a bandsaw, a body file or even a belt sander to remove this material. Just be sure to leave a smooth, deburred edge when you're done.

Finally, using a heavy-duty bolt cutter or a hacksaw, cut the hinge pin to a length of about **18-1/2"**. Use a bench grinder to slightly taper one end of the pin and put a **1/2"**, **90°** bend in the other end.

Completed: [ ]

Step 123: Position and Drill the Fuselage-Side Baggage Door Hinge

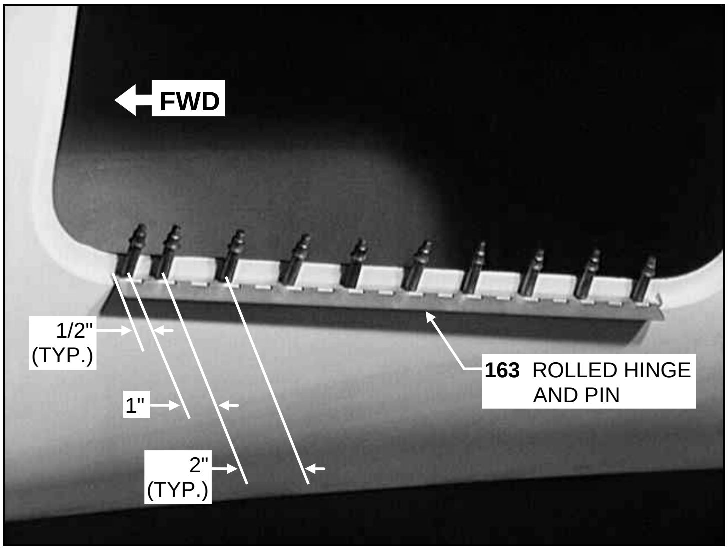

Figure 132: Positioning the Baggage Door Hinge

Figure 132 shows how the hinge is positioned inside the cutout. Before positioning the hinge, mark and center punch **ten** rivet hole locations on the **narrower** hinge half. These locations should be centered on the width of the flange, and the forward- and aft-most of them should be **1/2"** from the ends. Between the end hole locations, the spacing of the remaining eight locations is not critical. Figure 132 shows all the locations on 2" centers, except for the forward-most pair, which are 1" apart; you may prefer to space them evenly along the entire length, which means using an interval of about **1-7/8"**. In any case, the rivets driven in these holes will be hidden by the door seal when the installation is complete.

The exact left-and-right position of the hinge isn't too critical— simply center it by eye between the forward and aft ends of the baggage door cutout. In the inboard/ outboard direction, the inboard edge of the hinge half (i.e., the edge you trimmed) should be snug against the flange of the cutout.

Note Be sure the hinge is right-side up. This means that the bulb of the inboard half curves upward and the outboard downward. Refer back to Figure 131 for clarification.

Hold the inboard hinge half in position in the cutout (or, if you prefer, use the whole, assembled hinge, as shown in the figure) and drill through the hinge flange and into the fuselage with a **#30** bit. There is a high-density filler material under the exterior fiberglass laminates, so you'll have to drill to a depth of about **3/8"** in order to accommodate the blind rivets you'll use to secure the hinge. Cleco these holes as you go, and leave the Clecos in place after the drilling is completed.

Completed: [ ]

Step 124: Mark and Drill the Baggage Door

The lower edge of the **baggage door** [6] must be notched slightly to make room for the bulb of the hinge. Fold the outboard hinge half upward so that it's vertical and resting against the Clecos, as shown in Figure 133. Then fit the baggage door into the cutout. Of course, the door won't fit the cutout yet in the vertical direction because the hinge is in the way, and the door may be slightly too wide to fit side-to-side as well. Final sanding of the door to fit the cutout is best left till the very end of the installation, however, so at this point, sand only the minimum amount necessary from the sides to allow the door to fit into the frame side-to-side. Then slide it down until its lower edge is resting on the hinge bulb, as shown in the figure.

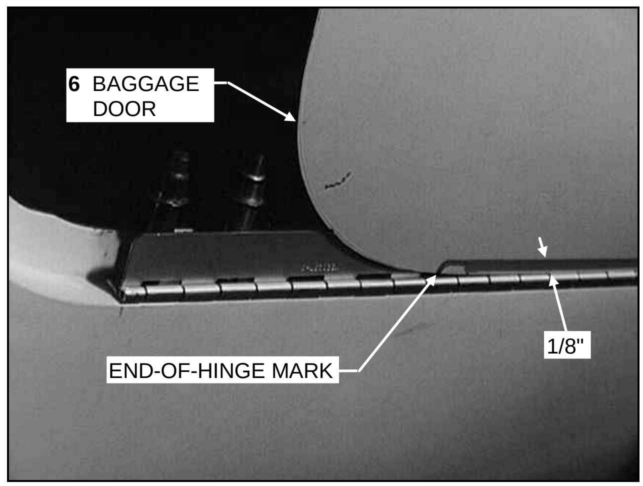

Figure 133: Marking the Baggage Door for Trimming

> **Note** In Figure 133, the baggage door is being held to one side simply so that the vertical position of the door-side hinge half against the Clecos can be seen. Don't let this mislead you from following the positioning directions in the text.

With the door positioned in this way, make a mark along the lower edge of the door at each end of the hinge, as shown in Figure 133. Remove the door and use a rotary cutter or sanding drum in a drill or die grinder to remove a strip of material between these marks about **1/8"** wide. Trial fit the door once again and sand or trim as necessary to get a good fit around the hinge bulb. (At this point, the door should be fitting all the way into the cutout so that it is flush with the fuselage shell all the way around its perimeter.)

When you're satisfied, mark **fifteen** rivet hole locations on the outside of the door. These marks should all fall on a line **3/16"** above the bottom edge of the door **where it touches the hinge**—not at the corners. The forward- and aft-most holes should be about **1/2"** in from the ends of the hinge, and the intervening holes should be evenly spaced; intervals of slightly less than **1-1/4"** will work best.

You will drill these holes with the door in place in its cutout. The Clecos holding the fuselage-side hinge half will help hold the door-side half tightly against the door, but you may find it helpful to slip a thin 18" strip of scrap wood or metal in between the Clecos and the door-side hinge. This will guarantee that the hinge is tight against the door.

With this strip in place, close the door on the hinge and drill on the marks with a **#40** bit, Clecoing as you go. Obviously, you'll want to take care not to drill into the Clecos, so start with a couple holes that fall between them, and then (once the door is Clecoed to its hinge half in a couple places) juggle the fuselage-side Clecos as necessary to keep them clear of the bit. Also, use a drill stop to prevent drilling into the fiberglass door frame flange.

> **Note** Take great care to hold the drill steady while drilling these holes; it's easy to inadvertently enlarge the holes in the door while drilling through the hinge flange.

When the drilling is completed, remove both hinge halves and deburr all the holes. Countersink the holes in the door on the outside surface to accommodate flush-head rivets.

Completed: [ ]

Step 125: Rivet the Hinge Halves

Rivet the fuselage-side hinge half in place with 1/8" AAPQ-42 blind rivets. These rivets will displace some of the filler material inside the fuselage shell and grip the outer fuselage laminate.

Use 3/32" AN470AD3 flush-head rivets to rivet the door-side hinge to the door.

Completed: [ ]

Step 126: Install the Baggage Door Seal

Using the same techniques you used to install the seal around the cabin doors, install the leftover seal around the baggage door. Once again, compress the seal as much as you possibly can in a lengthwise direction. When you've completed one circuit, cut off the remaining seal **3/4"** over-long and try to work this excess in. As with the cabin doors, the seam should be in the lower aft corner of the baggage door.

Completed: [ ]

Step 127: Final-Fit the Baggage Door

Re-assemble the fuselage- and door-side hinge halves, letting the door hang down. Tuck the bent end of the hinge pin under the rubber door seal; this is all the retention it needs.

> **Note** You may need to grind a little bit off the bent end of the pin in order to get it to fit neatly under the seal.

Now close the door tightly against the seal and check the clearance between the edge of the door and the frame all the way around. Sand as necessary to achieve a uniform gap of between **1/32"** and **1/16"**.

Completed: [ ]

Step 128: Install the Baggage Door Latches

To remain securely closed in flight, the baggage door must be latched at both the forward and aft upper corners. Install latches that pull the door in tightly against the rubber door seal so that the door fits flushly with the outside of the fuselage shell.

Door Lock/Key Ignition Option On our prototype, the door is latched with a pair of cabinet-style, cylindrical key locks. These locks are included in the Door Lock/Key Ignition Option Kit.

If you're installing the lock/ignition switch option, **turn to the option instructions now**. Return to the "TOP DECK INSTALLATION" sub-section of this *Assembly Manual* when the specified option steps have been completed.

☞

Completed: [ ]

TOP DECK INSTALLATION

The fiberglass **top deck** [1] spans the area between the upper wing surfaces to close out the fuselage above the cabin. Incorporated into the deck are two Plexiglas skylights that provide visibility in turns and two removable hatches that open to provide space for the inboard ends of the flaps when the wings are folded. Drain pans that keep rain out of the fuselage when the wing-fold hatches are open are available as an option. The wings must be installed on the airplane in order to fit the deck to the fuselage.

Note It's not necessary to bond in the Plexiglas **skylights** [26] before installing the deck, but it may be somewhat easier in the long run to do so. The overhead cage tubes make it more difficult (but not impossible) to wipe up excess window bonding adhesive if the deck is installed first. Refer to the "WINDOW INSTALLATION" sub-section below if you wish to bond in the skylights now. If you do bond in the windows first, of course, you will have to be more careful handling the deck during installation to avoid scratching the Plexiglas.

Step 129: Adjust the Fit of the Fuselage Shell to the Wing

The wing-root areas of the fuselage shell may require some adjustment to achieve a good match-up with the inboard ends of the wing. First, there should be a uniform gap between the lower wing skin and the lower edge of the wing-root area of the shell, as shown in Figure 134.

Ideally, this gap should be between **1/16"** and **3/16"** wide, but you have limited means at this stage to adjust this. One thing you can do fairly easily is to even the gap from the forward to the aft end by adjusting the shell relative to the uppermost cage attach tab on the diagonal tube just forward of and below the leading edge of the wing root area. (These tabs were labeled Tabs 1 and 2 in Figure 19 of "SECTION VIII: FUSELAGE ASSEMBLY." Refer back there to refresh your memory, if necessary.) If the wing root area is **further** away from the wing skin at its forward end than at its aft, then simply remove the machine screw through the cage tab and insert one or more nylon washer shims between the tab and the shell. This will push the shell **outboard**, evening the gap.

If the wing root area is **closer** to the wing skin at its forward end than at its aft, then you can relieve the fuselage shell under the attach tab so that the screw pulls the shell **inboard**, evening up the gap. If necessary, refer back to Steps 16—18 and Figure 15 of "SECTION VIII: FUSELAGE ASSEMBLY" to refresh your memory on this procedure.

Note If you cut through the inner fuselage laminates to relieve the shell, replace them with a small, single-layer laminate of bi-directional cloth over the relieved area.

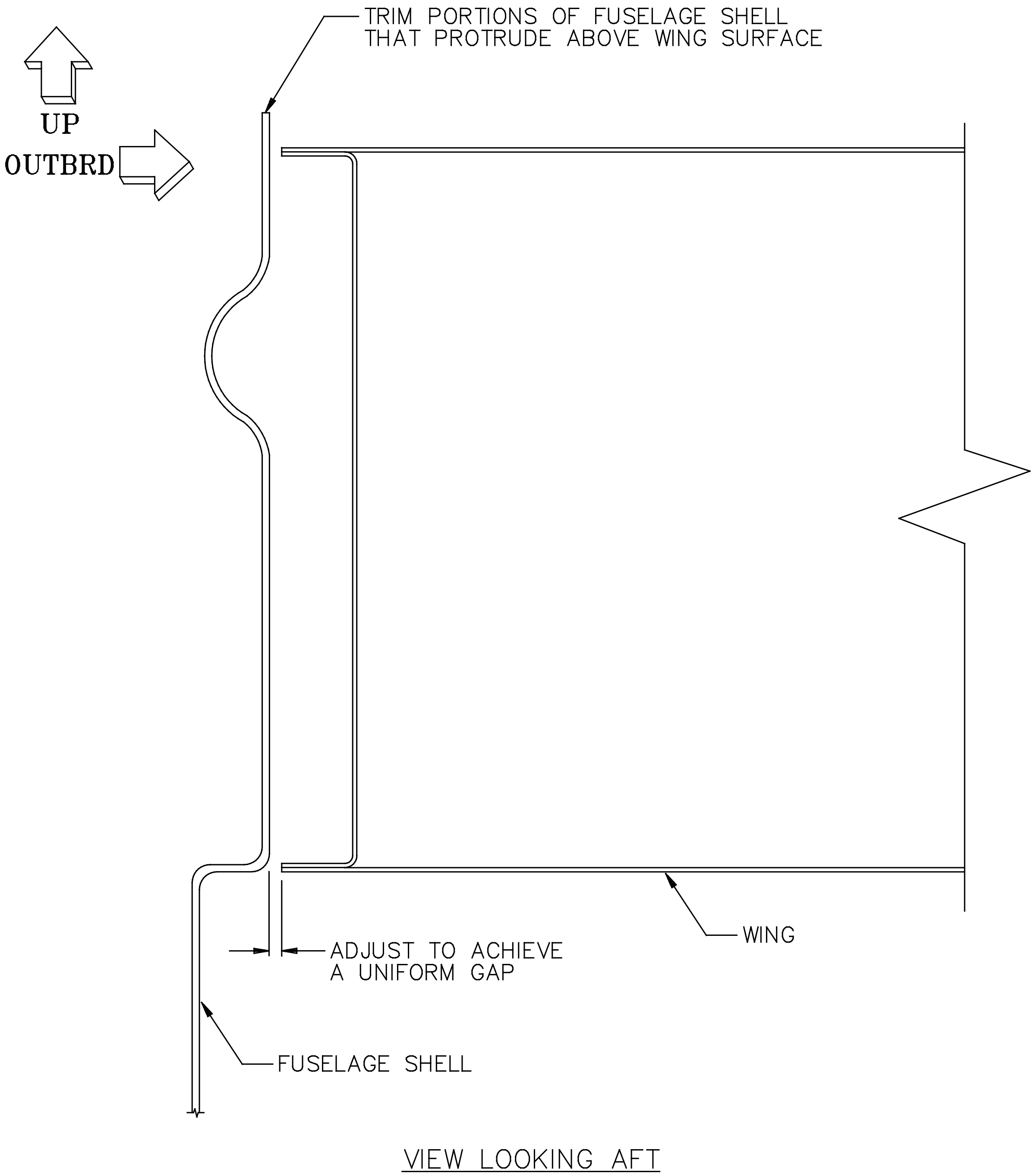

Figure 134: Adjusting the Fuselage Shell Wing-Root Areas

In "SECTION VIII: FUSELAGE ASSEMBLY," you were instructed to delay drilling the cage attach holes through the upper and lower shell attach fittings in order to allow the shell to flex a bit if necessary; this flexibility provides a second means to adjust the gap between the wing-root areas of the shell and the wing. Flex the shell inboard or outboard as necessary to achieve a uniform gap and then clamp it in place with a C-clamp on the upper shell attach fitting and its cage tab.

Note Be sure the door is securely latched when performing this adjustment.

Hint Keep in mind that the reasons for striving for an even gap are almost entirely aesthetic. If the existing gap is uneven, you'll have to decide for yourself how much effort it's worth expending to fix it. Any difference in flying characteristics will be negligible.

When everything is set, use a **1/4"** bit to drill through each cage tab and fitting, using the pilot hole in the tab as a guide, as shown in Figure 135. Deburr these holes carefully.

Secure the **lower** fittings to the tabs with AN4-5A bolts, AN960D416 aluminum washers and AN364-428A nylon self-locking nuts. The bolt head should be against the cage tab.

As shown in Figure 134.1, secure the **upper** fittings with AN4-11 bolts, eight AN960D416 washers (one under the head and the rest under the nut) and an AN364-428A nut. Install these bolts with the heads forward and the cotter pin holes horizontal. Install the aft door latch over-center spring attach hardware in the center door latch plate, as shown in Figure 134.1 and as described previously in Step 117 for the forward spring. Install the aft spring between the two bolts.

A final adjustment is to trim the upper edges of the shell wing-root areas even with the upper surface of the wing, as Figure 134 shows. Use a straightedge on the upper wing skin to identify areas of the fuselage shell that protrude above the upper wing surface. Trim all such areas until they are even with the wing surface.

Completed: Left [ ] Right [ ]

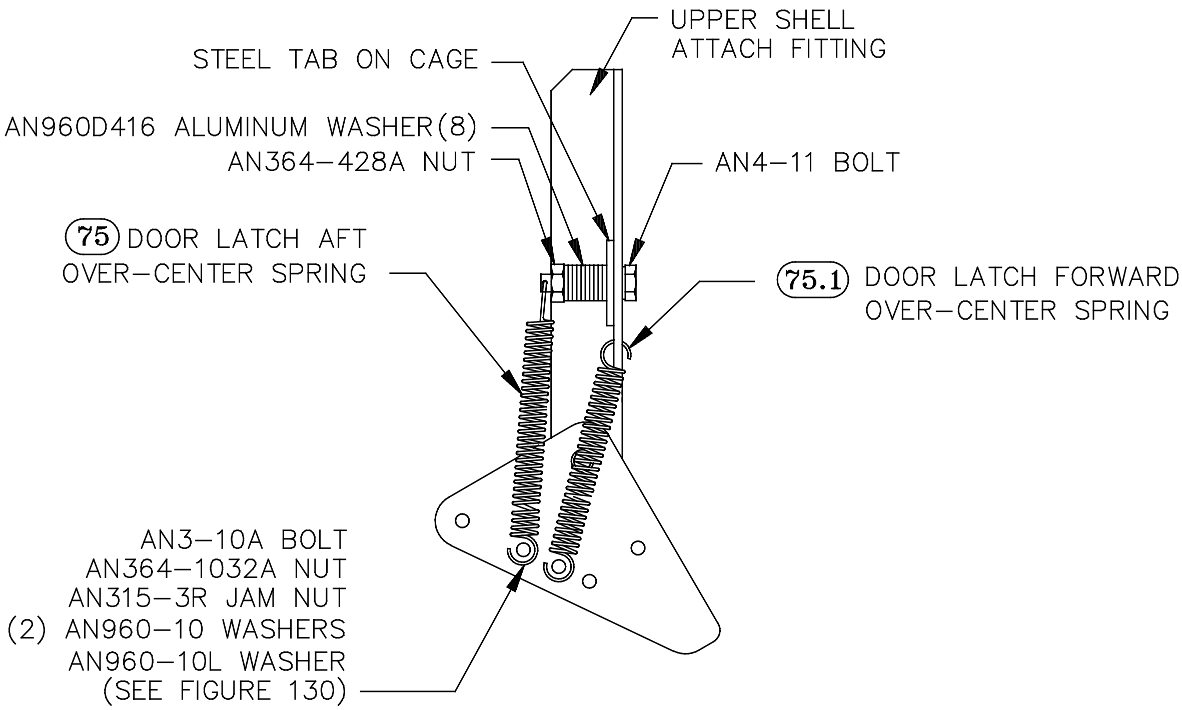

Figure 134.1: Aft Over-Center Spring Installation

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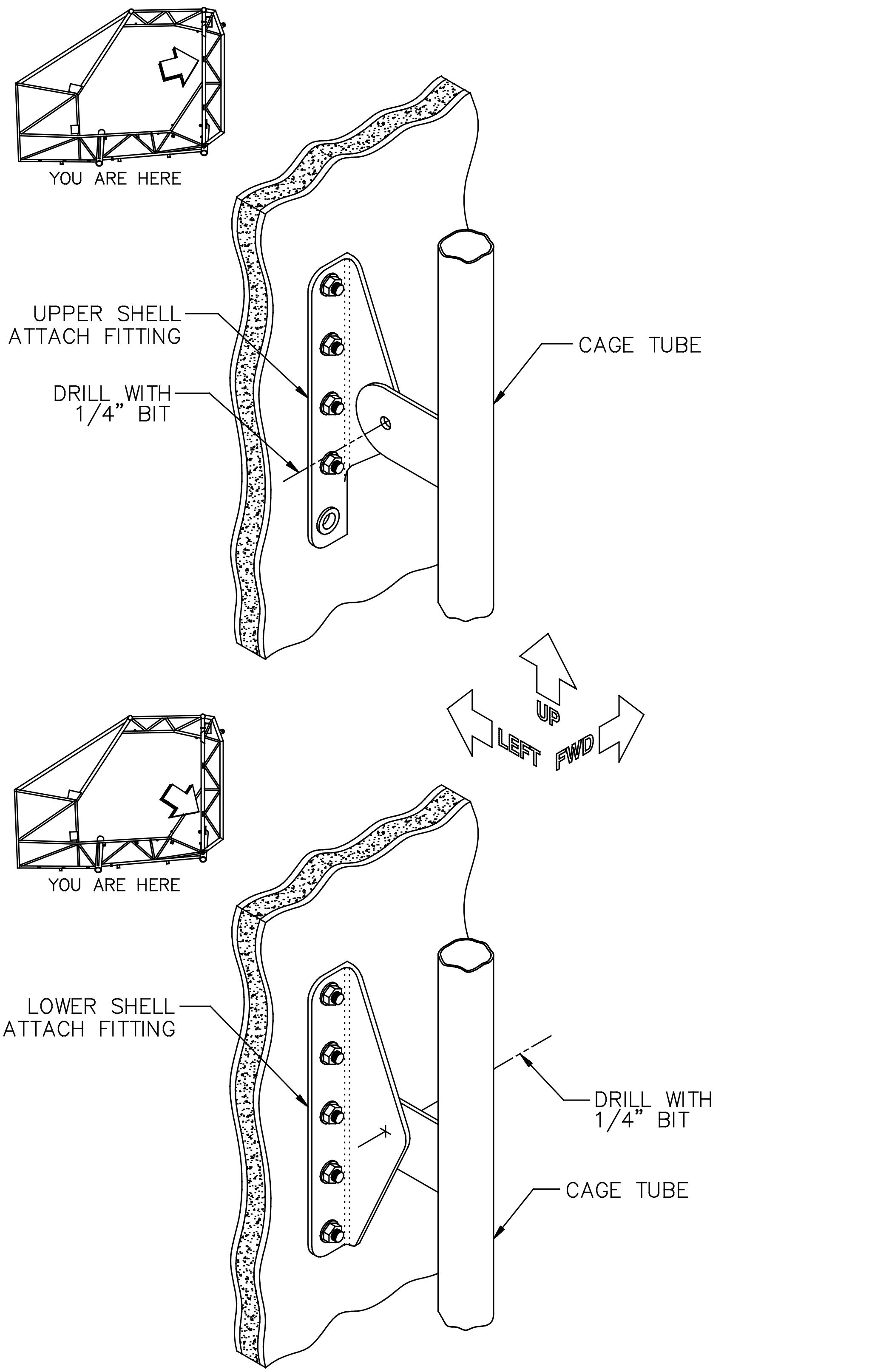


Figure 135: Drilling the Final Holes in the Shell Attach Fittings

Step 130: Cut Slots in the Top Deck for the Fuselage Lifting Eyes

As shown in Figure 136, slots must be cut in the top deck for the lifting eyes on the cage to protrude through. Cut the slots **1/4"** wide by **1-1/2"** long to start, and center them **3"** in from the outboard edges of the deck with their forward ends **1-1/2"** aft of the windshield joggle, as shown. The slots will be enlarged as necessary during the deck fit-up procedures in the next step.

Note The gaps around the lifting eyes can be sealed with silicone caulking after the airframe has been painted. If you want to keep the size of these gaps absolutely as small as possible, study the next step for an understanding of the goals to achieve in fitting the deck to the fuselage. You can then place the deck in its approximate position and mark the locations of the lifting eyes onto its underside before cutting the slots.

Completed: [ ]

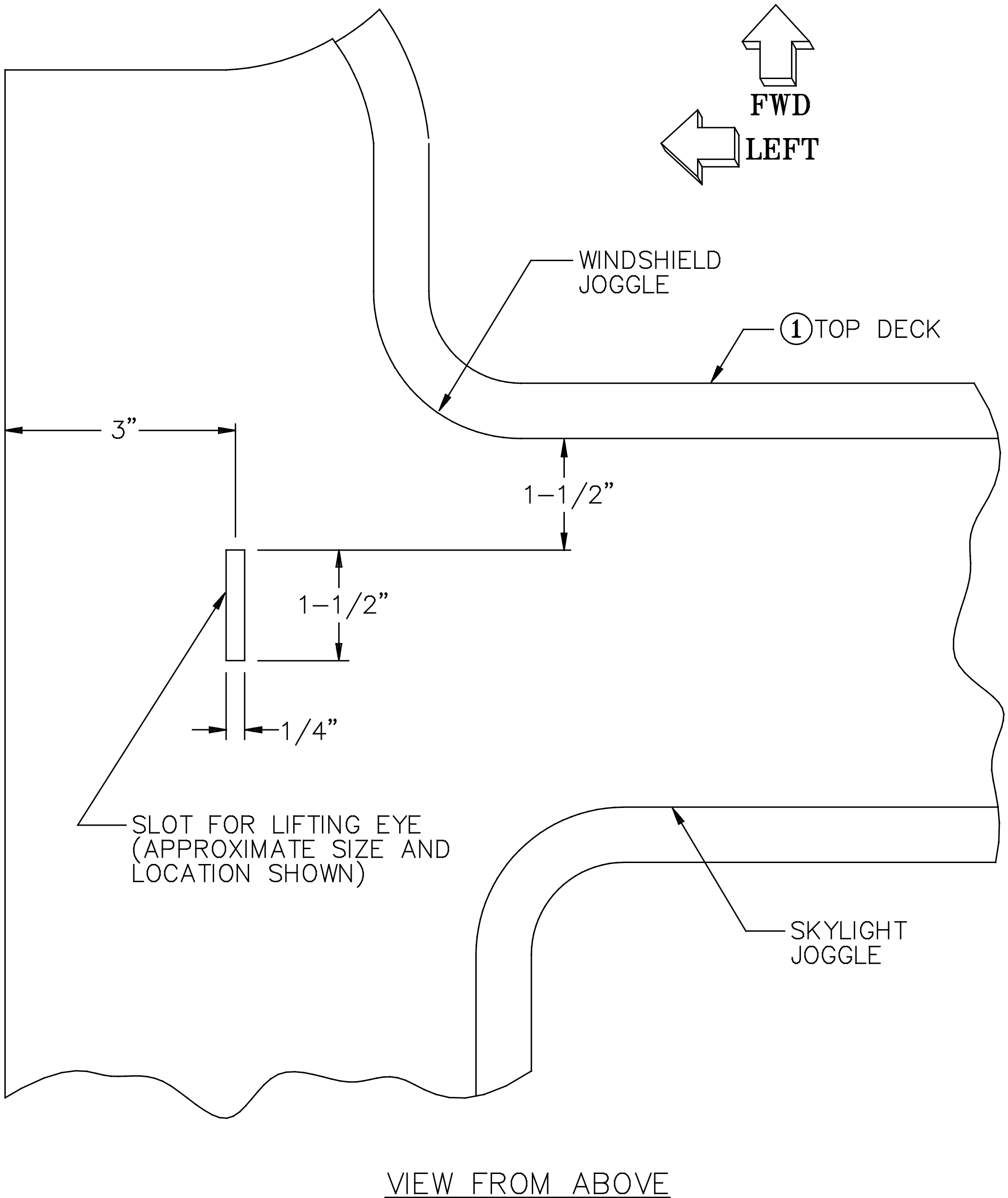


Figure 136: Cutting the Lifting-Eye Slots in the Top Deck

Step 131: Fit the Top Deck to the Fuselage

In fitting the top deck to the fuselage, keep the following main goals in mind:

A) The left and right wing leading edge areas of the deck must mate with the corresponding wing leading edge areas of the left and right fuselage shells.

B) There should be a uniform gap of between **1/16"** and **3/16"** between the deck and the inboard edges of the wing skins when the installation is complete.

C) The narrow aft portion of the deck must be approximately centered laterally on the fuselage so that the wing-fold hatches will fit the resulting recesses.

Begin by marking a centerline down the narrow aft portion of the deck, as shown in Figure 137. Place the deck on top of the fuselage and shift its position as necessary to align its leading-edge areas with the corresponding leading-edge areas of the fuselage shells and to center the narrow aft portion between the fuselage sides at the rear. Enlarge the lifting eye slots as necessary to accomplish this.

Note The aft end of the deck will initially overlap the outside of the fuselage and will be trimmed, in a later step, to match the joggle in the fuselage shell. When centering the aft end of the deck, **don't** use the fuselage seam as a reference; the fuselage seam is often not the true centerline.

Next, check the fit of the **left** [4] and **right upper wing-fold hatch halves** [5] in the recesses of the fuselage shell and top deck. With the aft end of the deck properly centered, the hatches should fit fairly well; if not, adjust the position of the deck to achieve the best fit.

When satisfied with the deck position, mark the edges of the aft end of the deck onto the fuselage shell so that the deck can be replaced in exactly the same position. Also, mark lines for trimming the sides of the deck as necessary to achieve the specified **1/16"–3/16"** gap between the deck and the upper wing skins. Remove the deck and trim it to the marked lines.

Completed: [ ]

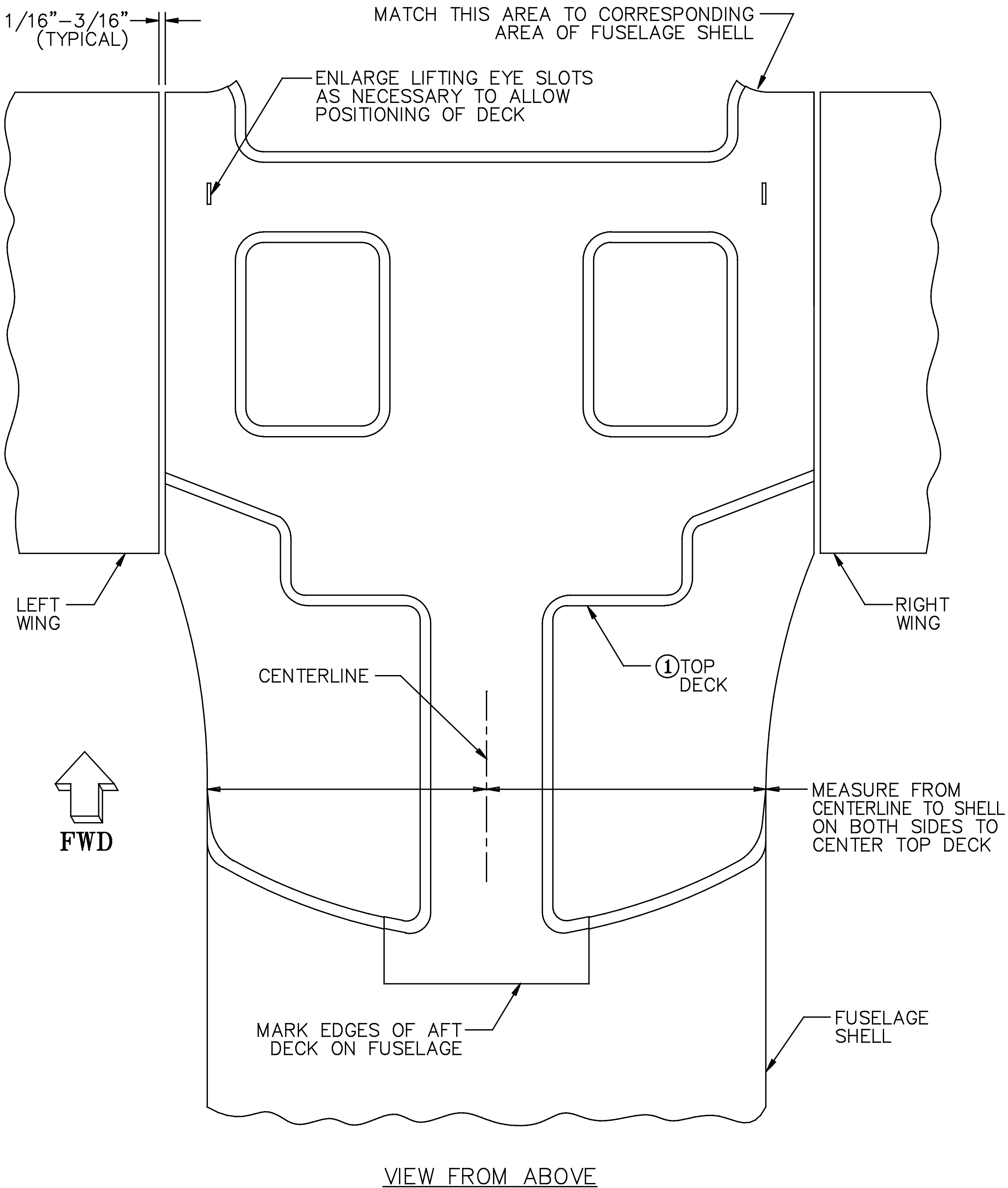


Figure 137: Fitting the Top Deck to the Fuselage

Step 132: Drill Holes for Securing the Top Deck to the Cage

The top deck is fastened to tabs on the fuselage cage in eight places, as shown in Figure 138, using similar procedures to those used in "SECTION VIII: FUSELAGE ASSEMBLY" for fastening the fuselage shells to the cage. If the deck is too **low** relative to the upper wing skins, its position can be adjusted with the same plastic washer shims used on the rest of the cage tabs.

If the deck is too **high** relative to the wing skins without any shim washers in place, it must be lowered by grinding away the inner laminates and foam core, using the standard procedure of re-laminating over all the relieved areas with one layer of bi-directional cloth.

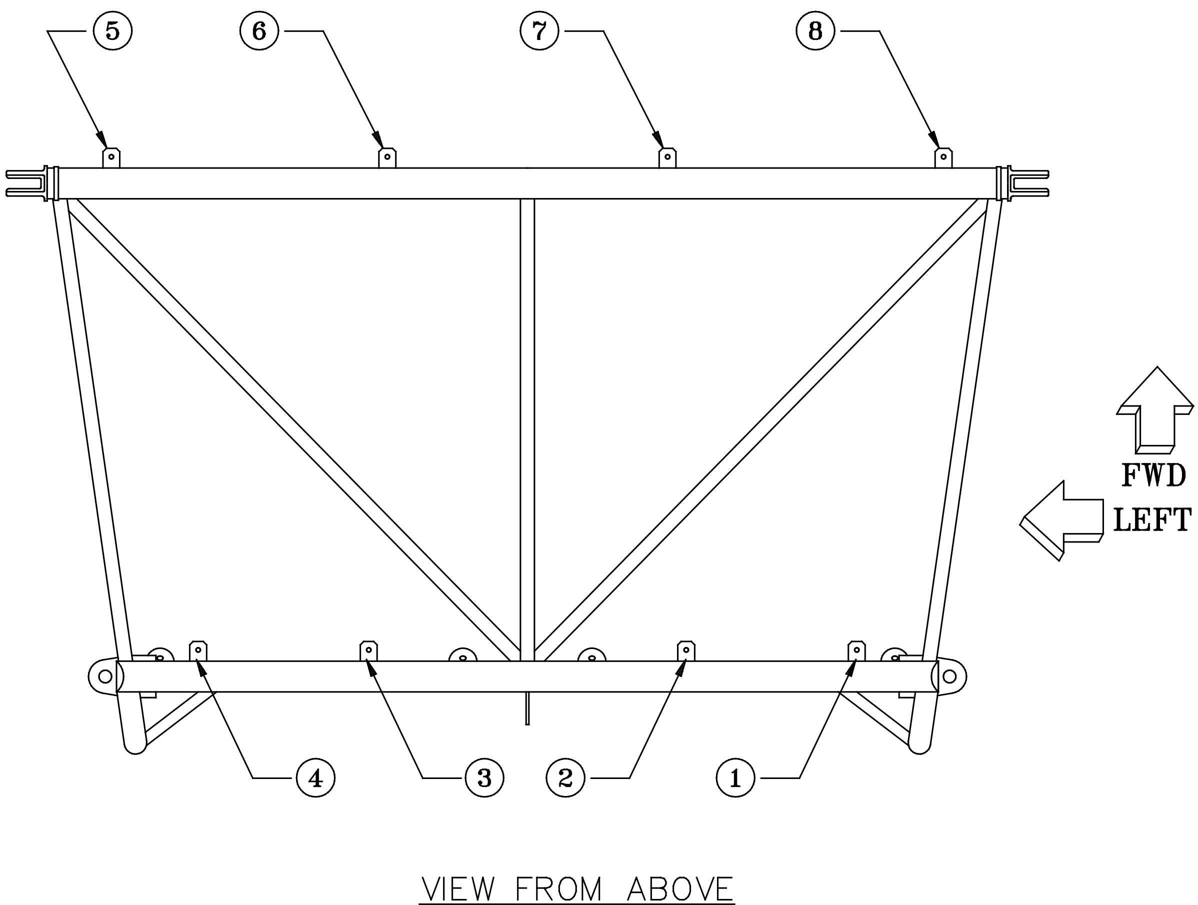


Figure 138: Cage Attach Tabs for the Top Deck

Hint If relieving the inside of the deck is required, grind a little deeper than necessary. It's a lot easier to add a shim washer than it is to repeat the grinding and laminating procedures twice.

When any necessary relieving of the inside of the deck has been completed, place the deck in position on top of the fuselage shell. Tape the deck to the fuselage shell in the wing leading edge areas and also where the narrow aft portion of the deck contacts the shell. Make sure the deck is positioned with the proper **1/16"–3/16"** gap between the wing skins and the outboard edges of the deck.

Use the holes in the cage tabs as guides to drill **#10** holes through the deck's **inner laminates only**. Then remove the deck and use the procedures described in Step 19 of "SECTION VIII: FUSELAGE ASSEMBLY" to provide Q-cell hard points at each hole. After the resin/Q-cell mixture has cured, drill all the way through the deck with a **#10** bit, and then use a #10-piloted cutter in a microstop countersink tool to countersink the holes on the outside of the deck for AN507-10 screws. Replace the deck on the fuselage and insert a screw of the appropriate length into each of the four corner holes; use the necessary nylon shim washers to hold the upper surface of the deck flush with the wing upper surfaces.

Note You should still be drawing on the supply of AN507-10R16 and -10R20 **flush-head machine screws** [131 and 132] left over from "SECTION VIII: FUSELAGE ASSEMBLY" for this procedure.

Completed: [ ]

Step 133: Fit the Aft End of the Top Deck to the Fuselage Shell Flange

With the aft end of the deck overlapping the fuselage shell, mark the locations of the forward and aft edges of the fuselage shell flange onto the deck, as indicated in Figure 139. Remove the deck and trim it, as shown in the figure, to fit cleanly into the joggled flange. Leave the underlying flange itself intact.

In preparation for bonding, sand the joggled fuselage flange to remove all the gelcoat in the area where the aft end of the deck mates against it. Also, if necessary, sand the **underside** of the aft end of the deck to a uniform thickness so that the upper surface of the deck will be flush with the upper surface of the fuselage after bonding.

Completed: [ ]

Step 134: Bond the Top Deck to the Fuselage Shell

Now that all the fit-up details are complete, the top deck is ready to be bonded to the fuselage shell.

Cut the following pieces of bi-directional cloth on the 45° bias:

A) For the left and right **leading-edge seams**, cut two **1" X 5"** pieces and two **2" X 5"** pieces. This is enough cloth for a two-layer laminate on each side.

B) For the left and right **side seams**, cut two **1-1/2" X 7"** pieces and two **1-1/2" X 18"** pieces. A one-layer laminate will be applied on each side, with the 7" strips used forward of the forward wing spar cutout and the 18" strips used aft of it.

C) For the **aft seam**, cut one **1" X 7"** piece, one **1-1/2" X 7"** piece, one **2" X 7"** piece and one **3" X 7"** piece. This will be a four-layer laminate.

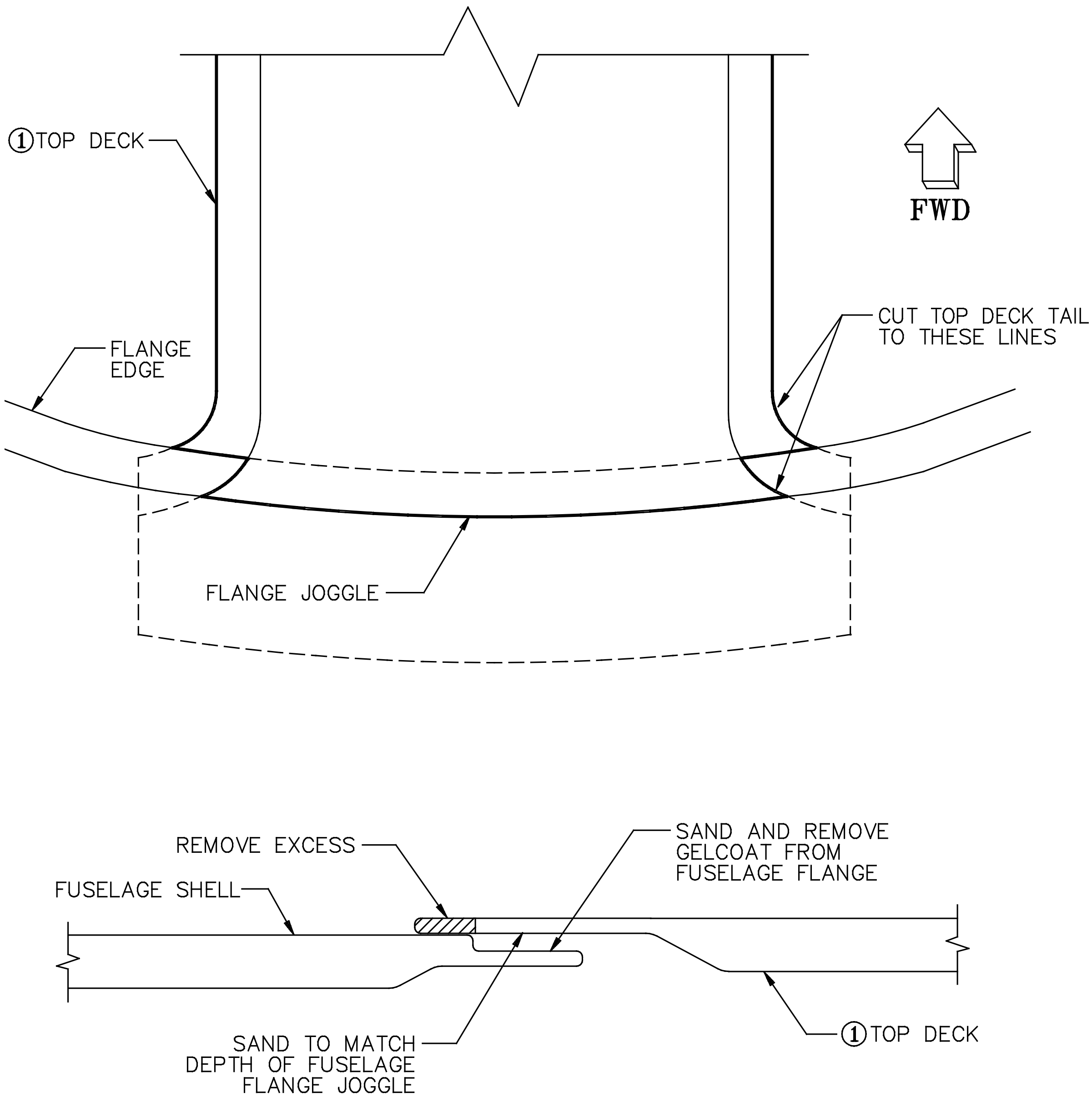


Figure 139: Trimming the Aft End of the Top Deck to Fit the Fuselage Flange

Place the deck in position on top of the fuselage shell for the last time. Secure the deck to the fuselage cage using all eight AN507-10 flush-head screws with their nylon shim washers, AN960-10 or -10L washers and AN364-1032A nuts. Use masking tape applied on the outside to tape the leading edge seams on both sides of the wing. Also tape the sides of the deck to the upper edges of the fuselage shell wing root sections on both sides. (Temporarily fold the wings back, one side at a time, to allow taping the side seams.) Use spacers between the deck and the wing roots, if necessary, to maintain a uniform gap while the seam laminates cure.

> **Note** In order to achieve good alignment between the outboard edges of the top deck and the upper and leading edge wing skins, it may be necessary to tolerate some degree of gap between the leading edges of the deck and the wing-root areas of the fuselage. Don't worry if this proves necessary; any gaps can easily be bridged by the seam laminates and filled with body filler for a smooth surface finish.

Mix up a small batch of resin. Take a small portion of the resin batch and make a thick resin/mill fiber mixture for bonding the aft end of the deck to the fuselage flange. Pry up the aft end of the deck and apply a small bead of the mill fiber mixture to the joggle, and then lower the end of the deck down into place, clamping it lightly to hold it while it cures. Clean up excess mill fiber mixture that squeezes out.

Use the remaining resin to saturate all the seam laminates. Note that **all** the laminates are laid up **inside** the fuselage. For the leading edge seams, first laminate the 1" X 5" piece on each side and then the 2" X 5" piece. For each of the side seams, laminate the single 1-1/2" X 7" and 1-1/2" X 18" plies on the inside of the corner between the deck and the wing root portions of the fuselage shell (access for laminating these pieces is somewhat difficult; do the best you can to get the laminates in place smoothly without air bubbles or wrinkles). Apply the aft seam laminates on the inside of the fuselage over the joint between the deck and the fuselage flange, starting with the narrowest ply and increasing the width with each successive laminate.

Trim the laminates at the edges of the parts when the resin reaches green cure. When the laminates have cured completely, sand any remaining roughness at their edges and remove the tape securing the seams on the outside.

Completed: [ ]

Step 135: Install the Upper Aft Shell Attach Fittings

In Step 11 of "SECTION VIII: FUSELAGE ASSEMBLY," you fabricated twelve aft shell attach fittings from .125" X 1" X 1-1/2" aluminum angle stock. Six of these were used for the lower aft shell attach fittings, as described in Steps 29–31 of SECTION VIII; four more were used to anchor the aft ends of the fuselage struts, as described in Step 85 of the same section. The remaining two fittings will be used here to anchor the upper center fuselage cage tab to the just-installed deck.

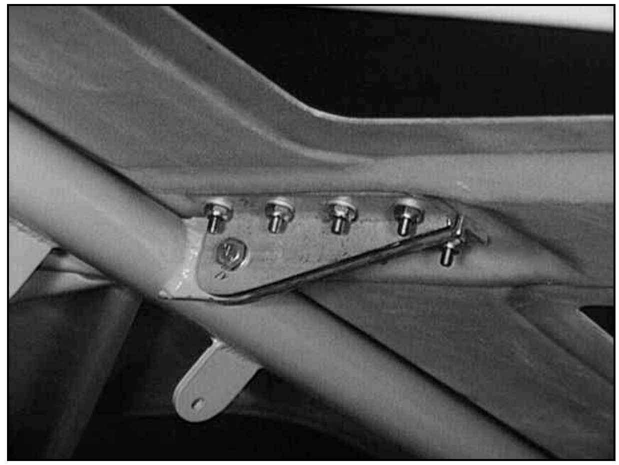


Figure 140: Upper Aft Shell Attach Fittings

> **Note** We recommend that you defer installing the upper aft shell attach fittings until the wings have been folded to assess clearance between the wing roots and the fuselage shell; see Step 139, below.

The procedures for installing the upper aft shell attach fittings are exactly the same as those used for the shell attach fittings at the bottom of the cage, with one exception: you'll use an AN4-10A **bolt** [124] instead of an AN4-6A bolt to fasten the fittings to the cage tab. (The extra length allows the bolt to be used also to secure a guide for the aileron crossover cables; fabrication and installation of this guide is described in the "FINAL CONTROL SYSTEM RIGGING" sub-section below.) Review the fitting installation procedures in Steps 29–31 of "SECTION VIII: FUSELAGE ASSEMBLY" if necessary to refresh your memory.

> **Note** The AN4-10A bolt takes an AN364-428A nylon self-locking nut with AN960D416 washers under both the bolt head and the nut. Until the cable guide is installed, just finger-tighten this nut. The eight holes through the fittings and the top deck take AN507-10R16 flush-head screws, AN960D10 washers and AN364-1032A nylon self-locking nuts.

Completed: [ ]

Step 136: Trim the Wing-Fold Hatch Mounting Flanges

The wing-fold hatches are supplied in two pieces, an upper and a lower for each side. The hatch halves must first be fit to the recesses molded into the fuselage and deck. Then the halves are bonded together with fiberglass laminates and installed with screws and nutplates.

Top Deck Hatch Quarter-Turn Fastener Option Instead of screws and nutplates, the wing-fold hatches can be secured with optional quarter-turn fasteners to provide quick removal and installation. We recommend the quarter-turn fasteners if you plan to fold your GlaStar's wings frequently. The kit includes installation instructions. Order P/N 945-01000-01.

The flanges on the fuselage and the deck where the hatches fit are rough-trimmed at the factory to a 1" width. Grind and block-sand these flanges to a smooth, uniform **7/8"** width, as shown in Figure 141.

Note The 7/8" width provides enough room to install the optional quarter-turn fasteners. You could trim the flange to a narrower width if you plan to install the deck hatches with screws and nutplates instead. Even in this situation, however, we recommend leaving the flange at the 7/8" width in case you ever decide to retrofit the quarter-turn fasteners.

Completed: Left [ ] Right [ ]

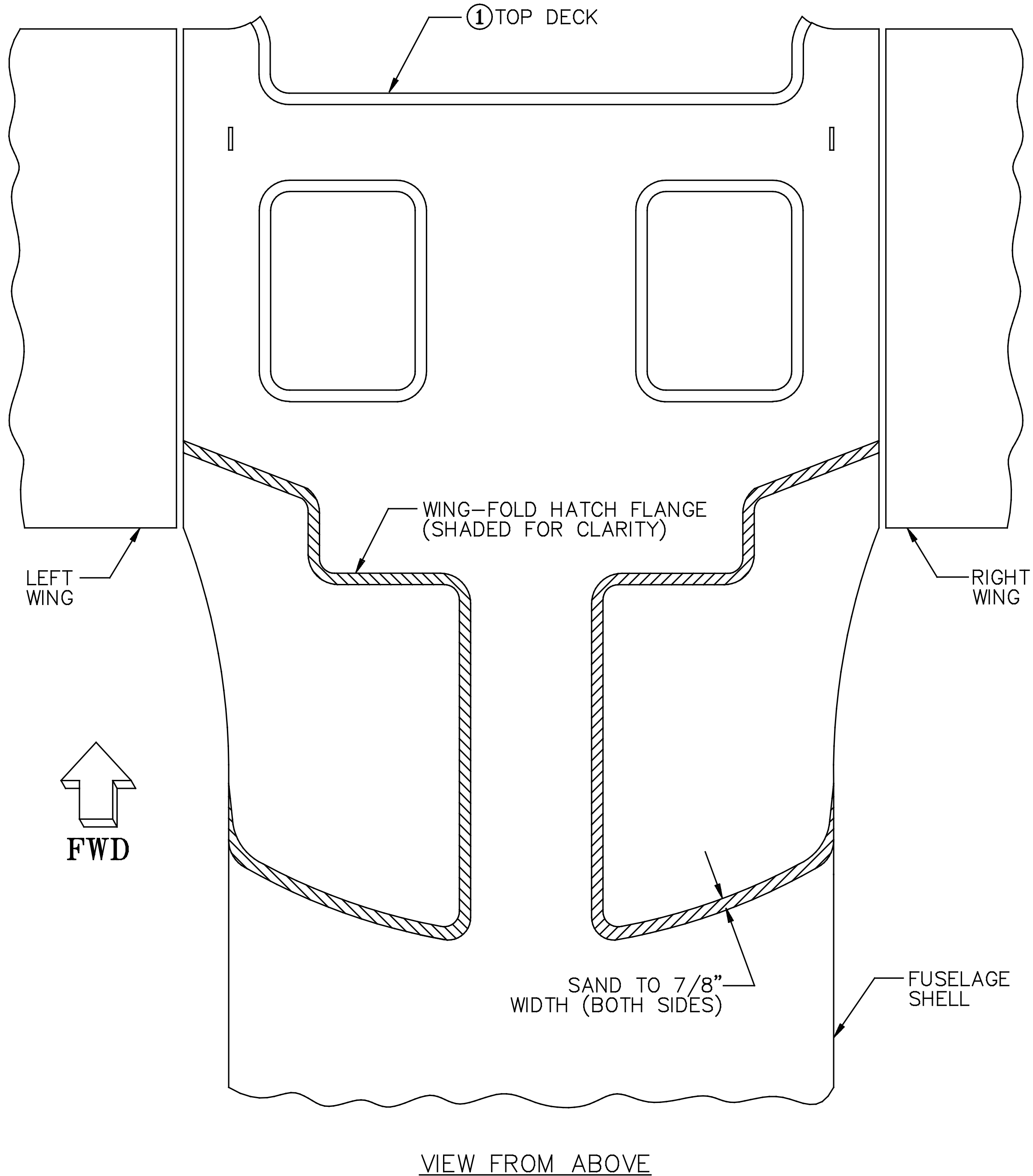


Figure 141: Trimming the Wing-Fold Hatch Mounting Flange

Step 136.1: Secure the Fuselage Strut Fittings to the Fuselage Shell

In Step 85 of "SECTION VIII: FUSELAGE ASSEMBLY" you installed the left and right fuselage struts. On the aft end of each strut, you bolted a pair of strut attach fittings. It's now time to secure these fittings to the fuselage shell. The reason we suggested waiting until this point is that this gives you one last opportunity to adjust the fuselage shell if necessary to achieve easy wing folding.

In some cases, builders have found that when they fold their wings, the flap trailing edges interfere with the aft edges of the top deck hatch cutouts to such an extent that the wings cannot be completely folded. In other cases, there has been some interference in this location, but not so much that the problem couldn't be resolved simply by sanding the cutout flanges a little bit.

Perform a test wing folding at this time to see if you experience any interference. Note that, because the flap cables go slack when the wing is folded, the flaps **will** droop and will ride on the aft edge of the hatch cutout. **This is perfectly normal**. However, if you encounter resistance from the flaps against the cutout edge, then you must take some corrective action.

As mentioned above, the first corrective step you should try is to sand the aft hatch mounting flanges down to a narrower width than the 7/8" called out in Figure 141. Sand a bit, re-fold the wing and check again for interference. It's acceptable to sand this flange down to almost nothing in the aft, inboard corner, if necessary.

If the interference is so pronounced that sanding the flange will not relieve it, then more drastic action is called for. Use ratcheted loading straps and/or weights to deform the fuselage shell downward just at the aft ends of the hatch cutouts. Very little deformation should be required, and the shells should be flexible enough that this can be achieved without too great an effort.

When you have deformed the shell enough to get the clearance you need for the flaps, apply a heat gun to the entire area of the top deck and both fuselage shells around the aft ends of the hatch cutouts. Keep the gun moving, but apply it until the fiberglass is **almost** too hot to hold your fingertips on. Let the fiberglass cool completely, and then remove the straps and/or weights.

Fold the wings again to confirm that you have achieved the required clearance and, if necessary, repeat the heating process.

When you're finally satisfied with the flap clearance, go ahead and install the strut attach fittings. These fittings are installed using procedures very similar to those prescribed in "SECTION VIII: FUSELAGE ASSEMBLY" for installing the other shell attach fittings.

Because of the curvature of the shells, there is obviously no way the fittings will lie perfectly flat against the shells. For this reason, a Q-cell shim must be provided under each pair of fittings. (Actually, the shim goes **above** the fittings, relative to the aircraft.) Mix a thick batch of Q-cell and spread it liberally on the shell under each pair. Then wax the bearing surfaces of the fittings and press them into the Q-cell bed. Try to keep the fittings parallel with one another and with the inner surface of the shell. Hold the fittings in place until the Q-cell cures by strapping the struts to the shell with duct tape.

After the Q-cell has cured, drill through the fitting and shell at each of the four #30 pilot holes in each fitting with a **#10** bit. Then break the fittings out of the Q-cell, clean the mold-release wax off them, deburr them and corrosion-proof them. Countersink the outside surface of the shell to accommodate AN509-10R14 screws, and then secure these screws with AN960D10 aluminum washers and AN364-1032A nylon self-locking nuts.

After the fittings have been screwed tightly to the shells, tighten all the other strut hardware.

Completed: [ ]

Step 137: Fit the Upper Wing-Fold Hatch Halves to the Mounting Flanges

Now you need to fit the left and right upper wing-fold hatch halves to their respective mounting flanges in the fuselage and the top deck. Before you can do this, you must cut a pass-through slot for the control cables in the wing root section of each upper hatch half. As shown in Figure 142, make the slot about **1"** wide and **2-3/4"** long, centered vertically on the control cables, to provide about 1/2" of clearance from the cables all around. At the same time, trim about **1/4"** from the lower edge of the wing root section starting about **1-1/2"** from the trailing edge, as shown.

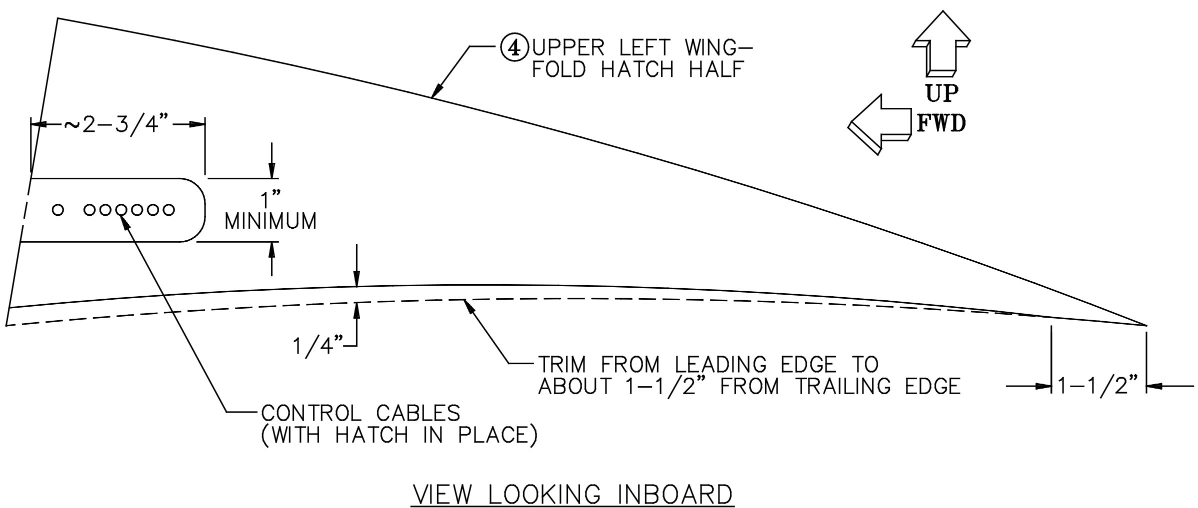


Figure 142: Cutting a Cable Clearance Slot in the Upper Hatch Half

Block-sand the edges of each upper wing-fold hatch half to fit within the perimeter of its flange on the fuselage and top deck. Scribe lines are provided on the outside surface of the hatch half to guide this trimming, but you need to trim enough to provide a **1/16"** gap between the edge of the hatch and the joggle so the hatch clears the radius at the bottom of the joggle, as shown in Figure 143.

Note The wing-fold hatches are intentionally made thinner than the depth of the flange joggle to provide space for weather-stripping to keep the rain out.

When fitting the wing-fold hatch, adjust its side-to-side position by sanding its inboard edges so that the gap between the hatch and the upper wing skin matches the gap between the deck and the upper wing skin.

Complete the procedures in this step for both the left and the right upper wing-fold hatch halves.

Completed: Left [ ] Right [ ]

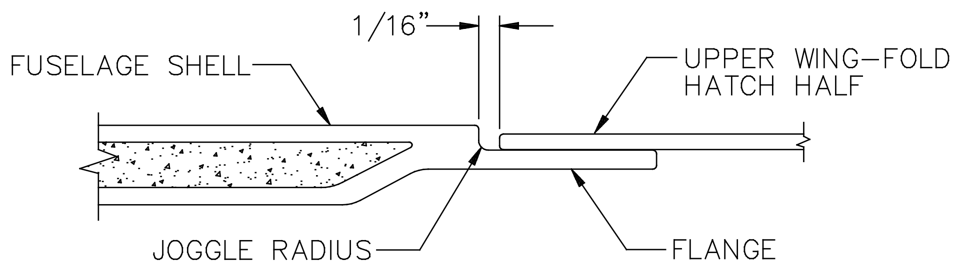


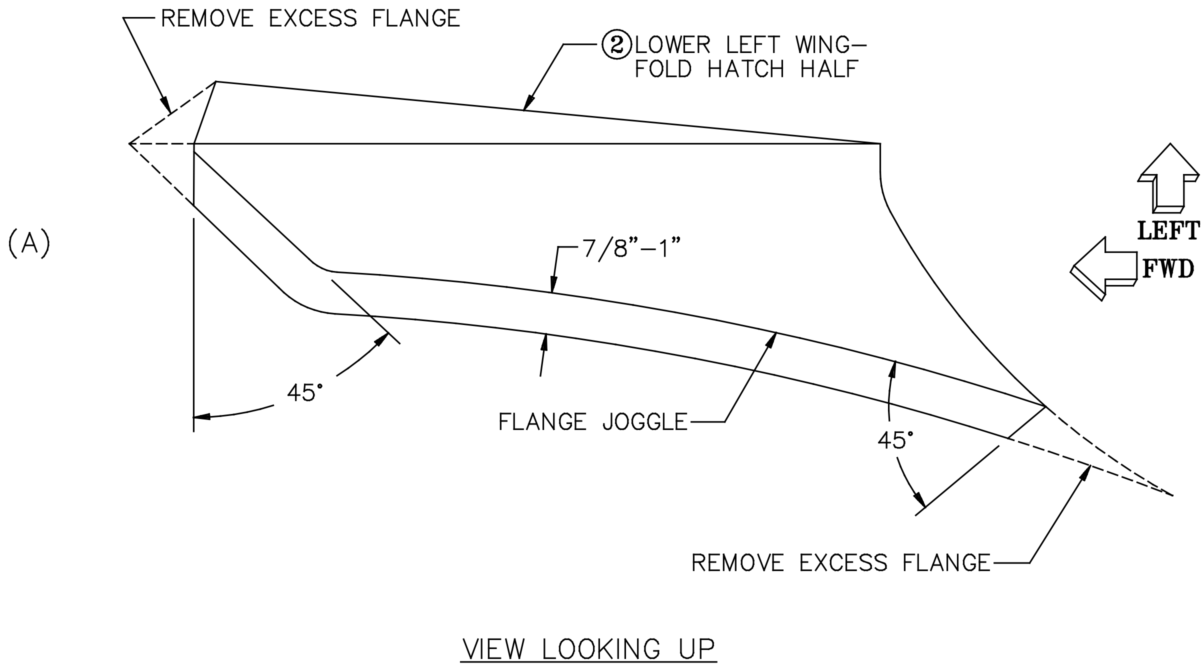
Figure 143: Fitting the Upper Hatch Half to the Flange Joggle

Step 138: Trim the Lower Wing-Fold Hatch Halves

Trim the flanges along the lower edges of the **lower left** [2] and **right wing-fold hatch halves** [3] to a smooth, uniform width of between **7/8"** and **1"**, as shown in Figure 144a. Trim both ends of the joggle at about a **45°** angle, as shown, removing the excess at both ends.

On the flat, wing-root portion of each lower hatch half, mark a line **1"** from the lower edge, as shown in Figure 144b, extending from the forward side of the wing-root area to a point where the line crosses the centerline of the wing-root area (this point is about 8" forward of the trailing edge). From this point, continue the line along the curving centerline of the wing-root area to the trailing edge, as shown. Cut away the wing root area of the hatch above the line just marked to provide clearance for the wing control cables. Sand the trimmed edge smooth. The wing-root portion of the upper hatch half will be trimmed to match this edge before the two halves are bonded together.

Completed: Left [ ] Right [ ]



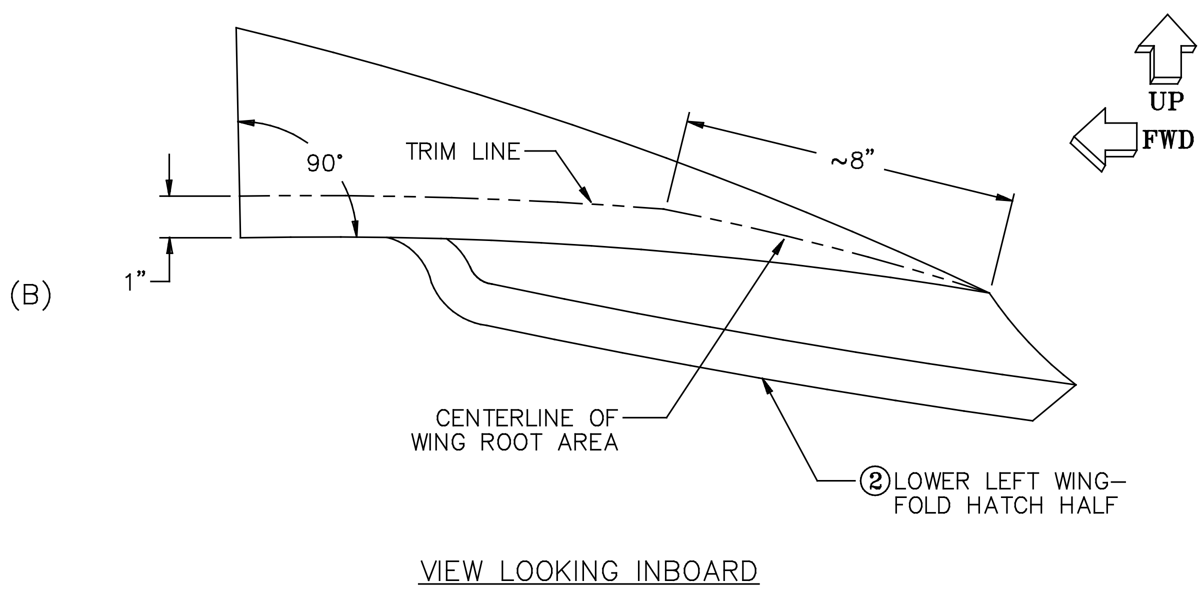


Figure 144: Trimming the Lower Wing-Fold Hatch Half

Step 139: Fit the Lower Wing-Fold Hatch Halves to the Fuselage

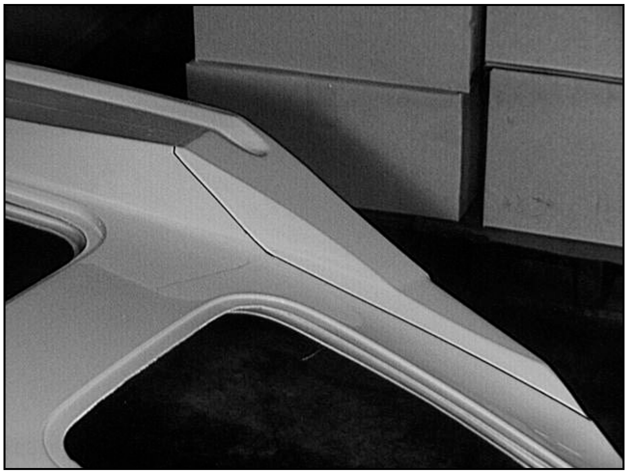


Figure 145: Scribe Line on the Fuselage for the Lower Wing-Fold Hatch Half

As shown in Figure 145, a scribe line is molded on the outside of the fuselage shell on each side in the area where the lower wing-fold hatch half mounts. (The line is enhanced with a pen mark in the photo.) This line serves as a guide for trimming the fuselage to fit the lower hatch half. As with the upper hatch halves, the lower halves must be fitted to match the gap between the fuselage shell and the lower wing skin. Additionally, the trailing edges of the lower hatch halves must be fitted to match the trailing edge of the flap, so make sure the flap is in the fully retracted position during the fit-up; use tape to secure the flap in the retracted position, if necessary.

Initially trim the fuselage about 1/4" outside the scribe line and then trial fit the lower hatch half. Note where additional trimming is necessary to achieve the goals described in the previous paragraph (a uniform gap between the hatch half and the inboard end of the wing, and the hatch half trailing edge at the same height as the flap trailing edge). Use a sanding block to adjust the fuselage edge, check the fit again and repeat until the hatch half fits well. Sand additionally as necessary to smooth the trimmed edge of the fuselage.

Also, trim the upper and lower hatch halves so that their trailing edges blend smoothly into the fuselage shell. The trailing edge of the lower hatch half is shown marked for such trimming in Figure 146.

Repeat for both sides.

Figure 146: Fitting the Lower Hatch Half Trailing Edge

Note Don't be overly concerned if the flanges of the lower hatch halves don't fit tightly against with the side of the fuselage; there is an easy remedy for this problem, which will be described in a later step. Neither is the match-up with the flap trailing edge critical; if you get the hatch trailing edge within about 1/4" of the flap trailing edge in either direction, you're close enough. The final position of the hatch trailing edge can be adjusted further when the upper and lower halves are bonded together.

Completed: Left [ ] Right [ ]

Step 140: Drill the Fastener Holes for the Hatches and Mark the Halves for Final Trimming

Top Deck Hatch Quarter-Turn Fastener Option The instructions for this step apply to both screw-and-nutplate and quarter-turn fastener installations.

Mark the locations of the fastener holes on the upper wing-fold hatch halves, as shown in Figure 147a. All the holes are spaced **1/2"** from the edge. The hole pattern for the lower wing-fold hatch halves is shown in Figure 147b. Mark these hole locations on the outsides of the **fuselage** along the edge where the lower hatch half fits, spacing the holes **1/2"** from the fuselage edge.

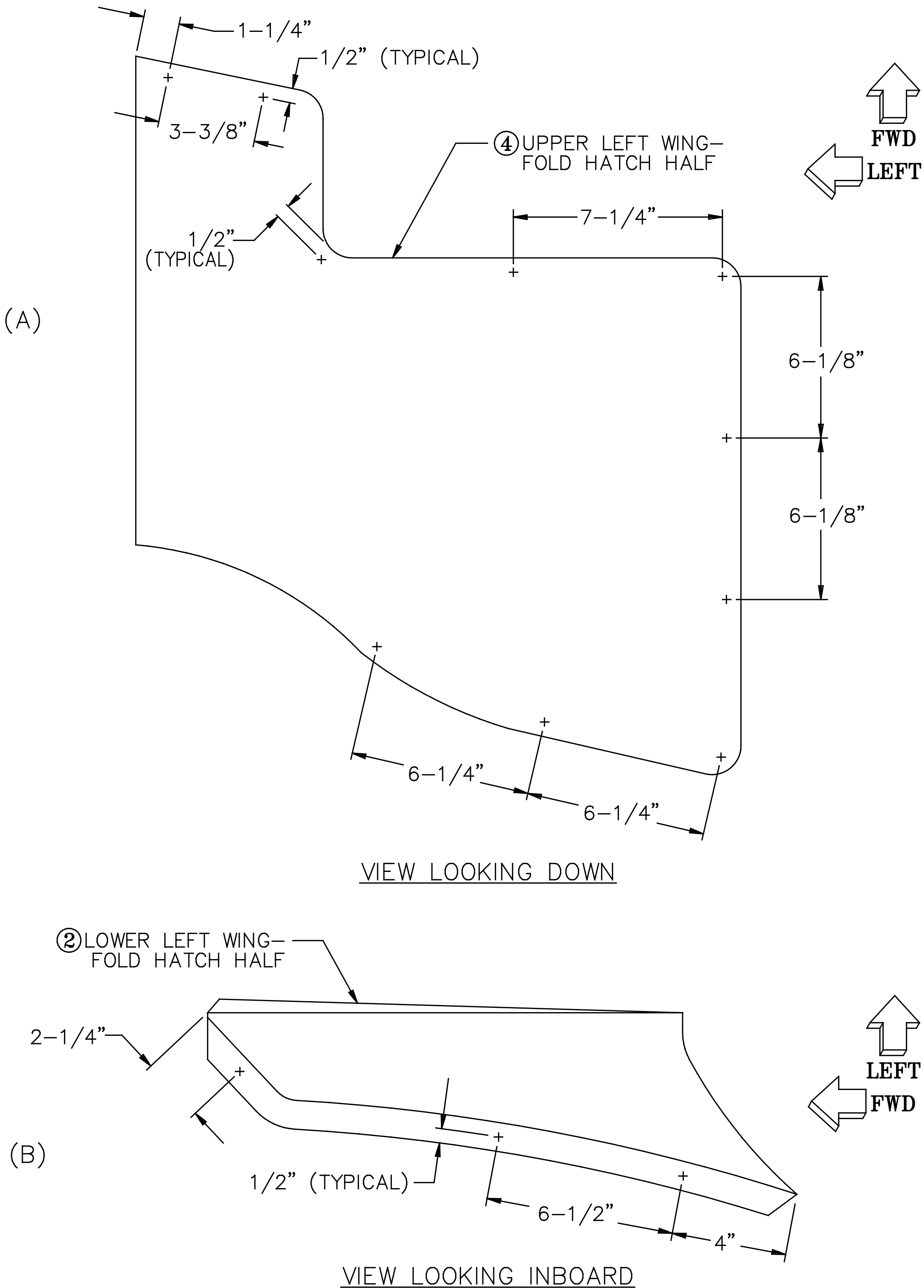


Figure 147: Fastener Locations for the Wing-Fold Hatches

Use wide masking tape to tape the upper hatch halves into position, making sure the gap is even all the way around each hatch. Then tape the lower hatch halves into position with their wing root portions on the **outboard sides** of the wing root portions of the upper halves, as shown in Figure 148.

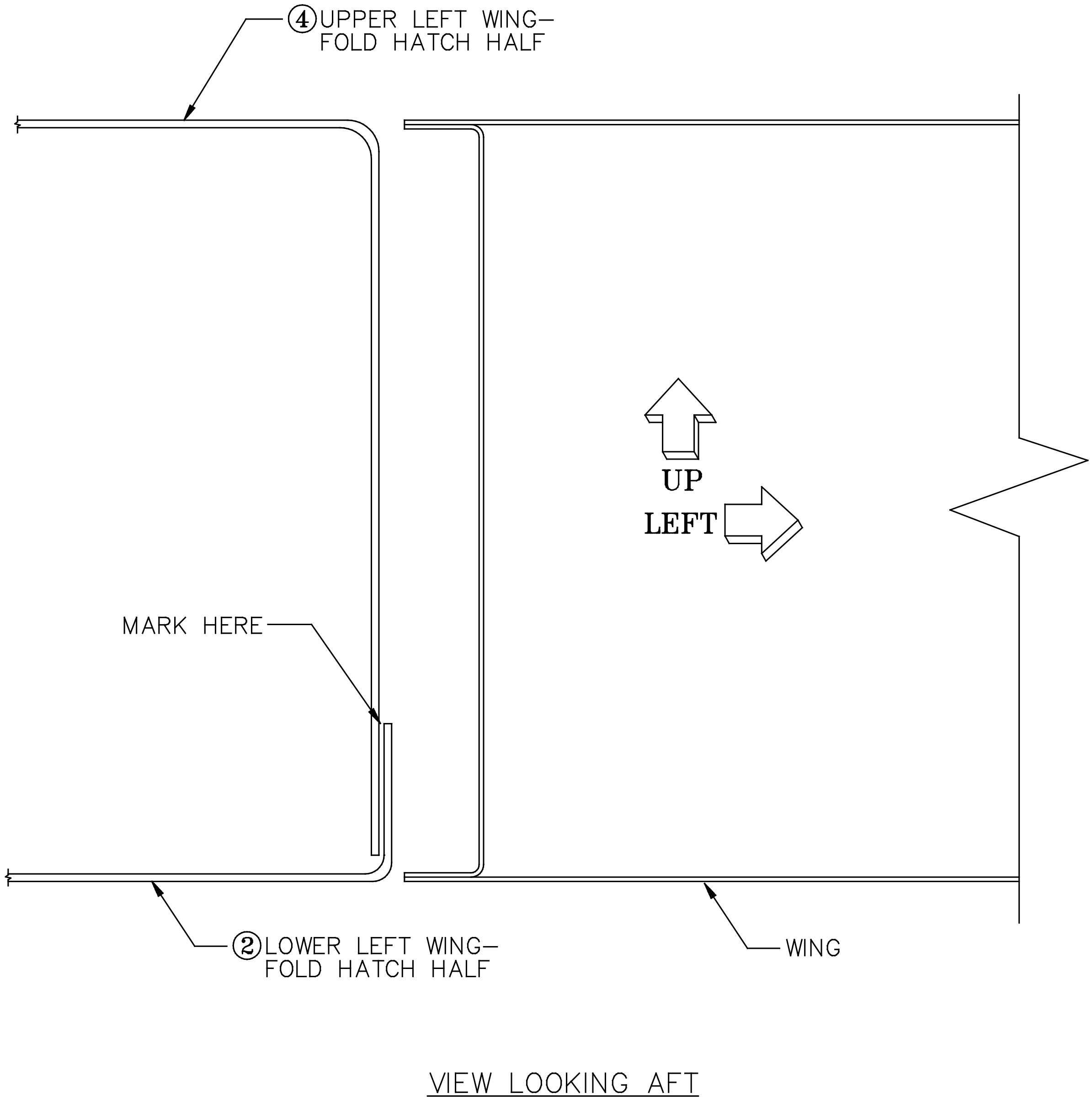


Figure 148: Fitting the Lower Hatch Half to the Upper Half

Before drilling any fastener holes, check that the upper and lower hatch halves have uniform gaps from the wing skins that match the existing gaps between the fuselage shell and the wing skins. Adjust the position of the hatches as necessary.

Drill all the fastener holes with a **#30** bit, inserting Clecos to maintain alignment as you go. Apply back-up pressure on the inside of each lower half's flange while drilling in order to keep the flange in firm contact with the fuselage. (If the flanges of the lower halves don't fit tightly against the fuselage shell, the fit can easily be adjusted with a heat gun. This adjustment will be described in a later step.)

With both the upper and the lower hatch halves still in place, verify that the outside surfaces of the two halves on each side are even with the upper and lower wing skins; squeeze the two halves together to accomplish this (it may be necessary to further trim the edge of the upper half's wing root portion). Also verify that the trailing edges of the two halves are even with the flap trailing edge and are in the same position on both the left and right sides. Adjust the positions of the trailing edges, as necessary.

Note Air loads tend to force the flaps upward in flight. Exert an upward force on the flap trailing edge, therefore, to simulate the air loads and make sure that the flap trailing edges are not drooping while you are checking the match-up of the hatches.

When satisfied with the fit of the hatches, mark the edge of the wing-root portion of the lower hatch half onto the wing-root portion of the upper hatch half, as shown in Figures 148 and 149. (Lower the flaps, as shown in the photo, to do this.) Remove the upper hatch halves and trim their wing-root portions to the lines just marked.

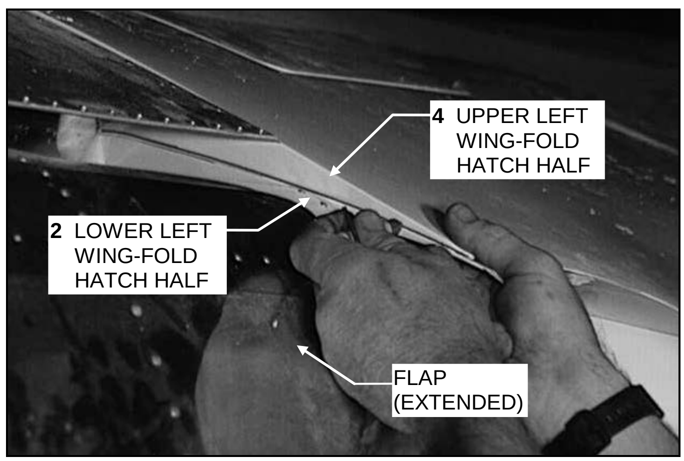


Figure 149: Marking the Wing-Root Portions of the Upper Hatch Halves for Trimming

Reinstall the upper hatch halves and check their fit with the lower halves where the two halves now butt together in the wing-root area. Adjust the fit of the edges, as necessary. When satisfied, you are ready to bond the upper and lower halves together.

Completed: Left [ ] Right [ ]

Step 141: Bond the Upper and Lower Hatch Halves Together

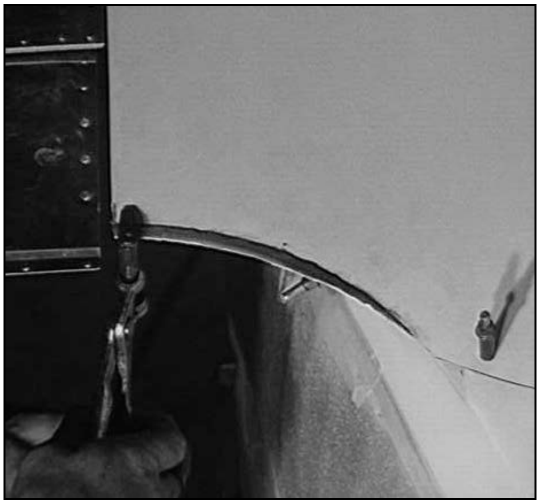


Figure 150: Clamping the Hatch Trailing Edge

For the first part of this step, the upper and lower hatch halves should be Clecoed to the fuselage, and the flaps should be supported in their fully retracted positions.

Mix up a small batch of thick resin/mill fiber mixture. Pry the trailing edges of the hatch halves apart and apply a small bead of the mixture between the halves. Close the trailing edge, adjust its height to match the flap trailing edge and lightly clamp the two halves together, as shown in Figure 150. Let the trailing edge bond cure, and then remove the hatch assemblies from the fuselage.

> **Note** If the trailing edge of the hatch needs to be extended to match the flap trailing edge, you can bond a two- or three-layer pre-cured laminate between the hatch trailing edges, if you want. To finish the trailing edge extension, use lightweight body filler to blend it into the rest of the hatch and sand it smooth.

After the trailing edge seams have cured, remove the hatches from the fuselage. Tape the two halves of each hatch assembly together on the **outside** of the wing-root butt-joint seam, as shown in Figure 151.

For each hatch assembly, cut the following pieces of bi-directional cloth on the 45° bias: one **1" X 10"** strip for the trailing edge; one **3/4" X 16"** strip and one **1-1/2" X 16"** strip for the wing-root seam. Adjust the lengths of the strips as necessary to match the lengths of the seams on your hatches.

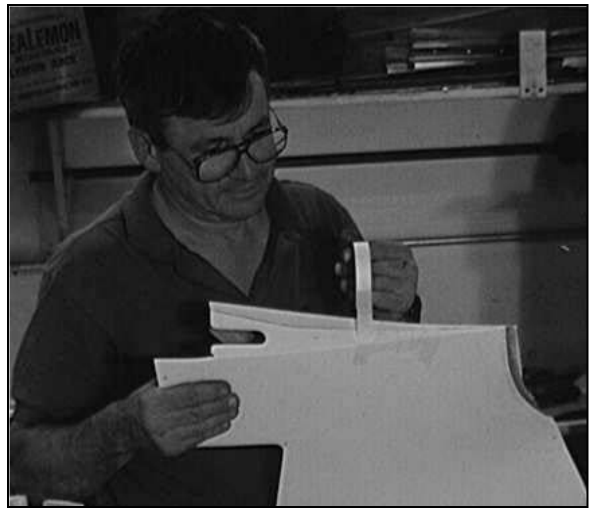


Figure 151: Taping the Wing-Root Seam

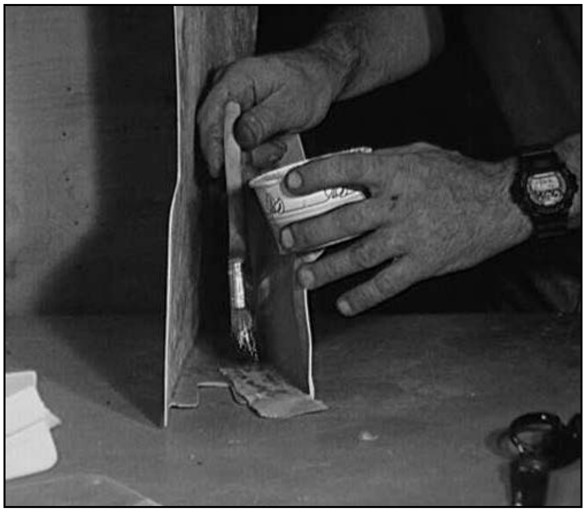


Figure 152: Laminating the Wing-Root Seam

Laminate the trailing edge seams first. Prop the hatches up with the trailing edges down and apply a 1" X 10" strip of cloth to the inside of the seam.

Then, prop the hatch assemblies up vertically with the wing-root sections down, as shown in Figure 152, and apply the wing-root area seam laminates. Laminate the 3/4"-wide strip first and then the 1-1/2"-wide strip, as shown in Figure 153, to provide a smoother finished laminate. Trim both the trailing edge and the wing-root seam laminates even with the edges of the underlying fiberglass when they reach the green cure condition. Sand any remaining roughness smooth, especially in the trailing-edge area, after final cure.

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Right [ ]

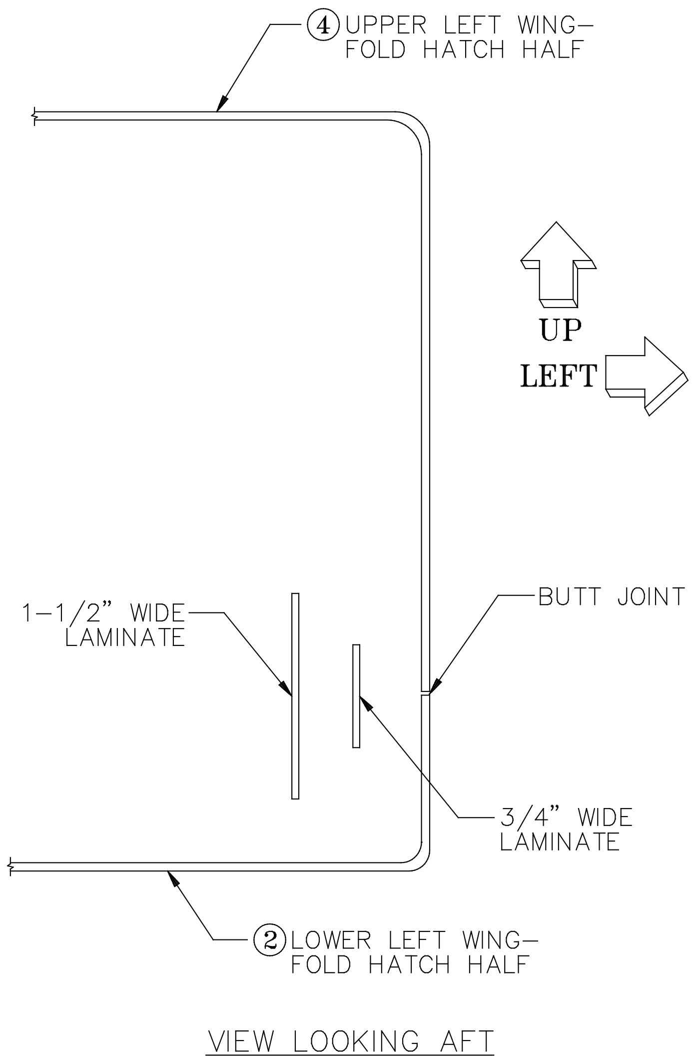


Figure 153: Wing-Root Seam Laminates

Step 142: Adjust the Lower Hatch Flange (If Necessary)

When the seam laminates have fully cured, use Clecos to reinstall the hatches. Ideally, the flange along the lower edge of hatch will lie flush against the lip at the top of the fuselage shell. However, you may find that there is a gap between the shell and the hatch flange. If this gap is fairly small—say, **1/8"** or less—then the screws or Camlocs you use to secure the hatch will easily pull the two parts together, and the amount of flexing involved will not pose any problems.

If the gap is larger than about 1/8", however, steps must be taken to reduce it. Using the fasteners to pull in a gap larger than that can result in unsightly cracking in the gel coat around the fasteners, as well as making it difficult to secure the hatches in the field.

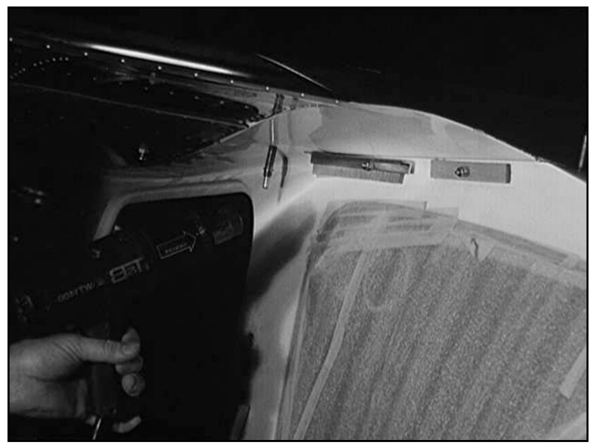


Figure 154: Adjusting the Lower Hatch Joggle

If you end up with a large gap, first enlarge the mounting holes through the hatch flange and fuselage to **#19** diameter. Use 5/32" bolts or screws, padded with strips of wood as shown in Figure 154, to pull the flange and the fuselage together. Then use a heat gun to heat the fiberglass laminates locally until they are **almost** too hot to hold your hand on them. Let the laminates cool to room temperature. Remove the bolts clamping the parts together and check the fit again. If the parts don't remain in their "persuaded" condition, clamp them up again and try a little more heat. Keep the clamps in position overnight, if necessary.

Completed: Left [ ] Right [ ]

Step 143: Install the Hatch Mounting Nutplates

Top Deck Hatch Quarter-Turn Fastener Option If you are installing the optional quarter-turn fasteners, **turn to the option instructions now**. Return to Step 144 of this *Assembly Manual* when the specified option steps have been completed.

☞

Cleco the top deck hatches in place. One-by-one, enlarge the mounting screw holes to **#19** diameter for AN526-8R8 round-head machine screws, reinstalling 5/32" Clecos as you go. Use standard procedures to install K1000-08 nutplates on the fuselage and top deck flanges.

Note The top deck hatches are too thin to permit countersinking for flush-head screws.

Completed: Left [ ] Right [ ]

Step 144: Install Weather-Stripping and Mount the Hatches

Apply thin (about 1/16") weather-stripping material (not supplied) to the fuselage and hatch joggles to weather-proof the top deck hatches. A good material to use is adhesive-backed, flexible foam strip. Punch holes in the weather-stripping to clear the fasteners. Then, use either the AN526-8R8 screws or the quarter-turn fasteners to secure the hatches in place.

Completed: Left [ ] Right [ ]

Step 145: Install the GPS Antenna (Optional)

If you're installing an external GPS antenna, the area of the top deck between the skylights is a good location. Follow the mounting instructions provided by the antenna manufacturer.

> **Hint** When choosing a location for the antenna, be sure to pay attention to the underlying tubing structure of the cage, both so you can avoid drilling down into the tubing and so that the antenna will be positioned conveniently relative to the tubing for routing the antenna cable.

Completed: [ ]

Step 146: Install the Wing-Fold Drain Pan *(Optional)*

When the wing-fold hatches are removed and the wings folded, the cabin becomes open to the elements. For this reason, if you intend to fold your wings often—and especially if you intend to park your GlaStar outside with the wings folded—we strongly recommend the installation of a drain pan under the wing-fold hatches.

Such a pan can be fabricated of sheet metal or composite. Our GlaStar prototype has a rather elaborate, bent-up sheet metal pan that works very well but was a lot of work to construct. One of our early builders installed a composite pan made up of pre-cured laminates bent and cut to fit the fuselage. This was a much simpler and equally effective installation.

No matter what the construction, drain tubes should be provided from the lowest point of the pan to the outside of the fuselage so that water caught in the pan doesn't collect there. Route the tubes along the cabin roof (where they can be hidden behind upholstery), through Bulkhead A, and then out through the bottom of the fuselage.

Completed: [ ]

INSTRUMENT PANEL INSTALLATION

In this sub-section, you'll install the instrument panel; mount, wire and plumb the instruments and avionics; and fabricate and fit the glare shield.

Step 147: Cut Out and Fit the Instrument Panel

A full-sized **instrument panel template** [63] is included in the kit. Tack this template to the **.063" X 12" X 43" aluminum sheet** [70] and use a bandsaw to cut out the panel.

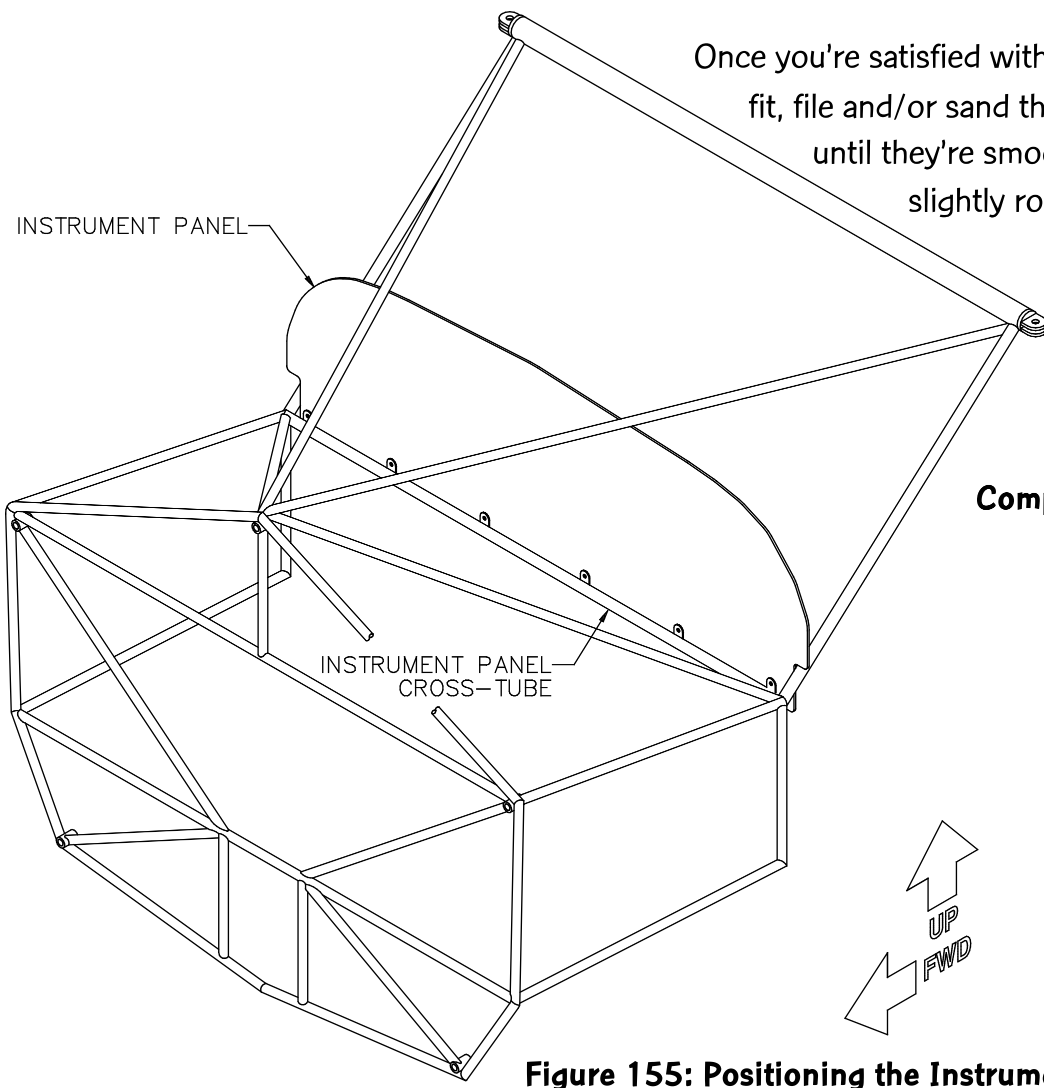
Note The template gives a suggested shape only; the exact shape of the panel can be varied widely to suit your preferences.

Also note that some early GlaStar kits were supplied with an instrument panel blank 12" high X **42" long**. If you have the shorter blank, simply center the panel template on the available material. The amount by which the template exceeds the material is negligible and can be disregarded.

Trial-fit the panel by positioning it in the cage with its lower edge on the panel-mounting cross-tube, as shown in Figure 155. Check for any interference between the ends of the panel and any fuel lines or wiring running up the cage between the windshield and door cutouts. Note any interference and relieve the end(s) of the panel as necessary to provide clearance. You don't need to leave a lot of room, but keep in mind that the panel will tend to flex and vibrate in flight, and so you absolutely can't tolerate any chafing between the edges of the panel and adjacent fuel lines or wiring.

Continental IO-240 Engine Installation If you've installed the Continental IO-240, then you'll definitely have to relieve the ends of the panel to clear your fuel return lines.

Once you're satisfied with the panel's fit, file and/or sand the cut edges until they're smooth and slightly rounded.



Completed: [ ]

Figure 155: Positioning the Instrument Panel

Step 148: Lay Out the Panel and Make the Instrument Cutouts

You've probably been working on this step since long before you bought your kit! Most builders spend a lot of time pondering the arrangement of their instrument panels, and with good reason—you'll be spending a lot of time pondering those instruments while flying your GlaStar, and your safety and enjoyment depend in good measure on a well thought-out panel.

Note The GlaStar offers ample space for the most sophisticated IFR panel, but because of the cage structure, there are a couple locations where depth behind the panel is limited. When laying out your instruments and avionics, be sure to check that adequate depth exists for each item.

Once you've settled on a layout, make the cutouts and drill the mounting screw holes for the instruments, switches, breakers, avionics, etc., that you have selected. If you haven't yet accumulated everything you intend to put in your panel, you'll have opportunities to add these things later, but the more complete job of hacking and cutting you can do now, the easier things will be later on.

The instrument cutouts can be made either with a fly cutter or hole saws in a drill press, or with special instrument hole-cutting dies available from aircraft tool catalogs. **Don't** try to make these cutouts with a hand drill! It's virtually impossible to get good, clean holes of such large diameter using a hand drill.

Hint In addition to making the cutouts, trace onto the back of the panel the outlines of the instruments along the **upper** edge of the panel. These references marks will be helpful in the next step when you rivet a stiffener bow across the top of the panel.

Completed: [ ]

Step 149: Fabricate and Rivet the Panel Bow

A "bow" of .063" X 1/2" X 1/2" aluminum angle is bent to shape and riveted across the top of the panel to stiffen it. The first step is to determine the proper length of the bow. Since exact panel dimensions can vary widely from airplane to airplane, you need to measure your panel. Figure 156 shows the distance to be measured, labeled "X." Cut a piece of angle stock to the measured length.

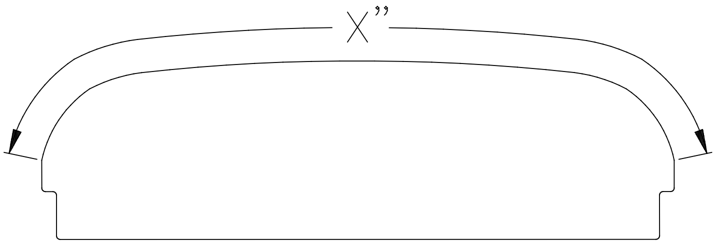


Figure 156: Measuring the Panel Bow Length

In order to bend the angle stock to match the shape of the panel top, you need to cut a number of slots through one flange of the angle, as shown in Figure 157. These slots allow the other flange of the angle to be bent into a curved shape. Start each slot with a **#10** or **3/16"** hole drilled as close to the inside radius of the angle as possible. Then use a hacksaw or bandsaw to cut a slot to meet the hole.

There's no precise number of slots necessary to bend the bow to match the top of the panel. Our GlaStar prototype has only two slots in the center 18" or so of the bow where the curve is slight, and then slots roughly every **1/2"** from there outboard where the curve gets tighter. In any case, that's about as close together as you ought to cut the slots.

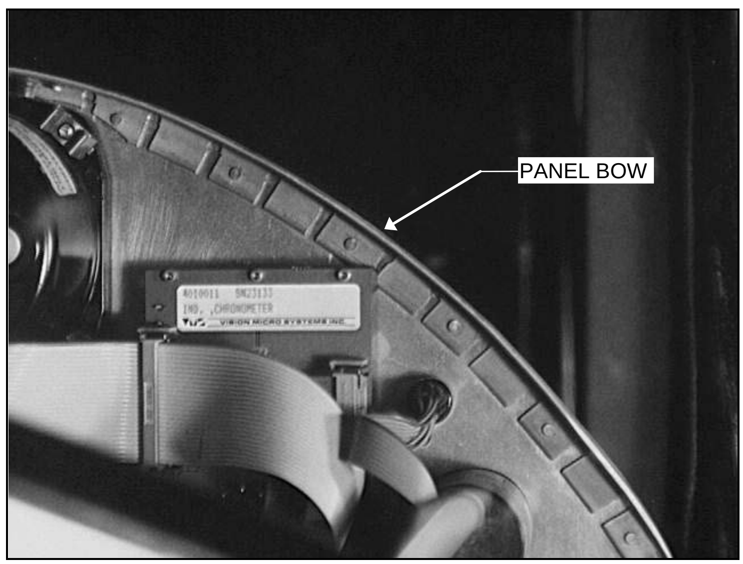


Figure 157: Bending the Bow

Bend the bow to match the panel as shown in Figure 157, and then check for interference between the tabs and the outlines of the instruments you marked on the back of the panel. Relieve any interference by cutting back the tabs. In Figure 157, the tabs around the corner of the airspeed indicator have been trimmed in this fashion.

Next, center punch rivet hole locations on the tabs. Not every tab requires a rivet—aim for a spacing interval of about **1-1/2"**. Clamp the center-punched bow to the panel with several small C-clamps, and then drill through the bow and the panel at each punched locations with a **#40** bit. Cleco as you go. Deburr all the holes in the bow and on the forward side (relative to the aircraft) of the panel, and countersink the aft side of the panel (relative to the aircraft) to accommodate 3/32" AN426AD3 flush-head rivets.

Corrosion-proof the panel and bow as you wish, and then rivet the bow to the panel.

Hint You may be tempted to prep and paint the face of the panel at this time, and indeed you can do so if you wish. However, our experience has shown that it's best to wait as long as possible—perhaps until after all the instruments and avionics have been function-tested—before finishing the panel. It seems that there's always one more hole to drill or cutout to make after you think you're all done!

Completed: [ ]

Step 150: Drill the Lower Mounting Screw Holes

The panel is secured to the fuselage cage through six attach tabs located on the cross-tube at the bottom of the panel. These tabs come with 3/16" pilot holes, which must be used to drill matching holes in the panel.

Position the panel against the attach tabs and clamp it in place with three or four Vise Grip-style locking C-clamps. The panel should be centered laterally and positioned vertically so that its lower edge is about **3/8"** above the **bottom** of the cross-tube, as shown in Figure 158.

With the panel clamped in position, drill through the unclamped attach tabs and the panel from the **forward** side with a **#10** bit. A 90° drill motor will make this drilling much easier. After each hole is drilled, screw the panel to the tab temporarily with the hardware shown in Figure 158: an NAS603-7P round-head machine screw, an AN960D10L thin aluminum washer, an AN960-10L thin steel washer and an AN315-3R jam nut. When the panel has been tightly screwed to all the unclamped tabs, remove the clamps and drill the remaining tabs. There's no need to insert screws in those holes at this time.

Hint Because the cross-tube lies immediately behind the attach tabs, you need to position the nut and the forward washer **before** inserting the screw.

Completed: [ ]

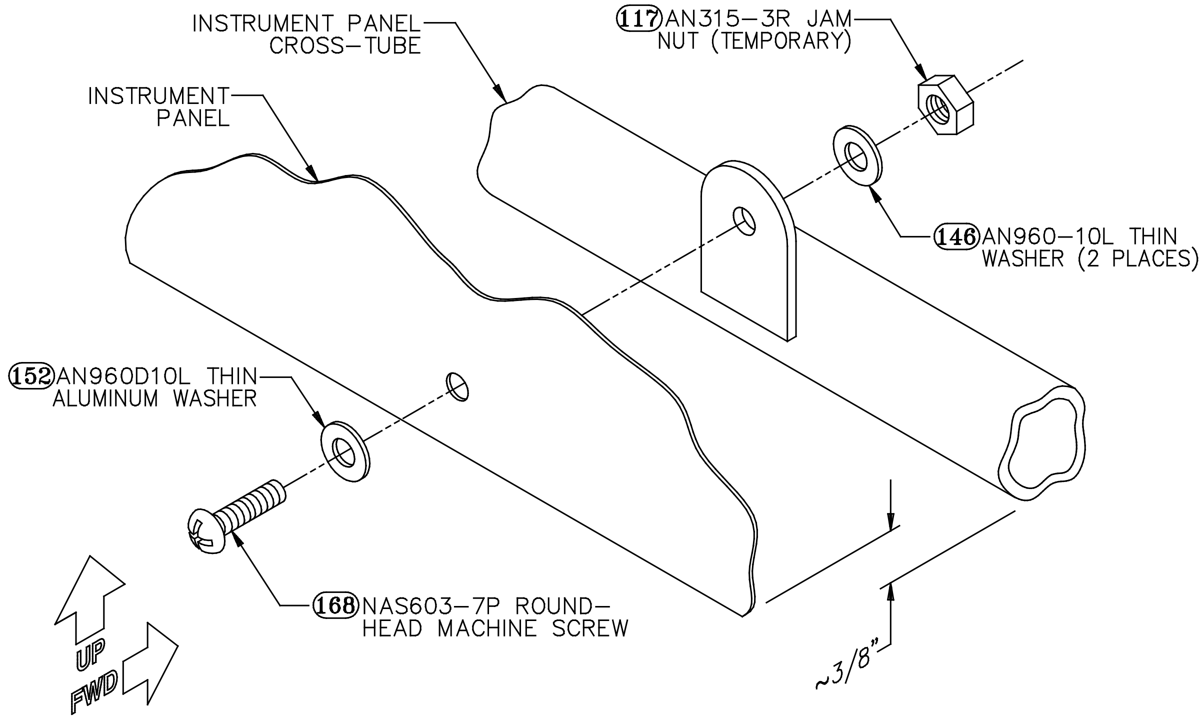


Figure 158: Temporary Panel Hardware

Step 151: Install Mounting Angles at the Ends of the Panel

In addition to the six screws along the bottom of the panel, a screw at each end helps secure it. There are no attach tabs on the cage for these screws; instead, they are secured to laminated attach tabs on the sides of the fuselage shell. Each tab is laid up in place from two layers of DBM cloth. Begin by cutting four **2" X 2"** squares of the material, two for each end of the panel.

As shown in Figure 159, the mounting angles are laminated right into the corner formed by the instrument panel and the fuselage side on the forward side of the panel (relative to the aircraft). Apply mold-release wax or equivalent to the panel in this area and roughen the adjacent fuselage shell with coarse sandpaper. Thoroughly clean the sanded area with acetone. (You may need to remove the panel to do this conveniently.) Then laminate the two squares of DBM in place and let them cure.

> **Note** The laminated angles can be shifted vertically and/or trimmed as necessary to clear any fuel lines or wiring that might run alongside the shell in this area. Wrap such plumbing and wiring in vinyl tape to prevent the laminations from adhering to them.

When the angles have cured fully, mark and drill a hole through each end of the panel and the underlying angles. Use a **#10** bit. The precise location of these holes isn't critical, but since the screw heads will be visible on your panel, try to make them the same at each end.

When the drilling has been completed at both ends, remove the panel and deburr the holes.

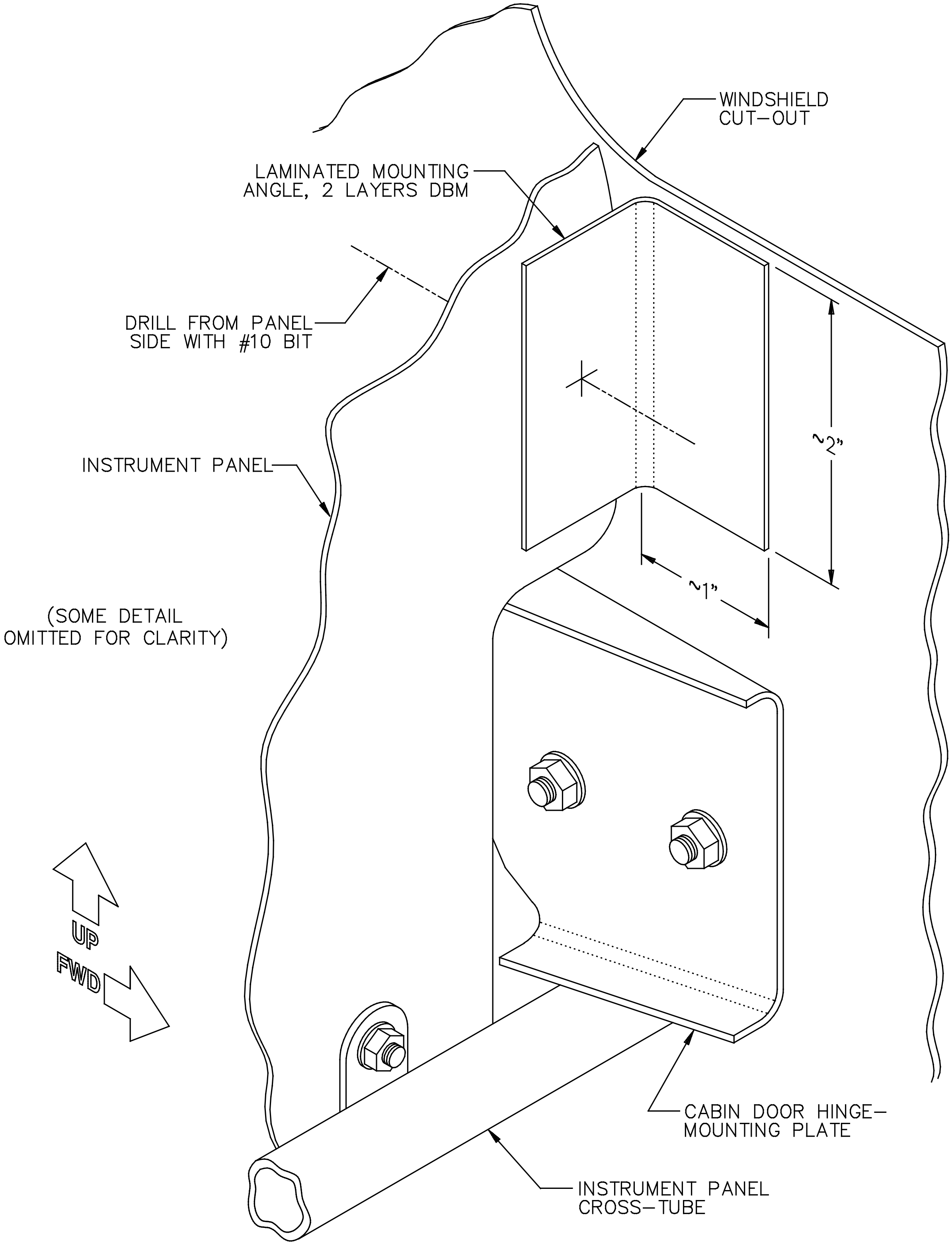
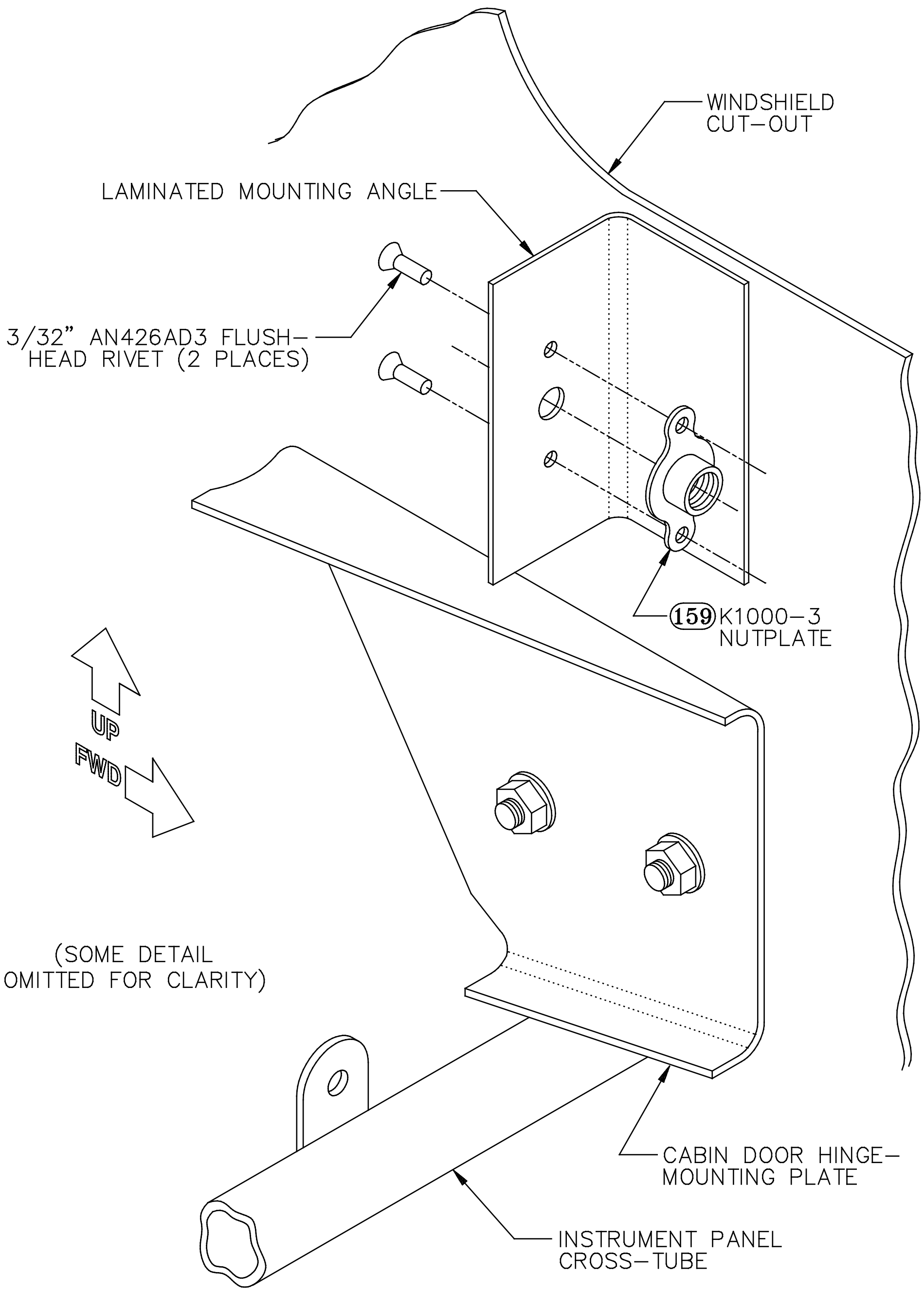


Figure 159: Laminating and Drilling the Panel-End Mounting Angles

Next, install K1000-3 nutplates on the forward faces of the two attach angles, as shown in Figure 160. Countersink the **#40** rivet holes on the **aft** face of the angle to accommodate 3/32" AN426AD3 flush-head rivets, and then rivet the nutplates in place.

Replace the panel, securing it temporarily with an NAS603-7P round-head machine screw through each of the two end holes and two or three of the six lower holes. Use an AN960D10L thin aluminum washer under each screw head. On the lower screws, use an AN960-10L thin washer and a temporary AN315-3R jam nut on the forward side of each attach tab.



Completed:
[ ]

Figure 160: Installing Nutplates on the Panel-End Mounting Angles

Step 152: Fabricate and Install the Panel Braces

Two braces made of aluminum angle stock run from the top of the panel to the front of the cage to provide support to the upper edge of the panel. Cut these braces from the remaining length of .063" X 1/2" X 1/2" angle stock; each brace should be **18"** long.

Each end of each brace must be prepared for mounting, as shown in Figure 161. The figure shows the left-hand brace; be sure to make the right-hand one a mirror image. First, cut away about **3/4"** of the **horizontal** flange at the forward end. Bevel the forward edge of the remaining horizontal flange to about **45°**. Next, mark and drill a **#19** hole through the **vertical** flange of the brace **1/4"** in from the forward end. The hole should be roughly centered vertically on the flange; just eyeball this. After drilling and deburring the hole, round the forward end of the brace, as shown. A **1/4"** radius is ideal here, but this isn't too critical—just knock the corners off the angle without shortening its overall length.

On the aft end of the brace, you need to cut away about **1-1/4"** of the **vertical** flange and bevel its aft edge to about **45°**. Then round the aft end of the brace as shown. Finally, sand or file all the cut edges smooth.

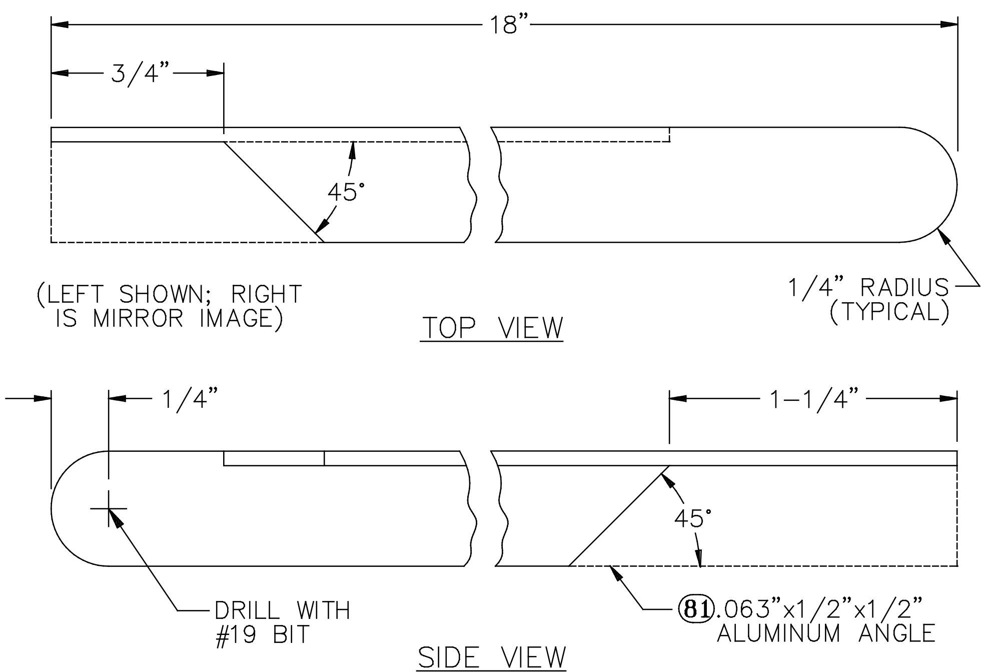


Figure 161: Trimming and Drilling the Panel Braces

Next, temporarily bolt the forward end of each brace to the angle brackets you positioned back in the "FIREWALL INSTALLATION" sub-section. As shown in Figure 163a, the braces are secured to the **inboard** side of the brackets with AN515-8R10 **round-head machine screws** [138], AN960D8L thin aluminum washers and AN364-832A nylon self-locking nuts. Don't tighten the nuts now—just get them started.

When the forward ends of the braces are secured, the aft ends should end up right at the forward side (relative to the aircraft) of the instrument panel. If necessary, file a bit of material off the aft end of the brace so that it fits cleanly. Next, bend the horizontal flange of the brace downward slightly at the aft tip so that when it is pulled up under the horizontal flange of the panel bow, it meets the bow squarely. Finally, with the brace held firmly against the underside of the bow, drill a **#19** hole down through the bow and brace, as shown Figure 163b.

Note The braces should be roughly perpendicular to the instrument panel, but this is not critical.

Complete the braces by installing a K2000-08 single-lugged **nutplate** [161] at the aft end of each one, as shown in Figure 162. Countersink the **#40** rivet holes on the **upper** surface of the horizontal flange to accommodate 3/32" AN426AD3 flush-head rivets, and rivet the nutplate in place.

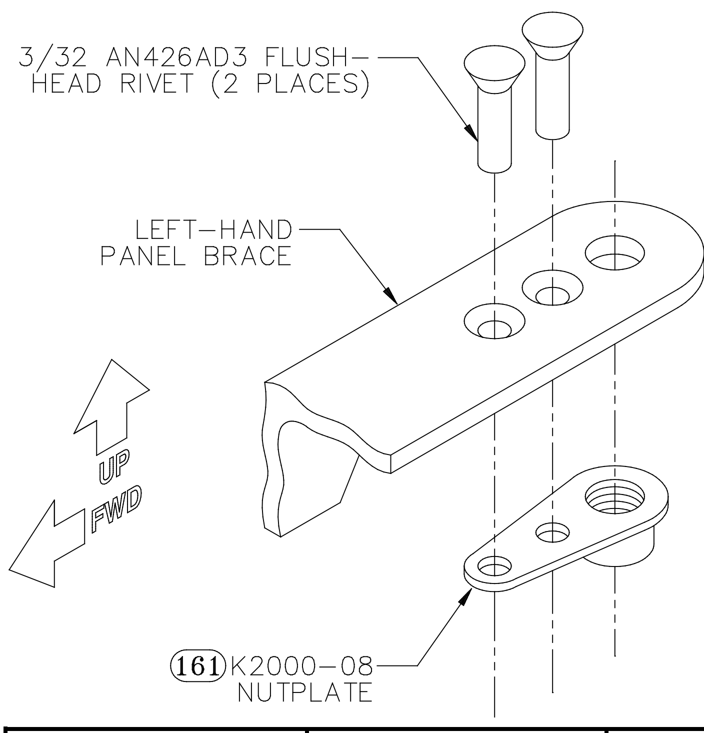


Figure 162: Riveting a Nutplate to the Aft End of the Panel Brace

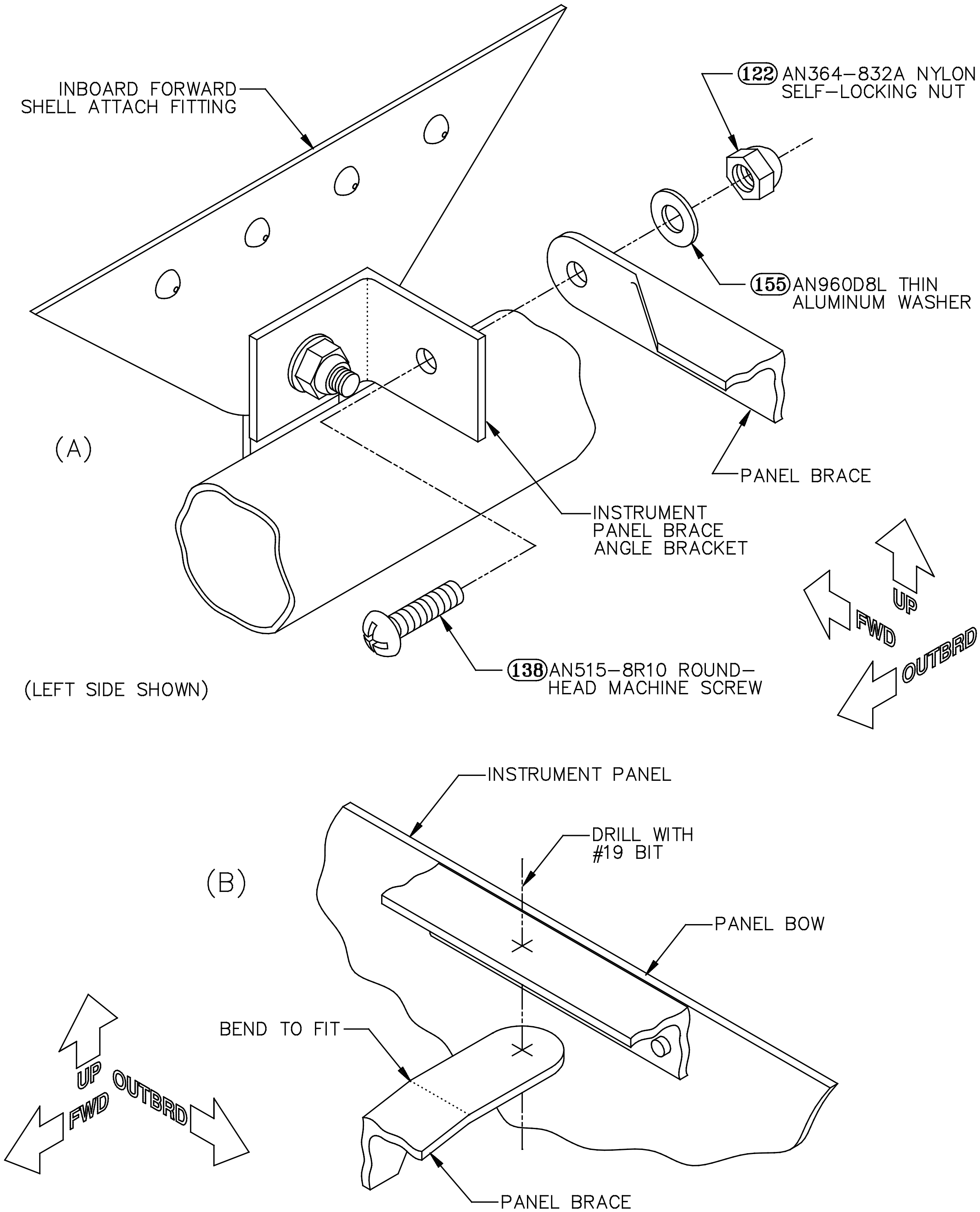


Figure 163: Drilling the Aft End of the Panel Brace

Finally, countersink the upper side of the two brace holes in the panel bow to accommodate AN507-8R8 **flush-head machine screws** [133]. Secure the aft ends of the braces temporarily by threading these screws into the nutplates.

Completed: [ ]

Step 153: Fit the Glare Shield and Install Its Mounting Tabs

The glare shield closes out the area between the top of the instrument panel and the base of the windshield. It is best constructed of thin aluminum sheet (**.016"**-thick material is ideal) in two halves with a seam down the middle. Materials for the glare shield are not included in the standard GlaStar kit.

We recommend that you first fashion cardboard templates and then, after fitting them to your satisfaction, transfer the shapes to the glare shield material. The shield should extend **2"–3"** aft of the instrument panel to provide a bit of shade from direct sunlight for the instruments. The aft edge of the shield should be rolled or otherwise provided with a blunt edge. The shield can be secured with screws through the panel bow to nutplates.

At the forward edge, simple mounting tabs that hold the shield against the inside of the windshield frame are sufficient to secure the shield (see Figure 164a). These tabs can be fabricated from sheet aluminum (**.025"**-thick material is best) or from a two- or three-layer pre-cured laminate of bi-directional cloth. Use blind rivets through the inner fuselage laminate to secure aluminum tabs; glass tabs can simply be bonded in place with resin.

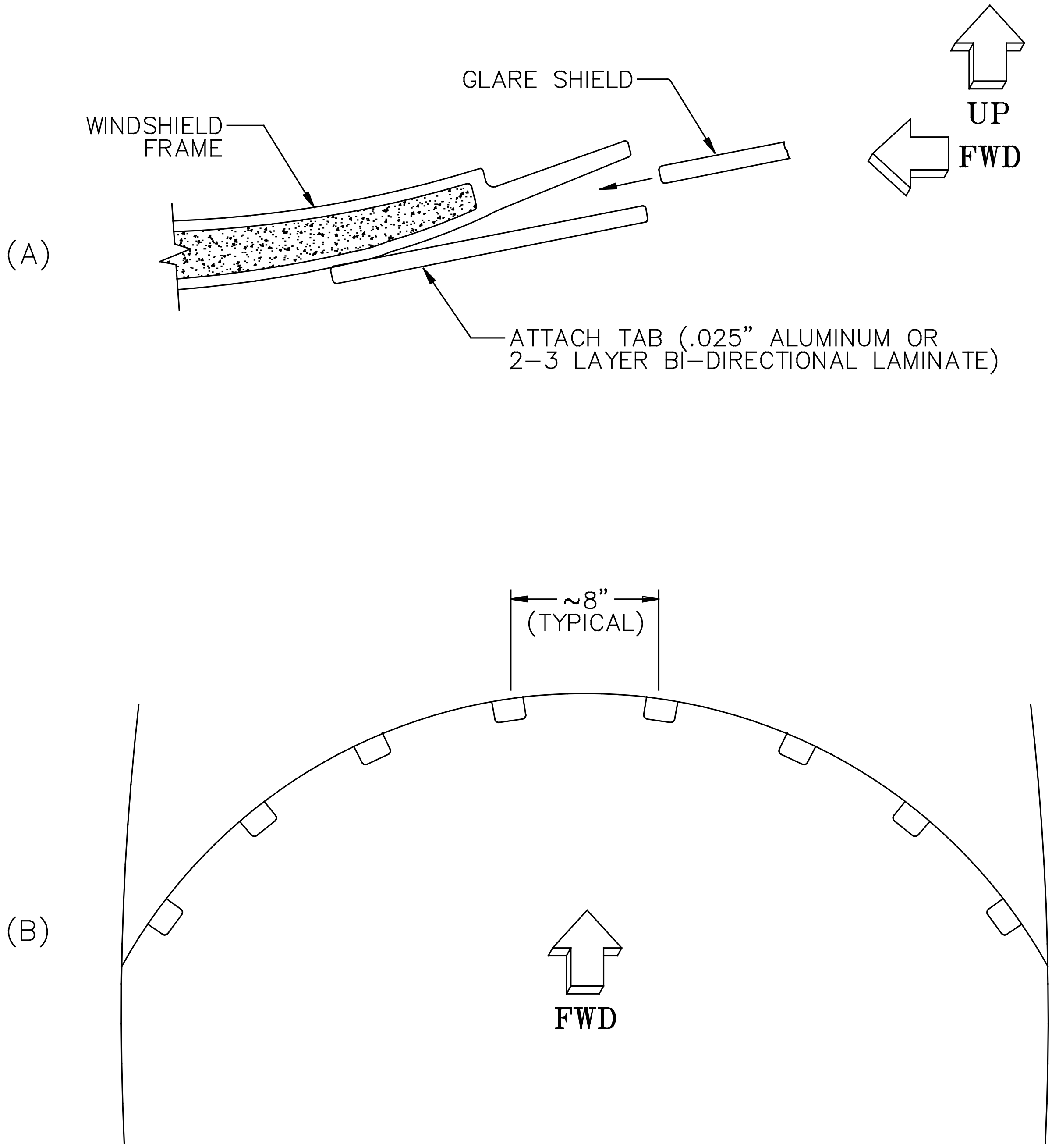


Figure 164: Glare Shield Mounting Tabs

As Figure 164b shows, space these tabs about every **8"** for best results.

Completed: [ ]

Step 154: Drill Fastener Holes in the Aft Edge of the Glare Shield

With the tabs securing the glare shield around its forward edge, you only need four or five fasteners along the aft edge to hold the shield in place. The simplest installation would be screws into nutplates riveted to the underside of the panel bow.

Position the glare shield, drill the appropriate holes through the shield and the bow, and rivet the nutplates in place. Then set the glare shield aside.

Completed: [ ]

Step 155: Mount the Instruments and Avionics in the Panel

At this time, remove the panel from the airplane and install all the goodies in it—instruments, avionics, switches, breakers, etc. Also, label the panel at this time; you'll find this much easier to do on your bench than in the cabin.

> **Note** Don't forget your "Passenger Warning" placard. You can bet that your airworthiness inspector won't! See "SECTION I: INTRODUCTION" for the required wording.

Completed: [ ]

Step 156: Install the Panel in the Cabin for the Final Time

Return the completed panel to the airplane, securing it at every location. Use NAS603-7P screws (with AN960D10L thin aluminum washers under the heads) at each of the two end holes and all six of the lower holes. The end screws should be tightened into their nutplates, and the lower screws should be secured with AN960-10L thin washers and AN364-1032A self-locking nuts.

Next, position the aft ends of the panel braces under their respective holes in the panel bow and tighten AN507-8R8 flush-head screws into the nutplates. Finally, tighten the pair of AN364-832A self-locking nuts at the forward ends of the braces.

Completed: [ ]

Step 157: Plumb the Pressure Instruments

Pitot/Static System Options If you're installing either of Stoddard-Hamilton's Pitot/Static System Option Kits, **turn to the *Option Instructions* now**. Return to Step 158 of this *Assembly Manual* when the specified option steps have been completed.

☞

Connect your airspeed indicator, vertical speed indicator, altimeter and/or altitude encoder to the static system and your airspeed indicator to the pitot system.

Completed: [ ]

Step 158: Wire the Panel

Like Step 7 of this section, in which you "completed" the firewall forward installation, wiring the panel is a much bigger job than a single "step." And, also like the firewall forward stuff, the task of wiring the panel varies so much from airplane to airplane that we cannot offer much guidance here. However, instructions for wiring individual components are typically provided by the manufacturers; be sure to follow all such instructions rigorously.

Some builders like this part of the project better than just about any other, while other builders can't wait to get somebody else to do it. In either case, be methodical and be neat. Mark **both ends** of every wire and draw a schematic of your wiring installation as an aid to future trouble-shooting. When you have to crawl under the panel to tackle a balky radio or trace a short circuit, you'll be grateful for every hour you spent making a clean job of the wiring!

Completed: [ ]

Note The glare shield can be installed now if you wish, but we recommend leaving it out until after your final inspection prior to flight. It will be a particular nuisance if it's in place during the installation of the windshield.

Window Installation

The procedures for installing all the Plexiglas windows in the GlaStar are the same, except for differences in the methods for clamping the various windows in place while the bonding mixture cures. The following instructions therefore describe generic procedures that you can adapt to whatever particular window you're working on.

The windows can be installed in any order, but we recommend starting with the smallest ones—the skylights—to perfect the procedures before moving on to the larger, more difficult ones. We also recommend leaving the **windshield** [21] unbonded until the last possible moment; although you were encouraged in the last sub-section to complete the instrument and avionics wiring and plumbing and the glare shield installation, it's not unlikely that you'll need to get back in there again before you're done, and such work is **much** easier with the windshield area left open. You'll minimize your opportunities to scratch the Plexiglas windshield that way, too!

The window installation procedure can be summarized as follows:

A) Check the fit of the window inside the joggled mounting flange and make minor adjustments, if necessary.

B) Sand the mating surfaces of the window and the mounting flange on the fuselage in preparation for bonding.

C) Mask off all surfaces of both the window and the fuselage near the bonding area to prevent damage from excess resin.

D) Bond the Plexiglas in place with a black-pigmented mixture of catalyzed vinyl ester resin and **Cabosil** [91]. (Cabosil is a fine powder used to thicken resin somewhat like mill fiber, but, since Cabosil is much finer, it makes a smoother, easier-to-use mixture.)

E) After the resin cures, sand any rough areas and remove the masking material.

> **Note** In addition to the skylights and windshield already discussed, the other windows to be installed include the **left** and **right quarter windows** [24 and 25] and the **left** and **right door windows** [22 and 23].

Step 159: Fit the Window to Its Mounting Flange

The windows are trimmed at the factory to provide about a **1/10"–1/8"** gap between the glass and the joggle on the mounting flange. This fairly wide gap saves a lot of time during the window installation since it eliminates most of the tedious fitting that would otherwise be necessary.

Place the window in position on its mounting flange and check its fit. Mark any places where trimming might be required to achieve a uniform gap all around the glass. Check also that the glass rests flat against the mounting flange all the way around and not on any part of the radius in the corner of the joggle (see Figure 165). Mark for trimming any areas where the glass contacts the flange joggle radius.

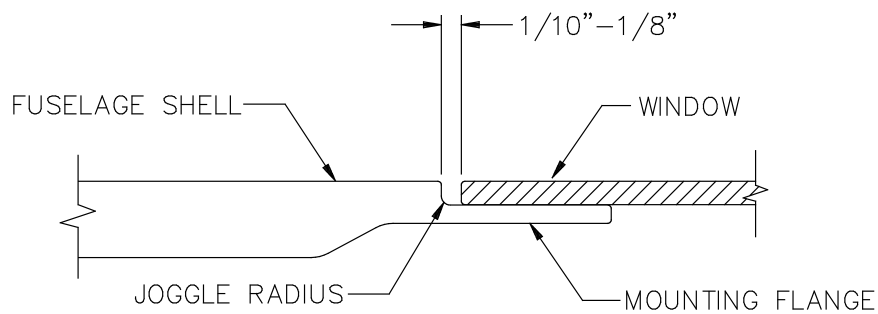


Figure 165: Checking the Fit of the Window to the Mounting Flange

Note The thickness of the windows varies somewhat. When installing them, therefore, you'll have to vary the thickness of the bonding material to bring the surface of the glass flush with the surface of the surrounding fiberglass. (There's no absolute requirement that the two surfaces be flush with each other, but most builders will want to make them flush for cosmetic reasons and to minimize drag.) The procedures for doing this are further described below; don't worry about any thickness variation in the Plexiglas at this point.

Remove the window and use sandpaper on a sanding block to trim its edge where necessary to adjust its fit. When the Plexiglas fits satisfactorily with a uniform gap to the flange joggle all around, use sandpaper to smooth the edge of the window all the way around. The goal of this final sanding is to remove from the edges of the Plexiglas all nicks, scratches and irregularities that could possibly induce cracking. In particular, the slight, scalloped indentations left by our trimming router must be completely eliminated. You may find it necessary to begin sanding with coarser sandpaper and finish up with 220 or even 320 grit paper. Sand parallel to the edge, not across it. When you are done, you should have slightly radiused each corner, as shown in Figure 165.1.

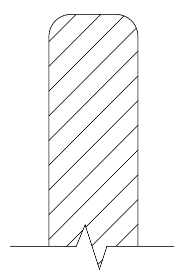


Figure 165.1: Properly Radiused Plexiglas Edge

Caution This final sanding with fine paper is an important step; removing any edge roughness eliminates stress risers that might lead to cracking.

Completed:

Skylight — Left [ ] Right [ ]
Quarter Window — Left [ ] Right [ ]
Door Window — Left [ ] Right [ ]
Windshield [ ]

Step 160: Mask and Prep the Mating Surfaces of the Mounting Flange and the Window

At this time mask the **outside** surface of the Plexiglas, as shown in Figure 166. The recommended masking consists of **vinyl striping tape** applied to the perimeter of the glass, right out to the edge, and paper masking tape securing masking paper to the vinyl tape inside the perimeter. The paper tape should overlap the vinyl masking tape, as shown, so the entire surface of the glass is protected.

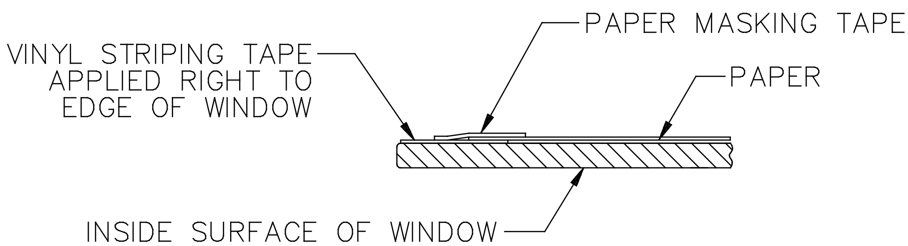


Figure 166: Masking the Outside Surface of the Window

> **Note** Vinyl striping tape (available at any automotive paint supply store) is recommended for use around the perimeter because it's impervious to the resin used to bond the glass into place. It's also very flexible so that it can be stretched to fit the sharp curves in the corners without bulging or wrinkling. Wrinkles in the tape around the edges will make it much more difficult to smoothly clean up excess resin mixture when the windows are bonded in.
>
> Black, 1/2"-wide tape is recommended. This color is best so that, in the event you inadvertently let the bonding resin lap over the tape, you can simply trim it and leave it in place without leaving any unsightly evidence of your error!

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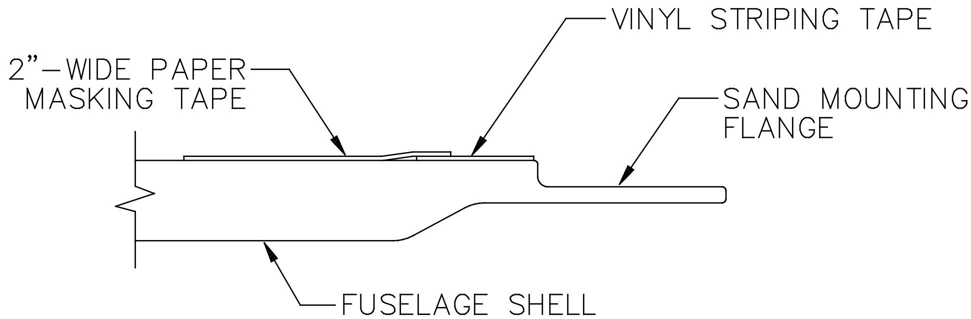

Figure 167: Sanding the Window Mounting Flange

Next, mask the fuselage around the window mounting flange by applying vinyl striping tape right up to the edge of the flange joggle all the way around, as shown in Figure 167. Then apply 2"-wide paper masking tape overlapping the vinyl tape around the perimeter to further protect the outside of the fiberglass structure. Also as shown in Figure 167, thoroughly sand the window mounting flange of the fiberglass fuselage shell with coarse sandpaper. There is no need to sand away all of the gelcoat on the bonding surface, but sand it thoroughly so that no shiny surfaces remain.

With the outside surfaces of the window and fuselage both masked, position the window in its cutout with equal gaps all the way around and temporarily tape it in place with wide masking tape. Then make three or four reference marks to allow the window to be returned to the exact same position later. Each mark should start on the taped window and extend across the gap onto the masked fuselage shell. Later, you can realign the window on these marks.

The mating surface on the **inside** of the Plexiglas must be sanded in preparation for bonding. With the glass taped in position on the mounting flange with a uniform gap between the glass and the flange joggle all around, mark the edge of the flange with a fine-point felt-tip pen on the inside of the glass, as shown in Figure 168. (Use a pen with black **water-soluble** ink to make clean-up easier; we recommend the “Vis-a-Vis” brand.) Remove the window and apply **two** layers of vinyl striping tape to **just slightly outside** the marked line, as shown in Figure 169.

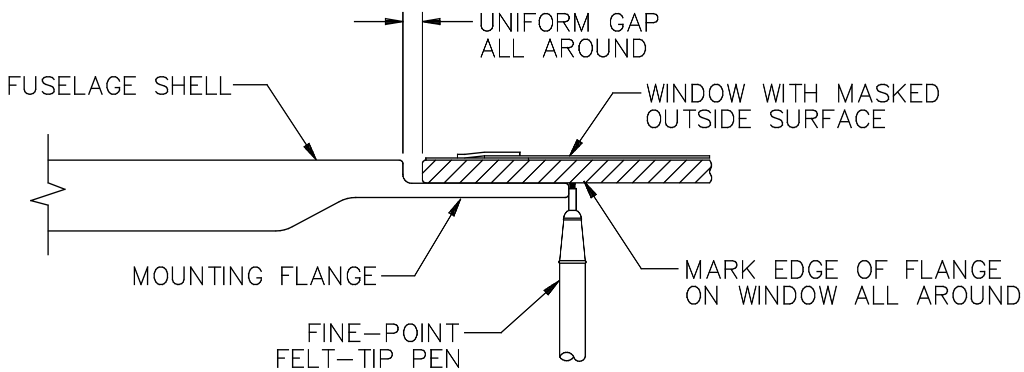

Figure 168: Marking the Edge of the Mounting Flange onto the Inside of the Window

Use coarse sandpaper (no finer than 100-grit) to thoroughly roughen the bonding surface of the window, as shown in Figure 169. Sand until no shiny surfaces remain. When finished, remove the original two layers of vinyl tape and apply two fresh layers along the edge of the bonding area all around the inside of the glass, as shown in Figure 170. Then mask the rest of the inside surface with paper masking tape and heavy paper, just as you did with the outside surface.

Completed:

Skylight — Left [ ] Right [ ]
Quarter Window — Left [ ] Right [ ]
Door Window — Left [ ] Right [ ]
Windshield [ ]

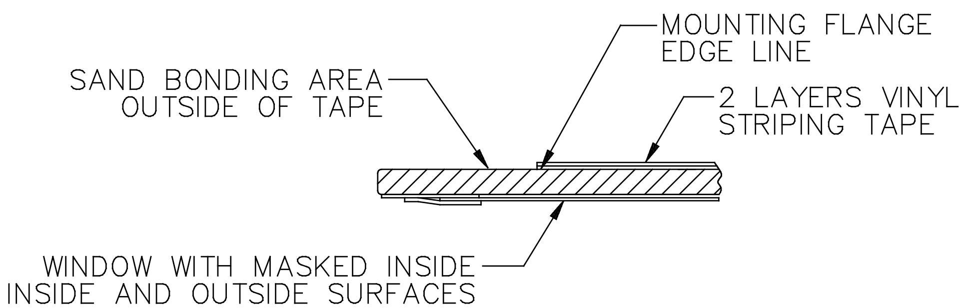

Figure 169: Sanding the Bonding Surface of the Window

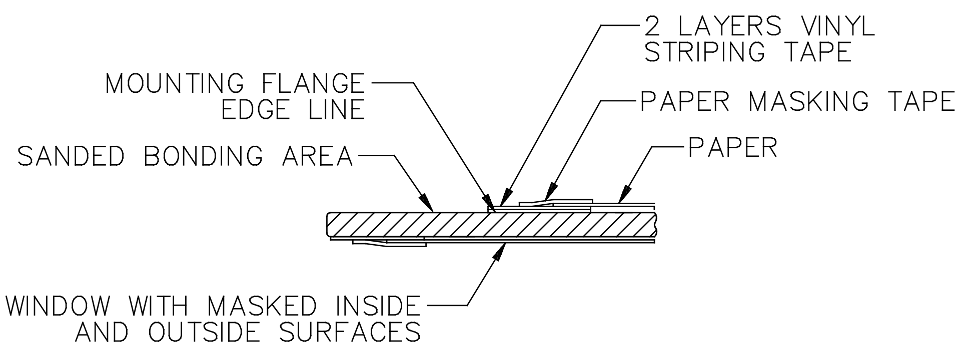

Figure 170: Masking the Inside Surface of the Window

Step 161: Paint the Bonding Surface of the Window

For the most attractive finished window installation, we recommend painting the prep-sanded bonding surface of the window with a resin/Cabosil mixture to which black pigment has been added, as shown in Figure 171. The result will be a smooth, opaque black finish around the perimeter of the glass that will hide any voids or irregularities in the bonding mixture.

Prepare a small batch of resin and add Cabosil to thicken it just enough to reduce the mixture's tendency to run. The mixture should still be thin enough that it can be easily applied to a surface with a brush. Add black pigment until a uniform black color has been achieved.

Note A good (and free!) pigment is used toner from a copy machine or laser printer. Alternatively, order **Fiberlay black pigment** (P/N 027-01000-01) from Stoddard-Hamilton. You will have to experiment with the used toner to see how much you need to make a dark, nearly opaque mixture; only a very small quantity (start with 1/8 teaspoon, or less) of the Fiberlay pigment is required to get a good color.

Use a brush to paint the pigmented resin/Cabosil mixture onto the inside of the bonding surface all around the Plexiglas. Apply a relatively thick coat over the entire surface, but every **6"–8"** build up an extra mound of mixture about **3/16"–1/4"** high, as shown in Figure 171. Try to avoid lapping the mixture over onto the masking tape; a small gap between the mixture and the tape is no problem.

After the mixture has cured, check it for opacity by holding the window up to a light. If the painted strip is at all translucent, apply a second coat and let it cure before proceeding.

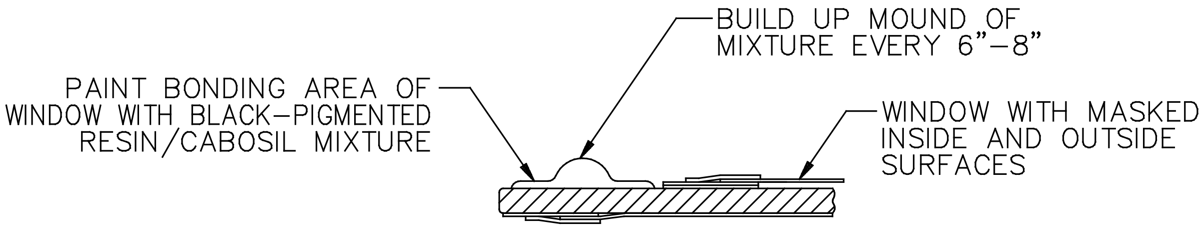

Figure 171: Painting the Bonding Surface on the Window

Trial fit the window with the cured resin/Cabosil mixture in place and check for a flush fit between the outside surface of the glass and the fiberglass shell. Sand the raised mounds of cured mixture as necessary to bring the window flush all the way around its perimeter.

Completed:

Skylight — Left [ ] Right [ ]
Quarter Window — Left [ ] Right [ ]
Door Window — Left [ ] Right [ ]
Windshield [ ]

Step 162: Bond the Window to its Mounting Flange

Now you are ready to bond the glass into place. In preparation, make a **resin clean-up tool** from a tongue depressor by sanding one end square and sanding about a **2"** radius into the other end. (See Figures 176 and 177.)

The skylights, quarter windows and windshield fit directly to flanges in the fuselage shell, so you don't have any choice in how you bond these in. With the door windows, however, you have to choose whether to bond them in with the doors installed in the fuselage or removed from the fuselage. With the doors installed and latched firmly closed, they will be held to their proper contours during window bonding so that the bond will be in the relaxed condition when the doors are latched. Installing the windows with the doors off the fuselage could change the shape of the doors slightly, making them harder to latch and straining the window bond when they are latched. On the other hand, removing the doors to install the windows makes the installation much easier since both sides of the door are more readily accessible for resin clean-up, and the windows on both doors can be bonded simultaneously, instead of one at a time. With the doors removed it is also easier to clamp the windows while the bonding mixture cures; you can simply position the doors with their outside surfaces up and use weights around the perimeter of the glass to hold it in firm contact with the mounting flange.

As shown in Figure 172, we placed the door on the edge of a work bench with the window area overhanging and the top of the door supported by a cardboard shipping tube cut to the proper length to fit between the floor and the door. The tube was taped in place to keep it from shifting. In this position, both sides of the window were accessible for excess resin clean-up.

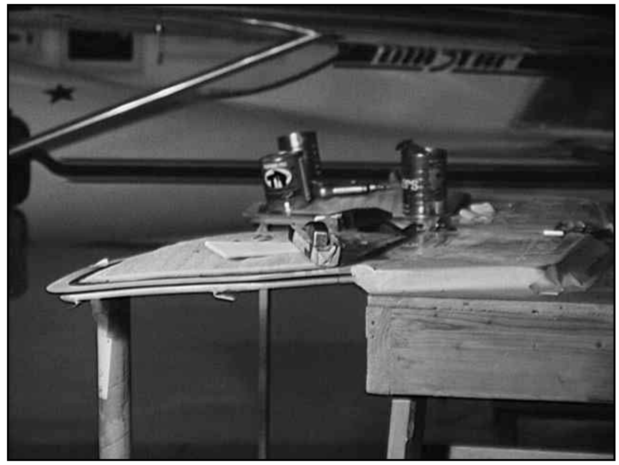

Figure 172: Bonding In the Door Window

Use your own judgment about whether to bond the door windows with the doors installed or removed. The deciding factor might be how well your doors fit the fuselage: if the door contours match the fuselage contours fairly well, you can bond in the windows with the doors removed; if the doors flex somewhat as the latches pull them closed, it might be better to bond in the windows with the doors installed in the fuselage.

The method of clamping the various windows also must be considered before mixing the bonding resin so there's no last-minute rush to figure it out. The skylights and the door windows (if installed with the doors removed from the fuselage) can be held with weights placed around their perimeters while the bonding mixture cures. You don't need a lot of weight for this; use just enough to keep the glass from shifting while the bond cures.

Figure 173: Clamping the Quarter Window

The quarter windows and the windshield will have to be held by other methods. For the quarter windows, we used 2 X 4 blocks placed near the mounting flange of the windows with strips of tape stretched tightly across the blocks to the surrounding fuselage. This method is shown in Figure 173. A similar method could be used for the door windows if they're bonded with the doors installed in the fuselage.

A variety of methods (including the tape-and-blocks method) can be used on the windshield. For the edge of the windshield next to the door post, try long-reach C-clamps, as shown in Figure 174. Tighten the clamps very lightly and pad them with thin wooden strips, as shown, to prevent damage to the Plexiglas.

Figure 174: Clamping the Windshield

In areas that are inaccessible for clamping by other methods, drill small holes in the gap between the flange joggle and the Plexiglas and use sheet metal screws and wooden strips to secure the edge of the glass, as shown in Figure 175. Position an extra shim between the strip and the glass to increase the clamping pressure. The small hole left by the screw can easily be filled later.

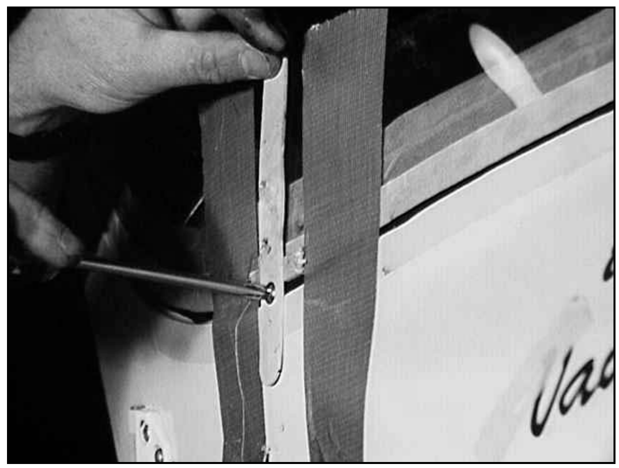

Figure 175: Sheet-Metal Screw Clamping Method

Hint One additional step you can take to improve the cosmetics of the finished window installation is to apply black paint for a couple of inches around the window opening on the **inside** of the fuselage shell. If you do this, any fiberglass edges not completely covered later by upholstery won't be as obvious.

With all necessary tools and materials for your chosen clamping method at hand, you are ready to mix the resin. Mix a batch of resin, add Cabosil to make a medium-thick mix (thick enough to adhere to a vertical surface without running) and then add black pigment until the mixture is a deep black color.

Caution Make sure that you mix an ample quantity of resin. Time is of the essence once the resin is mixed; if it begins to gel before the window is clamped in place, it could mean a ruined part. Much better to throw away some wasted resin!

Spread the resin/Cabosil mixture evenly on the mounting flange to a depth greater than the thickness of the shim mounds. Lower the glass piece into place and secure it with the chosen weights or clamps. Clamp just tightly enough to immobilize the glass and to hold it in contact with the flange shims. Clamping too tightly could destroy the flush fit of the window. Alternatively, excessive clamping pressure could warp the glass between the shim mounds, resulting in a wavy edge after the bonding mixture cures.

Before the bonding mixture cures, use the resin clean-up tool made from the tongue depressor to clean up excess resin. On the outside surface, use the rounded end of the tongue depressor to remove the resin and form a slight concave radius in the gap between the glass and the flange joggle. This is shown in Figure 176.

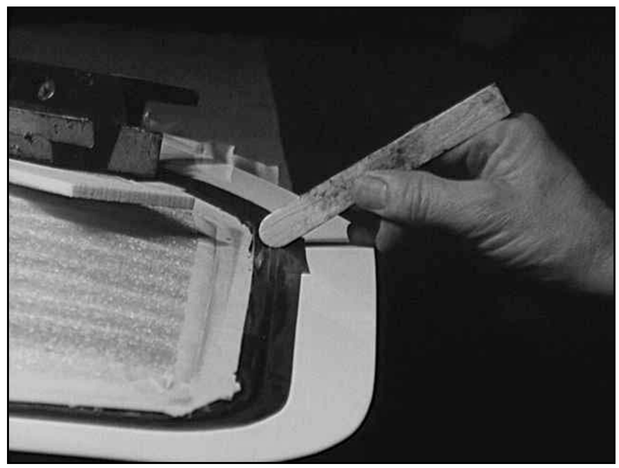

Figure 176: Cleaning Up Excess Resin on the Outside Surface

Note As noted previously, a 2" radius on the rounded end of the clean-up tool seems to be ideal; Figure 176 shows a much tighter radius that didn't work as well.

On the inside, use the square end of the clean-up tool to remove the resin even with the edge of the flange, as shown in Figure 177.

Figure 177: Cleaning Up Excess Resin on the Inside Surface

Note Taking extra care to clean up excess resin thoroughly and to form a smooth radius on the outside will save time in the long run because it is much easier to perform this clean-up work before the resin cures. If you are very careful to form a smooth radius in the gap on the outside, you will not have to do any further work later to improve the joint cosmetically.

Let the bonding mixture cure completely. You might want to consider leaving the masking material in place on both the inside and the outside of the window to protect it and to prevent damage while you finish the rest of the final assembly procedures, but, once the resin has cured, you can remove the masking material at any time you choose.

Completed:

Skylight — Left [ ] Right [ ]
Quarter Window — Left [ ] Right [ ]
Door Window — Left [ ] Right [ ]

Windshield [ ]

Step 163: Caulk the Gaps Around the Windows (Optional)

If you're dissatisfied with the resin/Cabosil radius you ended up with in the gap around any window, you can easily add non-structural caulking to produce a better appearance. A black polyurethane sealant like Sikaflex (available at any building-supply store) is recommended because of its good adhesion qualities. Whether you caulk everywhere or not, this material can also be used to fill in any sheet-metal screw holes you made.

Completed: [ ]

CONTROL SURFACE BALANCING AND FAIRING INSTALLATION

All the control surfaces of the GlaStar are counterbalanced to prevent the possibility of flutter. With the exception of the rudder, all the surfaces are balanced to 100%, meaning that they have the same moment forward of the hinge line as they do aft of it. For this balancing to be as accurate (and thus as safe) as possible, the surfaces should be balanced **after** they have been painted, since paint significantly affects the weight of the surfaces. If necessary, you can defer the next several steps until you're ready for them. However, the ailerons, trim tab and elevator definitely **must be counterbalanced prior to flight.**

Step 164: Install the Aileron Counterweights

In Steps 4 and 5 of "Section VII: Aileron and Flap Assemblies," you drilled holes in the aileron counterweight ribs and mounted nutplates for securing the aileron counterweights. In this step, you will fasten the aileron counterweights to the outboard ends of the ailerons. Begin by removing the wingtip fairings, if installed.

In early GlaStar kits, mounting holes were pre-drilled in the **left** and **right aileron counterweights** [36 and 37]. These holes were eliminated from the counterweights shipped with later kits due to alignment difficulties. If your aileron counterweights already have mounting holes, skip the procedure described in the following two paragraphs and in Figure 178.

To drill the mounting bolt holes most accurately, use the pre-existing holes in the aileron counterweight ribs as guides. Slide each aileron counterweight between its respective pair of ribs, as shown in Figure 178. Pay careful attention to the orientation of the weight, as shown in the figure: the "fat" sides of the counterweight go up and outboard. Slide the arm between the ribs until its aft end comes into contact with the spar web inside the aileron. Make a mark on the arm where it emerges from the aileron, as shown in Figure 178a. Then withdraw the arm from between the ribs until the mark is **7/32"** forward of the leading edge of the aileron, as shown in Figure 178b. With the arm in this position, mark the locations of the two mounting bolt holes, as shown.

> **Note** If, despite the precautions you took in "SECTION VII: AILERON AND FLAP ASSEMBLIES," the aileron counterweight ribs are too close together for the counterweight arms, it's acceptable to file a few thousandths off the sides of the arms to get them to fit.

Withdraw the arm from the aileron, center punch the two bolt hole locations and drill them with a **#10** bit. Drill all the way through both sides of the tubing. Use a drill press if you have one, but strive in any case to keep the holes perpendicular to the arm. Deburr the holes after drilling.

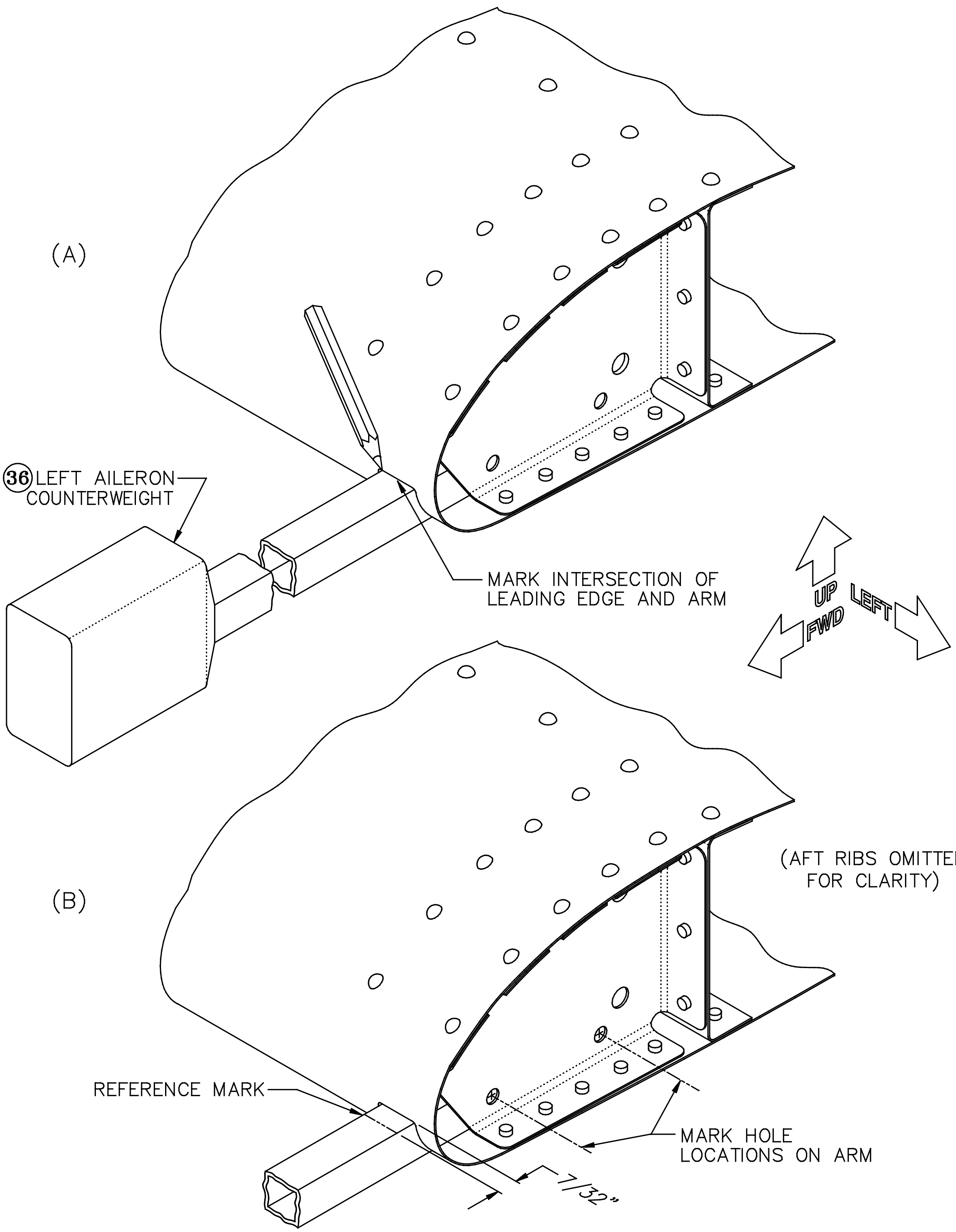

Figure 178: Drilling the Mounting Bolt Holes in the Counterweight Arms

Insert each drilled counterweight arm into its respective aileron and secure it, as shown in Figure 179, with AN3-7A **bolts** [116] and AN960D10L thin aluminum washers. Pay careful attention to the orientation of the lead weight so that you match the correct counterweight assembly to each aileron.

Hint The counterweight will have to be installed and removed several times during fit-up. To simplify installation and removal and to help preserve the self-locking feature of the nutplates, temporarily stack several extra washers under each bolt head to limit the bolt's penetration into the nutplate. Remove the extra washers before installing the counterweight for the final time.

Completed: Left [ ] Right [ ]

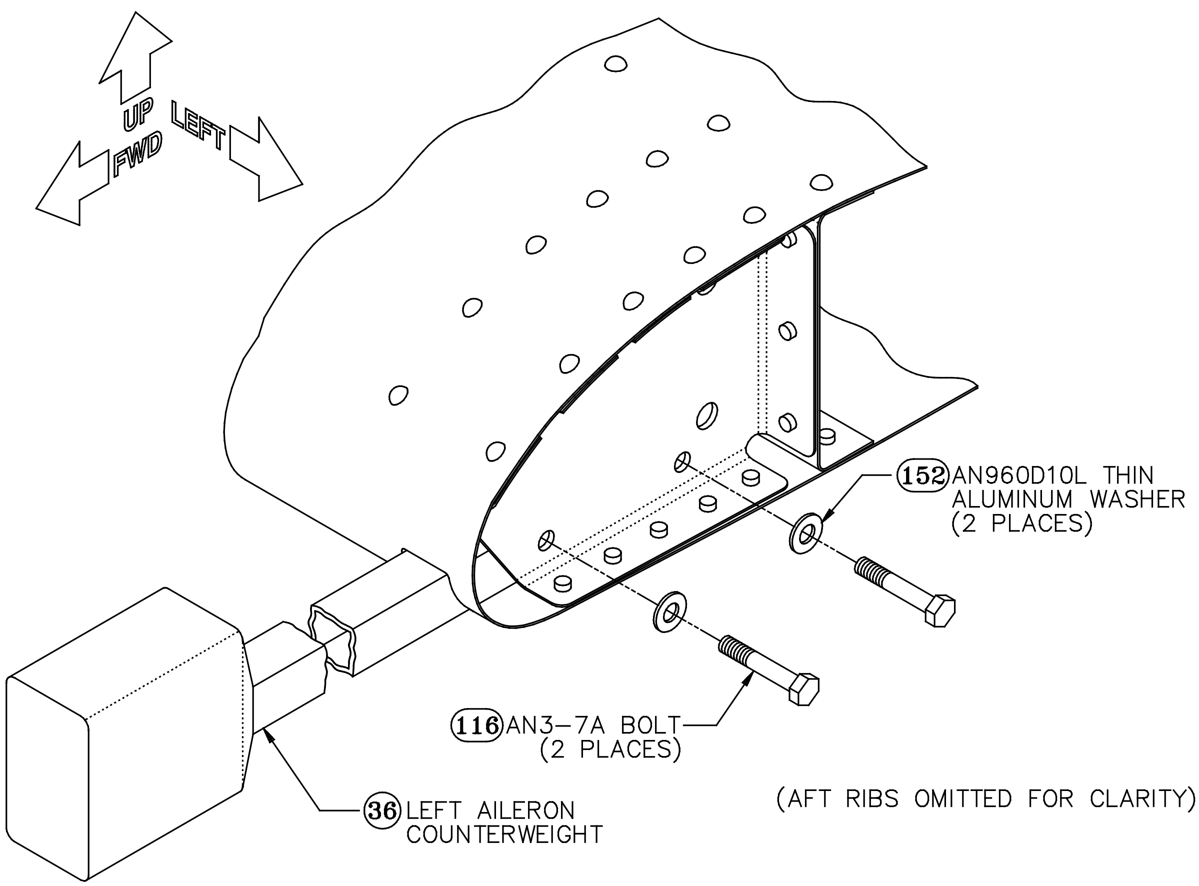

Figure 179: Installing the Counterweight

Step 165: Adjust the Aileron Counterweights

Scribe lines are provided on the wingtip fairing for a slot through which the counterweight arm passes. The scribe lines provide only an approximate reference for locating the counterweight slot. Cut about **1/8"** inside the lines first and then secure the tip fairing to the wing with one or two screws to check the fit of the counterweight in the slots.

Note To get the best fit in the scribed slot, you may have to bend the counterweight arm **outboard** slightly. Clamp the aft end of the counterweight arm in a vise, and bend the forward end about 1/8" outboard, measuring just aft of the lead weight. You can make the bend cold, but **do not** grasp the lead weight itself during bending. Even though the weight is secured with internal reinforcement dowel pins, you could still loosen it enough to cause it to rattle.

Enlarge the slot in the tip fairing until there is a minimum clearance of **3/16"** between the counterweight arm and the fairing. Smooth the slot with files and sandpaper.

Warning Make sure you provide a **minimum** 3/16" clearance for the counterweight. Since the counterweight can vibrate during flight, you want to be **absolutely certain** that it will not contact the tip fairing, causing the ailerons to bind.

Note When cutting the notch for the counterweight in the tip fairing, you will notice that the narrow portion of the fairing inboard of the counterweight arm is purely cosmetic, since it provides no structural support for the fairing. We think the fairing looks better with this small strip left in place (although you must be more careful with the fairing when it is removed from the wing), but you can cut it away if you choose, which will open up a gap about 1/2" wide on the inboard side of the counterweight arm.

Once the counterweight is well fitted relative to the slot in the fairing, bend the arm down until the weight is flush with the bottom of the fairing when the aileron is in the neutral position (you will need to bend the arm down approximately **1/4"** measured just aft of the weight). Again, clamp the arm in a vise and bend it cold, being careful not to loosen the lead weight.

Temporarily reinstall the arm in the aileron. Then temporarily disconnect the pushrod so the aileron is free to pivot on its hinges. As shown in Figure 180, trim lead from the forward upper corner of the counterweight until the aileron is balanced.

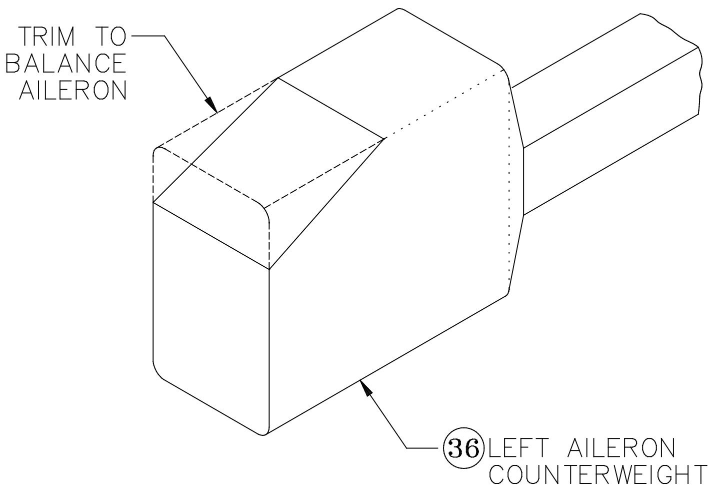

Figure 180: Trimming the Counterweight

When you've achieved a balanced condition, re-connect the pushrod. Deflect the aileron full-up and check to see that the control stick pivot bracket in the cabin contacts its stop **before** the aileron counterweight contacts the wingtip fairing. If necessary, put the arm back in a vise and bend it downward a bit more to eliminate this problem.

When the counterweight is fitted satisfactorily, you can smooth the lead weight with body putty (Bondo) and paint it if you want a nice finish. Then permanently install the counterweight arm, remembering to remove the extra washer from under the bolt heads.

Warning If you are installing wingtip lighting of any kind, it is essential that you install a **close-out bulkhead** in the wingtip fairing just aft of the aileron counterweight arm cutout. This close-out is necessary to preclude the possibility of light wiring jamming or impeding free movement of the ailerons. The close-out could consist of a simple two- or three-layer pre-cure of bi-directional cloth bonded into the fairing. Such a close-out is described in the instructions for Stoddard-Hamilton's Nav/Strobe Light Option Kit (P/N 921-02000-01)

Note The following eleven steps (Steps 166—176), which cover counterbalancing the trim tab and elevator, were included in slightly different form in the initial release of "SECTION V: ELEVATOR ASSEMBLY." If you completed your horizontal stabilizer, elevator and trim tab according to those early instructions, then you should just skim the following pages to make sure that you have completed the work.

Completed: Left [ ] Right [ ]

Step 166: Determine the Size of the Elevator Trim Tab Counterweight

Since no two trim tabs are likely to weigh exactly the same, the amount of weight required to counterbalance the tab will also vary from airplane to airplane, and must therefore be determined by experimentation. Begin by suspending the tab between two supports on short lengths of hinge pin, as shown in Figure 182. The supports can be anything that will hold the tab 10—12" above the bench—wooden blocks, paint cans, etc. The height is not critical but should be the same at both ends.

With the tab suspended between the supports, you can determine with a simple experiment how much weight is required on the counterweight arm to bring the tab into balance. Hang a weight from a thin string or wire through the forward-most hole at the bottom of the counterweight arm, as shown in Figure 182. Vary the weight until the tab is balanced in a roughly horizontal position, as shown.

Hint A good weight to use is a small container (like the bottom half of a tin can) filled with BBs, since it's easy to add or subtract weight.

Once the tab is balanced, remove the weight and weigh it (including the can and the string or wire) to the nearest ounce. We'll call this the **experimental weight**. We also need the horizontal distance from the hingeline to the forward hole in the counterweight arm, which we'll call the **experimental arm**; this is **4.0"**. Multiplying the experimental weight by the experimental arm gives us the **total moment** of the trim tab. Now, the **actual arm** of the counterweight is slightly smaller than the experimental arm, because the counterweight isn't centered on the forward-most hole in the arm but rather between the two holes; this distance turns out to be **3.7"**. Now we're almost home: dividing the total moment by the actual arm yields the **actual weight** required.

Figure 181 shows a sample calculation.

Note Keep in mind that your weights will almost certainly be different than those used in the example. However, the experimental and actual arms in the example **are** the real figures that you should use in your own calculations.

Completed: [ ]

Experimental Calculation	**Actual Calculation**
EXPERIMENTAL WEIGHT = 5 oz.	
EXPERIMENTAL ARM = 4.0 in.	ACTUAL WEIGHT = TTL. MOMENT ÷ ACTUAL ARM
EXP. WEIGHT X EXP. ARM = TOTAL MOMENT	20 in.-oz. ÷ 3.7 in. ≅ **5.5 oz.**
5 oz. X 4.0 in. = 20 in.-oz.	

Figure 181: Sample Trim Tab Counterweight Calculation

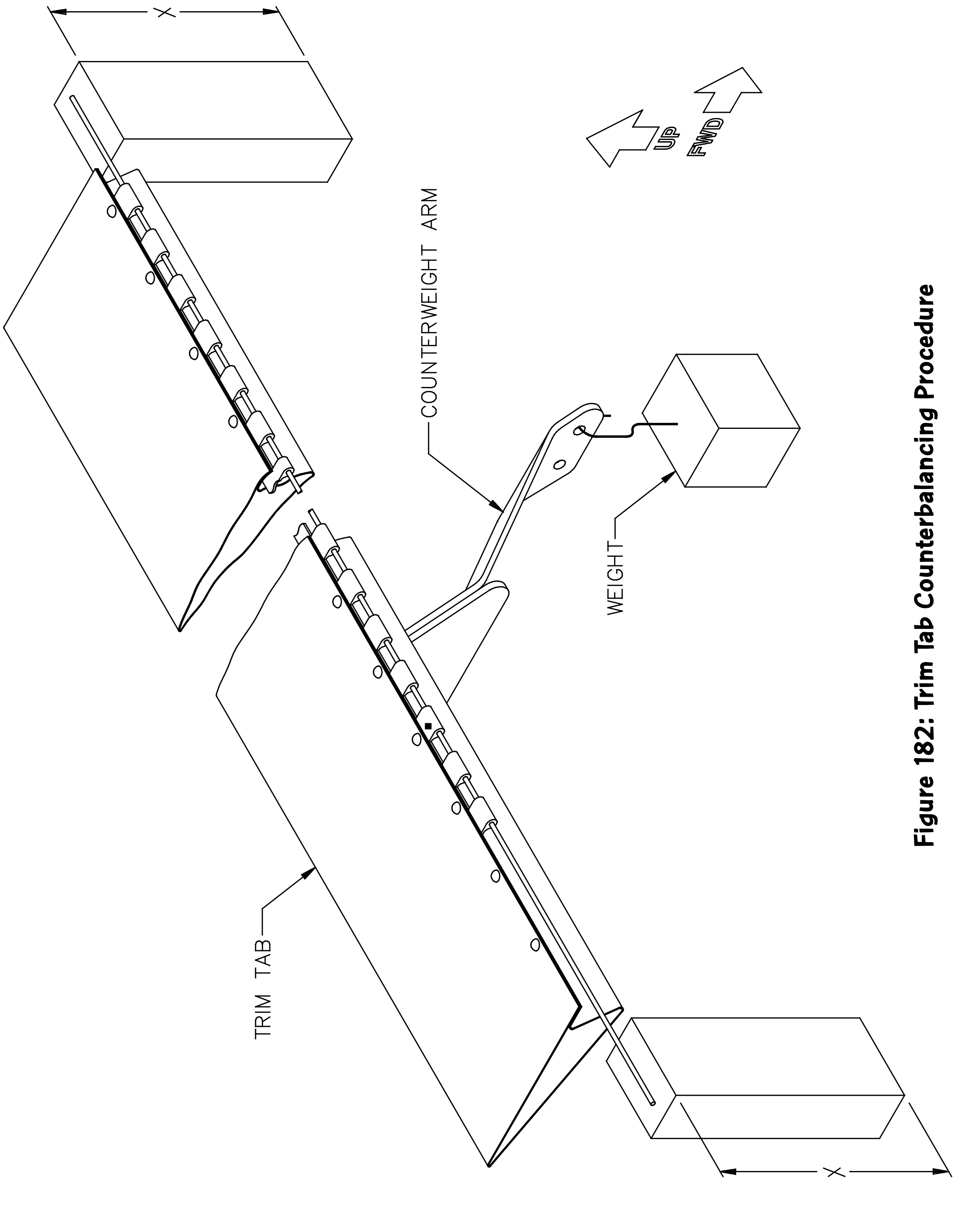

Figure 182: Trim Tab Counterbalancing Procedure

Step 167: Cut and Install the Trim Tab Counterweight

From the **12"-wide lead sheet** [109] left over from "SECTION III: RUDDER ASSEMBLY," cut several small pieces approximately **1-3/8" X 2"**, as shown in Figure 183. As the figure shows, the upper forward corner of each piece should be lopped off at about a 45° angle; this ensures that the counterweight won't hit the stabilizer or fuselage when full down elevator is applied. Cut a couple more pieces than are necessary to equal the counterweight amount you calculated in the preceding step.

Stack up the pieces and drill two **#10** holes through the stack corresponding to the two holes at the bottom of the counterweight arm. As shown in Figure 183, the holes should be drilled about **1/2"** above the lower edge of the lead and centered longitudinally.

When you have completed the lead pieces, weigh them along with their mounting hardware: two AN509-10R13 **flush-head machine screws** [134], two AN970-3 **large washers** [156] and two AN364-1032A nylon self locking nuts. Subtract lead pieces and/or trim them slightly to achieve the required weight you calculated. Then mount the lead **outboard** of the arm, as shown in Figure 183. The large washers may have to be ground down slightly to clear one another.

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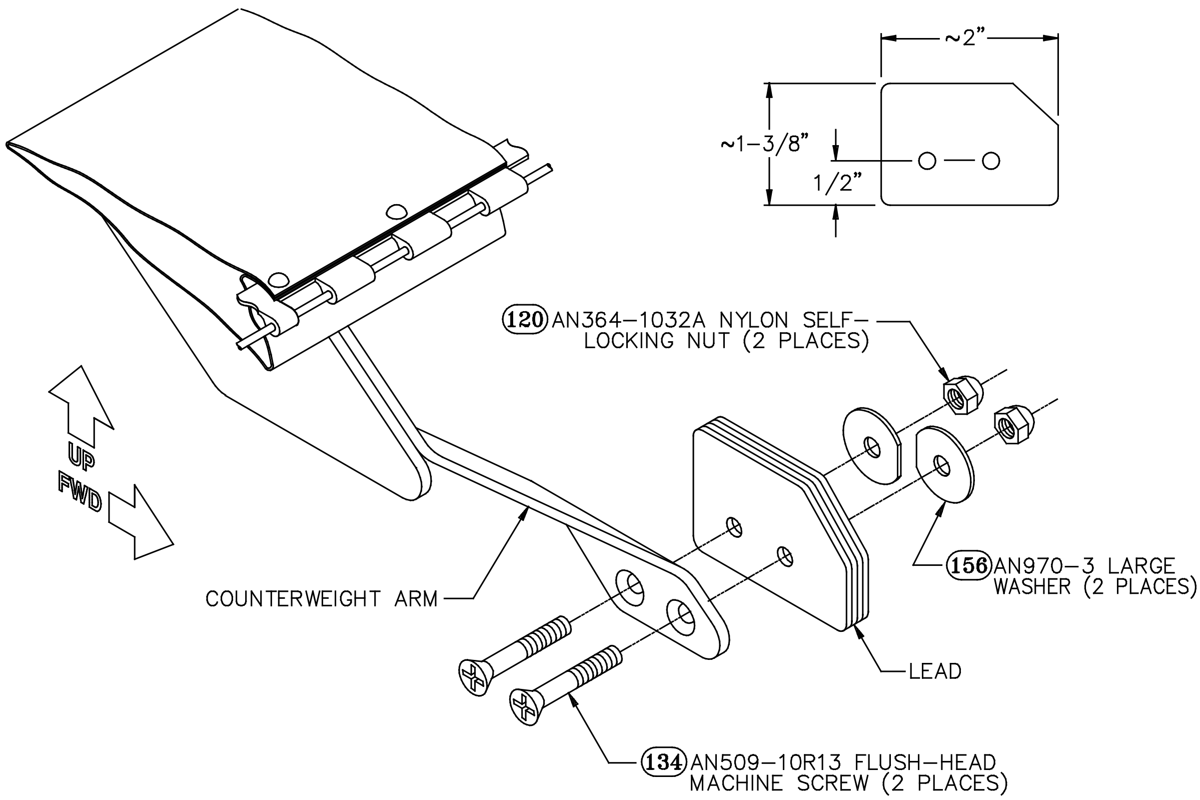

Figure 183: Cutting and Installing the Trim Tab Counterweight

Step 168: Install the Trim Tab on the Elevator

Align the trim tab hinge halves and insert the hinge pin, with its bent end to the **right**. A light coat of WD-40 or Teflon spray lubricant on the pin will help it go in more easily. Don't worry about safetying the hinge pin yet; that will be taken care of in a subsequent step.

Completed: [ ]

Note The next several steps concern the horizontal stabilizer and elevator tip fairings. In early GlaStar kits, these fairings were supplied in the Tail Kit and consisted of a one-piece horizontal stabilizer/elevator fairing (P/N 303-00014-01) and separate horizontal stabilizer and elevator close-out pieces (P/N 302-00015-01 and 303-00015-01, respectively). All these parts were of laminated composite construction. In later kits, these parts are made of vacuum-formed ABS plastic, which allows the elimination of the close-outs. In these kits, the **horizontal stabilizer** and **elevator tip fairings** [48 and 49] are separate units.

The procedures for installing these different styles of fairings are substantially the same, but there are a few differences. Therefore, note that some of the following steps (or parts thereof) apply only to one style or the other.

Step 169: Cut Out the Horizontal Stabilizer and Elevator Tip Fairings (Fiberglass Fairings Only)

The fiberglass tip fairings are molded in one piece; you need to cut each unit into separate stabilizer and elevator fairings. As you receive it from the factory, each fairing unit is notched to indicate where you need to cut, as shown in Figure 184. Saw the unit in two along this line using a fine-toothed, hand or power saw such as a coping saw, saber saw or bandsaw.

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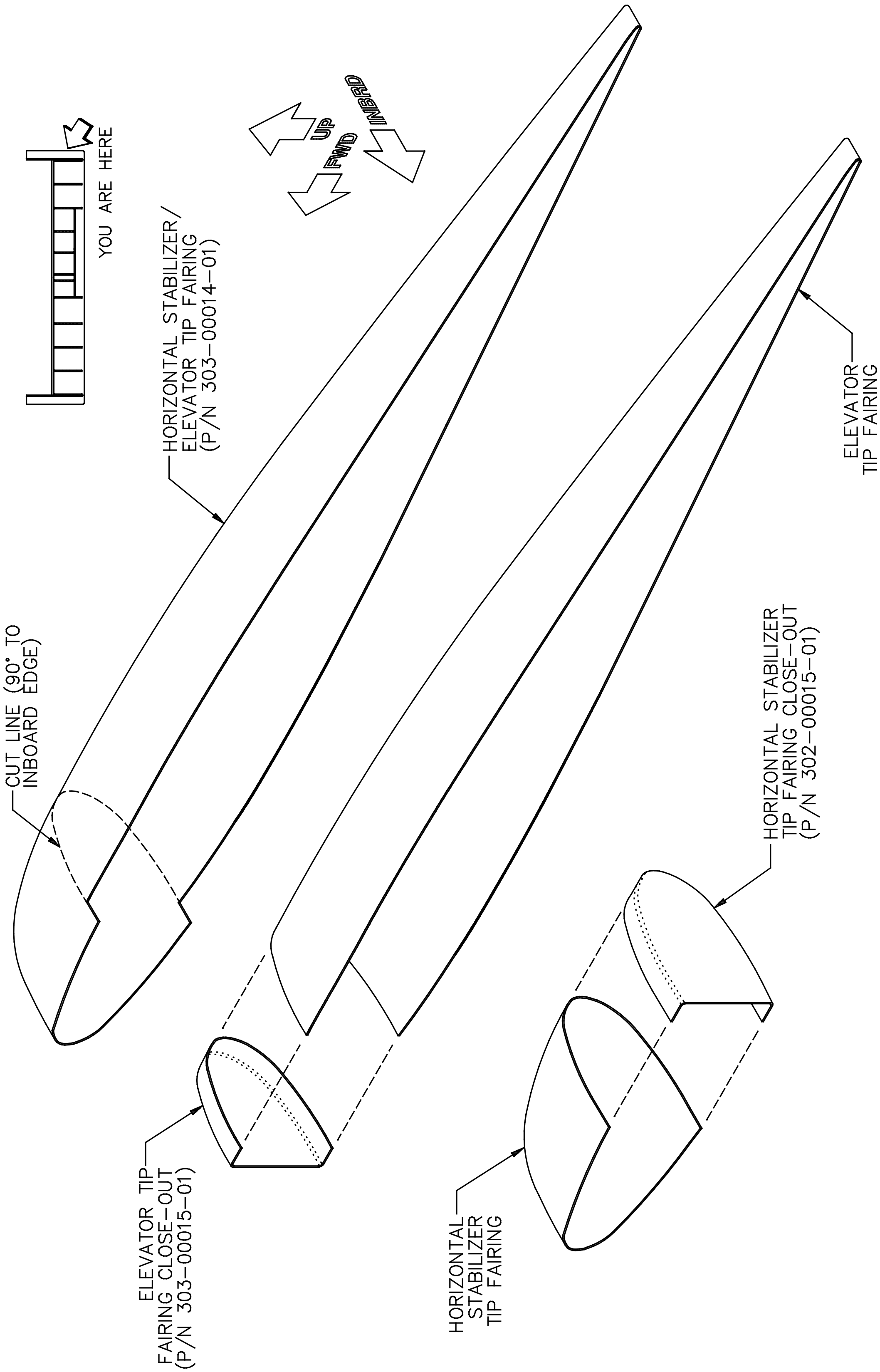

Figure 184: Cutting Out the Tip Fairings (Fiberglass Fairings Only)

Step 170: Install the Horizontal Stabilizer Tip Fairings

Figure 185 shows how the horizontal stabilizer tip fairings are positioned on the stabilizer: their inboard edges should be **11/16"** inboard of the end of the stabilizer, and they should be pulled back tightly against the leading edge bend. If you have ABS fairings, the 11/16" dimension will be achieved if you simply slide the fairing inboard until the vertical close-out portion of the fairing contacts the end of the stabilizer. If you have fiberglass fairings, you'll have to measure and mark an 11/16" reference line as shown in the figure.

Next, you must mark four screw hole locations on each fairing. As shown in Figure 185, these holes should all be **3/8"** outboard of the inboard edge of the fairing. The fore-and-aft dimensions given—**1-1/2"** and **3-1/2"** forward of the aft edge of the fairing on both the top and bottom—are not critical. Just be sure the holes avoid the flutes in the center of the upper and lower flanges of the tip rib.

Note In very early kits, the horizontal stabilizer skins were pre-punched over the tip rib flanges in six places. If you have such a skin, you can position your screw holes to coincide with four of these six holes. The remaining two holes can, at your discretion, either be drilled and riveted with 3/32" AN426AD3 flush-head rivets or simply left alone.

Additionally, in most cases, the fiberglass tip fairings were supplied with pilot holes already drilled for the screw holes. If your fairing is pre-drilled, check the positions of the pilot holes to ensure that they miss the flutes and are either well aligned with or well clear of any pre-punched skin holes. It may be necessary for you to ignore one or more of the pilot holes and replace it with a hole you position and drill yourself. If this is the case, the unused pilot hole(s) can easily be filled with body filler and painted or gel-coated over.

With the screw hole locations marked and/or the pilot hole locations verified, position the fairing on the stabilizer and tape it in place with duct tape or masking tape. Then drill through the fairing, the skin and the underlying tip rib flange at each location with a **#19** bit.

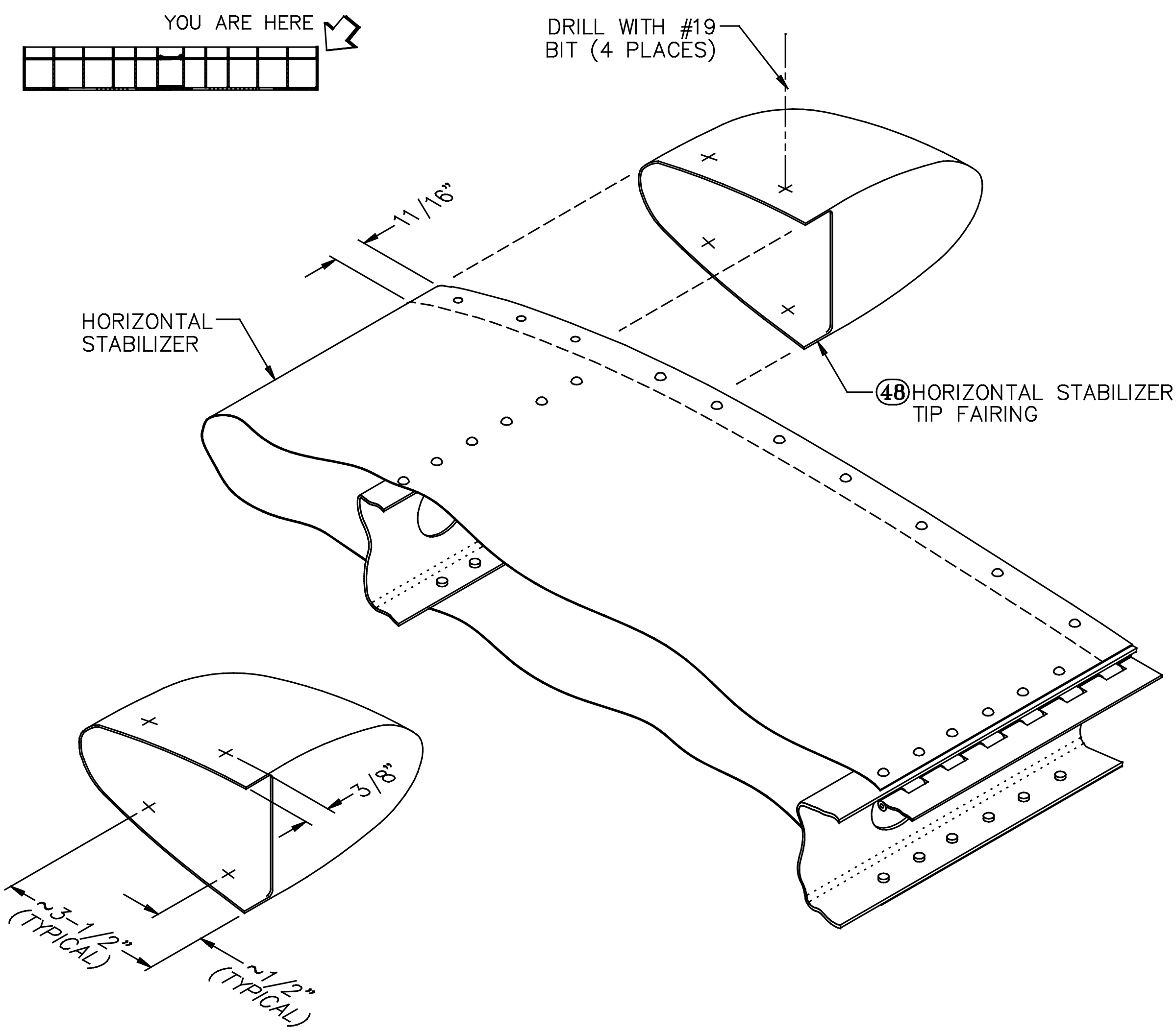

Figure 185: Positioning and Drilling the Horizontal Stabilizer Tip Fairings

Remove the fairing, and then position and drill K1000-08 nutplates at each hole using standard procedures. After drilling, thoroughly deburr all the holes and, if necessary, use a chip chaser to clean any aluminum shavings out from between the skins and the rib flanges.

Dimple the skins and rib flanges and rivet the nutplates in place with 3/32" AN426AD3 flush-head rivets. Also rivet any extra skin-to-rib holes at this time. Finally, using AN526-8R7 round-head machine screws, install the fairings.

Completed: Left [ ] Right [ ]

Step 171: Install the Elevator Tip Fairings

> **Note** The current ABS fairings differ from the fiberglass fairings shipped with early GlaStar kits mostly in the shape of the fairings' leading edges. The fiberglass fairings have a squared-off leading edge that is finished by installing the fairing close-outs described below in Step 172. The ABS fairings have a rounded leading edge to minimize drag when the elevator is deflected from the neutral position. **For the ABS fairings only**, the first step is to trim the forward ends of the elevator tip ribs so they just fit inside the fairings. Hold the fairings in place against the elevator tip ribs and mark the rib's web and flanges where they must be trimmed. Use a hacksaw or snips to trim the ribs and then smooth the cut edges with files and/or sandpaper. The **fiberglass fairings** may also require that the forward corners of the elevator tip ribs be trimmed, but this trimming is minor compared to that required for the ABS fairings.

The elevator tip fairings and their nutplates are positioned and drilled in much the same way as the stabilizer fairings and nutplates. Begin by laying out and marking **sixteen** hole locations along the upper and lower edges of each fairing. As shown in Figure 186, all these locations should be **1/4"** outboard of the inboard edge of the fairing. **For the ABS fairings only**, the forward-most holes top and bottom should be positioned about **1/2"** aft of the leading edges of the trimmed tip rib flanges; for the **fiberglass fairings**, the forward-most holes top and bottom should be positioned about **1/2"** aft of the leading edge of the fairing. For both the fiberglass and the ABS fairings, the aft-most holes should be located roughly **4"** forward of the trailing edge of the fairing. The intervening holes should be spaced on roughly equal centers, but they should be shifted fore or aft as necessary to remain clear of the flutes in the rib flanges.

> **Note** Because of the taper at the aft end of the tip rib, the aft-most two pairs of holes top and bottom must be staggered slightly to provide clearance for the fairing mounting screws.

When the hole locations have been marked, slide the fairing over the tip rib and position the fairing as far forward as possible so that the elevator trailing edge nests snugly in the fairing trailing edge.

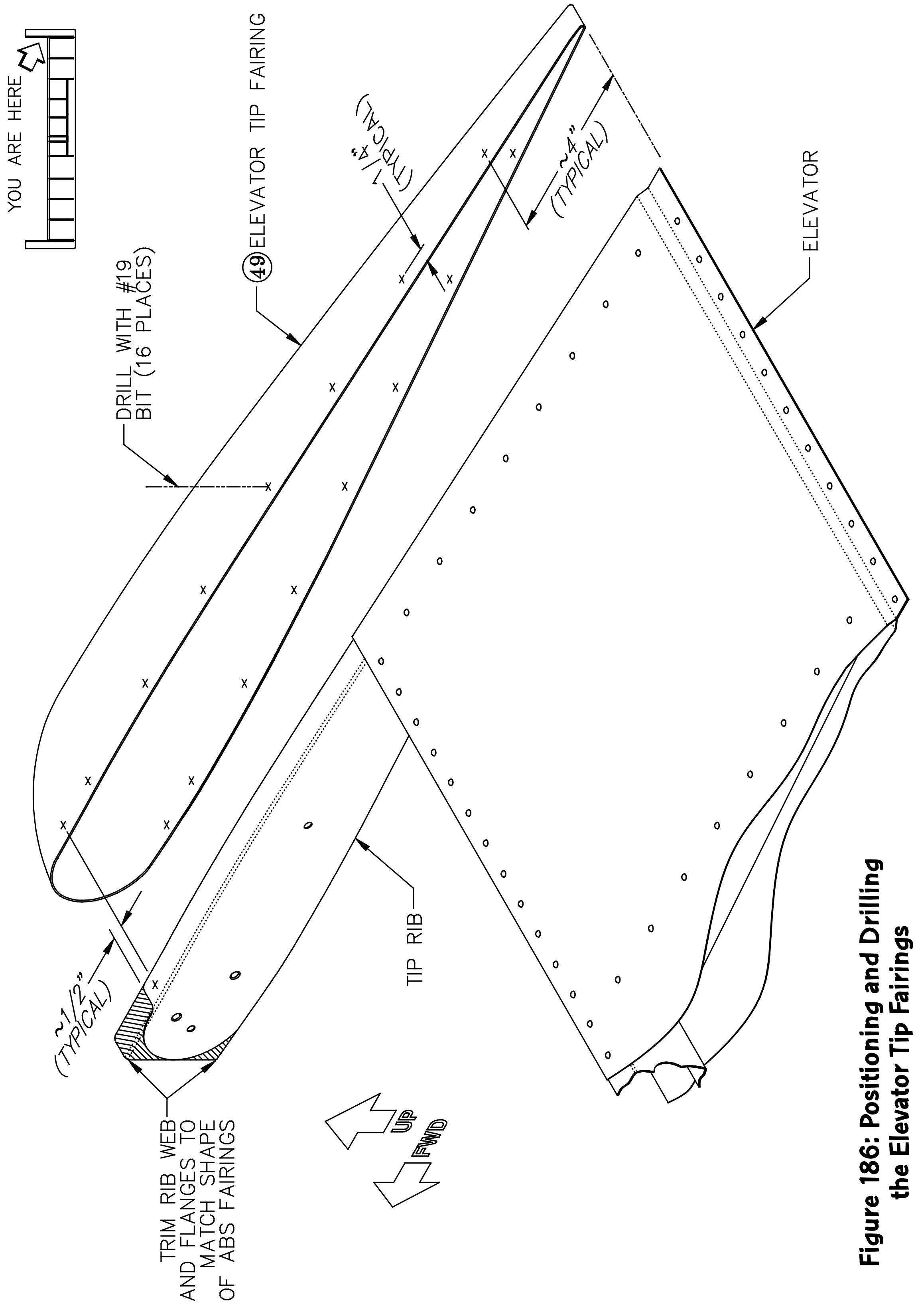

Figure 186: Positioning and Drilling the Elevator Tip Fairings

> **Note** If you have fiberglass fairings, don't worry if the gap between the horizontal stabilizer and elevator fairings appears too small. You will adjust the gap when the fairing close-outs are installed in a subsequent step. For now, just snug the aft end of the elevator fairing up tight against the trailing edge of the elevator.

With the fairing properly positioned fore and aft, confirm that all the hole locations are clear of the rib flutes. Then position the fairing so that its inboard edges are flush top and bottom with the web of the tip rib. With the fairing held in this position, check the alignment of the outboard edge of the fairing with the outboard edge of the corresponding stabilizer fairing. Ideally, they will be flush. Adjust the elevator fairing left or right as necessary, and then tape it in place to the elevator.

With the fairing in position, drill at each of the sixteen hole locations with a **#19** bit. Use these holes in the rib flanges to position and drill rivet holes for K1000-8 nutplates. Thoroughly deburr all the holes and remove any shavings from between the skins and rib flanges. Then dimple the rivet holes to accommodate 3/32" AN426AD3 flush-head rivets and install the nutplates.

The fairings will be secured with AN526-8R7 round-head machine screws, but it's a bit premature to install them at this time

Completed: Left [ ] Right [ ]

Step 172: Install the Fairing Close-Outs (Fiberglass Fairings Only)

The open ends of the fiberglass tip fairings—the aft ends of the stabilizer fairings and the forward ends of the elevator fairings—are finished off with special close-out pieces, as discussed above. These pieces are designed to fit **inside** the radii of the fairings (see Figure 184). The close-outs are very similar in appearance, but they are not interchangeable. The flanges of the horizontal stabilizer close-outs (P/N 302-00015-01) angle **inward**, while those for the elevator (P/N 303-00015-01) angle **outward**. Check that you have correctly distinguished the parts before proceeding.

Using six or eight AN526-8R7 screws on each, mount the elevator fairings. Determine how far the flange on each close-out should be inserted into its respective fairing to provide a minimum clearance between them of **3/8"**. (Every horizontal stabilizer and elevator will be slightly different, and so you have to determine the placement that is uniquely appropriate for your GlaStar.)

When you have determined how far the close-outs must be inserted into the fairings, mark this distance off on the flanges. Next, check the length of the close-outs in a spanwise direction relative to the available space. Trim them to fit.

Remove the fairings from the stabilizer and, using a generous amount of thick resin/mill fiber mixture, bond the close-outs in place. At this point, don't worry about filling or sanding the gaps around the close-outs.

Completed: [ ]

Step 173: Calculate the Size of the Elevator Counterweight

It's necessary to calculate the amount of weight required to balance your elevator just as it was for the trim tab. To prepare for the necessary experiment, install both elevator tip fairings with at least six or eight AN526-8R7 screws, if you haven't already done so. Then temporarily disconnect the elevator pushrod so that the elevator is free to pivot on its hinges.

Place an object of known weight near the end of each tip fairing, as shown in Figure 187. The two objects don't need to be of identical weight, but each should be about **5 pounds**. Move the objects forward or aft as necessary to balance the elevator in a horizontal position.

> **Note** If your GlaStar is a taildragger, raise the tail to approximately level-flight attitude for this procedure.

Next, measure the distance from the hingeline to the approximate center of mass of each object. We'll call these distances the **left** and **right experimental arms**. Multiply each arm by the weight of the corresponding object and add these two products. This sum is the **total moment** of the elevator.

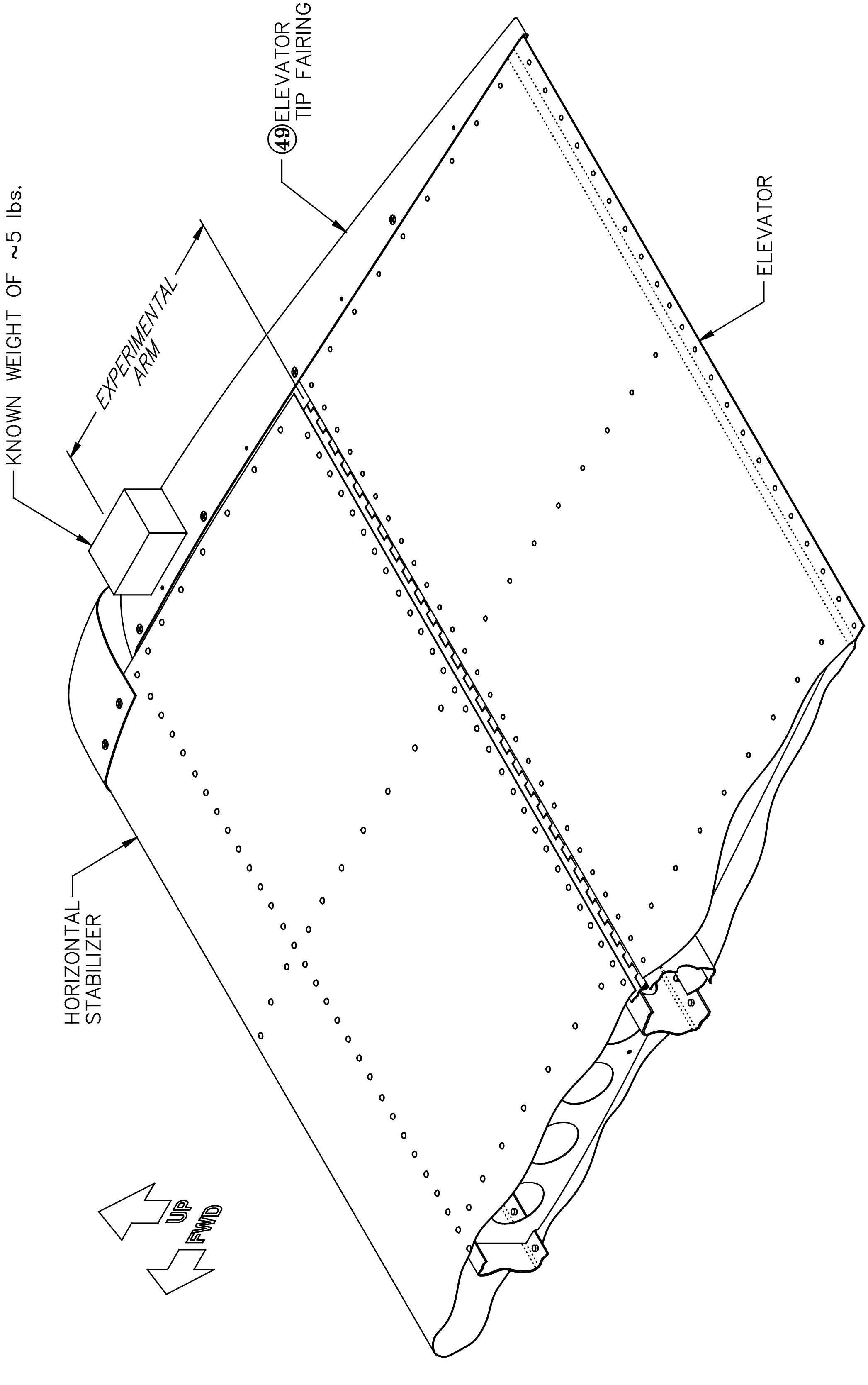

Figure 187: Elevator Counterbalancing Procedure

To find the amount of weight that actually needs to go in each elevator tip rib, you need to divide the total moment by the **actual arm**—that is the actual distance between the hingeline and the center of mass of the counterweights. On the GlaStar, this distance is **11.75"**. Finally, of course, the total weight must be divided by two to get the amount required in each tip. An example of these calculations is given in Figure 188.

When you've completed your calculations, re-connect the elevator pushrod.

Completed: [ ]

Experimental Calculation

LEFT EXPERIMENTAL WEIGHT = 5 lb., 8 oz. = 5.5 lb.

LEFT EXPERIMENTAL ARM = 9-3/8 in. = 9.375 in.

LEFT EXPERIMENTAL WEIGHT X LEFT EXPERIMENTAL ARM = LEFT-SIDE MOMENT

5.5 lb. X 9.375 in. = 51.56 in.-lb.

RIGHT EXPERIMENTAL WEIGHT = 5 lb., 4 oz. = 5.25 lb.

RIGHT EXPERIMENTAL ARM = 9 in.

RIGHT EXPERIMENTAL WEIGHT X RIGHT EXPERIMENTAL ARM = RIGHT-SIDE MOMENT

5.25 lb. X 9.0 in. = 47.25 in.-lb.

LEFT-SIDE MOMENT + RIGHT-SIDE MOMENT = TOTAL MOMENT

51.56 in.-lb. + 47.25 in.-lb. = 98.81 in.-lb.

Actual Calculation

TOTAL MOMENT ÷ ACTUAL ARM = ACTUAL WEIGHT

98.81 in.-lb. ÷ 11.75 in. = 8.4 lb.

WEIGHT PER TIP = ACTUAL WEIGHT ÷ 2

8.4 lb. ÷ 2 = **4.2 lb.**

Figure 188: Sample Elevator Counterweight Calculation

Step 174: Cut and Install the Elevator Counterweights

As with the trim tab counterweight, the elevator counterweights are simple stacks of lead sheet. The exact number and dimensions of the lead pieces you'll need obviously depend on the results of your calculations in the preceding step. However, we recommend that you cut pieces about **2"** high by **3-1/2"** long. Cut a couple more pieces than are necessary to equal the counterweight amount you calculated in the preceding step.

Hint For the neatest job, make a cardboard template of the shape of the tip rib, marking the locations of the two mounting screw holes. Use this template to cut out and drill the lead sheets.

Note The calculations by which you determined the amount of weight needed to counterbalance your elevator were based on a specific actual moment arm. This arm will be correct **only if the weight you install is centered between the two mounting holes** you drilled in the tip ribs back in "SECTION V: ELEVATOR ASSEMBLY." Keep this in mind when sizing your stacked lead.

Remove the tip fairings, stack the lead pieces together in two equal stacks and drill two **#10** holes through each stack corresponding to the holes you drilled in the elevator tip rib webs in Step 40 of "SECTION V: ELEVATOR ASSEMBLY." Dimple the two #10 counterweight-mounting holes in each rib web with the male die **inboard**. Countersink the first piece of lead in each stack to match the dimples.

Note Refer back to Step 17 in "SECTION III: RUDDER ASSEMBLY" for the procedure for dimpling a #10 hole. Use one of the AN509-10R24 **flush-head machine screws** [137] as the male die.

Finally, weigh the lead with its mounting hardware: four AN509-10R24 flush-head machine screws, four AN970-3 large washers and four AN364-1032A nylon self-locking nuts, as shown in Figure 189. Subtract and/or trim lead pieces until the entire counterweight is equal to the required weight, and then install the weights on both sides, as shown in Figure 189.

Completed: Left [ ] Right [ ]

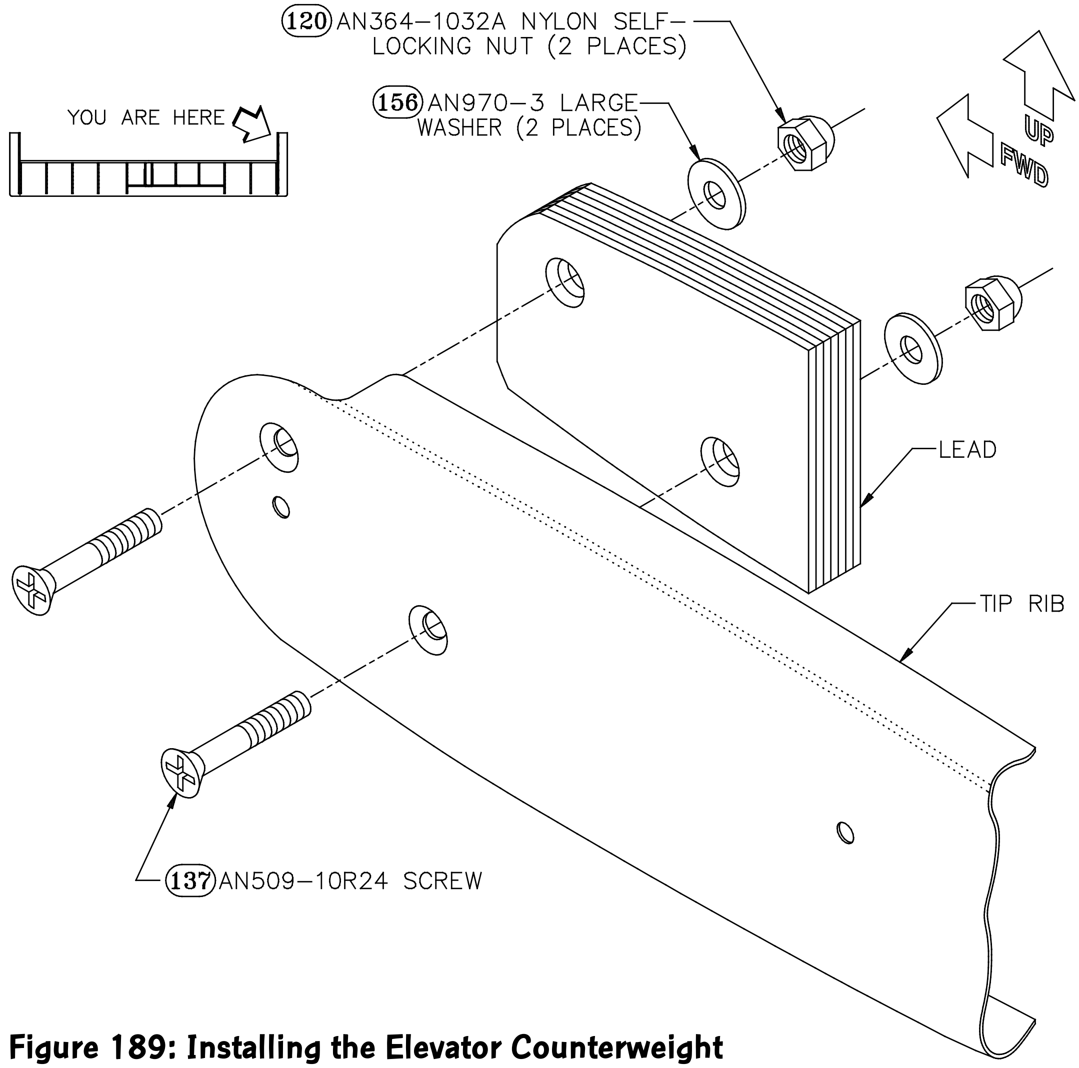

Figure 189: Installing the Elevator Counterweight

Step 175: Finish the Tip Fairings (Fiberglass Fairings Only)

Now that you're through stacking weights on them, you can finish the elevator tip fairings, along with the stabilizer fairings. Fill the gaps where the close-outs meet the fairings with body filler and file and sand the corners round. Then sand and finish the entire fairing to your own standards and preferences. See the discussion of "PREPARING FIBERGLASS PARTS FOR FINISHING" in "SECTION II: TOOLS AND TECHNIQUES."

Completed: [ ]

Step 176: Fabricate and Install Hinge-Pin Retainers on the Elevator and Trim Tab

The final step in this sub-section has nothing to do with counterbalancing or installing fairings on control surfaces, but the elevator and trim tab hinges need to be safetied, and this is as good a time as any to do it!

Begin by fabricating **five** hinge-pin retainers from leftover hinge stock; either the extruded hinge stock left over from the elevator or the rolled stock left over from the main gear leg fairings can be used. As shown in Figure 190, cut off five "knuckles" from the hinge. Drill a **#19** hole in the center of the tab of each knuckle and install an MF5000-08 floating nutplate there. Angle the nutplate to fit the available space. Countersink the **#40** rivet holes for 3/32" AN426AD3 flush-head rivets, as shown.

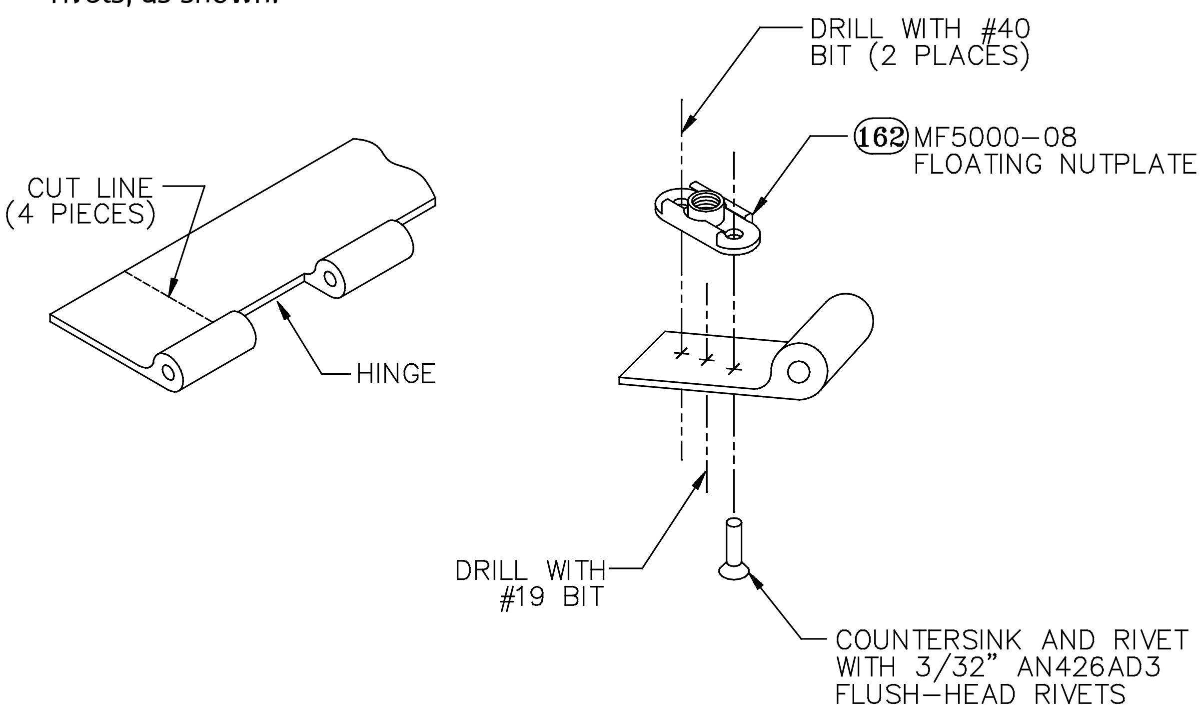

Figure 190: Fabricating the Hinge-Pin Retainers

Earlier, in "SECTION V: ELEVATOR ASSEMBLY," you left five unriveted holes along the elevator and trim tab hinge lines—one for each outboard elevator hinge, two for the center elevator hinge and one for the trim tab hinge. (If necessary, refer back to Figures 55 and 56 in that section to refresh your memory. We certainly had to!) Drill each of these holes now with a **#19** bit. After drilling, clean and deburr each hole thoroughly and, if necessary, use a chip chaser to remove shavings from between the layers of metal.

Then, as shown in Figure 191, slide a hinge-pin retainer over each bent pin end, position the retainer under the corresponding hole in the spar flange, and secure it to the spar with an AN526-8R6 round-head machine screw and an AN960D8L thin aluminum washer.

Completed: [ ]

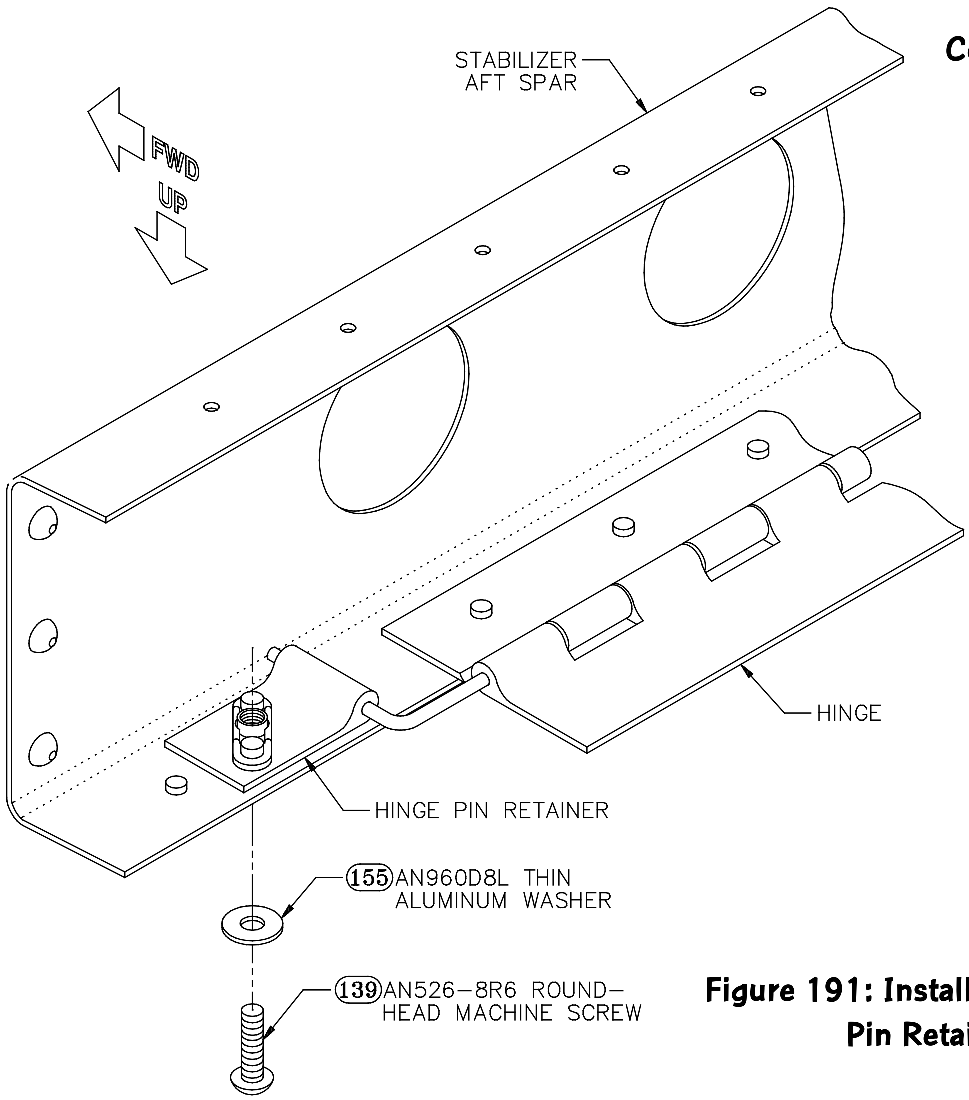

Figure 191: Installing the Hinge-Pin Retainers

Final Control System Rigging

This sub-section includes instructions for fabricating and installing the crossover cable guide, adjusting the control surfaces to achieve the required range of travel, installing stops for various controls, tensioning the cables and safetying the turnbuckles.

Step 177: Fabricate the Crossover Cable Guide

A guide is needed at the top center of the fuselage to organize the bundle of crossover cables and to keep them from wearing on each other. The guide is made from two pieces of phenolic with notches cut along one edge of each piece. The two pieces are fastened together with their notches opposite each other to retain and guide the cables. The completed guide assembly mounts to the same bolt that fastens the upper center aft shell attach fittings to the fuselage cage.

Cut the two pieces of the crossover cable guide from the supplied **3/16" X 3" X 4" phenolic sheet** [84], as shown in Figure 192. Drill the two **#10** holes in each piece for fastening the two pieces together. Cut the notches for the cables by first drilling **#19** holes in the locations shown and then cutting tangents from the holes to the nearest edge.

Note The one cable notch that is spaced wider from the others is for the aileron crossover cable. The guide will be installed with this notch **aft**.

Completed: [ ]

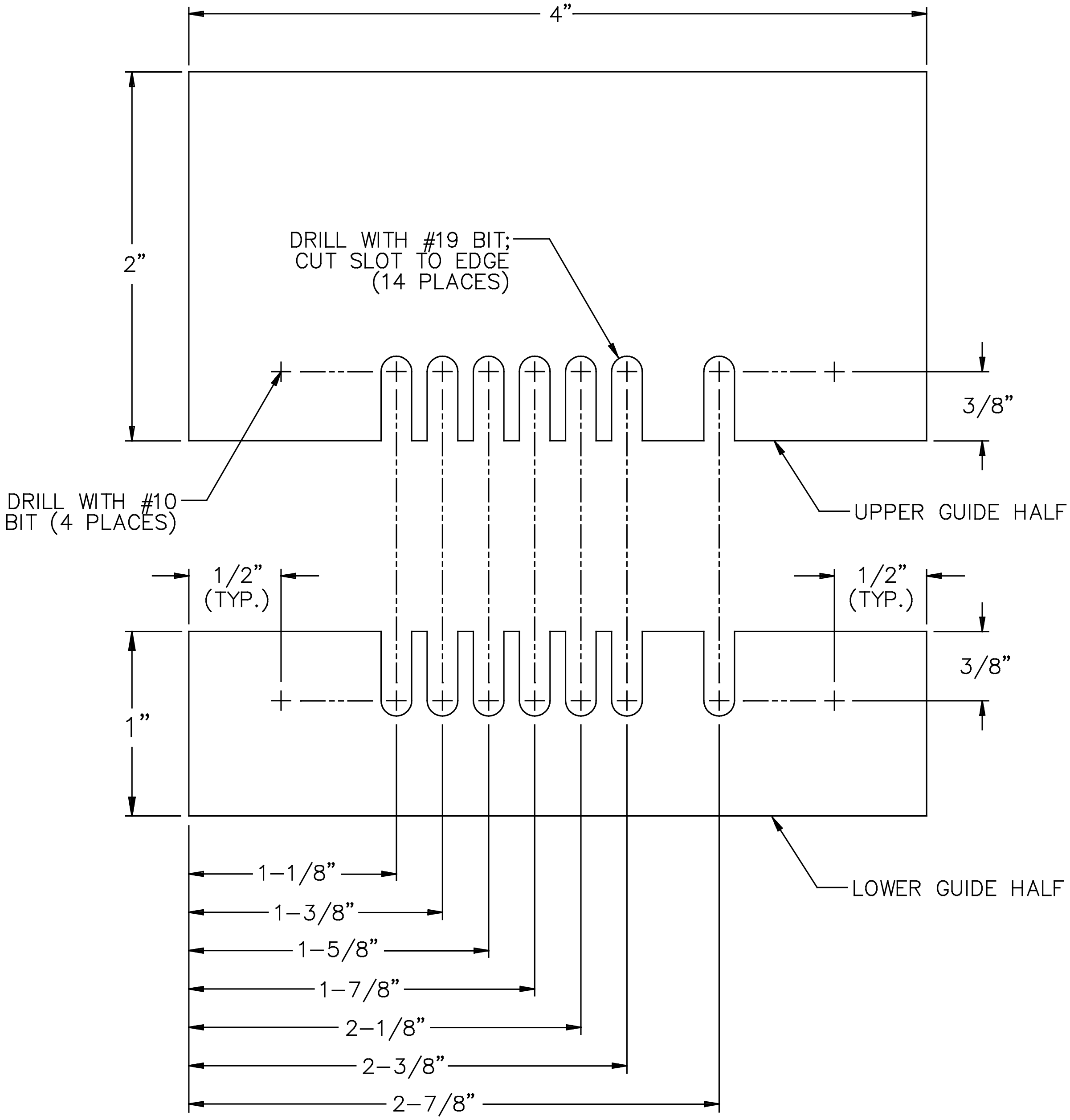

Figure 192: Cutting Out the Crossover Cable Guide

Step 178: Install the Crossover Cable Guide

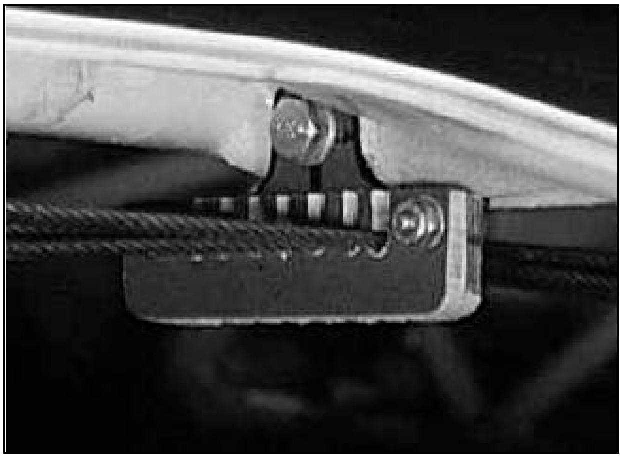

Figure 193: Finished Cable Crossover Guide

A finished crossover cable guide (slightly different than the one described here) is shown in Figure 193. To complete the installation, the location of the bolt that fastens the upper center aft shell attach fittings to the cage must be transferred to the cable guide. After a hole for this bolt has been drilled in the upper half, excess material will be trimmed away and the two halves will be joined and secured to the airframe.

With both wings extended (and the crossover cables thus taut), hold the upper guide half in position near the upper aft shell attach fittings. Fit the cables into the notches of the guide, being careful to arrange them in such a way that rubbing between cables is minimized. To coincide with their positions in the crossover pulley groups at the upper sides of the cage, the flap deployment cables should fit best in the forward two notches, the flap retraction cables should fit into the next two notches aft, the aileron actuation cables should fit in the third pair of notches from the front and, as mentioned previously, the aileron crossover cable should fit into the single, more widely spaced notch at the aft end of the guide.

With all the cables in the cable guide notches, the guide half will tend to rest in the position that deflects the cables the least amount in the fore-and-aft direction. With the guide half in this position, mark on the guide the longitudinal location of the upper aft shell attach fitting mounting bolt, as shown in Figure 194a.
Remove the guide half from the cables and drill a **1/4"** hole through it spaced **1/2" below** the upper edge at the marked fore-and-aft location, as shown in Figure 194b. Remove excess material from the upper half, as shown, being careful to maintain a **1/2"** edge margin to the center of the mounting hole and a **1"** minimum width at the forward and aft ends. Also, sand or file a roughly **3/8"** radius on the lower corners of the upper guide half and on all four corners of the lower half.

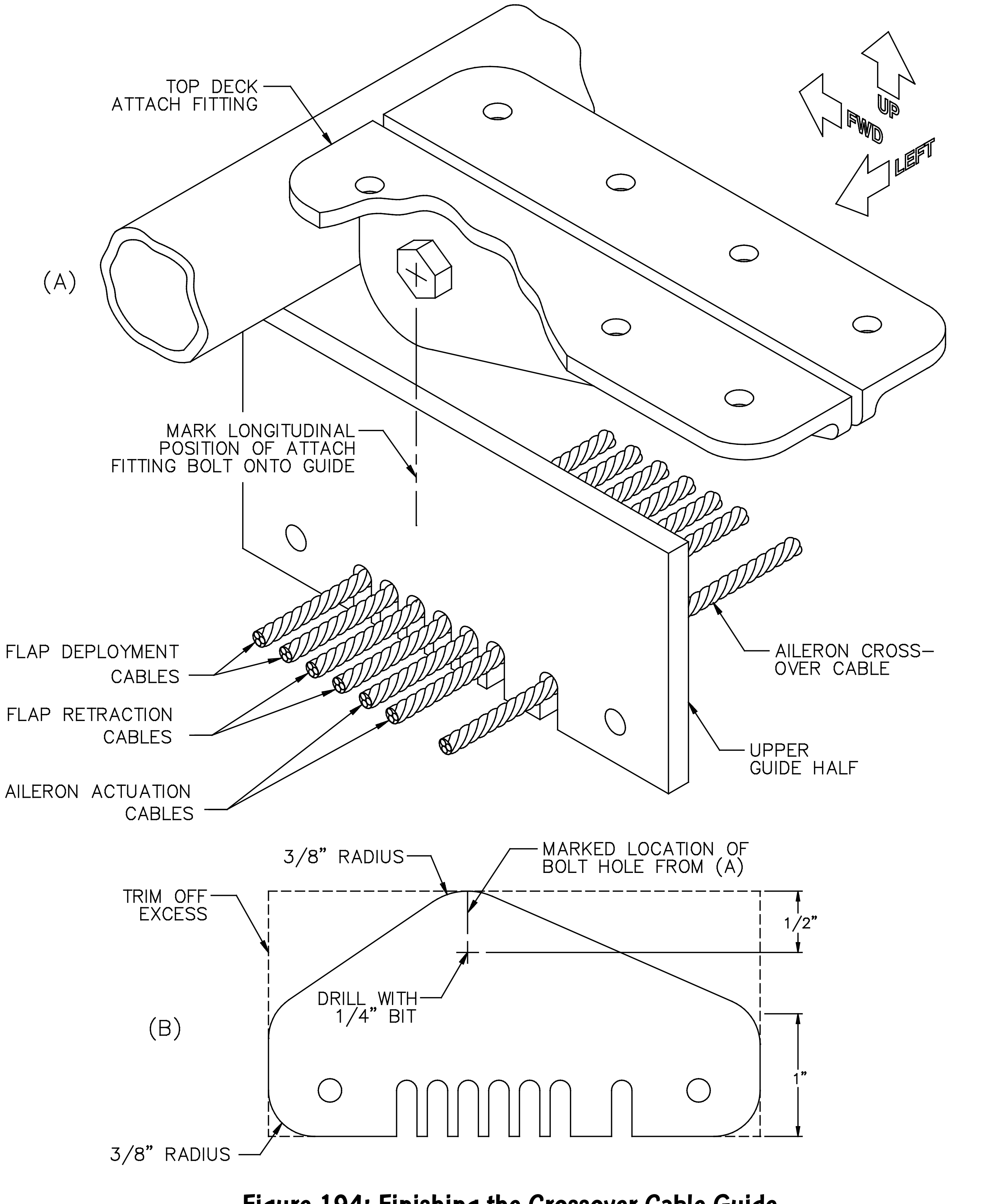

Figure 194: Finishing the Crossover Cable Guide

Remove the AN4-10A bolt, the two AN960D416 aluminum washers and the AN364-428A nylon self-locking nut fastening the upper aft shell attach fittings to the cage tab. (You installed this hardware back in Step 135.) Position the upper guide half over the cables as you did before, and then secure it to one of the shell attach fittings, as shown in Figure 195. It doesn't matter whether you select the left or right fitting. Then fit the cables into the notches in the lower guide half and fasten it to the upper guide with two AN3-6A bolts. Use two AN960-10 washers for each bolt—one under the head and one under the AN364-1032A nylon self-locking nut.

Completed: [ ]

Step 179: Safety the Rudder Cable Turnbuckles

Because the rudder control cables form an "open-loop system," they do not need to be tensioned, and you're therefore ready to safety the rudder cable turnbuckles for the final time. We recommend doing this with MS21256-1 **turnbuckle locking clips** [166] using the procedure described in *"Safetying Turnbuckles"* under "CONTROL CABLES" in "SECTION II: TOOLS AND TECHNIQUES." If you prefer, however, traditional safety wire is certainly acceptable. For a description of safety wire methods for turnbuckles, consult AC43.13, any A&P Technician General Textbook, or even the Aircraft Spruce and Specialty catalog. (See "RECOMMENDED READING" in "SECTION I: INTRODUCTION.")

Completed: [ ]

Step 180: Verify the Elevator Travel

The required elevator travel is **23° up** and **20° down**, with a tolerance of **±1°** in each direction. Use a bevel gauge and the procedures described in Step 60 of "SECTION VIII: FUSELAGE ASSEMBLY" to check the elevator travel. Set the bevel gauge to **157°** to check the up travel and to **200°** to check the down travel. Make both measurements on the **upper** surface of the stabilizer and elevator (the hinge side).

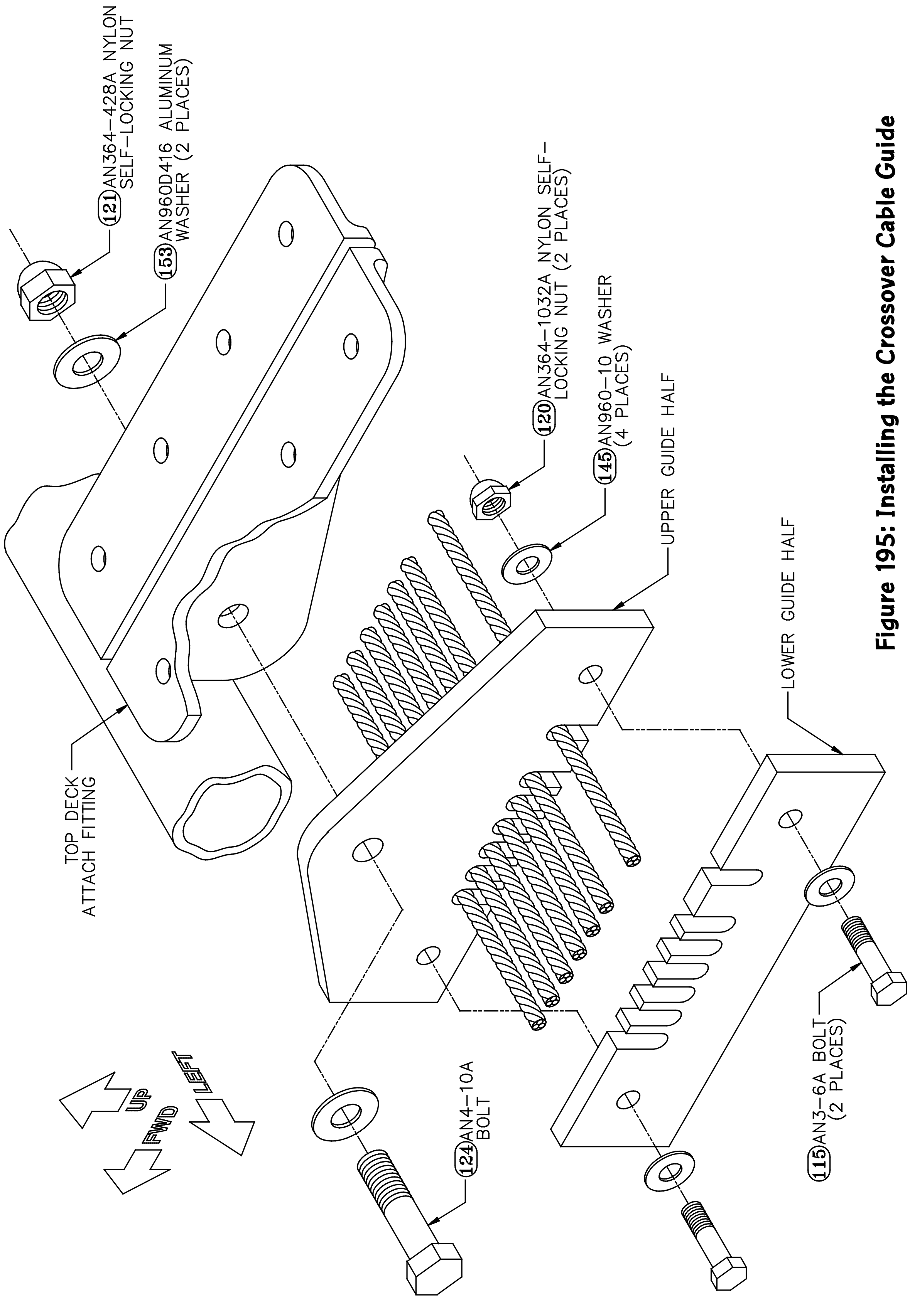

Figure 195: Installing the Crossover Cable Guide

The geometry of the elevator control system should permit more than enough elevator travel in both directions.

Note If the elevator travel is less than required in either direction, first check for obstructions in the control system. Remedy any such obstructions you find. You may have to enlarge the pushrod pass-through holes in Bulkheads D and E, for example, to achieve free elevator travel.

Completed: [ ]

Step 181: Fabricate and Install the Elevator Control Stop

Using the bevel gauge method to check, hold the elevator at its **up** travel limit of **23°** and mark the location of the aft face of Bulkhead E onto the elevator pushrod with a felt-tip pen. Then hold the elevator at its **down** travel limit of **20°** and make a similar mark on the pushrod. These marks will be used to position the bellcrank after the stabilizer/elevator assembly has been removed so that the elevator limit stops can be adjusted.

Disconnect the elevator pushrod from the control horns and remove the stabilizer/elevator assembly from the airplane. Next, disconnect the control cables from the elevator bellcrank by removing the clevis pins that secure the ends of the cables to the control cable attach tabs. Remove the bellcrank from the airplane by disconnecting the pushrod and removing the pivot bolt. Remove the cable attach tabs and associated hardware from the bellcrank.
Figure 196 is a **full-sized** template of the elevator stop plate. Use a bandsaw to cut the plate out from the **.125" X 6" X 12" aluminum sheet** [108]. File or sand the edges smooth.

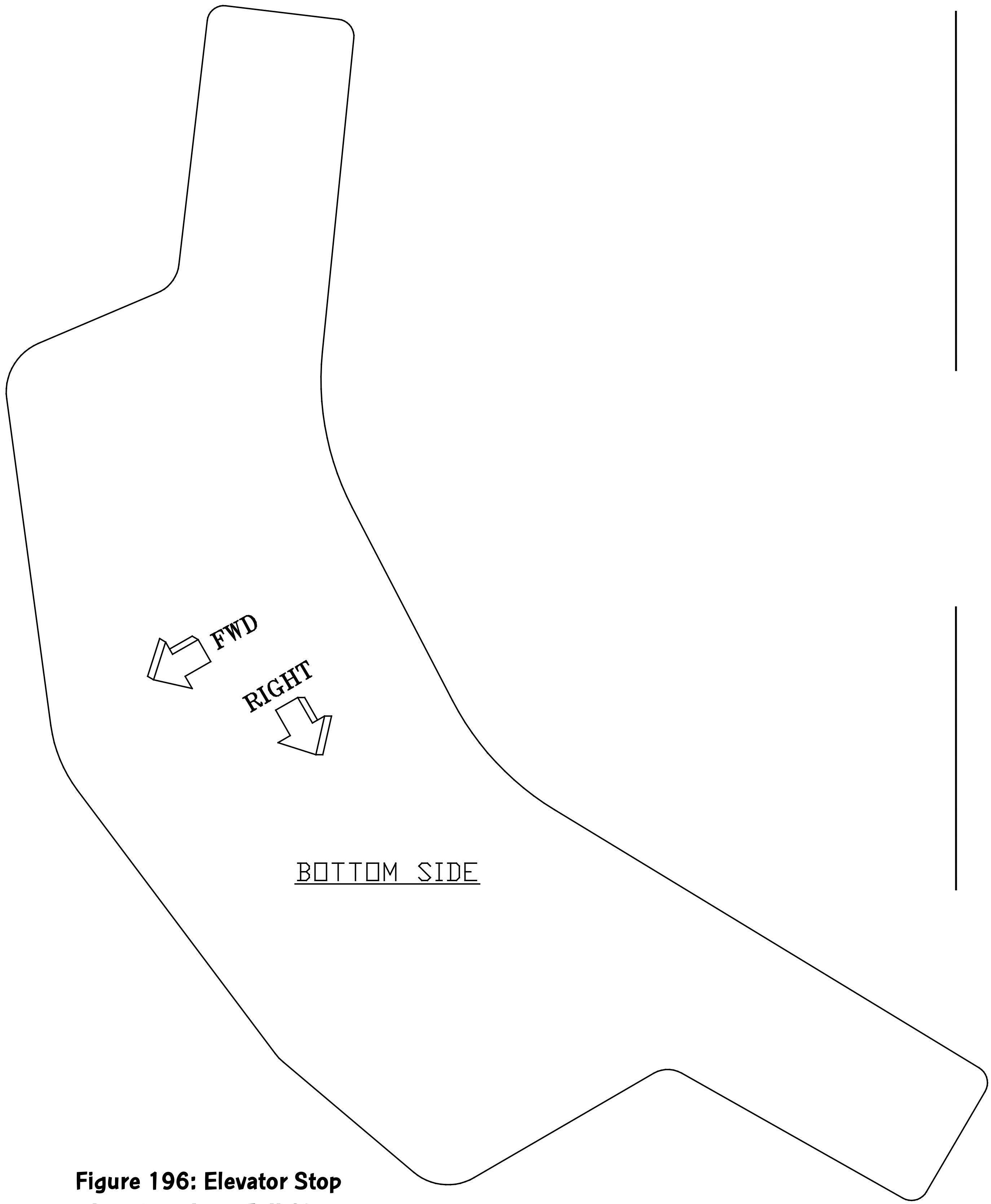

Figure 196: Elevator Stop Plate Template (Full Size)

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Position the plate against the lower half of the elevator bellcrank, aligning the forward edges of the two parts, as shown in Figure 197. Using the pushrod attach holes in the bellcrank as guides, drill a matching **1/4"** hole through the stop plate. Insert a bolt through these holes to maintain alignment. Then use the cable attach holes in the bellcrank as guides to drill **#10** holes through the stop plate. Finally, center punch the stop plate through the bellcrank bearing hole.

Remove the stop plate from the bellcrank and drill at the center-punched location with a **1/2"** hole saw; this hole is oversized to provide clearance for the NAS43DD4-39 aluminum spacer that goes under the bellcrank. Deburr all the holes.

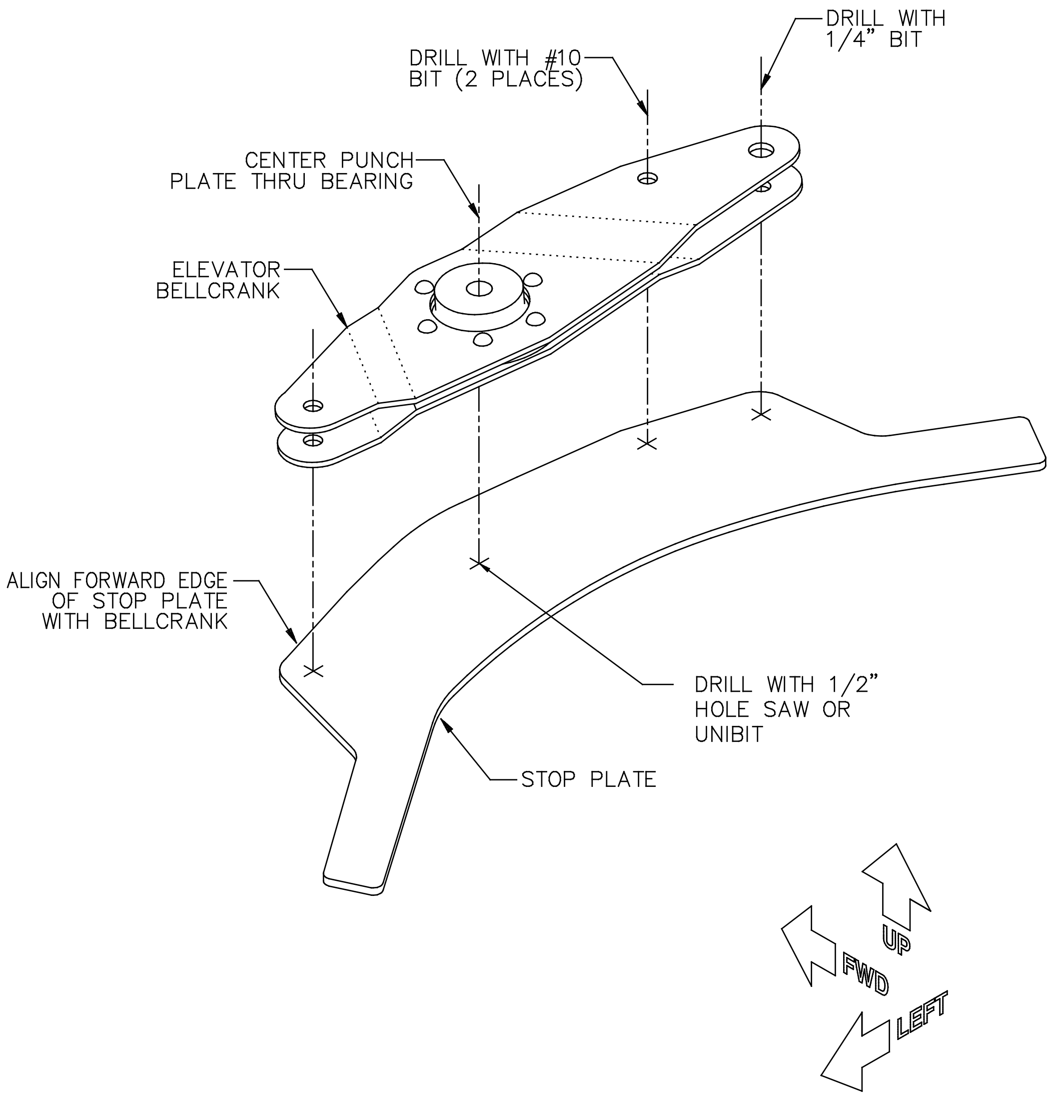

Figure 197: Drilling the Elevator Stop Plate

Use the original hardware to reattach the control cable attach tabs to the elevator bellcrank, as shown in Figure 198, fastening the elevator stop plate to the **lower side** of the bellcrank at the same time. The **left** end of the bellcrank is thinner than the right end. To accommodate the different thicknesses and to keep the stop plate parallel to the bellcrank, insert an AN970-3 large washer between the bellcrank and the stop plate at the **left** end, as shown.

Use the original pivot bolt and its associated spacers and washers to reinstall the bellcrank between the two bellcrank brackets on Bulkhead C. Use the original bolt to fasten the forward end of the elevator pushrod between the two halves of the bellcrank. Do **not** install the nuts on the pivot bolt or the pushrod-attach bolt for the time being; you will still have to remove the bellcrank assembly from the fuselage several times to adjust the elevator stop arms.

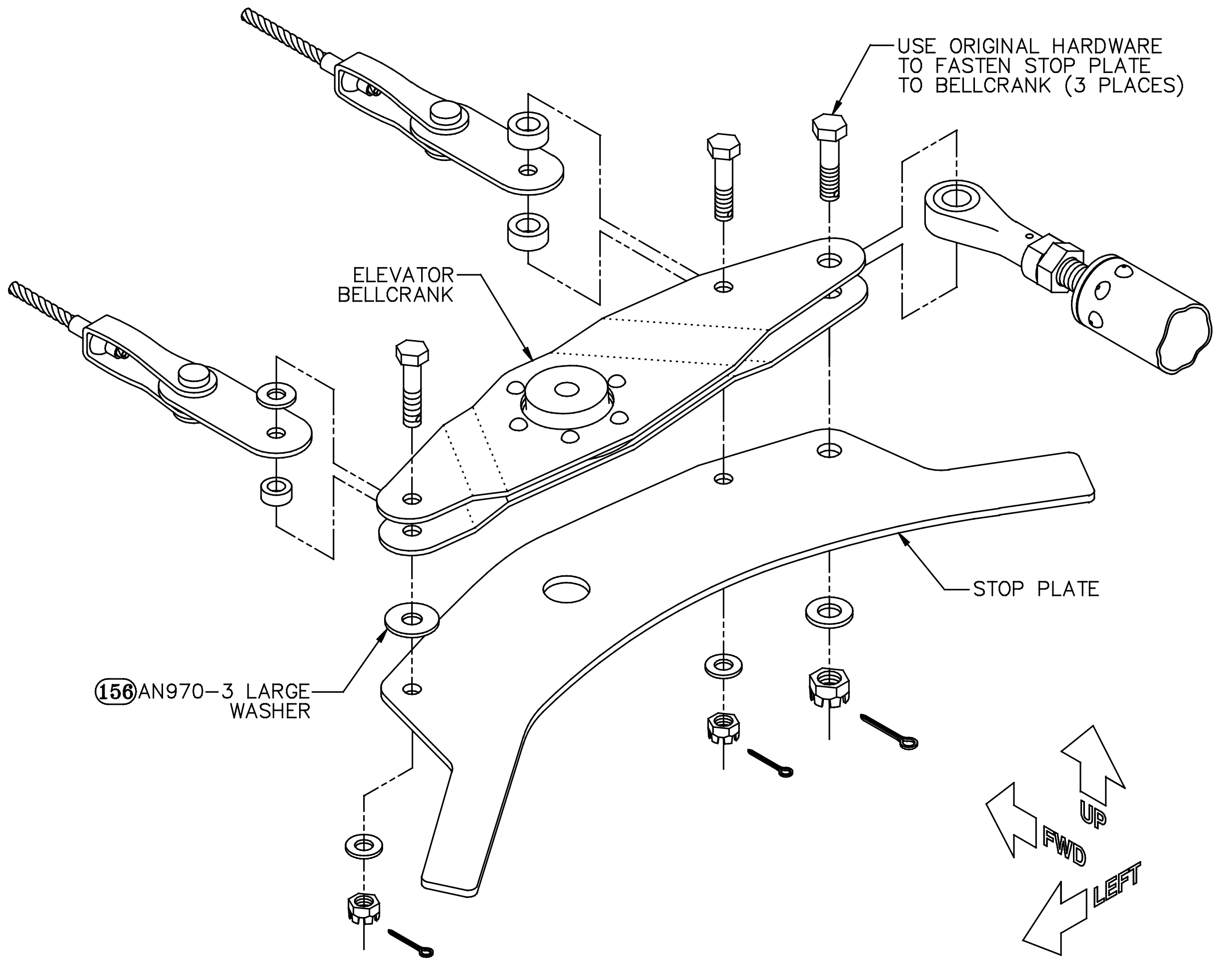

Figure 198: Elevator Stop Plate Installation

Cut two **1"** square elevator stop contact pads from the supplied **.125" X 2" X 2" UHMW polyethylene sheet** [101]. Temporarily tape the pads in place on the aft face of Bulkhead C between the bellcrank brackets where the arms of the stop plate contact the bulkhead (see Figure 199).

Trim the **forward** edges of the elevator stop plate arms until they contact the polyethylene pads just as the elevator reaches its travel limits. Trim the right-hand stop plate arm to adjust the **down** elevator travel; trim the left-hand stop plate arm to adjust the **up** elevator travel. Use the marks you made on the pushrod at the beginning of this step as a reference for the elevator travel limits. (This will save you having to re-install the stabilizer/elevator assembly to check the travel between each stop plate arm adjustment.) The easiest way to trim the stop plate arms is to remove the bellcrank assembly and use a belt sander. Several iterations of checking the travel, removing the bellcrank for stop plate adjustment, re-installation and re-checking may be required. When you're satisfied with the elevator stop adjustment, remove the stop plate from the bellcrank one last time. File and sand the trimmed edges of the arms smooth and apply corrosion-proofing.

Drill two **#30** holes through each polyethylene stop pad and through the **aft** laminates of Bulkhead C, as shown in Figure 199, being careful not to drill in areas where the stop plate arms contact the pads. Use **1/8" aluminum blind rivets** [105] to secure the contact pads to the bulkhead.

Re-install the bellcrank assembly, reconnecting the elevator cables to the attach tabs and the pushrod to the bellcrank, using all the original hardware (refer back to Figure 198). Make a final inspection of all the control system hardware that's accessible in the tail of the airplane. Make sure all nuts are tightened firmly and that cotter pins are installed and properly bent in all castle nuts and clevis pins. Verify that both rod-end bearings on the elevator pushrod are threaded on past their inspection holes. Make sure the jam nuts that secure the rod-end bearings are tightened firmly against the rod-ends.

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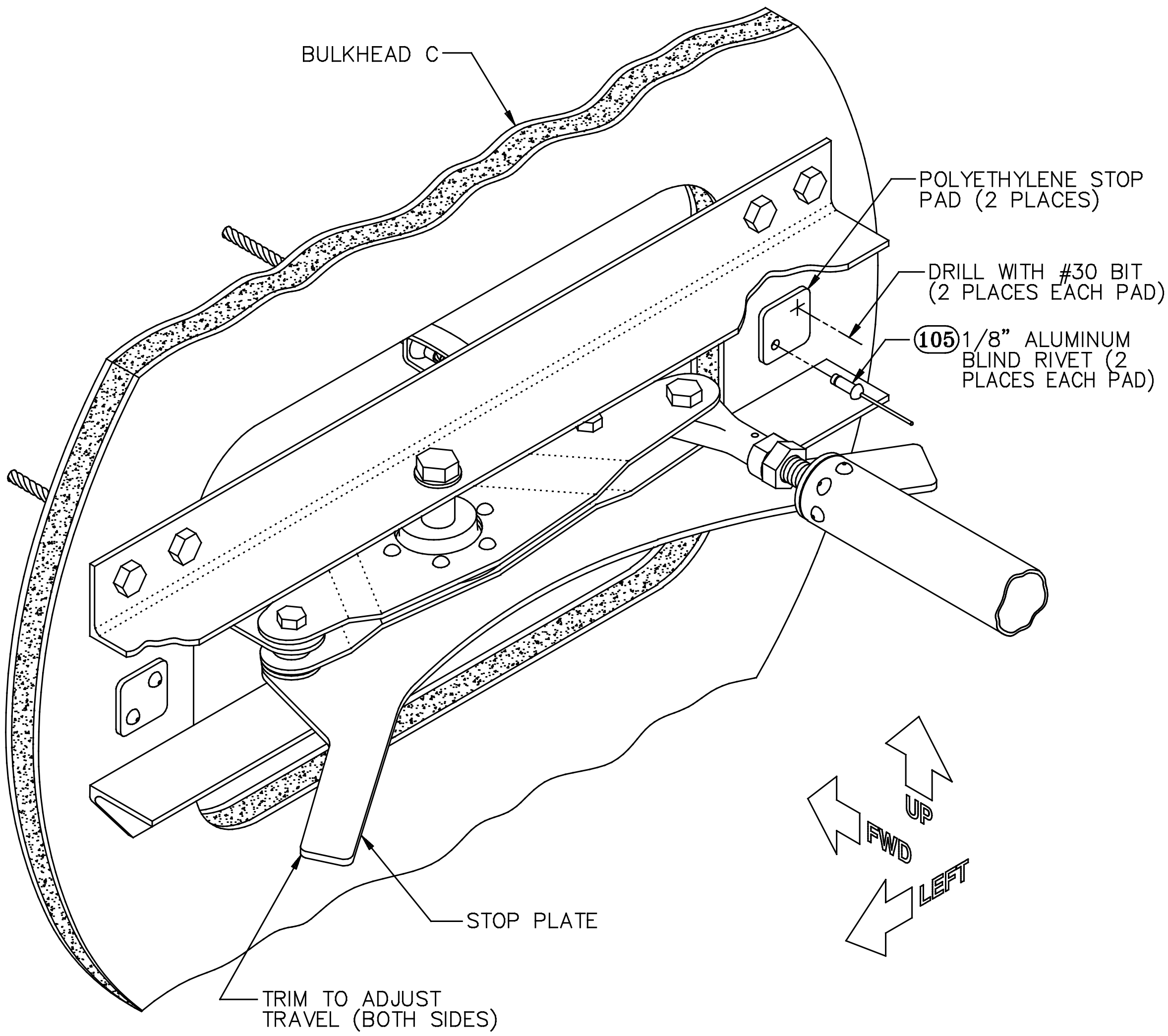

Figure 199: Elevator Stop Adjustment

Step 182: Tension and Safety the Elevator Control Cables

Because the elevator control cables form a "closed-loop system," they must be precisely tensioned. Determine the required tension for the elevator cables by using the cable rigging chart provided in Figure 8 in *"Tensioning"* under "CONTROL CABLES" in "SECTION II: TOOLS AND TECHNIQUES." Use the chart to determine the maximum cable tension for **1/8", 7 X 19** cable at the temperature of your workshop or hangar.

Use the turnbuckles to adjust the cable tension, checking your work with a cable tensiometer, as described in "SECTION II: TOOLS AND TECHNIQUES." Adjust the up and down cables equally so you don't change the elevator bellcrank and control yoke neutral positions. However, you need to check the tension in only one of the cables; since the two cables form a closed loop, the tension will be equal throughout the loop.

Note In tensioning these cables (as well as the flap and aileron cables in Steps 183 and 185), test the control system out after achieving the prescribed tension. The controls should move freely without binding or excessive friction. In our GlaStar prototype, we found that smooth control movement—of the ailerons in particular—required that the cables be slackened from the maximum prescribed tension. This is acceptable if necessary, but slacken the cables only enough to provide smooth control movement. For comparison, the standard tension in control cables for Cessna aircraft is 30 lb.

Once the proper cable tension has been achieved, follow standard procedures to safety the turnbuckles, using either locking clips or safety wire.

Completed: [ ]

Step 183: Adjust, Tension and Safety the Flap Control Cables

In Step 37 of "SECTION IX: SYSTEMS INSTALLATION," you adjusted the flap pushrod so that the flap bellcrank arms contacted the edges of their openings in the aft spars when the flaps were fully extended with the flap roller bearings at the aft ends of the slots in the flap tracks. Check that this condition still exists, and, if not, adjust the lengths of the pushrods to achieve it. Make sure that the jam nuts are firmly tightened against the rod-ends on both pushrods.

Move the flap handle to the flaps-extended position (with the flap plunger pin engaged in the highest notch in the ratchet plate). Tighten both the left and right flap **deployment** cables by turning the turnbuckles until the flaps are in the fully extended position (with the flap bearings firmly against the aft ends of the flap track slots). Loosen the flap retraction cables if necessary to achieve this. Refer to the cable rigging chart in "SECTION II: TOOLS AND TECHNIQUES" to determine the required cable tension, depending on the temperature, and use a tensiometer to set both the left and the right deployment cables to this tension, making sure the two cables are tensioned equally.

Now, with the flap handle still in the fully extended position, set the left and right **retraction** cables to the required tension, again making sure that the two cables are tensioned equally. If this operation moves the flaps out of the fully extended position, set the retraction cables to a tension **slightly** less than the deployment cables.

Check the operation of the system. When the handle is in the retracted position (with the pin in the lowest notch), the flap roller bearings should firmly contact the forward ends of the flap track slots. As you move the handle to the fully extended position (highest notch) the flap roller bearings should reach the aft ends of the slots slightly before the flap plunger pin snaps into the notch (this will pre-load the deployment cables slightly in the fully-extended position). At the two intermediate flap positions, the flaps should extend equally. Adjust cables and pushrods, as necessary.

When satisfied with the operation of the flap control system, follow standard procedures to safety the flap cable turnbuckles, using either locking clips or safety wire.

Completed: [   ]

Step 184: Eliminate Flap Cable Contact with the Fuselage Cage

There may be places near the flap handle where the flap cables contact the fuselage cage. This contact must be eliminated; otherwise, wear on the cables could weaken them or a hole could be worn in the cage tubing.

You can use any appropriate material to protect the cage where the cables contact. Small pieces of UHMW polyethylene or phenolic, or lengths of nylon tubing slit open lengthwise to fit over the cable and secured to the cage to keep them from sliding will all work well. The configuration of these wear pads will vary, depending on where the contact occurs. Secure the pads with cable ties, safety wire or any other means that keeps them positively in position between the cable and the cage.

> **Note** Any wear pads installed must be inspected at regular intervals—certainly no less often than during your annual condition inspection—for excessive wear. With this in mind, choose materials and installation methods that will make the pads easy to replace.

Completed: [ ]

Step 185: Tension and Safety the Aileron Control Cables

The required travel for the ailerons is **22.5° up** and **17.5° down**, with a tolerance of **±1°** in each direction. You verified aileron travel and set the aileron limit stops during initial aileron cable installation (Step 45 in "SECTION IX: SYSTEMS INSTALLATION"). At this time, perform a final check that you have the required aileron travel. Check also that the interconnect tie rod is centered relative to the elevator/aileron control yoke when the ailerons are in their neutral positions and that the aileron control stops are properly adjusted (i.e., the control stick pivot bracket arms contact the control yoke pivot arms when the ailerons are at their travel limits).

When satisfied that the aileron control system is ready, use standard procedures to adjust the cables to the proper tension. Follow standard procedures to safety the aileron cable turnbuckles, using either locking clips or safety wire.

Note When tensioning the aileron cables, you must adjust **all three** turnbuckles in the system in order to avoid changing the neutral positions of the ailerons, the bellcranks and the interconnect tie rod. However, because the crossover cable balances the two actuation cables (refer back to Figure 93 in "SECTION IX: SYSTEMS INSTALLATION"), you must tighten the crossover cable turnbuckle **two** turns for every **one** turn you tighten **both** actuation cable turnbuckles.

Completed: [ ]

Step 186: Tension the Tailwheel Steering Cables (Taildragger Only)

With the GlaStar sitting on its gear, neutralize the rudder and center the tailwheel. Unhook the steering chains from the forward connector clips on both sides.

Have an assistant grab a steering chain with a pair of pliers just forward of the spring and pull it forward in a direct line toward the end of the steering cable basically as hard as he or she can. The spring should be extended by this pull. With your assistant holding the chain in this position (i.e., doing all the real work!), take up the slack in the chain and hook it back up to the connector clip on the cable thimble. When the chain is released, both the cable and the chain should be under constant tension when the airplane's weight is on the tailwheel.

Repeat the process for the other side.

Completed: Left [ ] Right [ ]

Miscellaneous Final Assembly Details

Step 187: Install the Fuel Gauges or Fuel Gauge Sender Units in the Tanks

Fuel Gauge Options Fuel gauges are not included in the standard GlaStar kit. However, they are required under the FARs. Stoddard-Hamilton offers two fuel gauge options. The Mechanical Fuel Gauge is a plastic-floated, adjustable, lever-action gauge with a sealed dial assembly that bolts right onto the fuel gauge mounting flange on the inboard end of the main tank. Mounting hardware and gaskets are included with the gauge. Order P/N 201-40010-01; two are required per aircraft. If you're installing the mechanical fuel gauges, do so now.

The second option is to use electronic fuel gauges, which rely on capacitance probes in the tanks. Stoddard-Hamilton's Vision Standard Fuel Tank Probe Adapter Kit (P/N 933-03000-01) consists of special female threaded adapters that allow you to bolt such probes right to the fuel gauge mounting flanges of the main tanks. The adapters are designed specifically for the probes manufactured by Vision Microsystems, but they will accept any capacitance probe with male 3/4" NPT threads. All necessary hardware, gaskets and instructions are included in the kit.

Vision Microsystems probes can be installed as part of the VM 1000 integrated engine monitoring system or the EPI 800 individual-gauge system. The entire line of Vision Microsystems products is available at competitive prices direct from S-H.

If you're installing the Vision Standard Fuel Tank Probe Adapter Kit, **turn to the option instructions now**. Return to Step 188 of this *Assembly Manual* when the specified option steps have been completed.

☞

Completed: [ ]

Step 188: Install the Inboard Delta Wings

Taking care to match each inboard delta wing cap with its matching support, use 3/32" AN470AD3 universal-head rivets to rivet the pairs together. The manufactured heads should be on the upper surface of the cap. Then use 1/8" AAPQ-42 blind rivets to rivet the inboard delta wings to the wing-root areas of the fuselage, using the four holes for each support that you drilled in Step 93.

Completed: Left [ ] Right [ ]

Step 189: Install the Outboard Delta Wings

For access reasons, it's necessary to rivet the outboard delta wing supports to the wing leading edges before riveting the caps to the supports. Use 1/8" AAPQ-42 blind rivets to install the supports, using the four holes for each support that you drilled in Step 93. Then rivet the caps on with 3/32" AN470AD3 universal-head rivets.

Completed: Left [ ] Right [ ]

Step 190: Fabricate and Install a Cover for the Lower Aft Fuselage Inspection Hole

Here's one you probably thought we forgot about! In Step 61 of "SECTION VIII: FUSELAGE ASSEMBLY" you cut an inspection hole in the bottom of the fuselage shell. If you saved the plug from the hole, you can use it now to make a cover for the hole.

As shown in Figure 200, angled build-ups of thick resin/mill fiber mixture must be applied around the perimeters of both the inspection hole in the fuselage floor and the plug that you cut from the fuselage back in SECTION VIII. Apply a thick layer of this material to both areas, and then after it has cured use a sanding drum or a half-round file to bevel it as shown in the figure until you have a snug fit between the plug and the hole.

Next, cut a piece of .063" X 1/2" X 1/2" aluminum angle long enough to bridge the inspection hole with about **1/4"** overlap onto the solid fuselage floor at each end. Drill a **#10** hole in the center of one flange of the angle and install a K1000-3 nutplate there. Drill and countersink a matching **#10** hole in the center of the plug, and secure it with an AN507-10R16 flush-head machine screw. In order for the screw length to work out correctly, the angle should run perpendicular to the fuselage seam and contact the foam-core portion of the fuselage floor, as shown in the figure.

Completed: [ ]

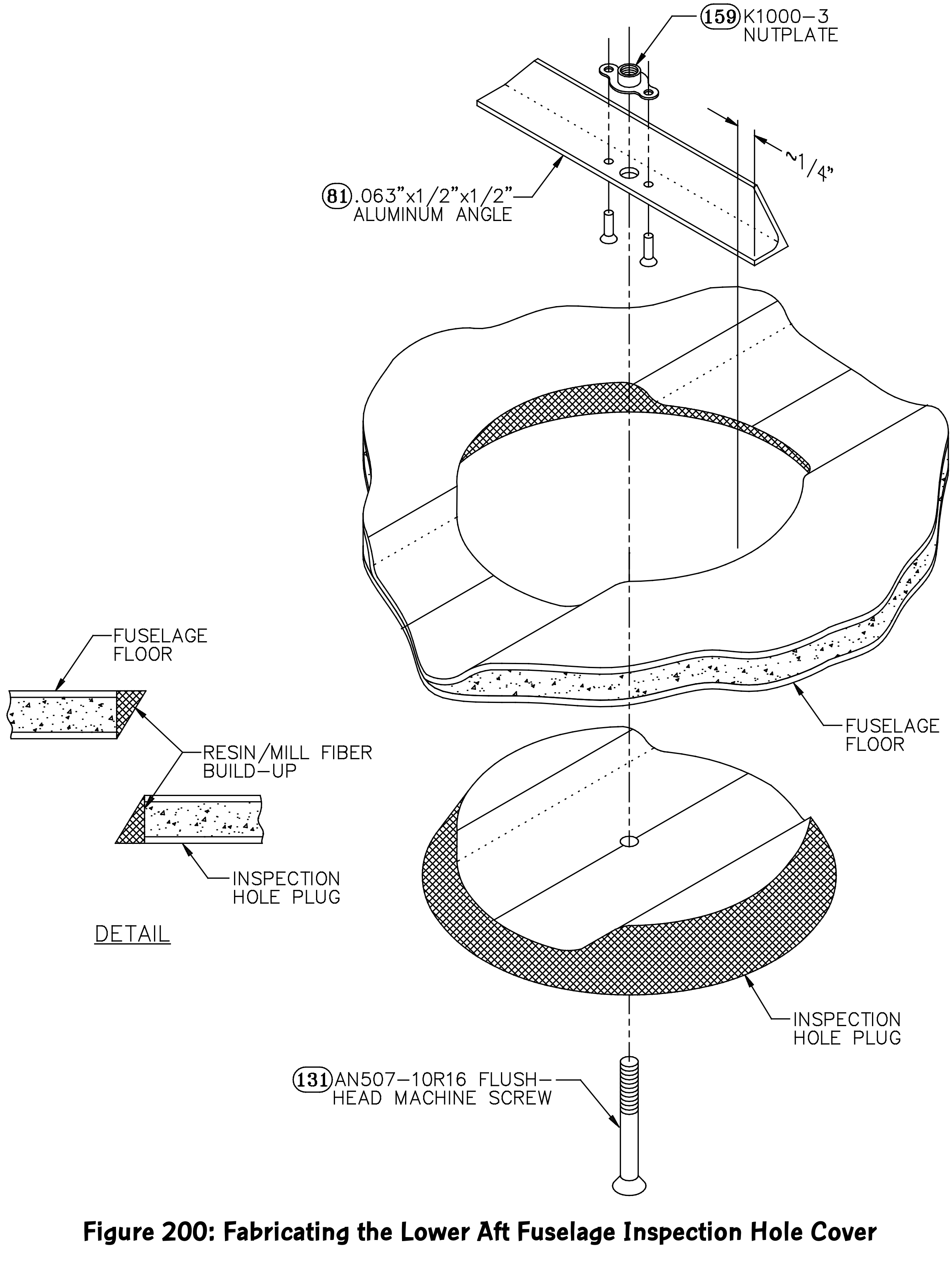

Figure 200: Fabricating the Lower Aft Fuselage Inspection Hole Cover

Step 191: Install the VOR Antenna (Optional)

Way back in "SECTION VIII: FUSELAGE ASSEMBLY" you may have installed the antenna cable in the vertical fin, reinforced the vertical fin rib and installed mounting hardware for a "cat-whisker" dipole antenna. We've waited until now to recommend finishing the installation to minimize potential damage to the antenna during the major construction work. Now it's finally time to connect the antenna to the cable and mount the antenna to the fin.

Swing the rudder as far one direction or the other as you can to expose the top of the vertical fin. Then use a single-bladed hacksaw, files and or a rotary file in a die grinder to make the necessary cutouts in the fin to accommodate the two ears of the antenna and the central disk over your mounting hardware. Connect the antenna to the cable and secure the antenna to the mounting hardware.

Warning After you have installed the VOR antenna, swing the rudder back and forth the full extent of its travel while checking for any interference or potential interference between the rudder and the antenna. There should be no gaps between any part of the rudder and the antenna or fin that is smaller than about **1/8"**. Relieve any interference or potential interference.

Completed: [ ]

Step 192: Set the Trim Tab Travel Stops (Manual Trim Only)

This step requires delicate work in an awkward location, but you're so close to the end now that we figured we could lay this on you without too much risk of revolt!

First, remove the trim gear box from the forward end of the trim cable, if it's in place. Also, remove the left and right gear box brackets from the box. (Remember to remove the screws from only one side of the box at a time to prevent the whole thing from falling apart on you!) Turn the trim wheel until the red trim position indicator bar on top of the box is centered in its slot.

Begin to replace the gear box on the cable end, just as you did in Step 116 of "SECTION IX: SYSTEMS INSTALLATION." However, before inserting the solid wire through the hole in the gear box's traveler block, insert it through one of the small, metal **cable clamps** [193] you took off the wire back in SECTION IX. Then insert the wire through the traveler block and the second cable clamp before threading the box onto the cable ferrule. As before, be sure the jam nuts and washer are in place on the ferrule, then thread the box **1/2"** onto the ferrule, stopping when the box is **upright**, and finally tighten the nuts against the box. Figure 201 shows how the parts should be arranged when you're done. However, the angle of vision in Figure 201 is probably impossible for you to achieve unless you're a lot more nimble than we are, so you'll have to confirm that everything's in the right place by touch, or use an articulated inspection mirror.

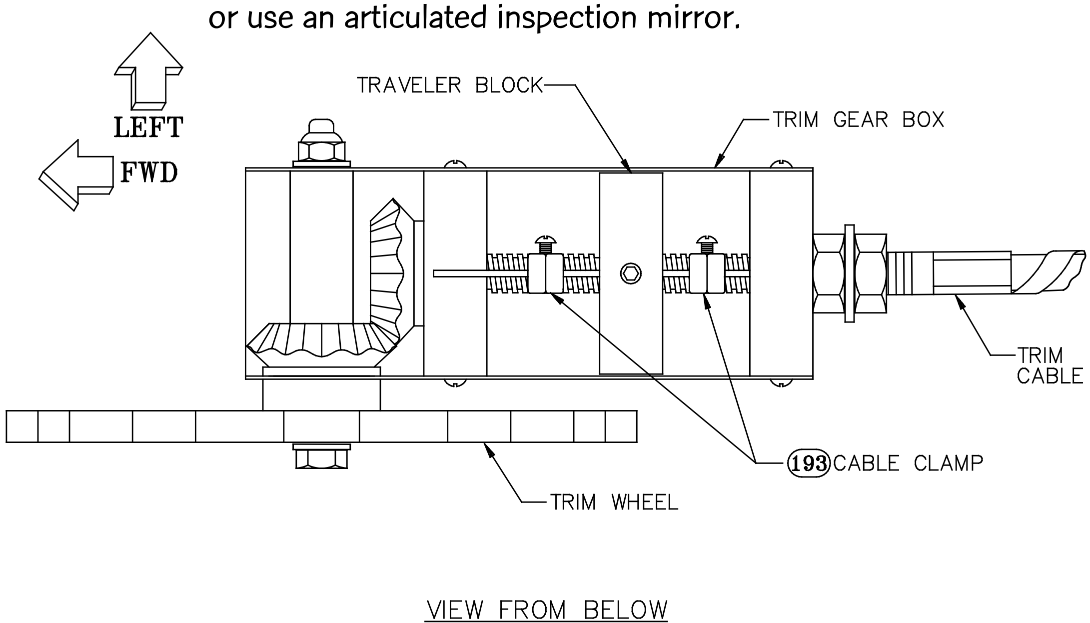

Figure 201: Arranging the Cable Clamps on the Trim Cable (Manual Trim Only)

At this point, the set screw in the traveler block should still be loose so the wire is free to move forward and aft. Before tightening the set screw, you need to secure your trim tab in its neutral position by taping some paint stirring sticks or equivalent flat slats across the gap between the tab and the elevator. Then tighten the set screw down **hard** onto the wire with a **3/32"** Allen wrench.

Next, position and tighten the two cable clamps. These clamps serve to limit the travel of the trim tab to the desired range of **1-1/4"**. To serve this function, the clamps must be positioned tight up against the traveler block on either side, as shown in Figure 202. The forward clamp will contact the forward block at the nose-up extreme, and the aft clamp will contact the aft block at the nose-down extreme. Use a stubby or an offset screwdriver to tighten them onto the wire. As with the set screw, tighten the clamp screws **firmly**.

After the clamps are set, use wire cutters to clip off the excess wire extending forward beyond the forward cable clamp. At this time, install the gear box brackets and then the control cable cover and gear box.

Completed: [ ]

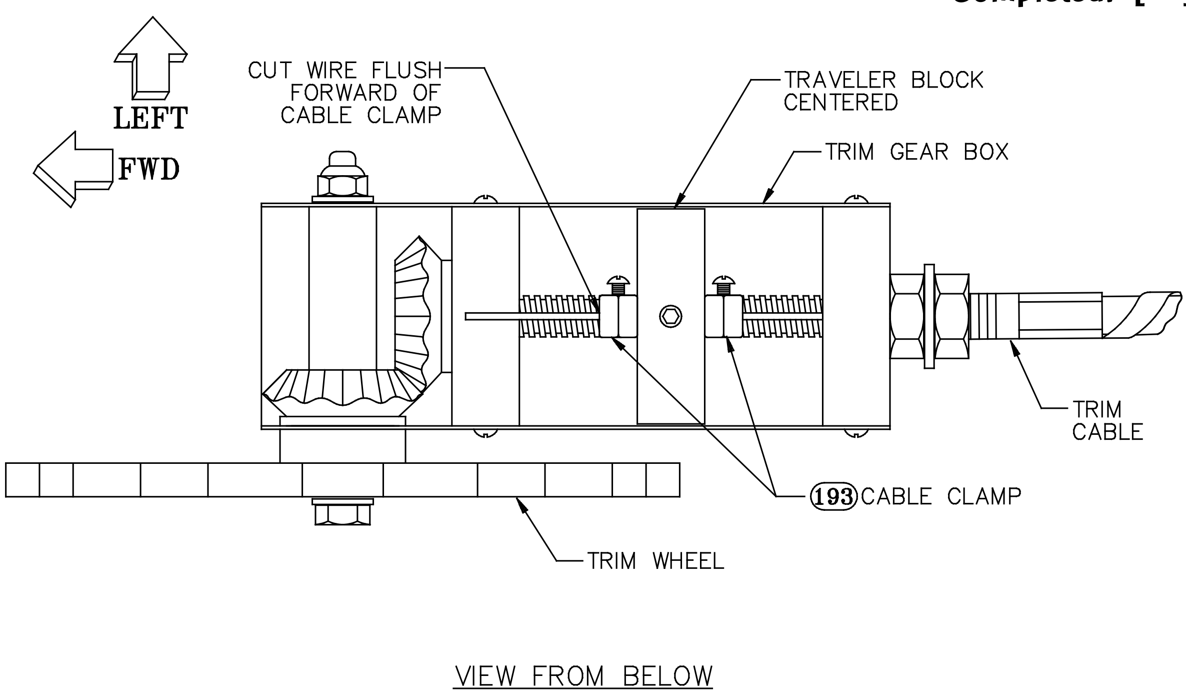

Figure 202: Positioning the Trim Tab Travel Stops (Manual Trim Only)

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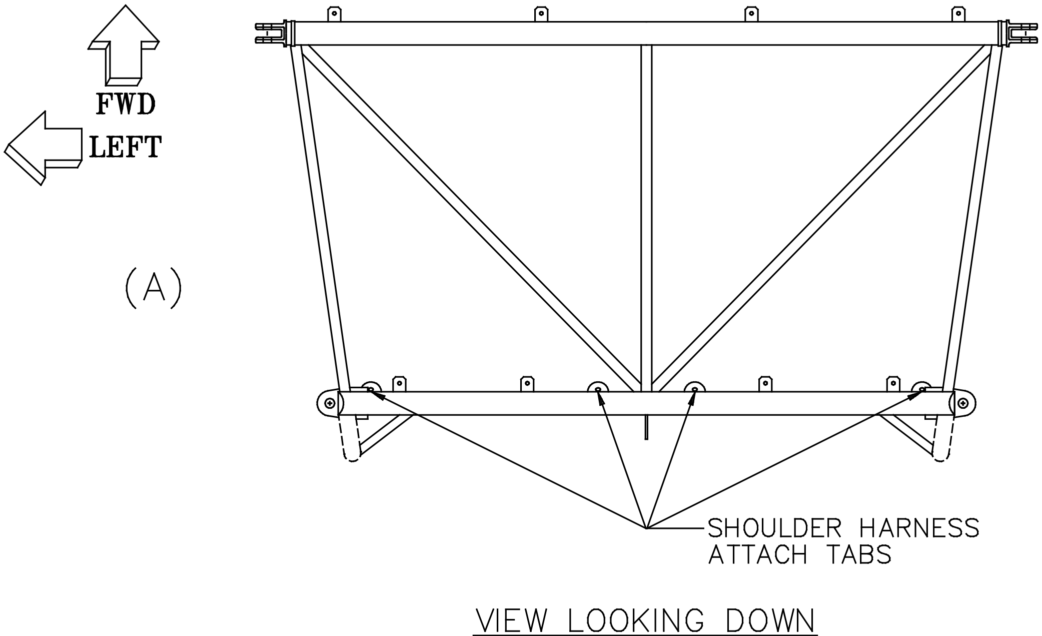
Step 193: Install the Seat Belts and Shoulder Harnesses

Seat belts and shoulder harnesses are not included in the standard GlaStar kit because most builders prefer to coordinate these items with their choice of carpeting, upholstery and so on. However, **seat belts and shoulder harnesses should in no way be considered optional equipment**; both the law and common sense dictate the installation of approved aircraft belt and harness systems in your GlaStar.

Seat Belt and Shoulder Harness Option Stoddard-Hamilton's Seat Belt and Shoulder Harness Set consists of FAA-approved belts and harnesses customized with the GlaStar logo. **Two** are required per aircraft; order P/N 803-00560-01.

The attach points for the belts and harnesses are provided in the cage structure. As shown in Figure 203a, four attach tabs are provided for the shoulder harnesses on the main cross-tube between the aft wing spar pivot lugs. Figure 203b shows the attach bushings for the outboard ends of the seat belts. The inboard ends of the belts are secured with the same bolt that secures the forward ends of the seat tracks, as described above in Step 22.



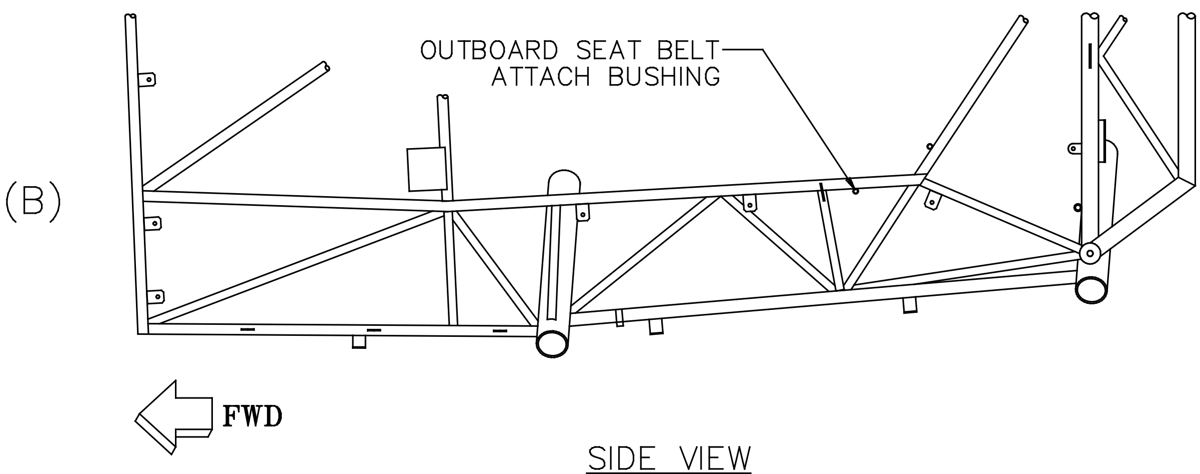


Figure 203: Seat Belt and Shoulder Harness Attach Points

The attach hardware for the belts and harnesses is included in the standard kit. Figure 204 shows the hardware used to attach the shoulder harnesses to the upper cage cross-tube: an AN4-6A **bolt** [130] through an AN970-4 large washer, and NAS43HT4-12 steel spacer, an AN960-416L thin washer and an AN365-428A nylon self-locking nut. The purpose of the spacer, which should be clamped tightly between the large washer and the cage tab, is to allow the harness attach tab to rotate freely around the attach bolt.

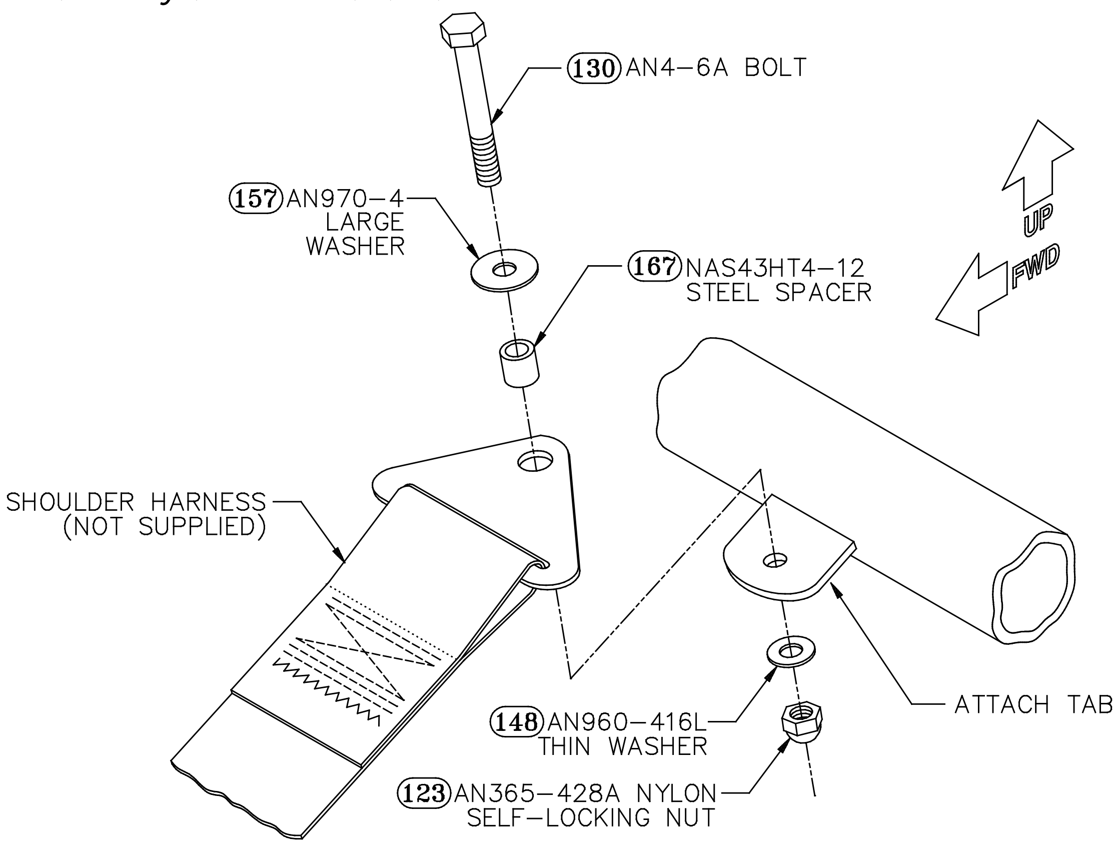
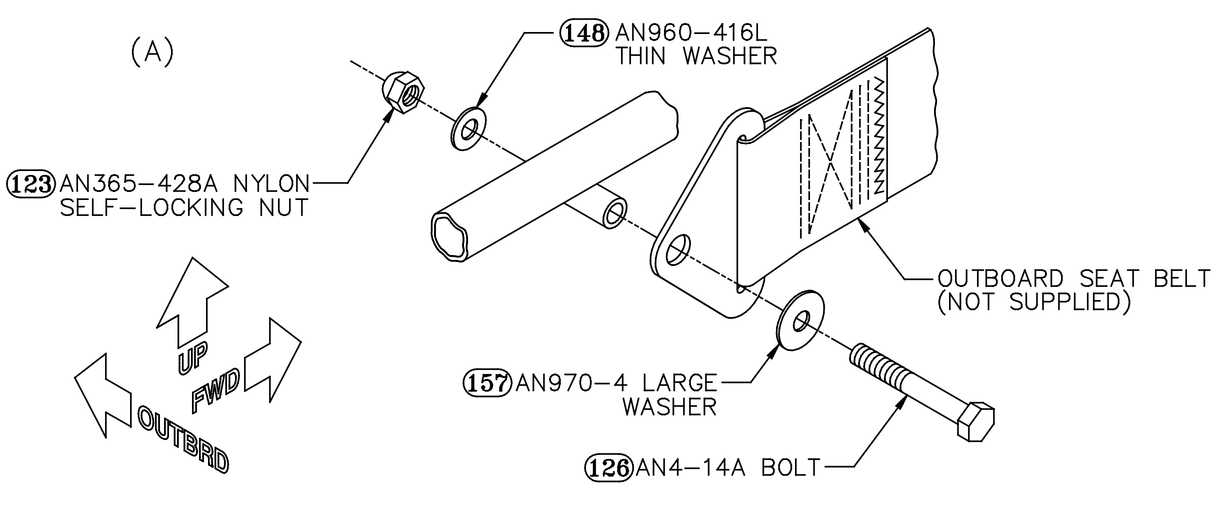


Figure 204: Shoulder Harness Attach Hardware

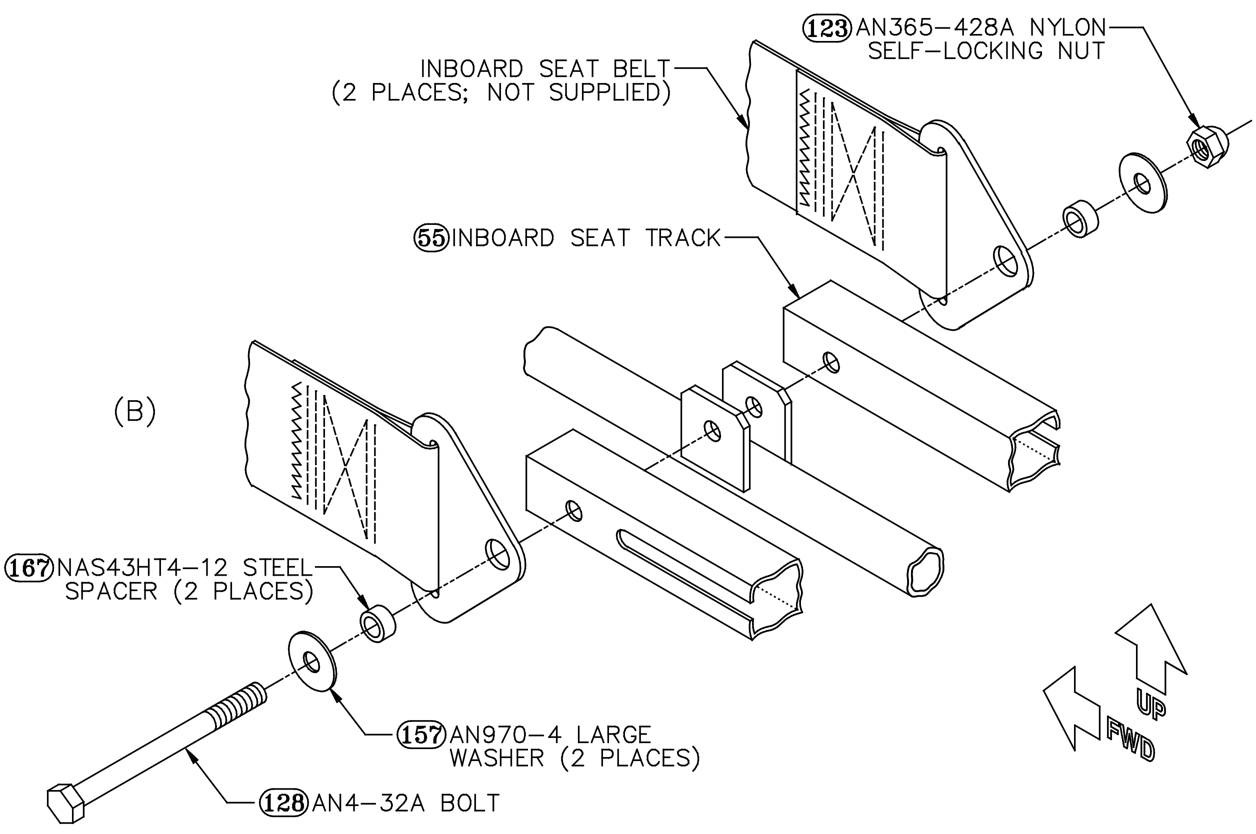
Figure 205 shows the seat belt attach hardware. The outboard seat belt attach tabs slide over the cage bushings and are clamped in place with AN4-14A **bolts** [126], AN960-416L thin washers and AN365-428A nylon self-locking nuts. An AN970-4 large washer should be used under each bolt head, as shown in Figure 205a.

The inboard belt attach tabs should be installed on the AN4-32A forward seat-track bolt with NAS43HT4-12 spacers and AN970-4 large washers under both the bolt head and the AN365-428A nylon self-locking nut, as shown in Figure 205b.

Completed: [ ]



OUTBOARD SEAT BELT ATTACHMENT



INBOARD SEAT BELT ATTACHMENT

Figure 205: Seat Belt Attach Hardware

Note Step 194 was deleted by Revision C.

SYSTEMS CHECK-OUT

This sub-section describes an inspection of all the aircraft systems to make sure they're working properly before taxi and flight testing. The following sub-section provides a detailed checklist for inspecting all the fasteners in the airframe. Although the two subjects are treated separately, it makes sense to think of the process as one overall inspection and to check for proper fastener installation and safety as you inspect each system. So, as you complete each step in "SYSTEMS CHECK-OUT," look ahead to the appropriate step in "FASTENER INSPECTION AND SAFETYING" and check off each set of fasteners as you're sure its installation is final.

Note Before the first flight, the aircraft must be inspected and signed off by the FAA (or its equivalent for non-U.S. builders). Refer to "FAA INSPECTION AND DOCUMENTATION REQUIREMENTS" in "SECTION I: INTRODUCTION" of the *Assembly Manual* for an overview of homebuilt aircraft certification procedures.

Step 195: Inspect the Control System

Make a final check to verify that all flight control surfaces have the prescribed travel, as follows:

Ailerons: 22.5° up, 17.5° down (±1°)
Elevator: 23° up, 20° down (±1°)
Rudder: 25° left and right (±1°)

Adjust the control stops, as necessary. Verify that the ailerons have the same travel on both sides, that all control surfaces respond correctly to control system inputs, and that all controls work smoothly without binding or excessive friction.

Verify that the flaps have full travel and that both flaps extend the same amount at each notch; the flaps should be fully retracted (with the flap track bearings at the ends of their slots) when the handle is in the lowest notch and fully extended when the handle is in the highest notch.

Check that all engine, propeller and accessory controls work smoothly and provide full travel (stop to stop).

Warning Make sure that none of the controls, when fully deflected, interferes with the movement of any of the other controls. In particular, check for interference between the control sticks and the throttle and mixture controls. Take steps to alleviate any unacceptable interference.

Check all control cables for proper routing and tension. All cables should contact only pulleys, fairleads, nylon guide blocks or other dedicated wear blocks. Install nylon or phenolic wear blocks if the cables rub on the fuselage cage or other parts of the airframe.

Insert a piece of wire into the inspection hole in each rod end bearing in the control system to verify that there are enough threads engaged. If the wire goes through the hole, the rod end bearing needs to be threaded further onto the control rod. Double check that all jam nuts are properly torqued (with a wrench) and witness-painted.

Make sure that the elevator, rudder, aileron and trim tab counterweights are tightly secured and do not contact any part of the airframe during any part of the control surface's range of travel.

Check the elevator trim system (regardless of whether it's electric or manual) for free travel throughout the entire range. Check to make sure that the trim position indicator registers properly when the trim tab is in the neutral position and, if necessary, adjust the indicator to achieve this.

Finally, make sure all moving parts are lubricated properly. We recommend light grease, except for rod end bearings, which should be lubricated with a greaseless spray lubricant (such as LPS).

Completed: [ ]

Step 196: Inspect the Landing Gear, Wheels and Brake System

Make a thorough inspection of the entire landing gear system. Make sure the tires are inflated properly and the main wheel axle nuts are cotter-pinned. Inspect all other fasteners for proper installation and tightness (see the following sub-section). Make sure the brake lines are adequately protected from rocks or other ground debris, and that they are routed well clear of the tires so that chafing cannot occur.

BLEED THE BRAKES

Aircraft brakes are bled from the bottom to the top (i.e., from the caliper to the master cylinder(s)). Use a fluid pump (such as an oil pump can) with a clear tube attached to the brake caliper bleeder fitting. Open the bleeder and pump fluid from the caliper through the master cylinder(s) to the reservoir until no air bubbles are evident in the reservoir; then, tighten the bleeder fitting. As the reservoir fills, siphon the fluid back down into the pump or some other container to prevent overflow. Repeat for both brake calipers until the brakes feel solid. Finally, drain the reservoir until it is about **7/8** full.

"BURN-IN" THE BRAKE LININGS

To provide maximum service life, the brake lining material must be properly broken-in by gently heat-curing the resins, as described below. However, the application of **excessive** heat before curing will carburize the lining material, lowering the coefficient of friction and reducing the service life of the linings.

Break-in the brake lining material during initial taxi testing by performing a **minimum** of **six** full stops from a speed of **between 25 and 40 mph**, using light pedal effort and letting the brakes cool partially (about one minute) between stops. This procedure generates enough heat to cure the resins in the lining, yet will not carburize the material by heating it excessively. Once the linings are properly cured, they will provide many hours of maintenance-free service.

Completed: [ ]

Step 197: Inspect and Flush the Fuel System

Remove the fuselage fuel drain valve and flush the fuel tanks with a gallon or so of gasoline per side. Strain the draining fuel through a fine screen or cloth to check for debris, and continue flushing until no evidence of debris is seen. Then reinstall the drain valve, using a thread sealant.

Next, remove the gascolator bowl and flush the rest of the fuel system, again straining the draining fuel for foreign matter. Continue flushing until no debris is evident. Replace the gascolator bowl, and then refill the tanks with a couple gallons a side.

Check the whole system for leaks. Make sure all fittings are tight and leak-free and that there are no obstructions in the vent lines. The fuel valve should operate smoothly and correctly and be mounted in a position to prevent its being closed accidentally during flight. Check the firewall-forward fuel lines for kinks and leaks. Turn on the electric boost pump and check it for proper function.

Note After ground run-ups and taxi testing but **before** the first flight, check the gascolator screen for foreign matter. If any is found, re-flush the tanks and fuel lines.

Completed: [ ]

Step 198: Inspect the Pitot/Static System

Check to see that the pitot tube is clear and that the airspeed indicator is working before the first flight. Have a helper watch the airspeed indicator for movement while you blow near the pitot tube. If there is movement in the indicator, the lines are okay.

Caution Do not blow closer than about **2"** from the mouth of the pitot tube. Blowing directly into it may damage the airspeed indicator.

Check that the static ports are free of obstructions. Check that all pitot and static line fittings are secure and that all lines are routed to avoid chafing from moving parts of the control system. Reroute lines, if necessary, to eliminate low points where moisture could accumulate. Double check that the pitot and static lines, respectively, are connected to the proper ports on the airspeed indicator.

If you have installed a heated pitot tube, check the function of the heating element.

Note We recommend having a certified avionics shop perform a leak check on the pitot/static system. If you have a Mode C transponder installed, such a check is part of the required certification of the transponder, but it is good practice in any case.

Completed: [ ]

Step 199: Inspect the Electrical System

Check all wiring, making sure the wires are bundled neatly together and routed clear of moving parts. Nylon cable ties and/or cable clamps are required to secure wire bundles in the cockpit and engine compartment areas. Secure wire bundles with clamps and use rubber grommets for abrasion protection where the bundles penetrate panels, such as the engine baffling, or bulkheads.

Double check all switches, circuit breakers and electrical components to verify that they work properly. Replace if necessary. Make sure all switches and circuit breakers are clearly and properly labeled. Test your ELT and check to see that its battery is current.

Completed: [ ]

Step 200: Check the Function of the Avionics and Certify as Required

Check the function of all installed avionics, both with the engine off and running. If required by government regulations, have certification checks performed by a qualified avionics shop.

Completed: [ ]

Step 201: Swing the Compass and Post a Compass Correction Card

A compass correction card is required for all aircraft detailing deviations from accurate magnetic readings at 30° intervals. Use an approved compass rose and the procedures outlined in AC43.13 to swing your compass to minimize these deviations, or have an avionics shop or A&P mechanic perform this task for you.

Completed: [ ]

Step 202: Inspect the Powerplant

Check the engine mount and propeller bolts for proper torque and the installation of appropriate cotter pins. Check for secure mounting of the carburetor, alternator, propeller governor and other engine accessories. Inspect the engine baffling and induction system components for security and integrity. Check all electrical wiring and fluid lines for correct installation and security. Fill the engine crankcase to the level recommended by the engine manufacturer with the proper grade of oil. Fill the engine cooling system, if applicable. Before taxi testing, run up the engine with the cowling removed and check for fluid leaks or vibration problems. Run the engine at various power settings from idle to maximum static rpm. Check for leaks after each engine run and top-up the engine oil level as necessary.

Caution Scrupulously follow all manufacturer's instructions concerning proper engine break-in procedures. In particular, if the engine has been overhauled, check the manufacturer's recommendations for the type of break-in oil and how long to use it.

Check the function of the cabin and carburetor heat, as well as all engine-monitoring instruments.

Completed: [ ]

FASTENER INSPECTION AND SAFETYING

Before flying your GlaStar, it's imperative that you perform a systematic inspection of the entire airframe, with an emphasis on checking that each fastener is properly installed, tightened and safetied as necessary. Use the following general guidelines for your inspection:

- **A)** Check that each bolt, screw and clevis pin has the proper grip length; if more than three washers are needed for an assembly, use the next size smaller fastener.
- **B)** Check that all nuts are tightened firmly (unless the connection is meant to rotate) and that **at least one-and-a-half threads** show past the end of each nut.
- **C)** Verify that all castle nuts are safetied with a cotter pin of the correct size and that both ends of each cotter pin are fully bent over.
- **D)** Check that all clevis pins are properly cottered and that a washer is installed under each cotter pin.
- **E)** Non-self-locking nuts that cannot be cotter-pinned to prevent rotation, such as the jam nuts that lock rod end bearings on control pushrods, should be checked for tightness. For these nuts, we recommend applying witness paint across the interface of the nut with the part it's tightened against as an inspection aid to detect rotation of the parts. Such rotation breaks the paint seal, indicating the need for corrective action. For witness paint, use a small dab of brightly colored fingernail polish or a product called "Torque Seal" made specifically for this application. Torque Seal is available direct from Stoddard-Hamilton; order P/N 620-0642-501.

What follows is a system-by-system checklist to assist you in inspecting every fastener in the airframe. In using the checklist, keep in mind the following points:

- **A)** **The checklist covers the components of the standard kit only**. Thus, the absence of a particular item from the checklist does not relieve you of the responsibility of verifying the safety of that item. In particular, the engine compartment should obviously be subjected to the most rigorous scrutiny.

B) **The checklist covers standard aircraft fasteners only**. Not included but still vital to check is the security of cable ties, loop clamps, plumbing fittings, etc. Check all plumbing and wiring for consistent use of standard installation practices. In particular, be on the lookout for any existing or potential chafing problems involving electrical wiring or fluid lines.

C) **The order of items on the checklist is not necessarily the best order in which to make the inspection**. The list is broken up by major system, but in some cases, inspection covers, fairings and so on from one system will have to be left off until the fasteners of a later system have been inspected. Just be certain that at the end of the process, all the items have been checked, and if you are forced to undo a fastener that you have already inspected, be sure to somehow note that it will require re-inspection later.

Step 203: Inspect the Fuselage Structure

- ☐ Fuselage shell/cage attach tab screws and nuts
- ☐ Forward shell attach fitting bolts and nuts
- ☐ Upper and lower shell attach fitting screws, bolts and nuts
- ☐ Aft shell attach fitting screws, bolts and nuts
- ☐ Fuselage strut attach fitting screws, bolts and nuts
- ☐ Wing pivot assembly bolts, nuts and cotter pins
- ☐ Engine mount bolts and nuts
- ☐ Firewall screws and nuts
- ☐ Forward inter-bulkhead shearweb bolts and nuts (after final government airworthiness inspection). Use 15 each AN3-4A bolts, AN960D10 aluminum washers and AN364-1032A nylon self-locking nuts to secure the shearweb.
- ☐ Aft inter-bulkhead shearweb bolts. Use 15 each AN3-4A bolts with AN960D10 aluminum washers threaded into the MF5000-3 nutplates.

Completed: [ ]

Step 204: Inspect the Fuselage Systems

- [ ] Instrument panel mounting bolts, screws and nuts
- [ ] Instrument panel brace mounting screws and nuts
- [ ] Brake reservoir mounting screws and nuts
- [ ] Left and right door hinge mounting screws and nuts
- [ ] Left and right door hinge pivot bolts and nuts
- [ ] Left and right door latch screws, bolts and nuts

Completed: [ ]

Step 205: Inspect the Main Landing Gear

- [ ] Left and right main gear leg bolts and nuts
- [ ] Left and right brake mounting flange bolts and nuts
- [ ] Left and right brake torque plate bolts and nuts
- [ ] Left and right brake caliper assembly bolts and nuts
- [ ] Left and right main wheel assembly bolts and nuts
- [ ] Left and right axle nuts and cotter pins

Completed: [ ]

Step 206: Inspect the Nose Gear *(Tricycle Gear Only)*

Taildragger Options If your GlaStar has taildragger landing gear, **skip this step.**

- [ ] Nose gear trunnion bolts, nuts and cotter pins
- [ ] Nose gear leg bolt and nut
- [ ] Nose gear stop assembly bolt and nuts
- [ ] Nose fork axle nut and cotter pin
- [ ] Nose wheel assembly bolts and nuts
- [ ] Nose wheel axle bolt, nuts and cotter pin
- [ ] Nose wheel pant mounting bracket retention screws and nuts

Completed: [ ]

Step 207: Inspect the Tailwheel Installation *(Taildragger Only)*

Tricycle Gear Option If your GlaStar has tricycle landing gear, **skip this step.**

- [ ] Forward spring attach bracket mounting bolts and nuts
- [ ] Aft spring block retainer screw and nut
- [ ] Spring stack screw and nut
- [ ] Forward spring attach bolt and nut
- [ ] Aft spring attach bracket mounting bolts and nuts
- [ ] Aft spring attach bracket cross bolt and nut
- [ ] Tailwheel assembly mounting bolt and nut
- [ ] Tailwheel steering cable clevis pins and cotter pins

Completed: [ ]

Step 208: Inspect the Wing Structure

- [ ] Left and right forward spar attach pins and locking clips
- [ ] Left and right aft spar attach bolts, nuts and cotter pins
- [ ] Left and right strut beam bolts and nuts (some of these are inaccessible for tightening; check the ones you can.)
- [ ] Left and right outboard wing strut attach bolts and nuts
- [ ] Left and right inboard wing strut attach bolts and nuts
- [ ] Left and right fuselage/wing strut attach fitting bolts, nuts and cotter pins

Completed: [ ]

Step 209: Inspect the Empennage Structure

- [ ] Horizontal stabilizer forward attach bracket bolts and nuts
- [ ] Horizontal stabilizer aft attach bracket bolts
- [ ] Elevator hinge pin retainers
- [ ] Trim tab hinge pin retainer

- [ ] Elevator counterweight screws and nuts
- [ ] Trim tab counterweight bolts and nuts
- [ ] Lower rudder hinge bolts and nuts
- [ ] Upper rudder hinge bolts (check both fin-side and rudder-side hinge halves)
- [ ] Upper and lower rudder hinge pivot bolts, nuts and cotter pins
- [ ] Rudder counterweight screws

Completed: [ ]

Step 210: Inspect the Rudder Control System

- [ ] Rudder control support bracket screws and nuts
- [ ] Brake master cylinder mounting bracket screws and nuts
- [ ] Rudder control pivot push nuts
- [ ] Rudder pedal pivot bolts, nuts and cotter pins
- [ ] Brake master cylinder bolts, nuts and cotter pins
- [ ] Rudder spring shackle clevis pins and cotter pins (early kits only)
- [ ] Forward rudder cable clevis pins and cotter pins
- [ ] Forward pulley group pivot bolts, nuts and cotter pins
- [ ] Forward pulley group cable guard pins and cotter pins
- [ ] Rudder cable turnbuckles (safety wire or clip)
- [ ] Bulkhead A pulley pivot bolts, nuts and cotter pins
- [ ] Bulkhead A pulley bracket cable guard pins
- [ ] Aft rudder cable clevis pins and cotter pins

Completed: [ ]

Step 211: Inspect the Elevator Control System

- [ ] Elevator/aileron control yoke bearing block bolts and nuts
- [ ] Forward elevator cable clevis pins and cotter pins
- [ ] Elevator cable turnbuckles (safety wire or clip)
- [ ] Aft elevator cable bolts, nuts, clevis pins and cotter pins
- [ ] Bellcrank mounting bracket bolts and nuts
- [ ] Bellcrank pivot bolt, nut and cotter pin
- [ ] Pushrod/bellcrank bolt, nut and cotter pin

- [ ] Pushrod/control horn bolt, nut and cotter pin
- [ ] Pushrod rod end jam nuts (witness paint)
- [ ] Trim tab cable end or pushrod/control horn bolt, nut and cotter pin
- [ ] Trim tab cable end or pushrod rod end jam nuts (witness paint)

Completed: [ ]

Step 212: Inspect the Aileron Control System

- [ ] Left and right control stick pivot bracket pivot bolts, nuts and cotter pins
- [ ] Left and right control stick mounting bolts and nuts
- [ ] Left and right primary actuation cable clevis pins and cotter pins
- [ ] Left and right forward aileron pulley pivot bolts, nuts and cotter pins
- [ ] Left and right forward aileron pulley guard straps
- [ ] Left and right aft aileron pulley pivot bolts, nuts and cotter pins
- [ ] Left and right aft aileron pulley guard straps
- [ ] Left and right crossover pulley pivot bolts, nuts and cotter pins
- [ ] Left and right aft wing spar aileron guide-pulley bracket bolts and nuts
- [ ] Left and right aft wing spar aileron guide-pulley pivot bolts, nuts and cotter pins
- [ ] Left and right aft wing spar aileron guide-pulley guard straps
- [ ] Left and right bellcrank/cable bolts, nuts, clevis pins and cotter pins
- [ ] Left and right bellcrank pivot bolts, nuts and cotter pins
- [ ] Left and right bellcrank/pushrod bolts, nuts and cotter pins
- [ ] Left and right pushrod rod end jam nuts (witness paint)
- [ ] Left and right pushrod/aileron bolts and safety wire
- [ ] Left and right hinge bolts and safety wire
- [ ] Aileron cable turnbuckles (safety wire or clip)
- [ ] Left and right counterweight attach bolts

Completed: [ ]

Step 213: Inspect the Flap Control System

- [ ] Flap handle pivot bolt and nut
- [ ] Flap ratchet plate mounting bolts and nuts
- [ ] Flap ratchet plate roll pin
- [ ] Flap handle/cable bolt, nut, clevis pins and cotter pins
- [ ] Left and right center flap pulley pivot bolts, nuts and cotter pins
- [ ] Left and right center flap pulley cable guard pins
- [ ] Left and right outboard flap pulley pivot bolts, nuts and cotter pins
- [ ] Left and right aft wing spar flap guide-pulley pivot bolts, nuts and cotter pins
- [ ] Left and right aft wing spar flap guide-pulley cable guard pins
- [ ] Left and right bellcrank cable-retainer clip mounting bolts and nuts
- [ ] Left and right bellcrank pivot bolts, nuts and cotter pins
- [ ] Left and right bellcrank/pushrod bolts, nuts and cotter pins
- [ ] Left and right pushrod rod end jam nuts (witness paint)
- [ ] Left and right pushrod/flap bolts, nuts and cotter pins
- [ ] Left and right flap-track bearing mounting bolts, nuts and cotter pins
- [ ] Flap cable turnbuckles (safety wire or clip)

Completed: [ ]

Step 214: Inspect the Manual Trim System *(Manual Trim Only)*

> **Electric Trim Option** If you've installed the electric trim system, **skip this step.**

- [ ] Forward trim cable jam nuts (witness paint)
- [ ] Gear box traveler block set screw (witness paint)
- [ ] Travel stop cable clamps (witness paint)
- [ ] Mounting bracket/cage screws
- [ ] Gear box/mounting bracket screws
- [ ] Aft cable retainer clip screws

Completed: [ ]

Step 215: Secure and Inspect the Cabin Interior

The items in this step and the following step should be secured and inspected after the final government airworthiness inspection.

- [ ] Bulkhead A close-out mounting screws
- [ ] Forward and aft control cable cover mounting screws
- [ ] Floorboard mounting screws
- [ ] Glare shield mounting screws
- [ ] Seat track mounting bolts and nuts
- [ ] Seat slider mounting bolts
- [ ] Seat back pivot bolts and nuts
- [ ] Seat belt and shoulder harness mounting bolts and nuts

Completed: [ ]

Step 216: Secure and Inspect the Fairings and Inspection Hole Covers

- [ ] Rudder base fairing mounting screws (AN526-8R8s)
- [ ] Tailcone mounting screws
- [ ] Rudder tip fairing mounting screws
- [ ] Left and right horizontal stabilizer tip fairing mounting screws
- [ ] Left and right elevator tip fairing mounting screws
- [ ] Left and right wingtip fairing mounting screws
- [ ] Left and right main wheel pant mounting screws (if installed)
- [ ] Left and right main gear leg fairing stiffener block screws
- [ ] Nose wheel pant seam screws (tricycle gear only)
- [ ] Nose wheel pant mounting screws (tricycle gear only)
- [ ] Nose gear leg fairing mounting screws (tricycle gear only)
- [ ] Nose gear leg fairing hinge pin safety wire (tricycle gear only)
- [ ] Wing-fold hatch mounting screws (or optional Camlocs)
- [ ] Wing inspection hole cover screws (AN526-8R6s)
- [ ] Aileron inspection hole cover screws (AN526-8R6s)
- [ ] Lower aft fuselage inspection hole cover screw

Completed: [ ]

WEIGHT AND BALANCE

> **Warning** To operate the GlaStar (or any other aircraft) safely, it must be flown within specified center of gravity (CG) limits. These limits must be **strictly** observed. Flight in either a nose-heavy or tail-heavy airplane is unsafe and can result in loss of control.

Because every GlaStar is different, you must determine the CG for **your** airplane in both empty and loaded configurations in order to establish safe loading criteria. This final sub-section of the *Assembly Manual* is devoted to these tasks. The sub-section concludes with instructions for constructing a battery tray. This task is left until the very end so that the battery location can be adjusted if necessary to achieve a more desirable empty weight CG. However, the aircraft should be **totally completed** in every other respect before proceeding with the steps in this sub-section. This means all firewall-forward installations should be complete (including the propeller, spinner and cowling), the instruments and avionics should be installed, the interior finishing (including upholstery) should be completed, and the aircraft should be painted (if you intend to paint it at all).

What follows are some general definitions and data useful in calculating the CG of your airplane. The specific steps required are detailed below.

General Definitions

ARM (OR MOMENT ARM) – the horizontal distance in inches from the datum to the center of gravity of a particular item.

CENTER OF GRAVITY (CG) – the point at which an object would balance if suspended in space. The CG of a particular part of the airplane or its load is typically expressed as a horizontal distance from the datum, while the CG of the aircraft as a whole is expressed as a percentage of the mean aerodynamic chord (see below).

DATUM – an imaginary vertical plane from which all moment arms are measured for weight and balance purposes. The datum is perpendicular to the waterline plane when the aircraft is in level-flight attitude.

MEAN AERODYNAMIC CHORD (MAC) – a chord is the straight-line distance from the leading edge to the trailing edge of an airfoil section. The MAC is the average chord across the entire wingspan. The MAC of a straight, constant-chord wing like the GlaStar's is the same as the actual chord at any point in the span. Aircraft CG locations are specified as percentages of MAC; these distances are measured from the leading edge of the wing.

MOMENT – the product of an item's weight multiplied by its arm.

STATION – a horizontal distance from the reference datum given in inches.

Generic GlaStar Weight and Balance Data

The following generic data are needed for the weight and balance calculations:

DATUM ....58" forward of the cowling mounting flange joggle

MEAN AERODYNAMIC CHORD (MAC) ....44"

MAXIMUM ALLOWABLE GROSS WEIGHT .... 1,960 lbs.

CG LIMITS

Forward .... 14.0% MAC (Station 95.6)
Aft ....32.0% MAC (Station 103.5)

VARIOUS MOMENTS ARMS

Datum ....Station 0.0
Cowling mounting flange joggle ....Station 58.0
Firewall ....Station 60.5
Wing leading edge ....Station 89.4
Pilot and passenger...Station 101.0
Fuel ....Station 108.0
Baggage, forward zone ....Station 136.0
Baggage, aft zone...Station 160.0

Note Step 10 of this "FINAL ASSEMBLY" section includes a description of the two different baggage zones. The dividing line between the two zones is located **25" forward** of Bulkhead A or just forward of the baggage door, as shown in Figures 206 and 207 below.

Step 217: Determine the Stations of the Landing Gear

The empty weight CG of the airplane must be determined before any additional CG calculations can be made. The first step in determining the empty weight CG is to measure the distances from the datum to the landing gear. These distances will vary slightly among GlaStars.

First, with the airplane supported with the wings and the waterline level, use a plumb bob to mark the location of the cowling mounting flange joggle (the cowling/fuselage split line) on the floor.

Note If you made the permanent waterline reference marks as recommended in the Hint at the end of Step 33 in "SECTION VIII: FUSELAGE ASSEMBLY," use them to level the waterline. To level a tricycle-geared airplane, position blocks under either the nose wheel or the main wheels (or partially deflate one or more of the tires). To level a taildragger, prop the tailwheel on a support of some kind and block it up to the appropriate height.

Measure forward **58"** from the cowling joggle mark and mark a line on the floor at this point perpendicular to the longitudinal centerline of the airplane. This line represents the intersection of a plane in space with the floor. This plane is defined as the reference datum (Station 0.0) from which all moment arms are measured.

The next steps vary slightly depending on whether your GlaStar has tricycle or taildragger landing gear. Follow the instructions specific to your configuration.

TRICYCLE GEAR

For a **tricycle-geared** GlaStar, measure and record the horizontal distances "X" and "Y" from the datum to the centers of the nose and main wheel axles, respectively. See Figure 206.

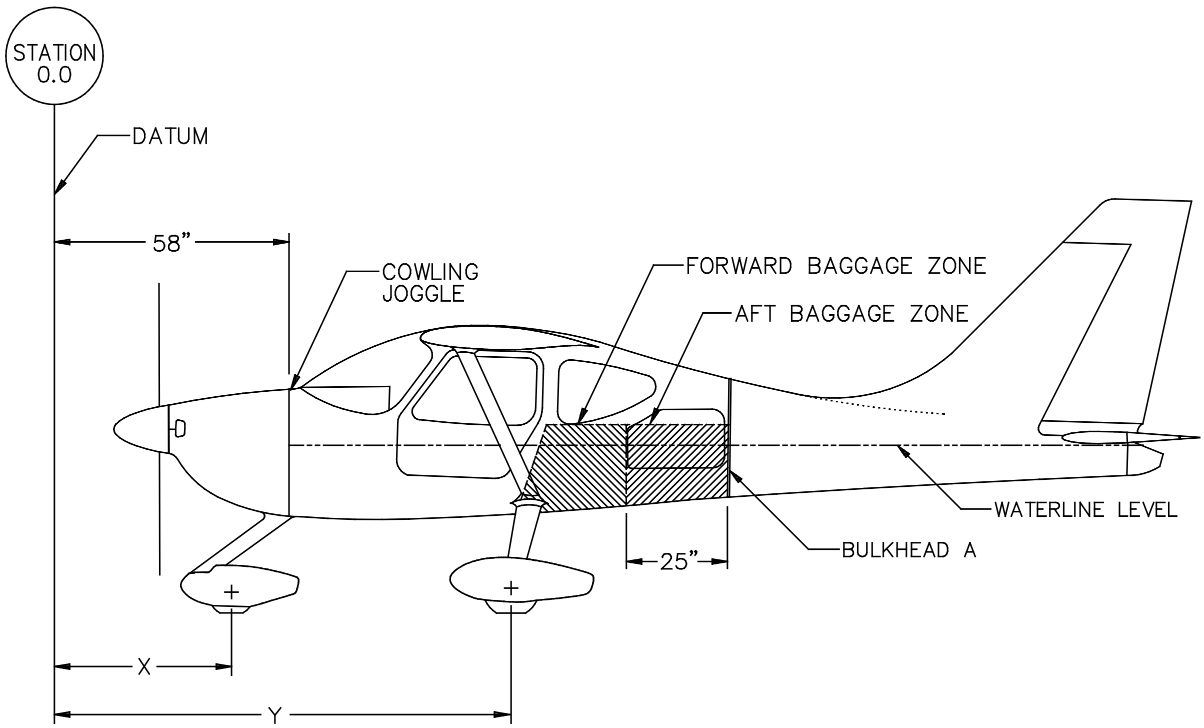


Figure 206: Measuring the Landing Gear Stations (Tricycle Gear Only)

Enter the results of your measurements here:

NOSE WHEEL (X) ___________

MAIN GEAR (Y) ___________

TAILDRAGGER

For a **taildragger**, measure and record the horizontal distances "X" and "Y" from the datum to the centers of the main and tailwheel axles, respectively. See Figure 207.

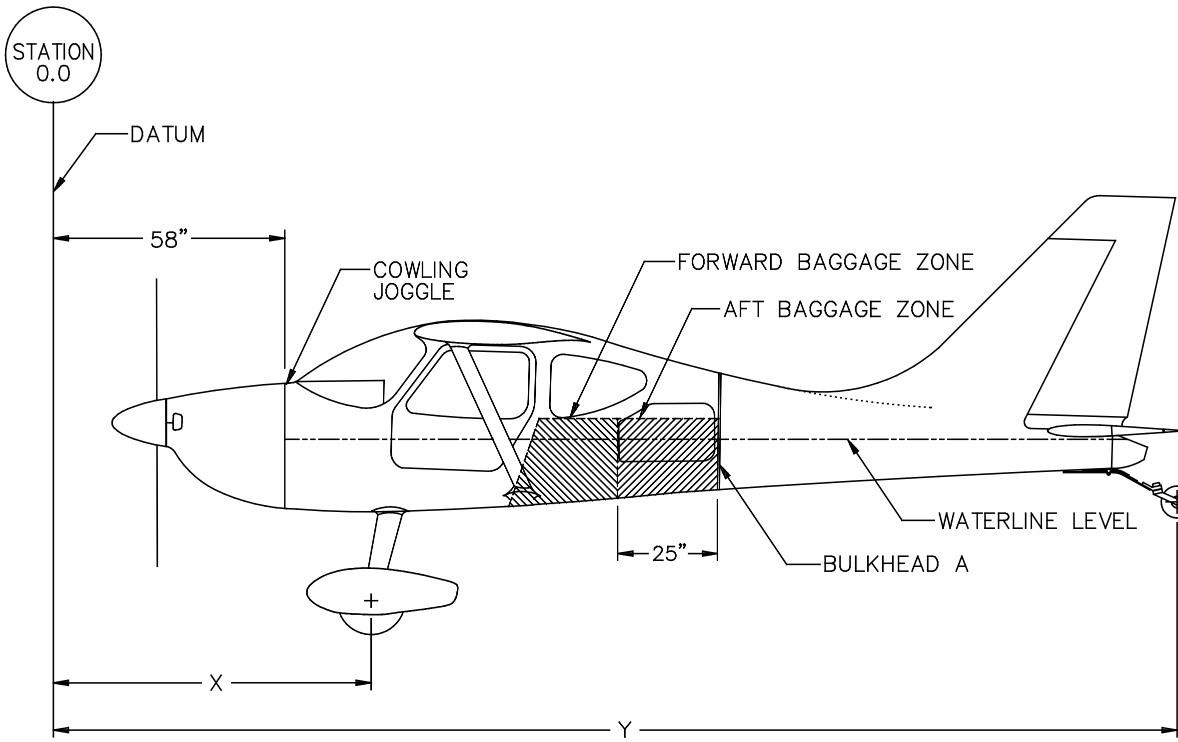


Figure 207: Measuring the Landing Gear Stations (Taildragger Only)

Enter the results of your measurements here:

MAIN GEAR (X) ___________

TAILWHEEL (Y) ___________

Completed: [ ]

Step 218: Weigh the Aircraft

Now it's time to weigh the airplane. This requires three scales—one under each wheel. The scales should each be capable of handling about 600 lbs. Most builders will find it worthwhile to hire a professional shop to do this job, but if you can lay your hands on suitable scales, have at it.

For this measurement, the fuel tanks should be empty, but the engine should be full of oil and—if it's a liquid-cooled engine—coolant. While weighing the airplane, block up the wheels as necessary to bring the waterline and the wings level. Be sure to subtract the tare weight of any blocks or wheel chocks used from the scale readings.

Note For initial CG calculation, set the aircraft battery on the fuselage floor immediately behind Bulkhead A. This is the most desirable location for the battery from an access standpoint, and so if you can come up with an acceptable CG range with the battery there, that's all to the good. If, on the other hand, you need to move weight aft, you can always do that later.

Also note that you need to record the weights registered by each scale individually—not just the total weight.

Enter the results of your initial weighing here:

	SCALE READING	–	TARE WEIGHT	=	WEIGHT
LEFT MAIN GEAR	____________	–	____________	=	____________
RIGHT MAIN GEAR	____________	–	____________	=	____________
NOSE GEAR/TAILWHEEL	____________	–	____________	=	____________
TOTAL AIRCRAFT	____________	–	____________	=	____________

Step 219: Calculate the Station of the Empty Weight CG

TRICYCLE GEAR

For a **tricycle-geared** GlaStar, use the following formula to calculate the station of the empty weight CG:

$$\text{Empty Wt. CG} = \frac{(\text{Nose Gear Wt.})(X) + (\text{R. Main Wt.} + \text{L. Main Wt.})(Y)}{\text{Total Aircraft Wt.}}$$

> **Note** "X" and "Y" in the above formula are the stations of the nose and main gear axles, respectively. Refer to Figure 206.

Following is a **sample** empty weight CG calculation, using the formula above and the data from the tricycle-geared GlaStar prototype. The prototype's empty weight with a Lycoming O-320, a prop extension and a Sensenich fixed-pitch metal propeller is 1,224 lbs., divided as follows:

Nose gear.. 351 lbs., Station 45.1
Left main gear.. 437 lbs., Station 113.3
Right main gear .... 436 lbs., Station 113.3

$$\text{Empty Wt. CG} = \frac{(351\text{ lbs. X } 45.1\text{ in.}) + (437\text{ lbs.} + 436\text{ lbs.})(113.3\text{ in.})}{1{,}224\text{ lbs.}}$$

$$= \frac{114{,}741\text{ in.-lbs.}}{1{,}224\text{ lbs.}}$$

$$= \text{Station } 93.7$$

Enter the results of your empty weight CG calculation here:

EMPTY WEIGHT CG STATION ___________

TAILDRAGGER

For a GlaStar **taildragger**, use the following formula to calculate the station of the empty weight CG:

$$\text{Empty Wt. CG} = \frac{(\text{Tailwheel Wt.})(Y) + (\text{R. Main Wt.} + \text{L. Main Wt.})(X)}{\text{Total Aircraft Wt.}}$$

> **Note** "X" and "Y" in the above formula are the stations of the main and tailwheel axles, respectively. Refer to Figure 207.

Following is a **sample** empty weight CG calculation, using the above formula and data from the taildragger GlaStar prototype. The prototype's empty weight with a Continental IO-240-B and a Sensenich fixed-pitch metal propeller is 1,155 lbs., divided as follows:

Left main gear ....527 lbs., Station 81.2
Right main gear ....526 lbs., Station 81.2
Tailwheel ....102 lbs., Station 279.0

$$\text{Empty Wt. CG} = \frac{(102\text{ lbs. X }279.0\text{ in.}) + (527\text{ lbs.} + 526\text{ lbs.})(81.2\text{ in.})}{1{,}155\text{ lbs.}}$$

$$= \frac{113{,}961.1\text{ in.-lbs.}}{1{,}155\text{ lbs.}}$$

= Station 98.7

Enter the results of your empty weight CG calculation here:

EMPTY WEIGHT CG STATION ____________

Completed: [ ]

Step 220: Perform the CG Limit Checks

In this step, you'll perform checks to see where the CG of your GlaStar in "worst-case" loading scenarios—extreme forward and extreme aft CG conditions—falls relative to the acceptable CG range. The results of these calculations will give you information about where best to position your battery in the final step of this sub-section, as well as establishing guidelines for safely loading your GlaStar for flight.

To perform the forward and rearward CG limit checks, tabulate the weights, stations and moments, as shown in the following examples. Add the weights and moments and divide the total moment by the total weight to obtain the station of the CG. Once you have that figure, use the following formula to calculate the CG as a percentage of MAC:

$$CG_{\%MAC} = \frac{\text{Station of the CG} - \text{Station of the Wing Leading Edge}}{\text{MAC}} \times 100$$

. . . in which the station of the wing leading edge is **89.4**, and the MAC is **44.0"**.

The following examples are based on the empty weight and empty-weight CG of the tricycle-geared GlaStar prototype; **your numbers will vary!**

Note For all weight-and-balance calculations, note that gasoline weighs 6 pounds per gallon.

FORWARD LIMIT CHECK

The FARs specify that the forward limit check should be performed using the **maximum** weights of items located **forward** of the forward CG limit and the **minimum** weights of items located **aft** of the forward CG limit. In the GlaStar, all items of variable weight—pilot and passenger, fuel and baggage—are located aft of the forward CG limit (Station 95.6), so the forward limit check conditions are: **no passenger, minimum fuel** and **no baggage**.

The FAA standard pilot weighs **170 lbs**. The standard formula for calculating minimum fuel is as follows:

$$\text{Minimum Fuel} = \frac{\text{Engine HP}}{12}$$

Thus, for our prototype with a 160 HP engine, the minimum fuel is **13.3 gal**. Calculate a minimum fuel figure for your GlaStar and enter the result here:

MINIMUM FUEL ____________

> **Note** If you weigh **less** than 170 lbs., you have the **option** of using your own weight to perform the forward and rearward CG limit checks. However, the converse is **not** true; if you weigh more than 170 lbs., you **must** use the 170-lb. standard weight.

ITEM	WEIGHT (LBS.)	STATION (IN.)	MOMENT (IN.-LBS.)
Empty GlaStar	1,224.0	93.7	114,741.0
Pilot	170.0	101.0	17,170.0
Passenger	0.0	101.0	0.0
Fuel (13.3)	79.8	108.0	8,618.4
Forward baggage	0.0	136.0	0.0
Aft baggage	0.0	160.0	0.0
TOTAL	**1,473.8**	—	**140,529.4**

Table 2: Sample Forward Limit Check

$$CG = \frac{\text{Total Moment}}{\text{Total Weight}} = \frac{\text{140,529.4 in.-lbs.}}{\text{1,473.8 lbs.}} = \text{Station 95.4}$$

$$CG_{\%MAC} = \frac{95.4 - 89.4}{44.0} \times 100 = 13.6\% \text{ MAC}$$

In this example, we can see that, although the total aircraft weight of 1,474 lbs. is well below the allowable gross, the CG at 13.6% MAC is slightly forward of the 14% MAC forward limit, and thus, the aircraft as loaded is not safe to fly.

Lay out a table like Table 2 for your GlaStar and perform your own forward limit check. Enter your result here:

FORWARD LIMIT CHECK — STATION ____________

Hint If you have a personal computer with spreadsheet software, use it to perform all your weight and balance calculations. The "Tech-Talk" column in the Second Quarter 1996 issue (No. 62) of the *Stoddard-Hamilton News* contains examples of the Microsoft Excel formulae used here at the factory for computing weight and balance on our airplanes.

If your forward limit check comes out beyond the forward CG limit, you have two options: 1) you can placard the airplane, prohibiting flight under loading conditions that would exceed the forward CG limit, or 2) you can shift the battery aft in an attempt to bring the forward-most CG aft of the forward limit. Option #2 is probably more attractive to most builders, and will be further discussed below.

Warning The preceding example illustrates that, as a result of the GlaStar's ability to carry so much baggage, its forward-CG limit is somewhat more sensitive than in some other aircraft when the baggage compartment is empty, especially when equipped with a relatively heavy engine and prop. Be particularly aware of your weight and balance condition when you fly with little or no baggage and low fuel, especially if you are flying solo.

Rearward Limit Check

In contrast to the forward limit check, the rearward limit check must be performed using the **minimum** weights of items located **forward** of the aft CG limit and the **maximum** weights of items located **aft** of the aft CG limit. The aft CG limit in the GlaStar is at Station 103.5, so the rearward limit check conditions are: **no passenger, maximum fuel** and **maximum baggage**.

Maximum standard fuel capacity in the GlaStar is **33 gal.**, and the maximum total baggage capacity is **250 lbs**.

Item	Weight (lbs.)	Station (in.)	Moment (in.-lbs.)
Empty GlaStar	1,224.0	93.7	114,741.0
Pilot	170.0	101.0	17,170.0
Passenger	0.0	101.0	0.0
Fuel (33 gal.)	198.0	108.0	21,384.0
Forward baggage	0.0	136.0	0.0
Aft baggage	250.0	160.0	40,000.0
Total	**1,842.0**	—	**193,295.0**

Table 3: Sample Aft CG Limit Check

$$CG = \frac{\text{Total Moment}}{\text{Total Weight}} = \frac{193{,}295.0 \text{ in.-lbs.}}{1{,}842.0 \text{ lbs.}} = \text{Station } 104.9$$

$$CG_{\%MAC} = \frac{104.9 - 89.4}{44.0} \times 100 = 35.2\% \text{ MAC}$$

Once again, although the airplane is under gross weight, the loading exceeds the CG limit. Of course, this is not surprising, since we're trying to load all 250 lbs. of baggage allowance into the aft zone of the baggage compartment. The solution to this dilemma is to divide the baggage up between the two zones and recalculate. Trial-and-error revealed that, in our prototype, a load distribution of 110 lbs. in the forward zone and 140 lbs. in the aft zone brings the CG exactly to the aft limit. This loading represents the aft-most approved loading condition, and **the airplane must be placarded to indicate this**.

REARWARD LIMIT CHECK — STATION __________

Perform a rearward limit check for your GlaStar, using a table like Table 3. If your GlaStar exceeds the aft limit, as it most likely will, determine how the maximum baggage load must be redistributed to bring the CG within limits, and then placard the compartment with the results.

Baggage compartment restrictions — Forward zone __________

Aft zone __________

MOVING THE BATTERY

As we saw in the example of the forward CG limit check above, our prototype GlaStar with the 160 HP Lycoming O-320 engine and metal prop can easily be loaded beyond the forward CG limit. With a relatively heavy engine and prop combination, the empty weight CG is too far forward to be balanced by the pilot and minimum fuel alone. If your GlaStar weight and balance looks similar, turn to your battery for help!

Because they're heavy, compact and relatively mobile, aircraft batteries make great CG adjustment devices. The battery in our prototype is immediately behind Bulkhead A at the rear of the baggage compartment. If it had been placed about two feet further aft, then the sample forward-limit check performed in the last step would have come out within allowable limits. Very small changes in battery location can have large effects on CG!

Use the following formula to determine where the battery should be placed:

$$BS_{new} = \frac{(CG_{desired} \times LW_{fwd}) - TM_{fwd} + BW\,(167.6\text{ in.} + (BL / 2))}{BW}$$

where,

BS_{new} = the station of the new battery location,

$CG_{desired}$ = the desired station of the CG at forward limit check,

LW_{fwd} = the loaded weight of the aircraft at forward limit check,

BW = the weight of the battery, and

BL = the length of the battery.

The value of $CG_{desired}$ will generally be the forward CG limit, **Station 95.6**. The figure of **167.6 in.** in the equation is the station of Bulkhead A; this station plus half the length of the battery equals the original station of the battery when you performed your initial forward limit check.

Plugging in the values from our sample forward limit check above, we get the following:

$$BS_{new} = \frac{(95.6\text{ in.} \times 1{,}473.8\text{ lbs.}) - 140{,}529.4\text{ in.-lbs.} + 20\text{ lbs.}\,(167.6\text{ in.} + (7.5\text{ in.}/2))}{20\text{ lbs.}}$$

$$BS_{new} = \textbf{Station 189.6}$$

Station 189.6 is about 22" aft of Bulkhead A; **centering** the battery at that location would produce a forward limit check CG at Station 95.6.

Work through the formula above using the values from your own forward limit check and enter the result here:

NEW BATTERY LOCATION — STATION ____________

Warning Any future modifications to the aircraft that add, subtract or shift weight will change the location of the empty weight CG. If any such modifications are made, you must recalculate the empty weight CG and re-perform the forward and rearward limit checks.

Completed: [ ]

Step 221: Install the Battery Tray

Now that you know where it should go, you can finish installing the battery. Construct a battery tray as shown in Figure 208.

Warning The battery tray design detailed on the following pages is suitable for a **sealed battery only**. Traditional-style lead acid batteries with removable caps require a sealed, vented battery box.

Begin by cutting out a floor and sidewall for the tray from the two remaining pieces of 1/2" X 12" X 12" 5-lb. density foam. Size the pieces to fit your particular battery: as shown in Figure 208, make the floor **3" longer** and **3" wider** than the base of the battery. The sidewall should be the same length as the floor. Its height will depend on the curvature of the fuselage shell at your battery location; size it to support the tray floor in a horizontal position, as shown.

After you have cut the foam pieces to size, cut **four** pieces of bi-directional cloth on the 45° bias big enough to cover **each** foam piece (i.e., **eight** pieces of cloth in total). Then apply a sealing layer of thin-mixture resin and Q-cell, followed by two layers of cloth to both faces of both foam pieces. When the laminates reach green cure, trim them even with the edges of the foam cores with a sharp utility knife.

While the laminates are curing, apply mold-release wax or equivalent to the lower **2–3"** of the **sides** of the **battery** all the way around. Allow the wax to lap over an inch or so onto the **bottom** of the battery case as well. When the laminates have fully cured, position the battery in the center of the floor laminate as shown in Figure 208, **1-1/2"** from all four edges of the laminate.

With the battery thus waxed and positioned, you will now use it as a form to lay up the retention angles that will hold it in place. As shown in Figure 208, each angle is laid up of two layers of DBM cloth lapped equally onto the floor laminate and the battery case. Begin by cutting **four** strips of DBM that are equal in length to the battery's length and **four** strips equal to the battery's width. Laminate these strips in place as shown in the figure and let them cure thoroughly (trimming them even with the edges of the floor piece at the green-cure stage). When they are fully cured, remove the battery and file or sand the edges of the laminated angles smooth. Radius the corners slightly as well.

The next step is to drill two **1/4"** holes for the hold-down bolts. As Figure 208 shows, these holes should be drilled **1"** from each end of the floor laminate. The left-and-right positioning of the holes should be determined by the configuration of your particular battery. Choose a location as near the middle of the floor laminate as possible but check to make sure that the **1"-wide** hold-down strap that will run between the bolts will clear any terminals or other projections on top of the battery.

After both hold-down bolt holes have been drilled, use standard practices to install a pair of K1000-4 **nutplates** [160] (the **last** two nutplates!) on the underside of the floor laminate. As shown in Figure 208, use 3/32" aluminum blind rivets for this application.

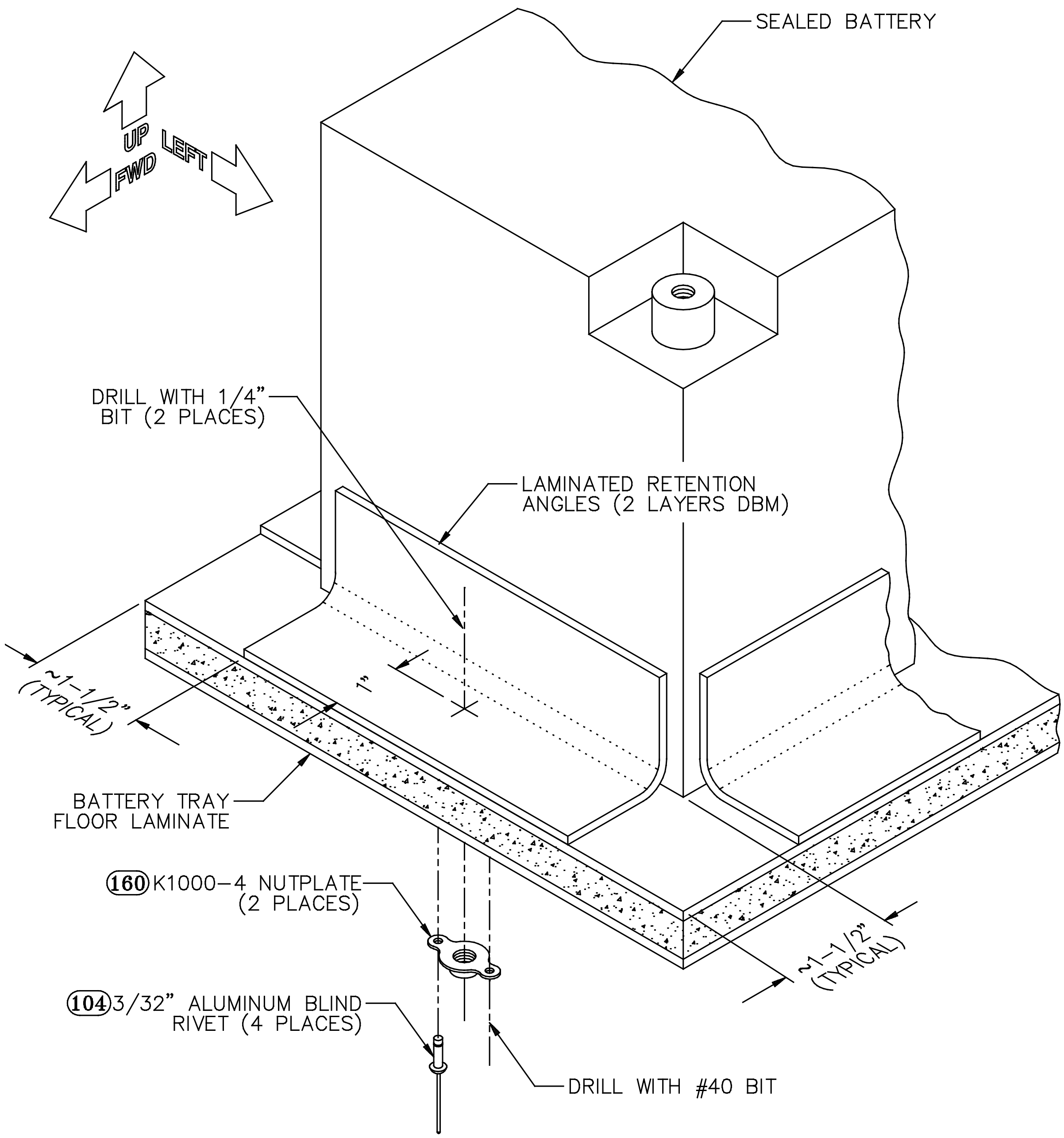


Figure 208: Constructing the Battery Tray (Sealed Battery Only)

The final step before actually installing the floor laminate is to cut and install the two hold-down bolts. These are cut from the **1/4"-28 threaded steel rod** [60], of which 18" is included in the kit. Size your bolts to be **1-1/2" longer** than your battery is high, and cut them to length with a hacksaw. Use a 1/4"-28 die to clean up the threads as necessary, and then thread the bolts into the nutplates at either end of the floor laminate, as shown in Figure 209. Since the threads in the middle of the rods will never be used, you can go ahead and grip them there with a pair of pliers in order to thread them all the way into the nutplates.

Now you're ready to final fit the floor and sidewall laminates for installation in the aft fuselage. As shown in Figure 209, the laminates must be beveled to fit against their adjacent laminates. Use a long sanding block to accomplish this. Bevel the outboard edge of the floor laminate to match the curvature of the fuselage sidewall, the inboard edge of the floor laminate to match the upper edge of the sidewall laminate, and the lower edge of the sidewall laminate to match the floor of the fuselage. Note that you should aim for about a **45°** angle between the floor and sidewall laminates, but this isn't too critical.

Note Figure 209 and 210 show the battery tray installed on the left side of the aircraft, but the right side works just as well.

When you're satisfied with the fit of the parts, mix a small batch of thick-mix resin and Q-cell and bond the parts in place. Leave a finger's-width fillet of Q-cell around the seams between the fuselage side and the top of the floor laminate and between the fuselage floor and the inboard face of the sidewall laminate.

Finish the installation by applying **two** layers of bi-directional cloth cut on the 45° bias to each of seams you just filleted, as well as to the top of the seam between the floor and sidewall laminates (see Figure 209). Each of these layers should run the full length of the seam and should lap **at least 1"** onto each side of the seam.

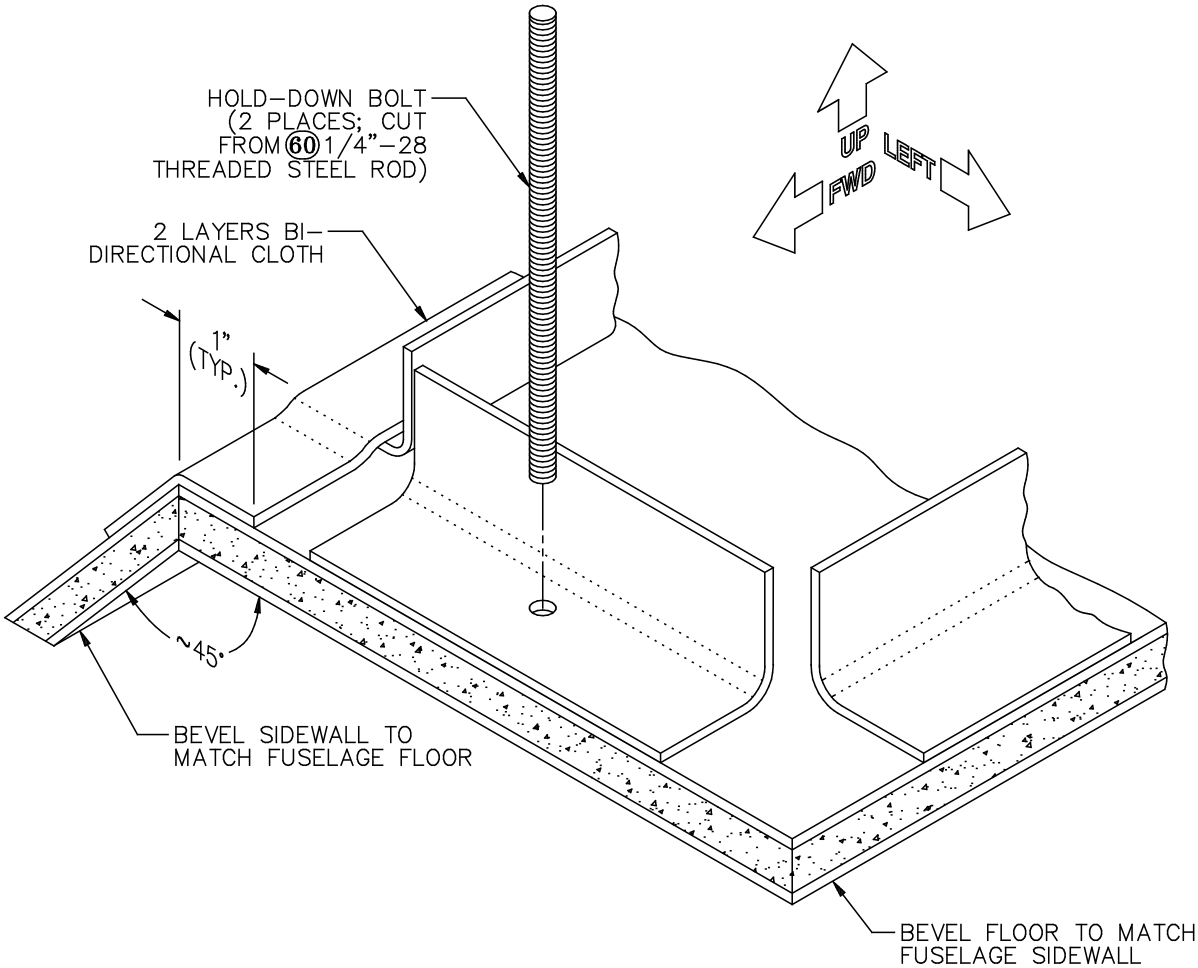


Figure 209: Installing the Battery Tray (Sealed Battery Only)

Finally, fabricate and install a hold-down strap over the battery. As Figure 210 shows, the strap is made of .063" X 1" X 1" aluminum angle stock. Measure the distance between the centers of your hold-down bolts and cut the strap **3/4"** longer than that. This provides the **3/8"** edge margin between the ends of the strap and the bolt holes shown in the figure. Bevel the ends of the vertical flange, as shown, and then drill and deburr the **1/4"** bolt holes. Corrosion-proof the strap as you see fit.

Set the battery in place inside the retention angles and install the hold-down strap with AN960D416L thin aluminum washers and AN365-428A nylon self-locking nuts. Tighten the nuts firmly but no tighter; your goal is not to crush the battery case!

Completed: [ ]

Step 222: Complete the Final Weight and Balance Statement

Now that the battery and tray are installed in the aircraft, you need to recalculate the new weight and balance in order to complete the weight and balance statement required by the FARs. Begin with Step 218, weighing the aircraft, and proceed through Steps 219 and 220, calculating the empty weight CG and performing forward and rearward limit checks. Enter the results of these measurements and calculations on a sheet to be permanently carried aboard the aircraft.

Completed: [ ]

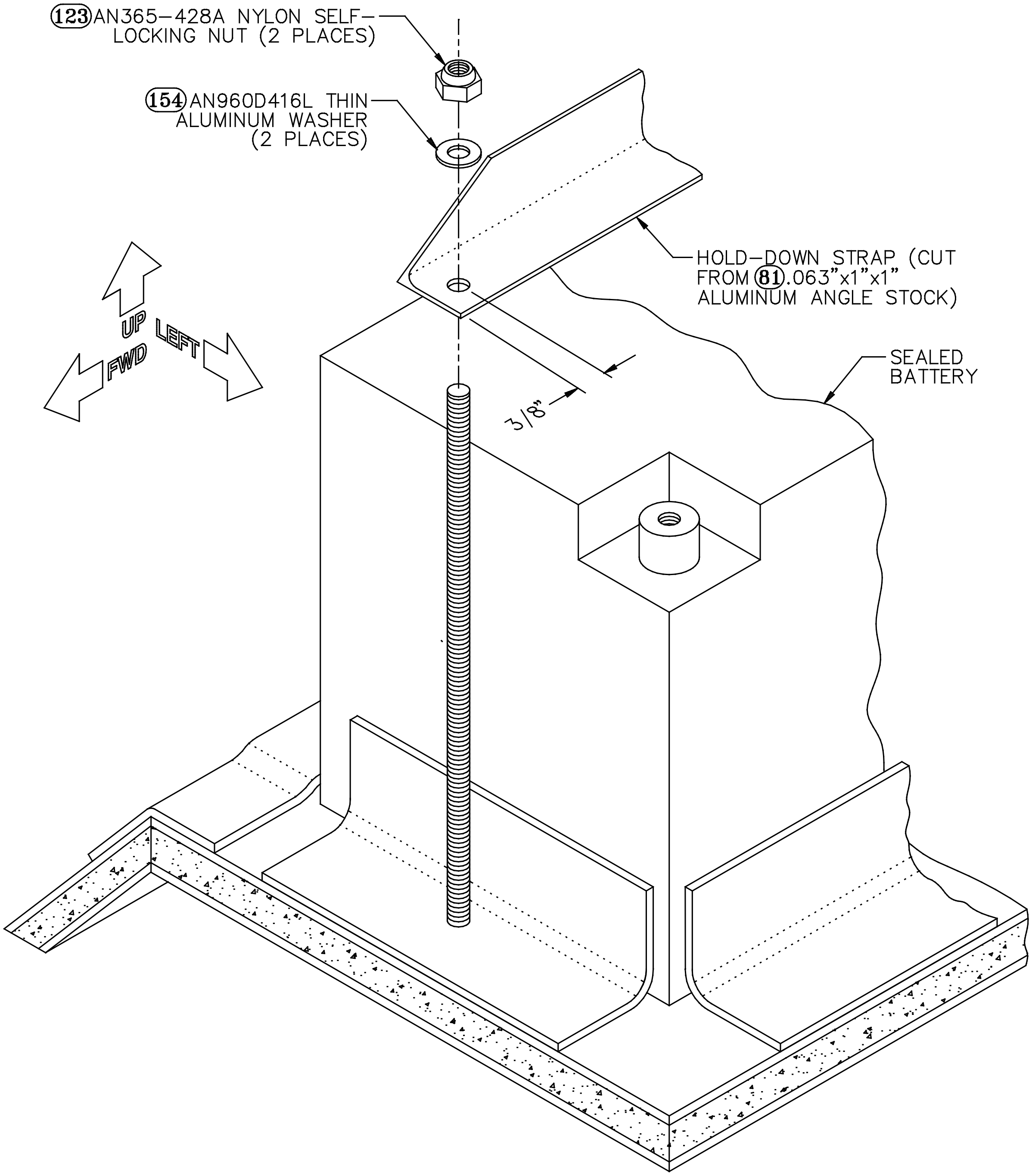
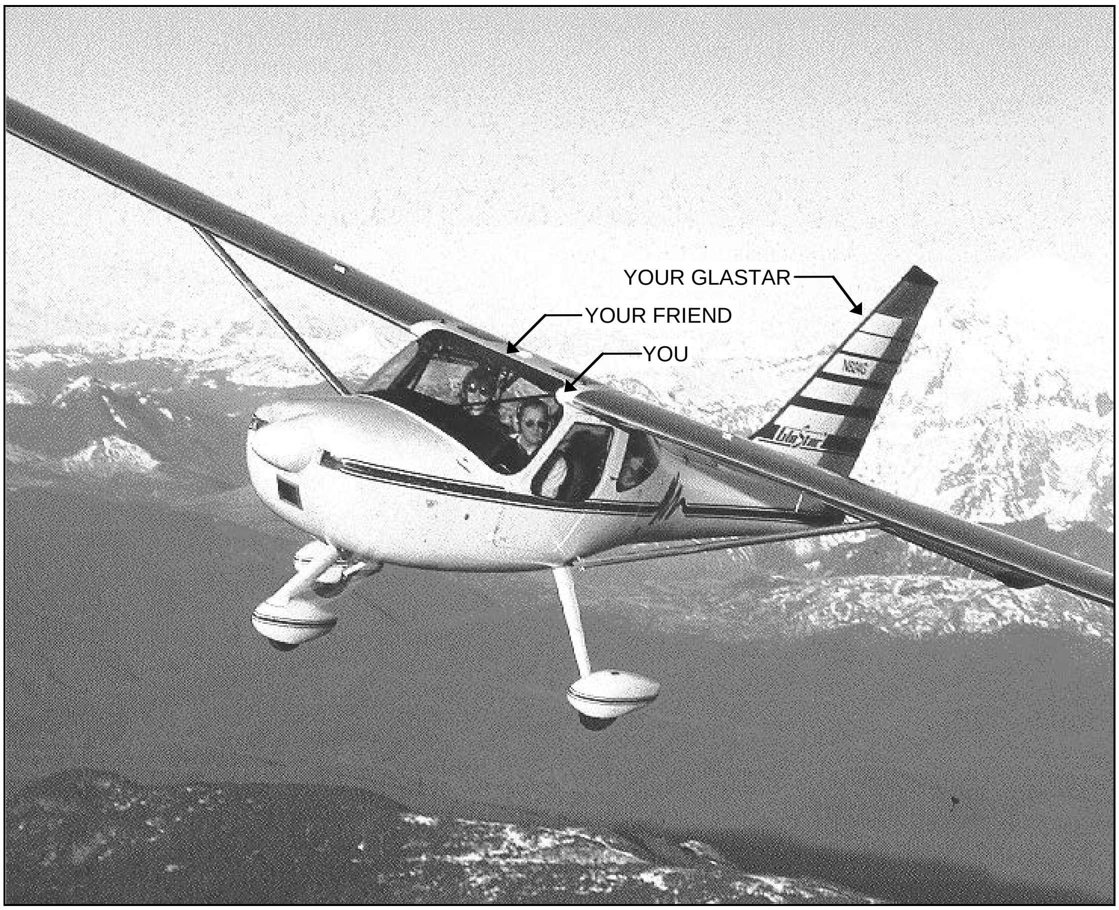


Figure 210: Installing the Battery Hold-Down Strap (Sealed Battery Only)

CONGRATULATIONS!

You did it! Through all the construction challenges and the *Manual*'s bad jokes, you persevered, and now you've got a rugged, fast, versatile, beautiful airplane to show for it! Which reminds us that we forgot **one last step**:

Step 223: Go Have a Ball!



Never to be completed . . .