

# REVISION LIST

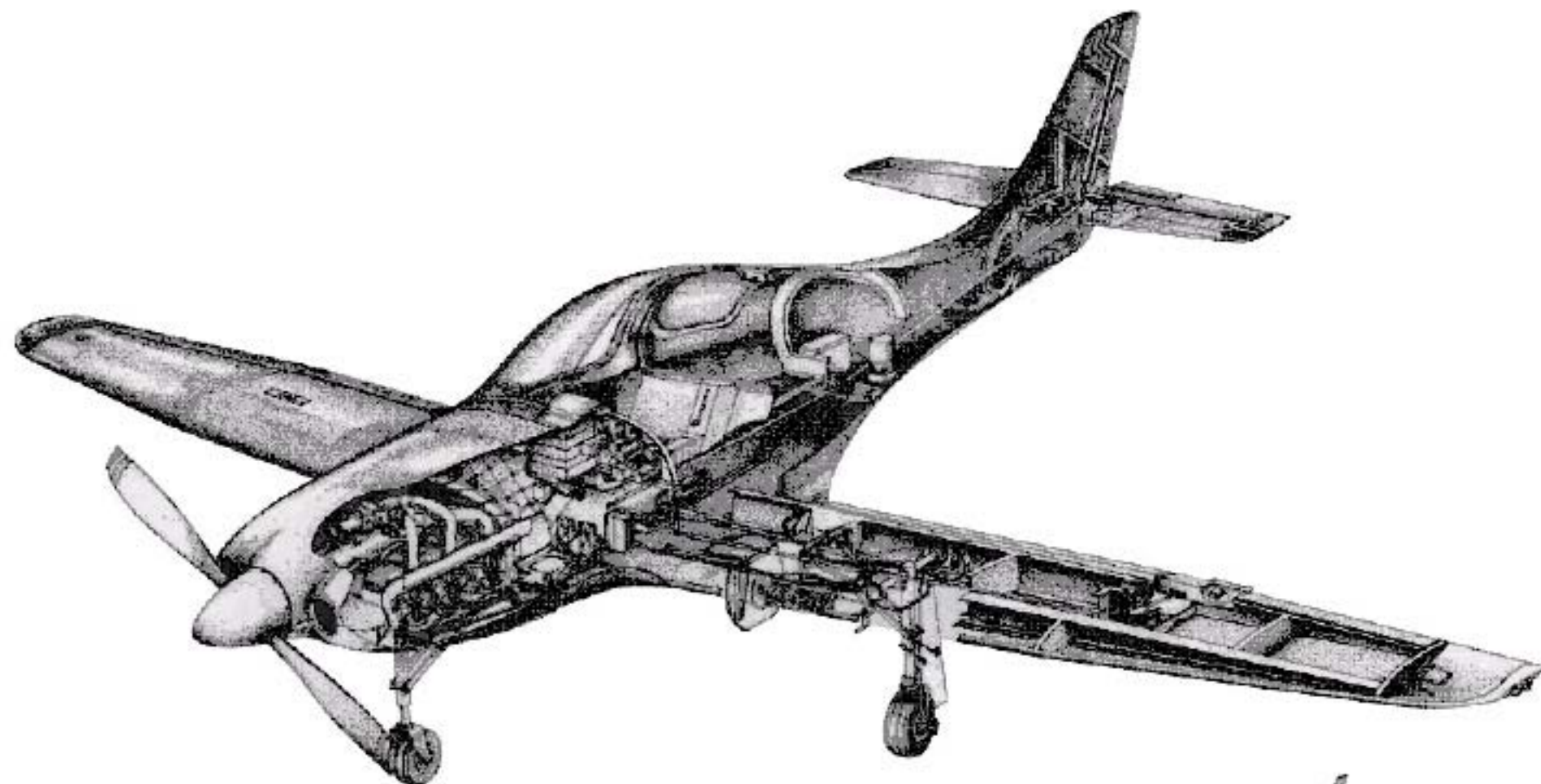
## CHAPTER 1: INTRODUCTION

The following list of revisions will allow you to update the Legacy construction manual chapter listed above.

Under the “Action” column, “R&R” directs you to remove and replace the pages affected by the revision. “Add” directs you to insert the pages shows and “R” to remove the pages.

<b>PAGE(S) AFFECTED</b>	<b>REVISION # &amp; DATE</b>	<b>ACTION</b>	<b>DESCRIPTION</b>
1-1 through 1-5	0/02-15-02	None	Current revision is correct
1-6	1/09-18-02	R&R	Text Correction
1-7	0/02-15-02	None	Current revision is correct
1-8	1/09-18-02	R&R	Text Correction
1-9	1/09-18-02	R&R	Text Correction
1-10 through 1-26	0/02-15-02	None	Current revision is correct
1-27	1/09-18-02	R&R	Text Correction
1-28 through 1-44	0/02-15-02	None	Current revision is correct
1-10	2/06-30-04	R&R	Text correction.
1-3	3/12-15-04	R&R	New table of contents with page numbers.
1-38	4/09-30-06	R&R	New guideline for rivet location in rod ends.
1-11, 1-28,	6/08/10/07	R&R	Hysol/Jeffco changes

ASSEMBLY MANUAL  
FOR THE LANCAIR LEGACY



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1-1

Chapter 1

REV.

0/02-15-02

INTRODUCTION



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Chapter 1    REV.    0/02-15-02

INTRODUCTION

# Chapter 1: Introduction

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# 1. INTRODUCTION

The purpose of this chapter is to familiarize the builder with the use of this manual, the general philosophy behind its layout, the terms we use and their definitions, and the construction materials and methods we will use throughout the manual. You should also read the texts recommended in the preface to familiarize yourself with the fine points of glassworking if you are a newcomer to fiberglass construction techniques. You may want to refer back to this section often as you build your plane. There is a lot of information here, and it would be difficult to absorb it in one reading, so refer to it whenever you aren't familiar with a term, or if you are about to start a step that you're not sure of. It may be explained here in more detail than it would be at each and every spot in the manual that it is used, such as the terms "BID" and "release", which will be found on nearly every page, but only explained in detail in this chapter.

## A. Recommended Background Information

This manual provides detailed step-by-step instructions for assembling the **Lancair Legacy 2000 Kit**. Hands on experience with fiberglass construction techniques and various hand tools is assumed. If you do not have that background knowledge, the study of other, more basic texts will be necessary. Suggested references are given on the following pages.

EAA  
Whittman Airfield  
Oshkosh, WI 54903-3065  
920- 426-4800  
www.eaa.org

## WARNING

**IF DURING CONSTRUCTION YOU HAVE ANY QUESTION OR DOUBT ABOUT A CONSTRUCTION PROCEDURE, DO NOT CONTINUE UNTIL YOU HAVE OBTAINED THE NECESSARY INFORMATION OR SKILL. IF YOU ARE NOT KNOWLEDGEABLE IN FIBERGLASS OR OTHER REQUIRED CONSTRUCTION TECHNIQUES OR TOOLS, OBTAIN THAT KNOWLEDGE BEFORE STARTING CONSTRUCTION.**

**NO CHANGE TO THE AIRCRAFT DESIGN OR SPECIFIED CONSTRUCTION PROCEDURES IS PERMITTED. SUCH CHANGES MAY ADVERSELY AFFECT THE AIRCRAFT'S STRUCTURAL INTEGRITY OR AIRWORTHINESS.**

**FAILURE TO FOLLOW THIS WARNING AND OTHERS FOUND THROUGHOUT THIS MANUAL COULD RESULT IN COMPONENT FAILURE AND LOSS OF AIRCRAFT CONTROL CAUSING SERIOUS INJURY OR DEATH.**

**COMPOSITE MATERIALS PRACTICE KIT:** This kit contains various materials with which to practice and develop your fiberglass construction technique. It also contains a copy of Burt Rutan's **Moldless Composite Sandwich Homebuilt Aircraft Construction** book described below. This kit is recommended for all newcomers to fiberglass construction and is a good refresher for others.

**MOLDLESS COMPOSITE SANDWICH HOMEBUILT AIRCRAFT CONSTRUCTION:** by Burt Rutan. Though the hot wire shaping technique covered by this book is not used on the Lancair, this book has a great deal of other excellent, basic fiberglass construction information. Highly recommended.

**BUILDING RUTAN COMPOSITES:** This is a video tape by Burt Rutan. Although it covers some techniques not used on the Lancair, it shows you how the experts handle fiberglass construction. Highly recommended.

**COMPOSITE CONSTRUCTION FOR HOMEBUILT AIRCRAFT:** by Jack Lambie. This book is an additional source of useful construction information and goes into the theory of aircraft design as well. Jack's Chapter 9, Safety in Working With Composite Construction, is particularly worth reading. This book would be a useful addition to the above.

**KITPLANE CONSTRUCTION:** by Ron Wenttaja. This is a resourceful book with information on metal, wood, and composites.

The above publications, practice kit and video tape are available from:

Aircraft Spruce and Specialty Company  
225 Airport Circle  
Corona, CA 91720  
Toll free order line (877) 477-7823  
Customer service (800) 861-3192  
Fax (909) 372-0555  
Email: info@aircraft-spruce.com

The following recommended books largely describe aspects of aircraft construction other than working with fiberglass:

**FIREWALL FORWARD:** by Tony Bingelis is packed with vital info about engine installation. You'll need this when you're getting ready to install the engine.

**THE SPORTPLANE BUILDER:** by Tony Bingelis has a lot of useful information on aircraft construction in general such as electrical systems, instrumentation and fuel systems. The chapter entitled "You and the FAA" gives important information on the procedures that you will need to follow during construction in order to get your homebuilt's airworthiness certificate.

These two books can be obtained from: **EAA Aviation Foundation**  
**Whittman Airfield**  
**Oshkosh, WI 59403-3065**  
**Phone: 1-920-426-4800**



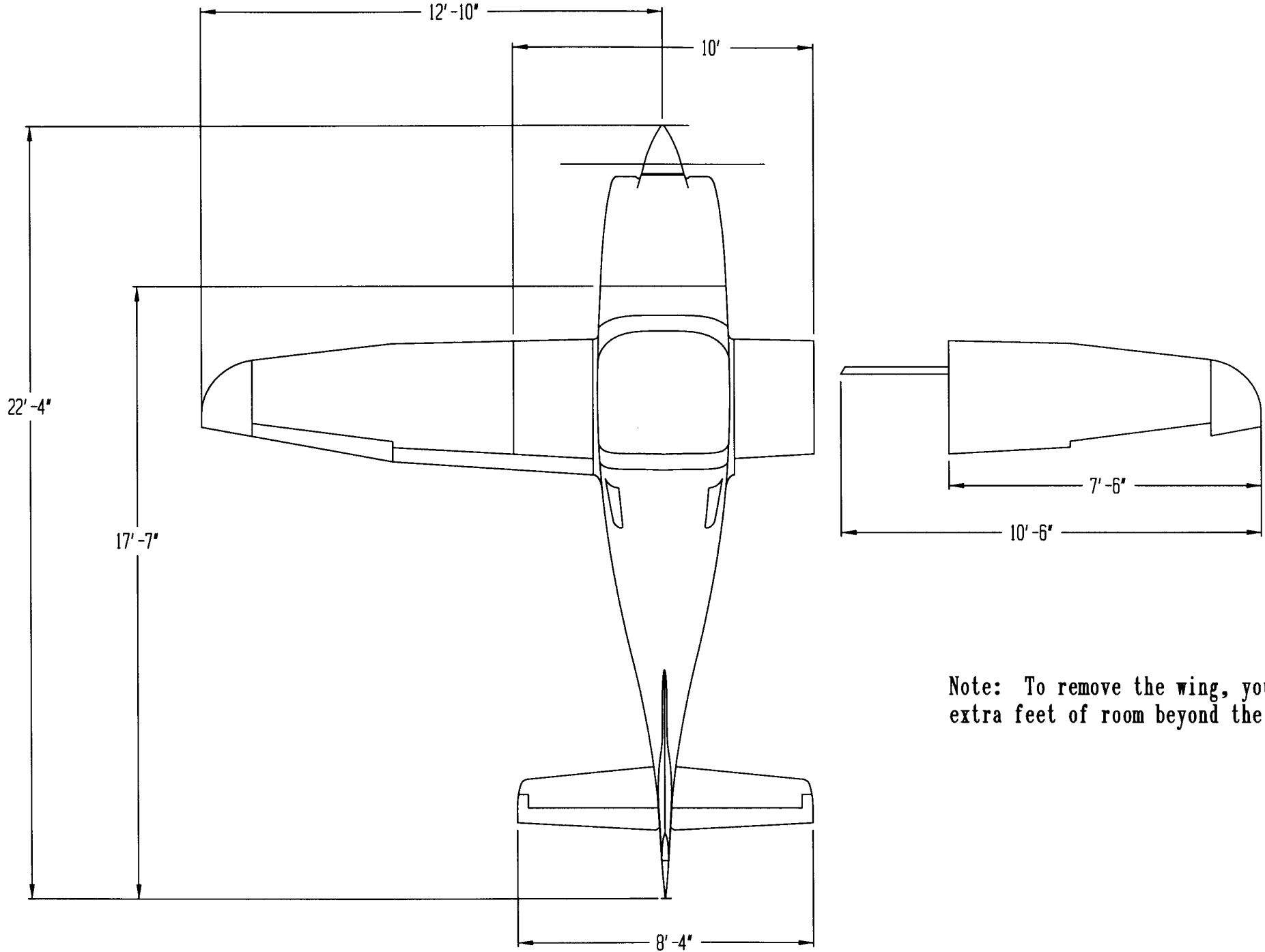
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1-4

Chapter 1 REV. 0/02-15-02

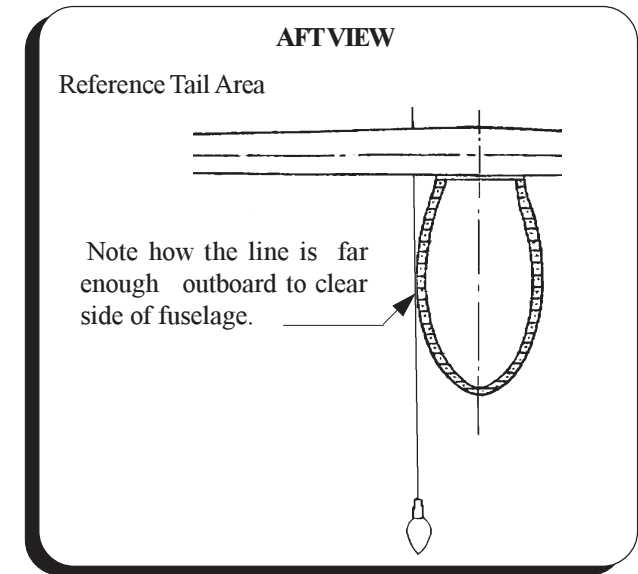
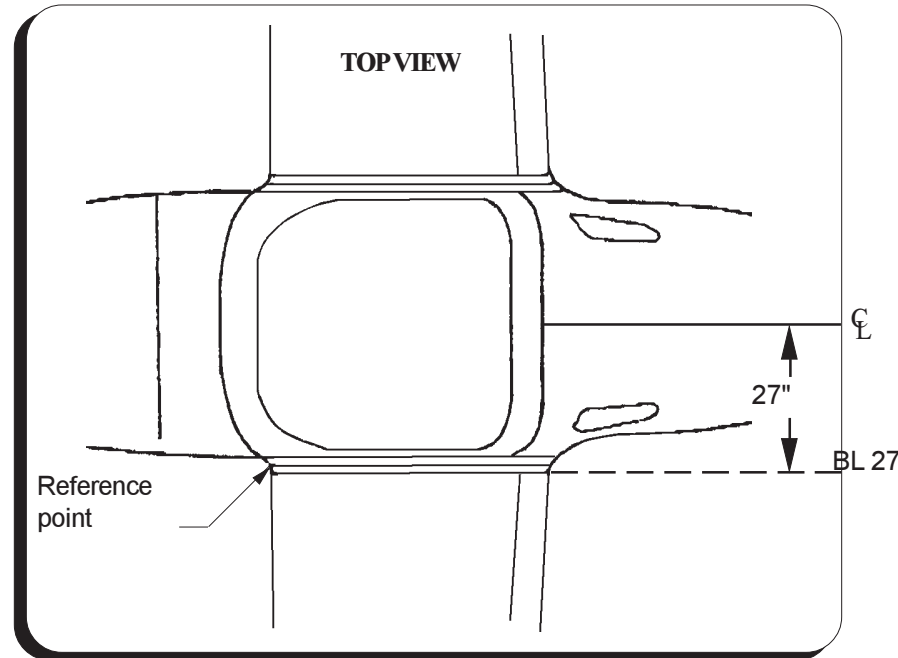
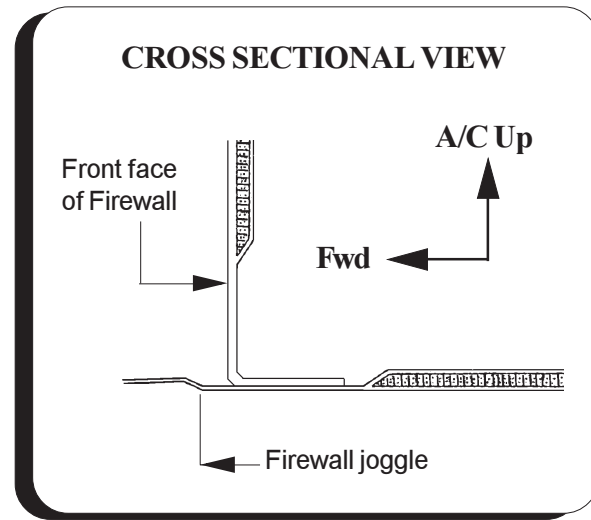
INTRODUCTION

Shop Floor Area  
Fig. 1:A:1

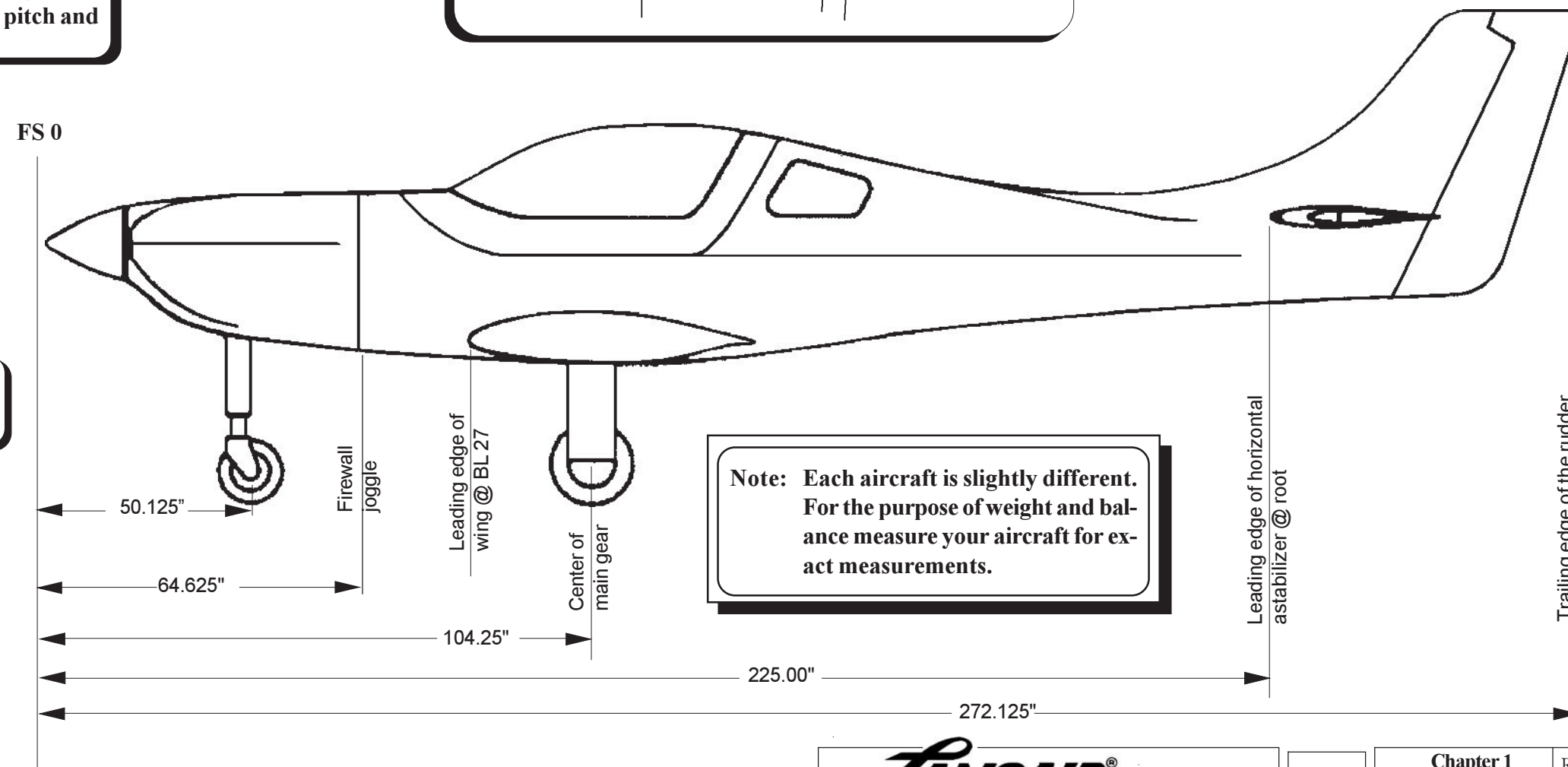


Note: To remove the wing, you need 4 extra feet of room beyond the wing tip.

**Aircraft Dimensions**  
**Fig. 1:A:2**



**Note: To level aircraft, open canopy. Use the longerons to level in pitch and roll.**



L.E. wing @ WS 27 is FS 81.72  
Main FS 104.25

**Note: Each aircraft is slightly different. For the purpose of weight and balance measure your aircraft for exact measurements.**



## B. Manual Layout and Use

PLEASE- READ THIS MANUAL. In this age of computers that are "user friendly", cars that talk and tell you what their status is, and all of the other bubble-packaged, pre-digested things on the market, many people have gotten out of the habit of reading the manual. That philosophy will not work here. While there really aren't any "complex" steps to building this aircraft, there are many that must not be overlooked. So, please do read this manual.

For ease of understanding and use, this assembly manual is laid out in a logical progression of assembly steps. The first section explains the technique used to prepare and join mating parts. This technique is used throughout the kit assembly process, and is shown in detail.

Following that, actual assembly instructions begin with the horizontal stabilizer. Directions are provided for preparing the necessary fixtures for alignment, installing the spars, ribs, etc.

Assembly instructions for the remaining parts are given in a sequence that either makes for convenient construction or is necessary due to the kit design.

## Chapter Organization

Each chapter is arranged in a similar sequence:

- 1. INTRODUCTION:** This describes, in a brief overview, the work that will be performed throughout that chapter.
- 2. SPECIAL PARTS, TOOLS & SUPPLIES LISTS**
  - A. PARTS:** providing a complete list of all parts or components within the chapter as well as diagrammatic exploded views of the components.
  - B. TOOLS**
  - C. SUPPLIES:** This list will consist of the tools and supplies required for assembly of components in that particular chapter.
- 3. CONSTRUCTION PROCEDURE:** This section is typically divided into specific areas of assembly, and each division is defined by an alphabetical prefix: a, b, etc.

## Revisions

From time to time, revisions to this assembly manual may be deemed necessary. When such revisions are made, you should immediately replace all outdated pages with the revised pages. Discard the outdated pages. Note that on the lower right corner of each page is a "revision date". Initial printings will have the number "0" printed and the printing date. All subsequent revisions will have the revision number followed by the date of that revision. When such revisions are made, a "table of revisions" page will also be issued on a "per chapter" basis. This page (or pages) should be inserted in front of the opening page of each chapter that is affected. A new "table of revisions" page will accompany any revision made to a chapter.

Each chapter should be read through entirely and understood before beginning the work it describes. The equipment and supplies called for in each chapter should be on hand and ready for use.

## C. Setting Up Your Shop

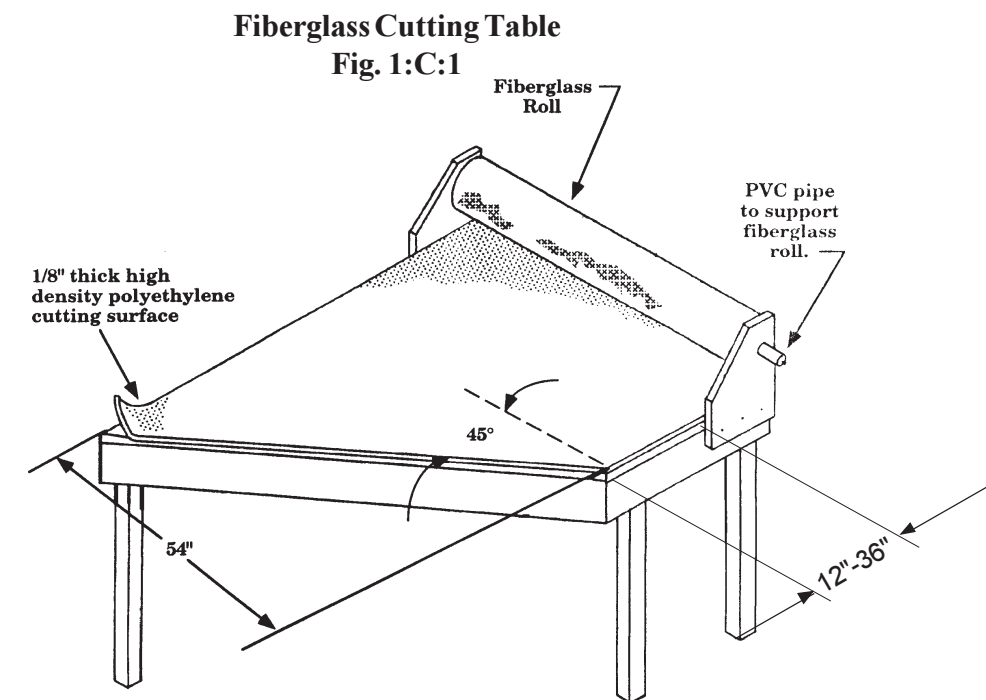
Your work area should be well lit, clean and uncluttered, and have at least one large table to cut on and work with the fiberglass. Since parts will be placed on the floor occasionally, oil, grease and dirt must be removed from the floor to prevent contamination of the parts.

If work is to be done when the outside temperature is less than 70°F, a heat source may be necessary. Working with adhesive or fiberglass resin at lower temperatures, wetting out the fiberglass becomes difficult.

## Cutting Tables

One of the focal points of any composite shop is the fiberglass cutting table. Those of us who previously built composite planes without a cutting table can't believe we were so naive. If you have the room, build a cutting table in your shop!

The cutting table should have the fiberglass roll mounted at one end so you can unwind the cloth onto the table. You should be able to unroll at least four feet of cloth onto the cutting surface. A PVC pipe, or any pipe, can be used as a roller for the cloth roll. Mount the pipe through two plywood supports nailed to the sides of your table.



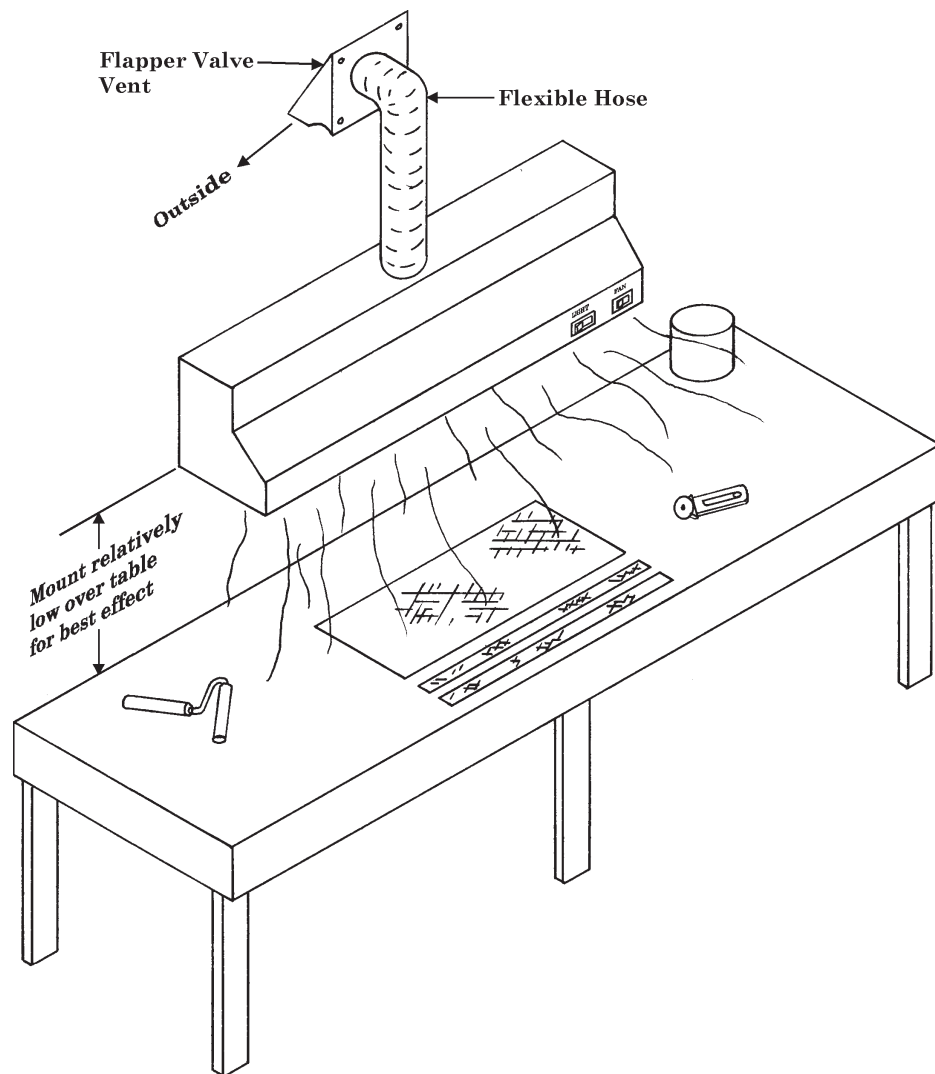


The cutting surface should be a hard plastic, such as 1/8" thick, high density polyethylene (HDPE). Some home supply stores have similar sheets of this material called "Tileboards" for use as shower liners. Check plastic supply stores also. When the plastic surface gets well used and you don't get clean cuts anymore, simply flip the plastic sheet over and use the other side, provided it still fits the table.

When the cutting table is not in use, it's a good idea to at least cover the fiberglass roll with plastic to keep the dirt from settling on it.

This setup for a layup table comes in quite handy when it comes time to start your wet layups. Construct the table about 3' X 8' and mount the exhaust hood low over the table surface. Use the same hard plastic as you installed on the cutting table.

**Layup Table**  
**Fig. 1:C:2**



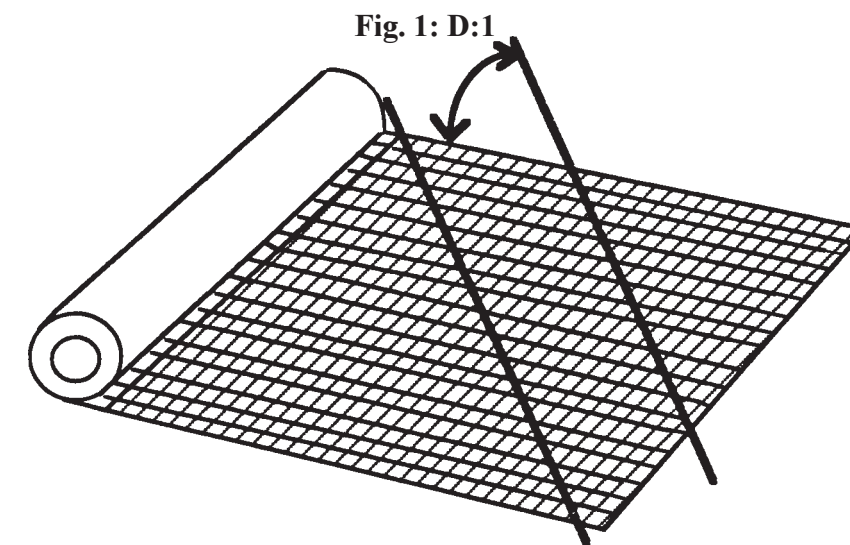
## D. Terms and Definitions

**Aft** Back side or measured back.

**BID tape** A strip of BID cloth cut on the bias, usually 2-4 inches wide.

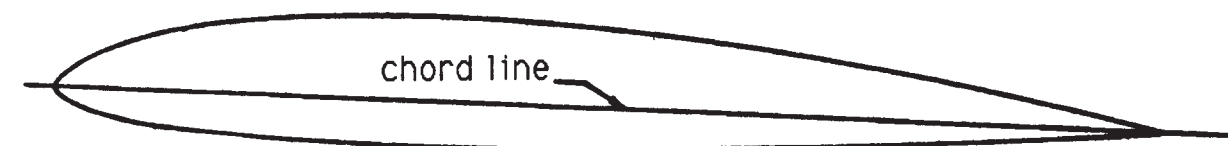
**Bidirectional glass cloth** Bidirectional glass cloth (BID) means that 50% of its fibers are running in one direction, and 50% of the fibers are running perpendicular (90°) to the other fibers.

**Cutting on the bias** Cutting BID cloth on the bias is to cut in such a way as to leave the fibers on a 45° angle to the edge. See drawing. You can wrap a smaller radius corner when the fibers are running on a 45° angle to the corner.



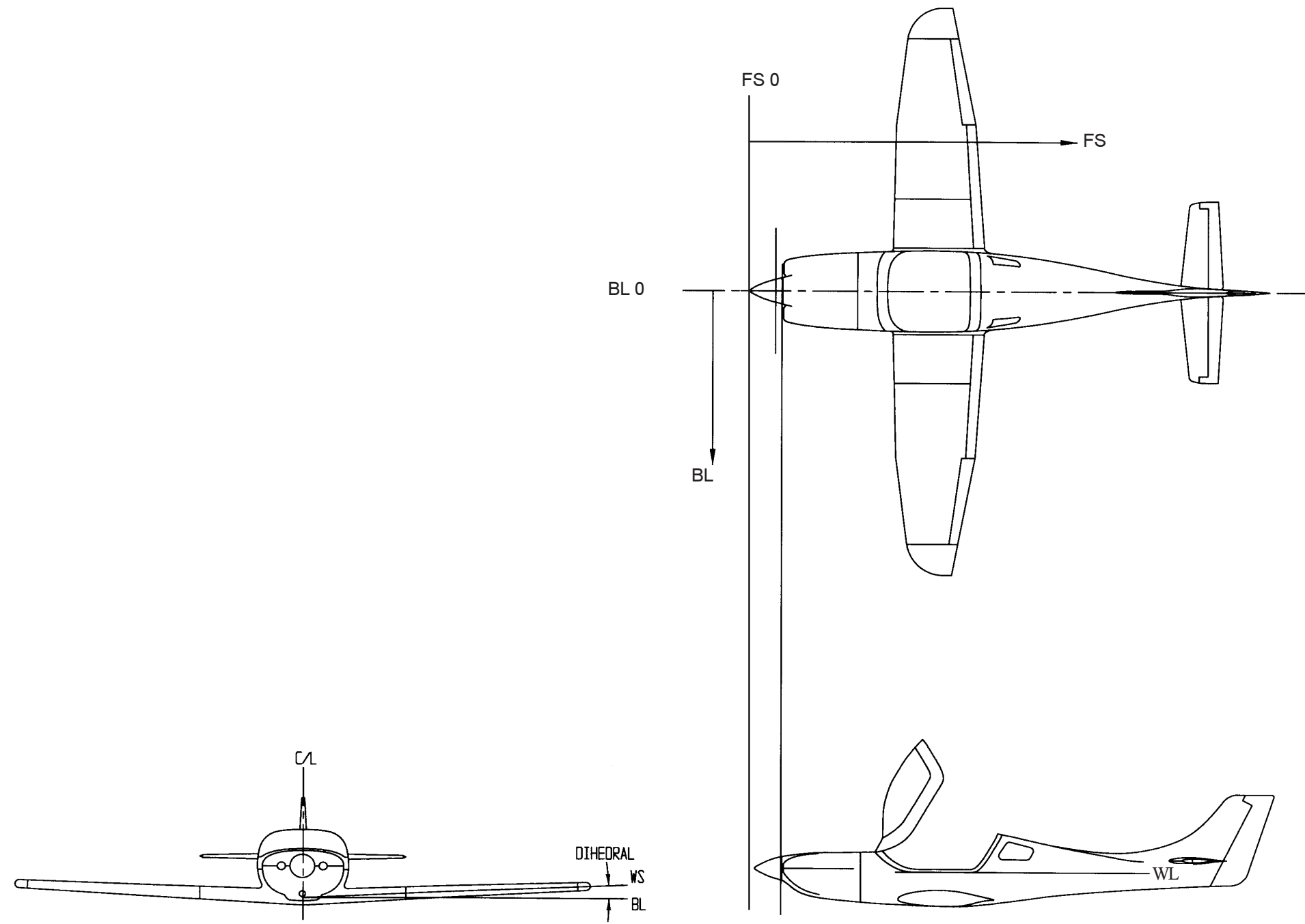
**Chord** The length of the airfoil; from the leading edge to the trailing edge of the wing.

**Fig. 1: D:2**



**Cotton Flox** Finely chopped cotton fibers which are in appearance nearly as fine as micro balloons. The big difference is that flox is structurally stronger than micro when combined with epoxy. **USE:** Mixed similarly to micro and used for strengthening glass to glass areas where BID tapes can't be used. This can fill small gaps where pure epoxy might run out and leave a void, also large amounts of pure epoxy is heavier and too brittle. Flox is heavier than micro. **Should be used sparingly - can add a lot of weight if used without discretion.**

Legacy Coordinate System  
Fig. 1:D:3



**Ctr** Center.

**BL** Baseline. This line is used to measure distances outward from the centerline of the fuselage. Thus, the baseline is the actual center line. BL measurements are given in inches and positive to the left or right.

**WL** Water line. This is an imaginary line used to measure vertical distances on the plane. On the Legacy 2000 the top of the longeron at the canopy is WL 25.

**WS** Wing Station. The line formed by the chord lines. WS 0 is in the middle of the fuselage

**FS** Fuselage Station. This imaginary line is used to measure distance forward or aft on the fuselage. FS 0 is forward of the spinner.

**Dihedral** Looking at the front of the aircraft, most non-swept wings form a positive angle to the horizontal. This angle is called dihedral. Dihedral improves roll stability on non-swept wing aircraft.



**FSLG** Fuselage.

**Ftg** Fitting.

**Fwd** Forward.

**Inbd** Inboard.

**Longeron** A lengthwise structural member of the fuselage. Some planes have top and bottom longerons.

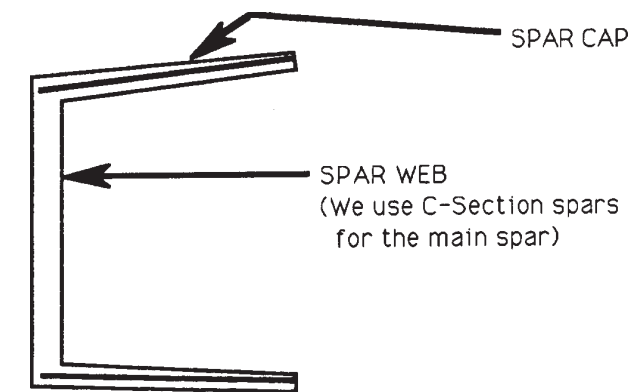
**Micro** Microballoons. These are very small thin-walled air-filled glass bubbles. Being extremely light for their volume, they can be added to resin to produce a very lightweight filler material that is easy to shape and sand. They do not add strength to the mixture however, and should be used where "cosmetics" is the consideration, not strength.

**Outbd** Outboard.

**Peel Ply** A non-structural fabric used in the manufacturing process but must be removed from the part. It is light in color and usually has darker stripes for identification.

**Shearweb** Typically the part of the wing spar that runs vertically.

**Spar cap** The top and bottom members of a spar, held in proper relation by the shear web.



**Typ** Simply means "typical" when seen on a drawing.

## E. Structural Adhesive

**DURING AIRCRAFT ASSEMBLY TWO TYPES OF EPOXY ARE USED: A STRUCTURAL PASTE ADHESIVE AND A LAMINATING RESIN.**

**THE LAMINATING RESIN IS USED TO MAKE FIBERGLASS LAYUPS AND IS ALSO MIXED WITH FLOX OR MICRO.**

**THE STRUCTURAL PASTE ADHESIVE IS USED TO STRUCTURALLY BOND MOLDED PARTS TOGETHER.**

**THESE EPOXIES ARE NOT INTERCHANGEABLE. FOLLOW THE INSTRUCTIONS CONCERNING WHICH SYSTEM TO USE.**

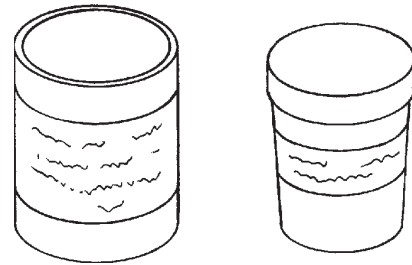
AN Bolt and Hardware Guide

Fig. 1:F:1

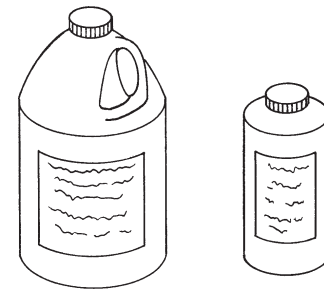
**NOTE:** Although Hysol 9339 Structural Adhesive and a laminating resin from Jeffco are illustrated, other structural adhesives may be used instead of this type if deemed appropriate by the factory. Mixing ratios will also differ. [Make sure you use Lancair approved products.](#)

**BE SURE TO CHECK FOR PROPER MIXING RATIOS OF STRUCTURAL ADHESIVES AND LAMINATING RESINS SUPPLIED. FAILURE TO PROPERLY MIX STRUCTURAL ADHESIVES OR LAMINATING RESINS COULD RESULT IN BOND FAILURE.**

HYSOL 9339 ADHESIVE  
Mix: 44.5 parts 9339A(blue)  
to 100 parts 9339B(White)



JEFFCO 3102/1307LV  
Mix: 25 parts 3102  
to 100 parts 1307LV







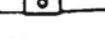





















SAMPLE ILLUSTRATIONS, OTHER SYSTEMS MAY BE SUPPLIED AS STANDARD WITH YOUR AIRFRAME KIT. SEE ABOVE WARNING.

NOTE: Most epoxies have a manufacturer's recommended shelf life of typically one year. In some cases this is quite conservative. However, the manufacturer's recommendations should be followed.

**F. AN- Bolt and Hardware Guide**





























This guide to AN hardware can be helpful if you are not familiar with the code number system.

- AN 3 thru AN 20 BOLT - HEX HD, AIRCRAFT 
- AN 21 thru AN 36 BOLT - CLEVIS 
- AN 42 thru AN 49 BOLT - EYE 
- AN 73 thru AN 81 BOLT - DR HD (engine) 
- AN 100 - THIMBLE - CABLE 
- AN 115 SHACKLE - CABLE 
- AN 116 - SHACKLE - SCREW PIN 
- AN 155 BARREL - TURNBUCKLE 
- AN 161 FORK - TURNBUCKLE 
- AN 162 FORK - TURNBUCKLE (for Bearing) 
- AN 165 EYE - TURNBUCKLE (for pin) 
- AN 170 EYE - TURNBUCKLE (for cable) 
- AN 173 thru AN 186 BOLT, CLOSE TOL. 
- AN 210 thru AN 221 PULLEY - CONTROL 
- AN 253 PIN - HINGE 
- AN 254 SCREW - THUMB, NECKED 
- AN 255 SCREW - NECKED 
- AN 256 NUT - SELF LOCK (Rt. Angle Plate) 
- AN 257 HINGE - CONTINUOUS 
- AN 276 JOINT - BALL & SOCKET 
- AN 280 KEY - WOODRUFF 
- AN 295 CUP - OIL 
- AN 310 NUT - CASTLE (Air Frame) 
- AN 315 NUT - PLAIN (Air Frame) 
- AN 316 NUT - CHECK 
- AN 320 NUT - CASTLE, SHEAR 
































AN hardware guide (continued)

- AN 335 NUT - PL. HEX (NC) Semi-Fin 
- AN 340 NUT - HEX, MACH. SCREW (NC) 
- AN 341 NUT - HEX, BRASS (Elec.) 
- AN 345 NUT - HEX, MACH. SCREW (NF) 
- AN 350 NUT - WING 
- AN 355 NUT - SLOTTED (Engine) 
- USAF 356 NUT - PAL 
- AN 360 NUT - PLAIN (Engine) 
- AN 362 NUT - PLATE, SELF-LOCK. (Hi-Temp.) 
- AN 363 NUT - HEX, SELF-LOCK. (Hi-Temp.) 
- AN 364 NUT - HEX, SELF-LOCK. (Thin) 
- AN 365 NUT - HEX, SELF-LOCK 
- AN 366 NUT - PLATE, SELF-LOCK 
- AN 373 NUT - PLATE, SELF-LOCK. (100° CTSK) 
- AN 380 PIN - COTTER 
- AN 381 PIN - COTTER, STAINLESS 
- AN 385 PIN - TAPERED, PLAIN 
- AN 386 PIN - THREADED TAPER 
- AN 392 thru AN 406 PIN - CLEVIS 
- AN 415 PIN - LOCK 
- AN 416 PIN - RETAINING, SAFETY 
- AN 426 RIVET - 100° FL. HD., ALUM. 
- AN 427 RIVET - 100° FL. HD., Steel, Monel, Copper 
- AN 430 RIVET - RD. HD., ALUM. 
- AN 435 RIVET - RD. HD., Steel, Monel, Copper 
- AN 442 RIVET - FL. HD., ALUM. 
- AN 450 RIVET - TUBULAR 
- AN 470 RIVET - UNIVERSAL HD., ALUM. 

AN hardware guide (continued)

- AN 481 CLEVIS - ROD END 
- AN 486 CLEVIS - ROD END ADJ. 
- AN 490 ROD END - THREADED 
- AN 500 SCREW - FILL. HD. (NC) 
- AN 501 SCREW - FILL. HD. (NF) 
- AN 502 SCREW - DR. FILL. HD. (Alloy Stl.) (NF) 
- AN 503 SCREW - DR. FILL. HD. (Alloy Stl.) (NC) 
- AN 504 SCREW - RD. HD. SELF TAP. 
- AN 505 SCREW - FLAT HD., 82° (NC) 
- AN 506 SCREW - FLAT HD., 82° SELF TAP. 
- AN 507 SCREW - FLAT HD., 100° (NF & NC) 
- AN 508 SCREW - RD. HD. BRASS (Elec.) 
- AN 509 SCREW - FL. HD. 100° (Structural)(ALLOY STEEL) 
- AN 510 SCREW - FLAT HD. 82° (NF) 
- AN 515 SCREW - RD. HD. (NC) 
- AN 520 SCREW - RD. HD. (NF) 
- AN 525 SCREW - WASHER HD. (Alloy Stl.) 
- AN 526 SCREW - TRUSS HD. (NF & NC) 
- AN 530 SCREW - RD. HD., SHEET METAL 
- AN 531 SCREW - FL. HD. 82° SHEET METAL (Type B) 
- AN 535 SCREW - RD. HD. DRIVE (Type "U") 
- AN 545 SCREW - WOOD, RD. HD. 
- AN 550 SCREW - WOOD, FLAT HD. 
- AN 565 SCREW - HDLESS., SET 
- AN 663 TERMINAL - CABLE, DBLE. SHK. BALL (FOR SWAGING) 
- AN 664 TERMINAL - CABLE, SGLE. SHK. BALL (FOR SWAGING) 
- AN 665 TERMINAL - CABLE, THDED. CLEVIS 



**AN 666 TERMINAL - CABLE, THDED (for swaging)**

**AN 667 TERMINAL - CABLE, FORK END (for swaging)**

**AN 668 TERMINAL - CABLE, EYE END (for swaging)**

**AN 669 - TERMINAL - CABLE, TURNBUCKLE (for swaging)**

**AN 737 CLAMP - HOSE**

**AN 741 CLAMP - TUBE**

**AN 742 CLAMP - PLAIN, SUPPORT**

**AN 900 GASKET - COP. - ASBESTOS, ANGULAR**

**AN 901 GASKET - METAL TUBE**

**AN 931 GROMMET - ELASTIC**

**AN 935 WASHER - LOCK, SPRING**

**AN 936 WASHER - LOCK TOOTH (Ext. & Int)**

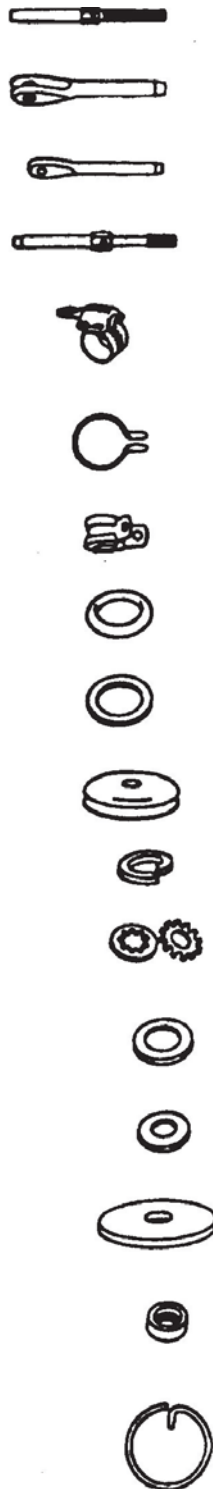
**AN 960 WASHER - FLAT, AIRCRAFT**

**AN 961 WASHER - FLAT, BRASS (Elec.)**

**AN 970 WASHER - FLAT, LARGE AREA**

**AN 975 WASHER - TAPER PIN**

**AN 986 RING - LOCK**



<p><b>AN804</b></p>  <p>TEE, Flared tube with Bulkhead on run</p>	<p><b>AN824</b></p>  <p>TEE, Flared Tube</p>	<p><b>AN842</b></p>  <p>HOSE ELBOW, Pipe Thread 90°</p>
<p><b>AN807</b></p>  <p>ADAPTER Hose to Universal</p>	<p><b>AN825</b></p>  <p>TEE, Flared Tube with Pipe Thread on side (MS20825)</p>	<p><b>AN844</b></p>  <p>HOSE ELBOW, Pipe Thread 45°</p>
<p><b>AN814</b></p>  <p>PLUG AND BLEEDER, Screw Thread</p>	<p><b>AN826</b></p>  <p>TEE, Tube with Pipe Thread on Run (MS20826)</p>	<p><b>AN911</b></p>  <p>NIPPLE, Pipe Thread</p>
<p><b>AN815</b></p>  <p>UNION, Flared tube</p>	<p><b>AN827</b></p>  <p>CROSS, Flared Tube</p>	<p><b>AN912</b></p>  <p>BUSHING, Pipe Thread Reducer</p>
<p><b>AN816</b></p>  <p>NIPPLE, Flared Tube and pipe thread</p>	<p><b>AN832</b></p>  <p>UNION, Flared Tube, Bulkhead and Universal</p>	<p><b>AN913</b></p>  <p>PLUG, Square Head, Pipe Thread (MS20913)</p>
<p><b>AN818</b></p>  <p>NUT, Coupling</p>	<p><b>AN833</b></p>  <p>ELBOW, Flared Tube, Bulkhead and Universal, 90°</p>	<p><b>AN914</b></p>  <p>ELBOW Internal and External Pipe Thread, 90°</p>
<p><b>AN819</b></p>  <p>(MS20819) SLEEVE, Coupling</p>	<p><b>AN834</b></p>  <p>TEE, Flared, Tube, Bulkhead and Universal</p>	<p><b>AN915</b></p>  <p>ELBOW, Internal and External Pipe Thread, 45°</p>
<p><b>AN821</b></p>  <p>ELBOW, Flared Tube, 90°</p>	<p><b>AN837</b></p>  <p>ELBOW, Flared Tube, Bulkhead and Universal, 45°</p>	<p><b>AN919</b></p>  <p>REDUCER, External Thread</p>
<p><b>AN822</b></p>  <p>ELBOW, Flared Tube and Pipe Thread, 90° (MS20822)</p>	<p><b>AN838</b></p>  <p>ELBOW Hose to Universal, 90°</p>	<p><b>AN924</b></p>  <p>NUT, Flared Tube, Bulkhead and Universal Fitting</p>
<p><b>AN823</b></p>  <p>ELBOW, Flared Tube and Pipe Thread, 45° (MS20823)</p>	<p><b>AN840</b></p>  <p>HOSE NIPPLE, Pipe Threaded</p>	<p><b>AN929</b></p>  <p>CAP, Flared Tube Fitting</p>



**Torque Chart**  
**Fig. 1:F:2**

BOLTS Steel Tension		BOLTS Steel Tension		BOLTS Aluminum	
AN 3 thru AN 20 AN 42 thru AN 49 AN 73 thru AN 81 AN 173 thru AN 186 MS 20033 thru MS 20046 MS 20073 MS 20074 AN 509 NK9 MS 24694 AN 525 NK525 MS 27039		MS 20004 thru MS 20024 NAS 144 thru NAS 158 NAS 333 thru NAS 340 NAS 583 thru NAS 590 NAS 624 thru NAS 644 NAS 1303 thru NAS 1320 NAS 172 NAS 174 NAS 517		AN 3DD thru AN 20DD AN 173DD thru AN 186DD AN 509DD AN 525D MS 27039D MS 24694DD	
NUTS		NUTS		NUTS	
Steel Tension	Steel Shear	Steel Tension	Steel Shear	Aluminum Tension	Aluminum Shear
AN 310 AN 315 AN 363 AN 365 NAS 1021 MS 17825 MS 21045 MS 20365 MS 20500 NAS 679	AN 320 AN 364 NAS 1022 MS 17826 MS 20364	AN 310 AN 315 AN 363 AN 365 MS 17825 MS 20365 MS 21045 NAS 1021 NAS 679 NAS 1291	AN 320 AN 364 NAS 1022 MS 17826 MS 20364	AN 365D AN 310D NAS 1021D	AN 320D AN 364D NAS 1022D

**FINE THREAD SERIES**

Nut-bolt size	Torque Limits in.-lbs.		Torque Limits in.-lbs.		Torque Limits in.-lbs.		Torque Limits in.-lbs.		Torque Limits in.-lbs.		Torque Limits in.-lbs.	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
8 -36	12	15	7	9					5	10	3	6
10 -32	20	25	12	15	25	30	15	20	10	15	5	10
1/4-28	50	70	30	40	80	100	50	60	30	45	15	30
5/16-24	100	140	60	85	120	145	70	90	40	65	25	40
3/8-24	160	190	95	110	200	250	120	150	75	110	45	70
1/2-20	450	500	270	300	520	630	300	400	180	280	110	170
3/4-20	480	690	290	410	770	950	450	550	280	410	160	260
5/8-18	800	1,000	480	600	1,100	1,300	650	800	380	580	230	360
3/4-18	1,100	1,300	660	780	1,250	1,550	750	950	550	670	270	420
1-16	2,300	2,500	1,300	1,500	2,650	3,200	1,600	1,900	950	1,250	560	880
1-14	2,500	3,000	1,500	1,800	3,550	4,350	2,100	2,600	1,250	1,900	750	1,200
1 1/4-12	3,700	4,500	2,200	3,300	4,500	5,500	2,700	3,300	1,600	2,400	950	1,500
1 1/2-12	5,000	7,000	3,000	4,200	6,000	7,300	3,600	4,400	2,100	3,200	1,250	2,000
1 3/4-12	9,000	11,000	5,400	6,600	11,000	13,400	6,600	8,000	3,900	5,600	2,300	3,650

**Note: All bolts should be torqued according to the above chart unless otherwise specified.**

**G Basic Shop Tools**

The tools listed are not mandatory for your shop, but we have found them extremely useful in ours. The tools we feel are most important are marked with an asterisk (\*). You probably won't be familiar with some of the tools listed, but the purpose and description of these items will be explained.

**Saber saw (jig saw)\***

Very handy for cutting out large or complex shapes from pre-preg material. You can use a manual saw, but it won't be fun, or a very pretty sight. Either way, be sure you get sharp blades, and change them often. Dull blades will chew up the edges and make for more sanding/smoothing work later. We use carbide tipped blades exclusively for composite cutting. They work great.

**Electric and / or cordless drill motor\***

Most of the material you would have to drill on a glass kit is fairly soft and thin, and should require no more than a small drill motor with at least a 3/8" chuck. If you don't already have one, go buy one with a variable speed (variable, not two speed), and get one with a 1/2" chuck. The extra couple of bucks they cost will be worth it in the long run, and some of the stuff you need to drill, like plastic parts, must be drilled at a very slow speed that is below the range of all single and most two speed drills.

**Drill press**

Here's a tool that most people don't have, but no one that's ever had one will be without again. For precision drilling it is a must. For instance, it can be used in drilling out broken bolts, and with a fly-cutting tip it can cut holes large enough to amaze your neighbors. I wouldn't run right out and buy one just for building the plane, but I would make friends with that guy down the street that has one gathering dust in his garage.

**Drill bits (Numbered AND Fractional)**

It takes a lot of cheap drill bits to make a lousy hole that one good bit could have made quickly and perfectly. If you have a vault to keep them safe in, bite the bullet and buy a good set of numbered drill bits. If cared for, they will last longer and give you better service than your foreign made car. Unfortunately, a good set will seem to cost about as much as that car.

**Rotary sander (rotary or orbital type)\***

This, I would go out and buy for building a kit-plane, unless you want arms like Arnold Schwarzenegger. It will definitely make sanding and smoothing the rough edges a lot easier, and a good orbital can be had with a trapper bag to keep a lot of the "stuff" out of the air. And your clothes. And your nose. And everywhere. We don't use one with a bag here, which is why sometimes even in July it looks like it just snowed in the shop.

**Die grinder (angle grinder)**

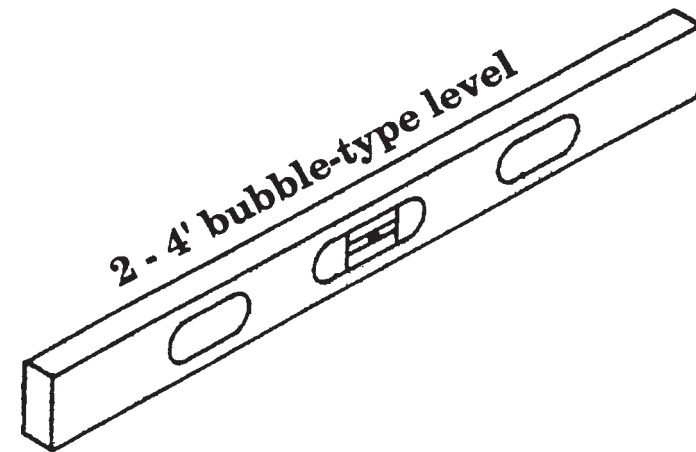
If you have one, bravo. This is a powerful tool that can custom fit your ribs and bulkheads quickly. Be very careful though, if the high speed grinder surface gets away from you, it can quickly customize everything in the general vicinity. While not a necessity, if you have a used tools store in the area, it would give you an excuse to browse around.



## 2 & 4 ft. Carpenter's levels\*

If you want a plane to fly straight, you should build it straight. These are indispensable in a good shop. Get the good aluminum ones (you'll be holding them up, down and at various angles in between for hours at a time), make sure they have straight edges, and round the sharp ends a bit so you won't gouge any holes into precious prepared surfaces. All you might find is just a few, little, easily filled dents.

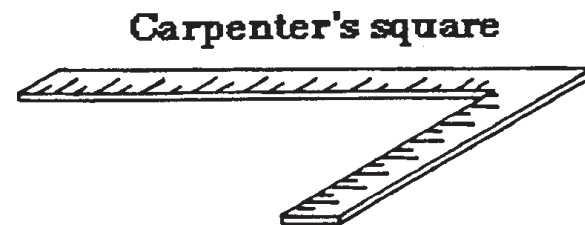
**Carpenter's Level**  
Fig. 1:G:1



## Carpenter's square

Buy this when you get the carpenter's levels, and for the same reason. Don't round these ends, just be careful.

**Carpenter's Square (Framing Square)**  
Fig. 1:G:2.



## Clamps (Vise grip clamps, spring clamps, and "C" clamps)

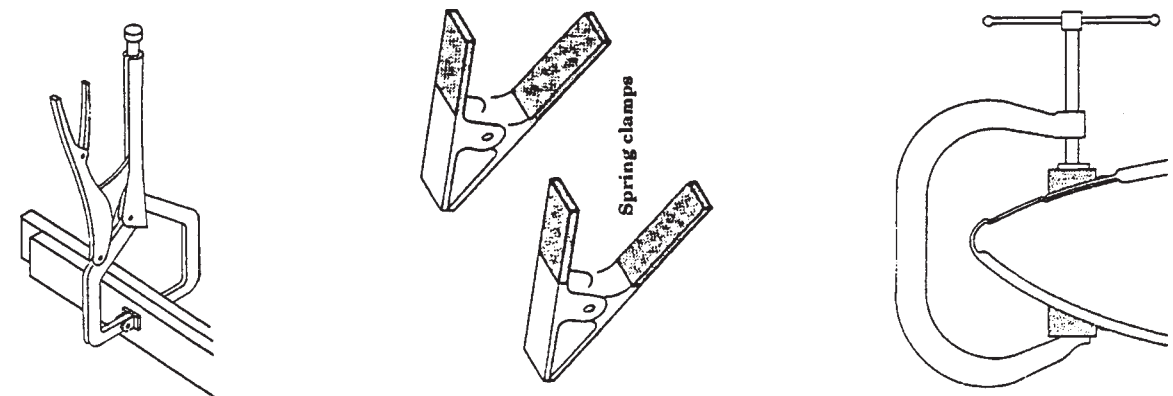
Here's a brief description of the clamps you will need.

A couple of the vise grip clamps for really forcing things together (never-stress again, never use these on any fiberglass, prepreg or carbon composite parts. They grip with enough force to do great damage to the parts, which may not be visible to the naked eye.)

Spring clamps- get a bunch of these when you wander through the used tool store. Three or four large ones like Arnold uses for strengthening his grip, and about a dozen that you can work with one hand while you try to hold the six other parts in exact proper position.

"C" clamps. These should be in the bin next to the spring clamps in the used tool store. If there is an assortment, get three or four of each. Again, use caution when applying these to any glass parts. Tighten slowly, and only until just snug.

**Clamps, Assorted**  
Fig. 1:G:3



Now that you have clamped the parts together and drilled the holes, the instruction book tells you that you need to insert pop rivets. The best thing to do this with is a pop rivet tool. The second best thing to do this with doesn't work. Get the pop rivet tool. It should come with three extra tips for use with all four common sizes of pop rivets, 3/32", 1/8", 5/32", and 3/16". Three cheap ones will get you through most any project, but a good one will last a lifetime. Get the good one. Besides, it's cheap if you buy it at that used tool store you've been spending so much time in lately.

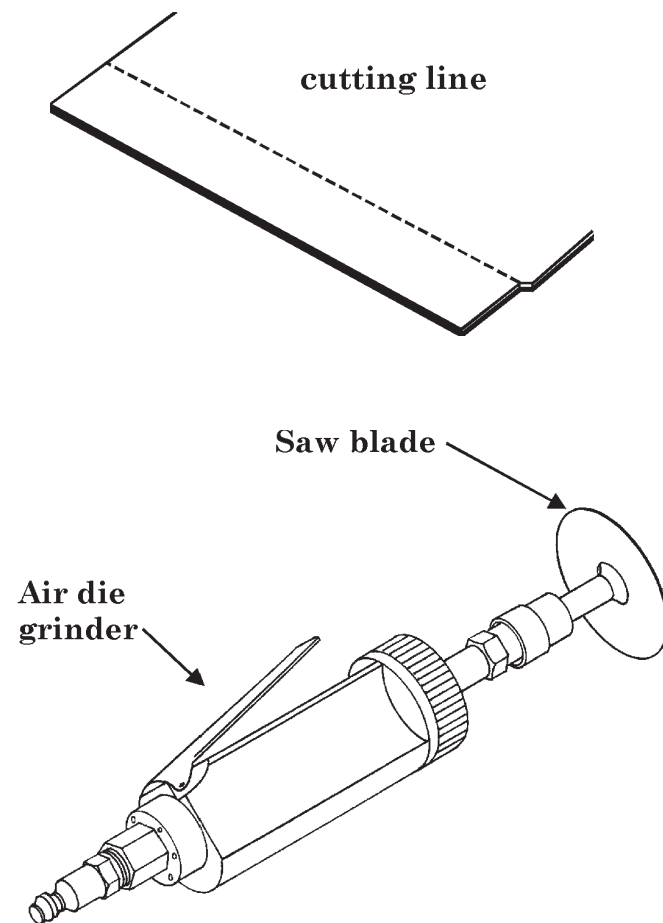
## Specialized Tools

We call them specialized shop tools because it makes it a little easier to swallow the higher price tags on these items. Again, the tools listed are not mandatory for your shop, but we have found them extremely useful in ours. The tools we feel are most important are marked with an asterisk (\*).

### Air die grinder tool\*

The one we have shown here has a saw blade installed, but they come with a fantastic array of special bits (there's that special word again). We can't imagine building a composite aircraft without a die grinder tool. You'll use this tool more than any other in your growing collection.

**Die Grinder**  
**Fig. 1:G:4**

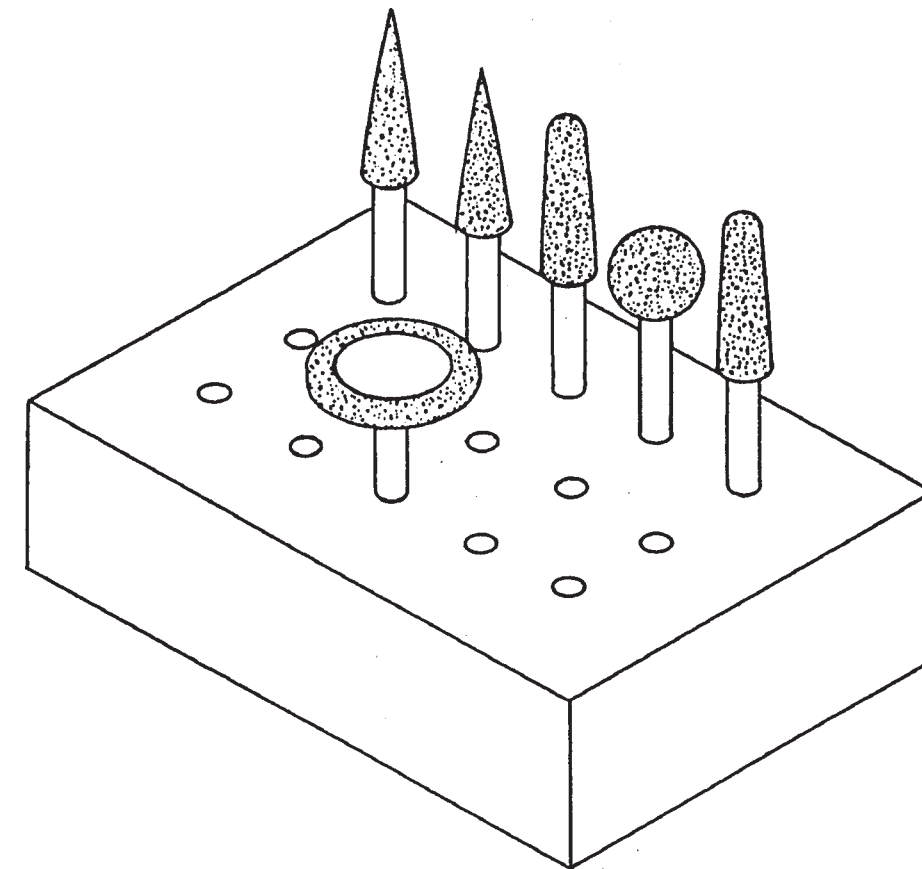


**Note:** If you don't have an aircompressor consider getting a Dremmel tool. The Dremmel works similarly to the air die grinder but it is not as powerful.

### Tungsten carbide bits for Dremel tool\*

During construction of the prototype Lancair we were in need of a Dremel bit that could easily cut prepreg. The prepreg is very easy to work with, but it eats power tool blades/bits for breakfast. Dremel's tungsten carbide cutters come in various shapes and sizes and are the best bet. Some Dremel part numbers to look for are 9931 through 9936. We now use these bits almost exclusively because they really cut. As long as you don't use them on aluminum or Kevlar™, which tend to gum them up, the carbide bits last a long time. They're expensive, though. We paid about \$12.00 for a single bit, but they're worth it in the long run. For availability check hobby stores, hardware stores, Sears, as well as the Lancair Kit Components, Inc. (KCI) Catalog. They also offer a wide range of cutting, grinding, buffing, polishing, etc. bits for use with the Dremel. If they have them at that used tool store, get one of each. You may never use them all, but they'll sure impress your neighbors. Especially if you make one of these snappy little holders to display them in. You can make it out of a piece of 2x4, drilling holes as you add bits to your collection.

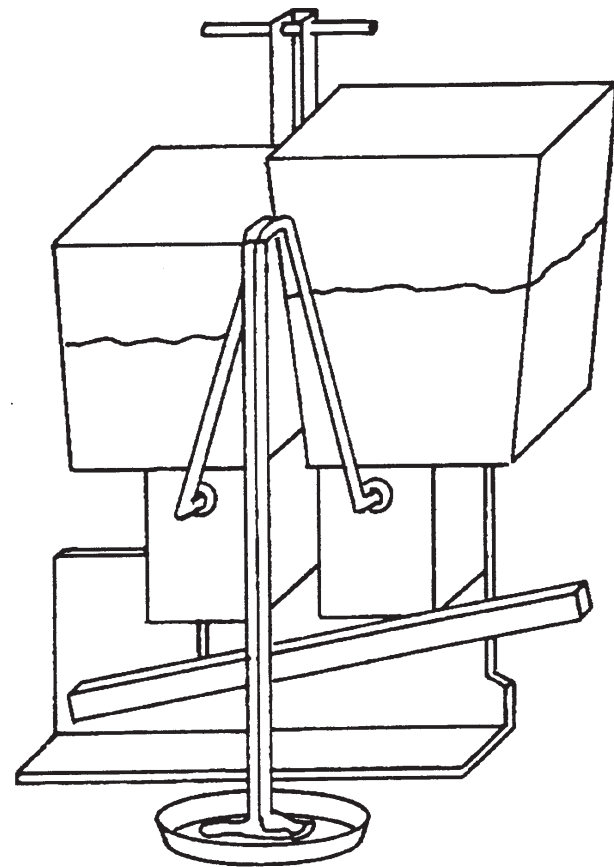
**Tungsten Carbide Bits and Snappy Little Holder**  
**Fig. 1:G:5**



### Epoxy pump (Sticky Stuff dispenser)\*

The Sticky Stuff dispenser will pay for itself in saved epoxy. With every pump of the handle, you receive the proper amount of resin and hardener, no weighing, no measuring. With practice you'll know the proper number of pumps needed for the size of lamination you are doing. We offer this item in our KCI catalog, and highly recommend its use. Many builders are using a light bulb heated box over their epoxy pumps to keep the epoxy warm and thin. This is fine, we do the same, but if you're not going to use the pump for a week or so, turn the light bulb off in the box. Otherwise the volatiles in the epoxy can evaporate out and cause faulty curing or no curing at all. If you are a dedicated builder, using the pump every night (I've heard there are such people) you needn't worry about evaporation and can leave the heat on. Use no higher than a 25 watt bulb in your pump box.

**Epoxy Pump**  
Fig. 1:G:6

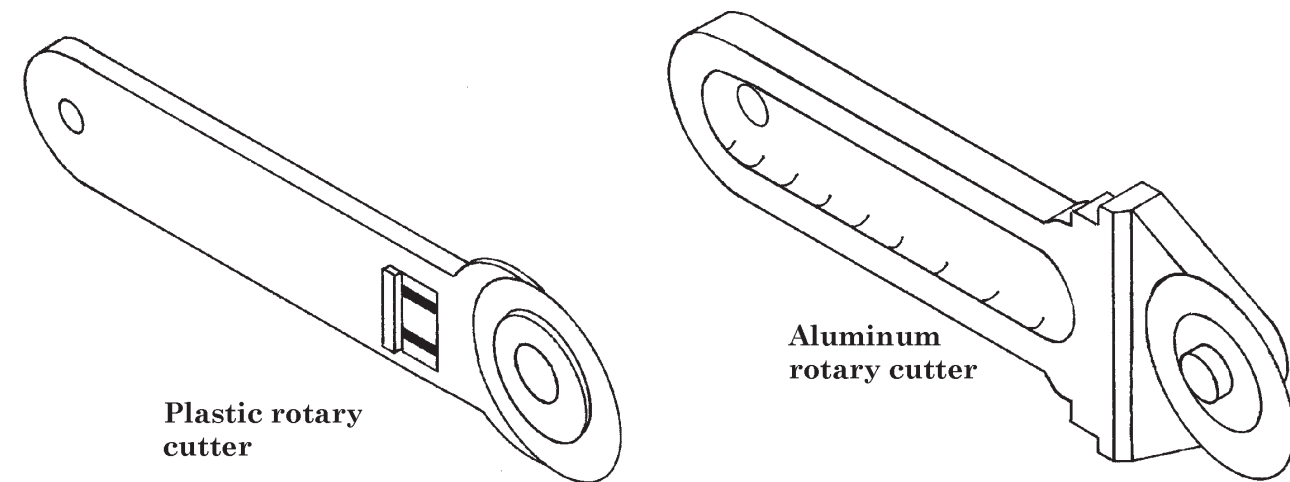


### Roller blade for cutting fiberglass\*

Don't even think of using scissors to cut the fiberglass you've just unrolled on your new cutting table. That's like using a 1/2" brush to paint the Golden Gate Bridge. Use a roller blade (looks like a pizza cutter, but it ain't) and you'll cut the time you spend cutting cloth in half (at least!). These roller blades are available through our KCI catalog, or your local fabric store. They sell under the names of roller blades, rotary cutters, and fabric cutters, but all models closely resemble each other. Pick up a couple of extra blades when you buy it and save yourself a trip later. We suggest getting the aluminum rotary cutter (P/N RB-1) for fiberglass work as it tends to last much longer and stands up to acetone.

### Roller Blade (a.k.a. pizza cutter)

Fig. 1:G:7

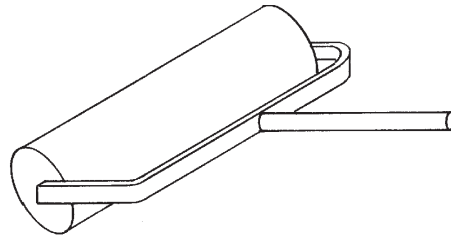


### 2" side paint roller (without furry part) or wallpaper roller\*

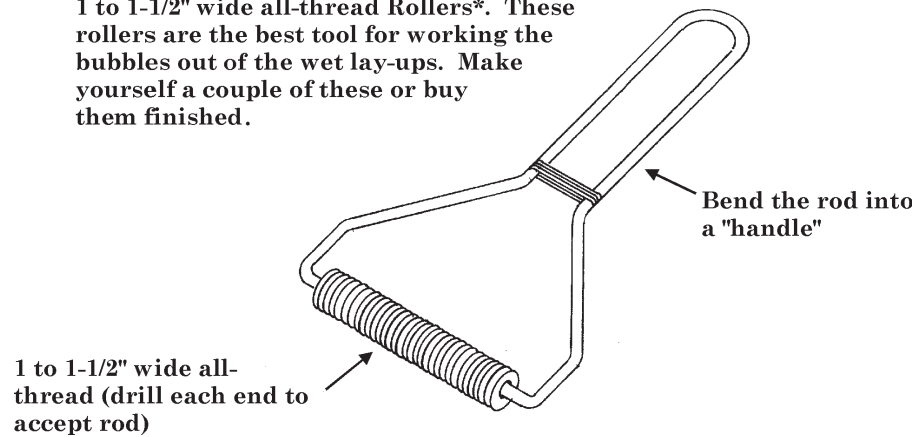
Another simple but handy tool in our shop is the roller. We use a small, 1-1/2" wide paint roller (without the furry paint sleeve), and a larger, 3" wide roller for pushing the air bubbles out from under laminates. Try sliding a length of PVC tubing onto the paint roller to get a smooth, hard rolling surface. Common paint rollers work okay, but we made a solid aluminum roller that works even better. Wallpaper rollers are also good for this application.



**Smooth, Hard Faced Roller**  
Fig. 1:G:8



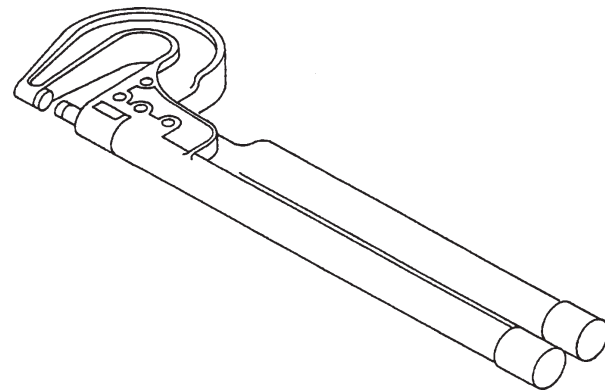
1 to 1-1/2" wide all-thread Rollers\*. These rollers are the best tool for working the bubbles out of the wet lay-ups. Make yourself a couple of these or buy them finished.



**Rivet squeezer**

This tool will save hours whenever you are installing rivets. Next trip to the used tool store, get one of these, too.

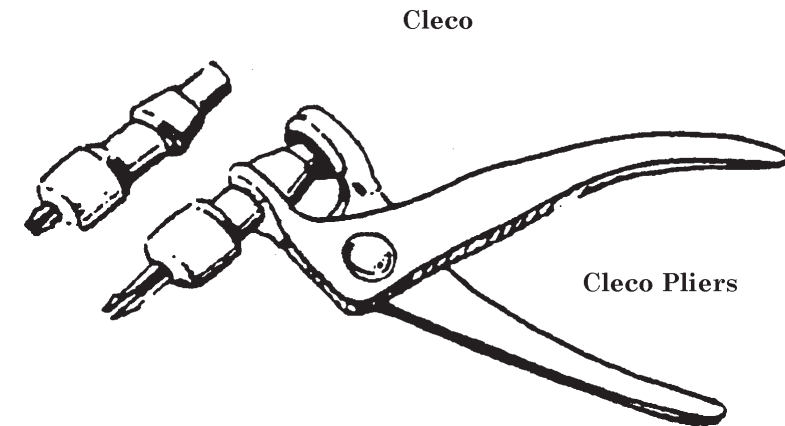
**Rivet Squeezer**  
Fig. 1:G:9



**Cleco™ Pliers and Clecos\***

These are very handy. You should have the Cleco plier (P/N C-200) tool and about 50 of the Cleco bits (P/N C-1/8). We sell them, use them and recommend them to all of our friends.

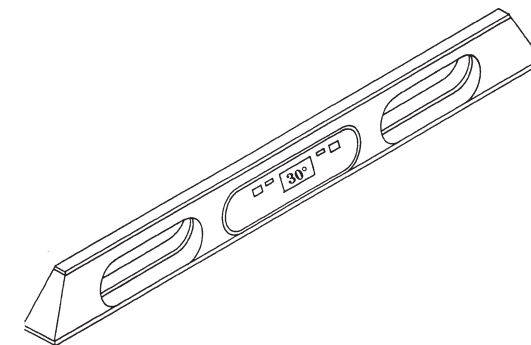
**Clecos and Cleco pliers**  
Fig. 1:G:10



**Digital level\***

The digital Level has an LCD readout instead of a bubble. The center of some digital Levels pops out to become a small, six inch level that's extremely handy for measuring control surface throws, seat back angles, firewall angles, engine thrust lines, etc., all with an accuracy of 1/10th of a degree.

**The Digital Level**  
Fig. 1:G:11



You aren't very likely to find one of these at that used tool mart. We've received a few inquiries where to buy digital levels. KCI is now carrying a digital level. It's not inexpensive and is progressively more expensive with the longer rails. This is a great tool, but always remember to re-calibrate the level module when you turn it on, otherwise you could be off by a couple of degrees.

KCI  
Kit Components, Inc.  
2244 Airport Way  
Redmond, Or. 97756  
541-923-2244  
kci@lancair.com



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### Tubing bender

This will be at the used tool store, where you should be on a first name basis with the owner by now. Tell him you just need one for 1/4" tubing. It should be in the bin right next to the 37° Flaring tool.

### 37° flaring tool

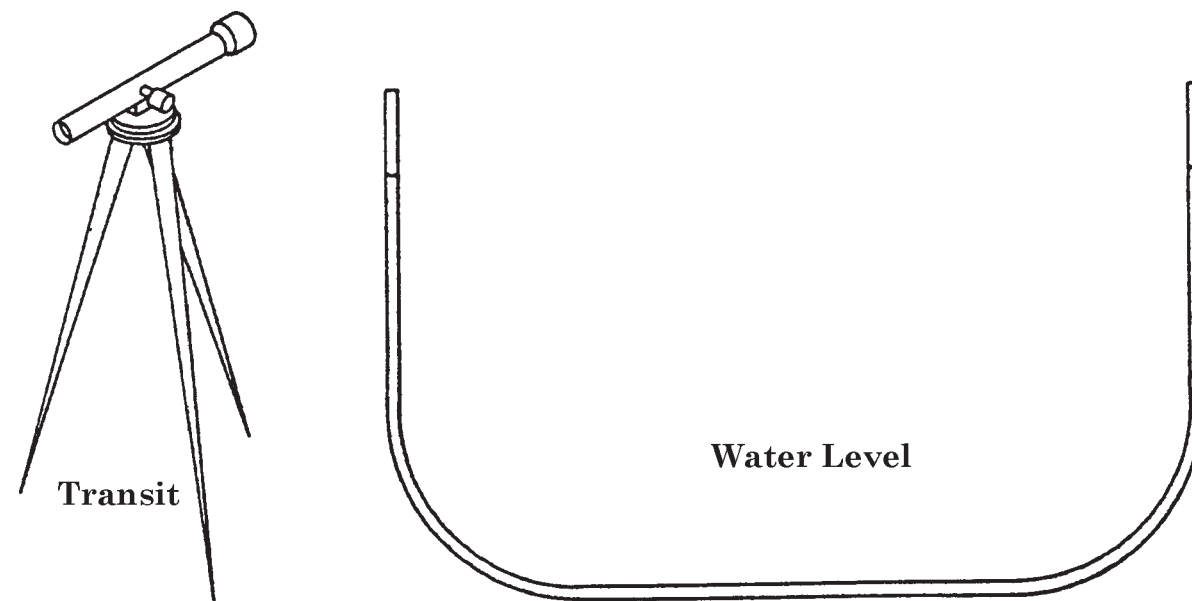
Keep this with your tube bender. You won't need it often, but when you do nothing else will work. Don't use automotive type flaring tools- they have a different flaring angle.

### Surveyor transit

If you love gadgets, this one will be fun, but a water level would work just as well for a whole lot less money (just keep a mop around). It may save you an hour or two in setup time, and can usually be rented from surveyor/construction suppliers. Like the water level, it still takes two people to use it effectively, but you can quickly level fuselages, wings, horizontal stabs and jigs, staying dry in the process.

### Transit and Water Level

Fig. 1:G:12



### Water level

A cheap and simple means of checking wing washout, horizontal stabilizer position, and other big jobs on the airframe. We use 1/4" inch I.D. clear tubing, available at the hardware store. I've heard that dyeing the water in your water level tube with food coloring can make it easier to read, but when I tried it, the coloring didn't help much, it just messed up the tube.

### Plumb bob

These should be laying around the tool store somewhere. Since you will be (hopefully) working indoor out of the wind, you will only need a small one for measuring things for vertical.

### 1" Makita belt sander

A real handy item, you might score one of these at the local tool shop (isn't your wife starting to wonder about all the time you've been spending there lately?). Get an assortment of different grit belts for it, they'll all come in handy before this is over.

### Heat gun

If you have one of these, it can help to warm a couple of parts you want to bond, to straighten a warped part, or a lot of other jobs. It can also destroy parts if care is not taken. Take care when using. The heat gun is a well used tool in our shop, not only for heating parts but for gently heating to cure epoxy, shrinking heat shrink tubing on electrical connections, etc.

## Supplies

### 1 mil thick plastic drop cloths

You will use a lot of these. Fortunately you can probably get them at most hardware stores for about a buck a roll. They're not only great for covering things, but you'll be using them in the preparation of BID tapes and other fiberglass layups. Get several, but be sure they are all the 1 mil thick ones. Thinner, and they won't be easy to handle and thicker, they will be too hard to work. More about that later.

### Paper towels

If you have a lot of storage room, buy these by the case. If not, keep at least 3 or 4 rolls on hand. You'll be using them for cleaning up drips and dribbles of this and that, as well as using them for some other trick things we'll talk about later in Chapter 5.

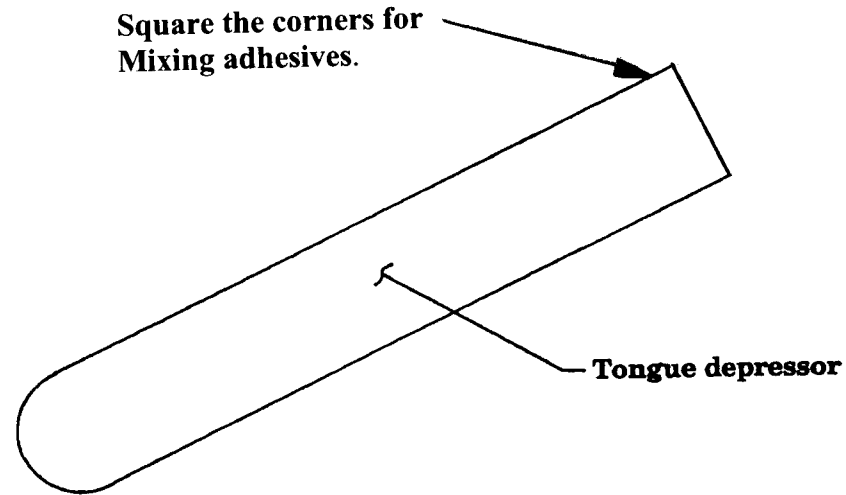
### Tongue depressors

We supply these in the kit, and there should be enough to complete the project with a few left over. You'll be using them mostly for mixing sticks to mix up the epoxy you pump from your nifty Sticky Stuff epoxy dispenser (you do have that on order now, don't you?). You will also be shown how to make a neat little tool out of one later, the kind that you will want to cherish and hang from a special hook on your shop wall.



**Tongue Depressor**  
Fig. 1:G:13

**Square the corners for  
Mixing adhesives.**



**Brushes (1" wide)**

These too are supplied in the kit. There's a whole bunch of them in there, but don't give them away, you'll need most of them for the project. Simply clean in acetone and re-use.

**Brush, 1" Wide**  
Fig. 1:G:14



**Note: Cut half of the bristles off**

**Rubber squeegees**

Hit up the auto parts store for a set of the plastic Bondo™ smoothing paddles. There should be 3 or 4 different sizes in the package. They will all come in handy for getting excess epoxy and air out of layups, applying and smoothing out micro, and any number of other things. Clean up is pretty easy and they should last through the project.

**Sandpaper and sanding blocks**

Purchase several sanding blocks and a lot of 40-grit sandpaper. Nearly every time you apply epoxy or BID tapes to a piece, you will have to rough it up with 40 grit first. Get this size for your belt sander and your sanding blocks. Get a couple of sheets of other grits.

3M Production Paper Sheets are the best we've seen for preparing fiberglass and carbon fiber. They are 2 3/4" x 17 1/2" and are meant for longboard sanders. If cut in half, they fit perfectly into most rubber hand sanding blocks. 3M calls this sandpaper "The Green Corps" and the paper is green. Autobody supply and auto paint stores should carry this item.

**Instant glue**

You'll find some of this in the kit, and it will come in handy for many of the steps called out in the manual. You can use it to temporarily tack most any parts together, it is void-filling, and it can become permanent if you use too much. Just a drop or two will suffice for any of the steps in the manual. You can use it to glue a piano hinge in place and measuring where clecoes would get in the way, and test the placement of brackets.

**Instant glue accelerator**

The ultimate stuff for impatient people, this makes instant glue even faster (more instant?). A quick spray of this stuff and the glue is set, right now.

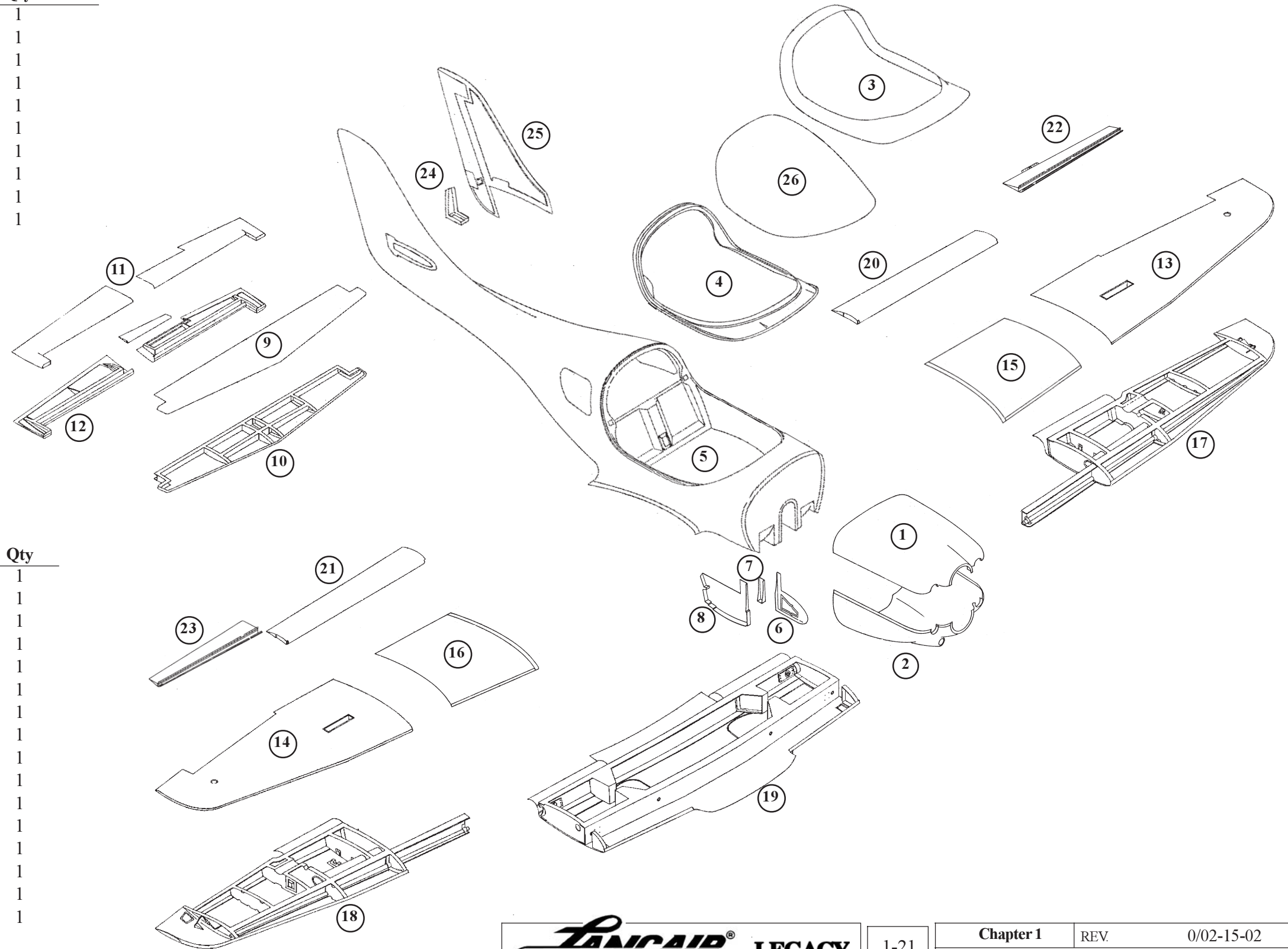
**The eyeball**

Our last tool used to check how straight an edge is, it is the most complicated in design and yet the cheapest and most accurate of all. It's called the human eyeball and should be used whenever possible. If an edge or surface looks straight to the eye, they are straight enough. Even minor discrepancies in wing tip washout can easily be detected by kneeling down ten feet in front of your Lancair, closing one eye, and swiveling your head. Sight one trailing edge tip above the high point of the wing, swivel your head, and sight the other tip, comparing the two.

## H. Premolded Parts - Exploded View

Legend:

#	Item	P/N	Qty
1	Cowl Top	4000-01	1
2	Cowl Bottom	4000-02	1
3	Canopy Frame Skin	4010	1
4	Canopy Frame Stiffener	4011	1
5	Fuselage Assembly	4020-FB	1
6	Load Pad Left Fwd	4025-01	1
7	Load Pad Left Center	4026-01	1
8	Rib BL25 Left w/ Load Pad	4232-01	1
9	Horiz. Stab. Top Skin	4100-01	1
10	Horiz. Stab. Bot Skin Assy.	4100-02FB	1



Legend:

#	Item	P/N	Qty
11	Elevator Skin Top	4130-01	1
12	Elevator Bottom Assembly	4130-02FB	1
13	Wing Outbd Left Skin Top	4200-01	1
14	Wing Outbd Right Skin Top	4200-02	1
15	Wing Inboard Skin Top	4200-03	1
16	Wing Inboard Skin Bottom	4200-04	1
17	Wing Left Lower Assembly	4210-01FB	1
18	Wing Right Lower Assembly	4210-02FB	1
19	Wing Center Lower Assy	4210-03FB	1
20	Flap Left Assembly	4310-02FB	1
21	Flap Right Assembly	4310-02FB	1
22	Aileron Left Assembly	4322-01FB	1
23	Aileron Right Assembly	4322-02FB	1
24	Horiz. Stab. Vert. Bkhd Upper	4049	1
25	Vertical Rudder Left Skin	4044	1
26	Canopy Windshield	4600	1

## Premolded Parts List - not included in figure

Legend:

#	Item	P/N	Qty
1	Canopy Hinge Support Outboard Left	4015-01	1
2	Canopy Hinge Support Outboard Right	4015-02	1
3	Canopy Hinge Support Inboard Left	4016-01	1
4	Canopy Hinge Support Inboard Right	4016-02	1
5	Mount Fuel Selector Valve	4021	1
6	Firewall Closeout Legacy	4023	1
7	Seat Support Left Center	4024-01	1
8	Seat Support Right Center	4024-02	1
9	Load Pad Right Forward	4025-02	1
10	Forward Load Pad Access Panel Left	4025-03	1
11	Forward Load Pad Access Panel Right	4025-04	1
12	Seat Support Left Outboard	4027-01	1
13	Seat Support Right Outboard	4027-02	1
14	Instrument Panel	4028	1
15	Center Console	4029	1
16	Center Console Access Panel Fwd Left	4029-01	1
17	Center Console Access Panel Fwd Right	4029-02	1
18	Center Console Glove Box	4029-03	1
19	Center Console Access Panel Top	4029-04	1
20	Center Console Access Panel Aft Left	4029-05	1
21	Center Console Access Panel Aft Right	4029-06	1
22	Seat Bottom Left	4033-01	1
23	Seat Bottom Right	4033-02	1
24	Floor Board Left	4034-01	1
25	Floor Board Right	4034-02	1
26	Push Pull Tube Closeout	4035	1
27	Control Tube Cover Top	4035-01	1
28	Flap Bay Closeout Left	4036-01	1
29	Flap Bay Closeout Right	4036-02	1
30	Seat Belt Attach Center Lower	4040	1
31	Bulkhead Cover	4041	1
32	Bracket Fuel Pump	4042	1
33	Rudder Leading Edge Closeout	4056	1
34	Battery Shelf	4038	1
35	Rudder Trim Tab	4061	1
36	Spar Closeout Forward Center	4214	1
37	Rib BL25 Right w/ Load Pad	4232-02	1
38	Gear Door Inboard Left	4264-01	1

#	Item	P/N	Qty	
39	Gear Door Inboard Right	4264-02	1	
40	Gear Door Outboard Left	4265-01	1	
41	Gear Door Outboard Right	4265-02	1	
42	Fairings Fuel Drain	4271	4	
43	Control Tube Elevator Forward	(1" x 62")	4465	1
44	Control Tube Elevator Aft	(1 1/4" x 76")	4466	1
45	Control Tube Aileron Center	(3/4" x 19 1/4")	4576	1
46	Control Tube Aileron Inboard	(3/4" x 35 1/2")	4577	2
47	Control Tube Aileron Outboard	(3/4" x 38 1/2")	4578	2
48	Control Tube Aileron Bellcrank	(3/4" x 11 3/8")	4579	2
49	Control Tube Rudder	(3/4" x 31")	4658	1



## I. Procedures

### Cleaning, care, and handling of parts

#### 1. Cleaning Parts

You will find instructions calling for the use of cleaning agents throughout this manual. We have found that Methylene Chloride (MC) cleaner is very good in its ability to remove impurities from surfaces. As with all cleaners, be sure to read and follow the safety directions. Acetone is a good cleaner but Methylene Chloride (MC) is superior. *MEK should not be used.*

#### 2. Storage of Premolded Parts

The manner in which your pre-molded parts are stored is very important. Care and thought should be exercised when laying pre-molded parts away for some future use which could be months away. Try to store these parts in a position that won't produce any distorting forces (i.e., store them supported in a position as close to the actual use orientation as possible).

Unlike fiberglass composite parts, the carbon fiber parts are much stiffer and less prone to distortion, however it is still highly recommended that great care be exercised when storing these valuable components. Also, all composite parts should be kept away from direct sunlight for any extended periods of time. An afternoon or a day is perhaps okay. However a week, for example, in direct sunlight would not be acceptable.

#### 3. Honeycomb Prepreg Panels

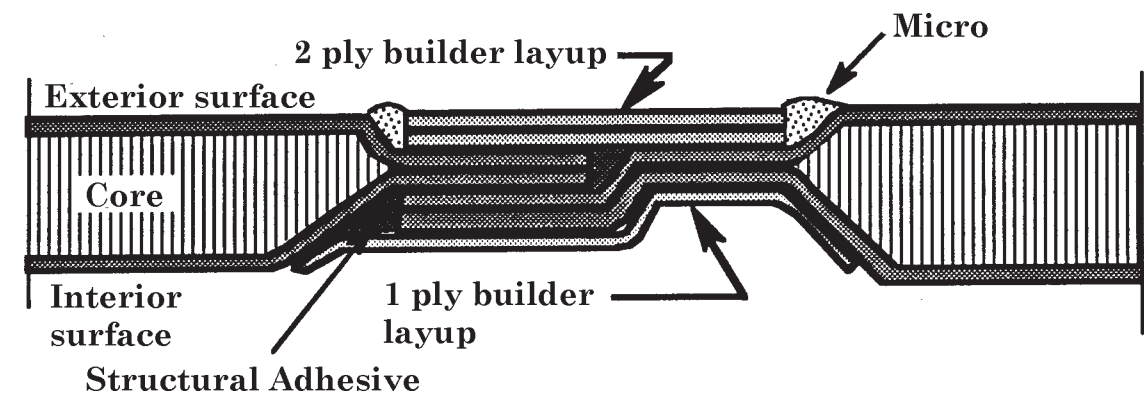
The prepreg honeycomb panels are available in two types: 3/8" core + 2 BID per side and 1/4" core + 1 BID per side. All BID ply schedules must remain the same when using prepreg panels (i.e., if a part calls for 6 BID on one side and 2 BID on the other side, the 2 BID honeycomb panel will require 4 additional BID on the first side). Also, all attachment BID schedules must remain the same (i.e., if plans call for a 6 BID attachment, then 6 plies (wet layup) must be used.) Typically 1" contact on each surface unless otherwise noted is sufficient.

## J. Joint Description

Adjoining parts are attached with bonded, overlapping joints (joggles) reinforced with fiberglass strips, see Figure 1:J:1. Figure 1:J:2 shows the overlaps prior to assembly (the dimensions shown in the figures are approximate). As supplied, the part edges may have excess material. To obtain the dimensions shown the excess material must be trimmed by the builder.

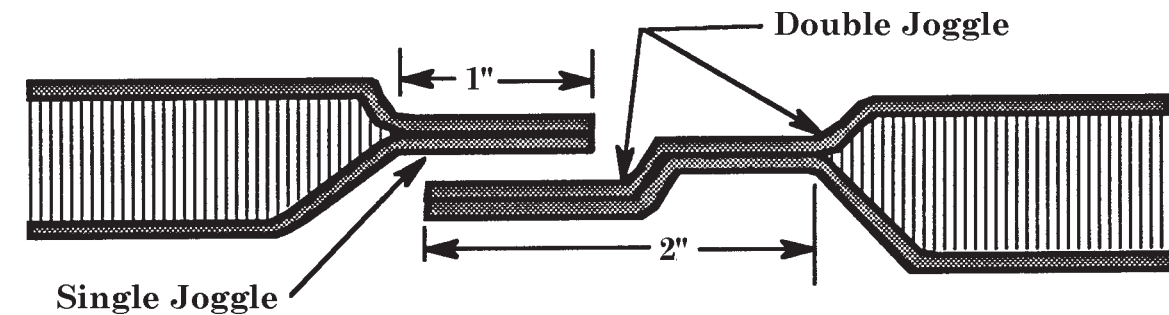
Reinforced Overlapping Joints

Fig. 1:J:1



Trimmed Parts

Fig. 1:J:2



*Note: Before trimming, single and double joggle surfaces may look similar. To learn what each looks like, examine the front of the fuselage. The joggle that is forward of the firewall, where the bottom cowl will meet, is an example of a single joggle. The area above and behind the firewall, where the forward deck will mount, is a double joggle.*

#### CAUTION:

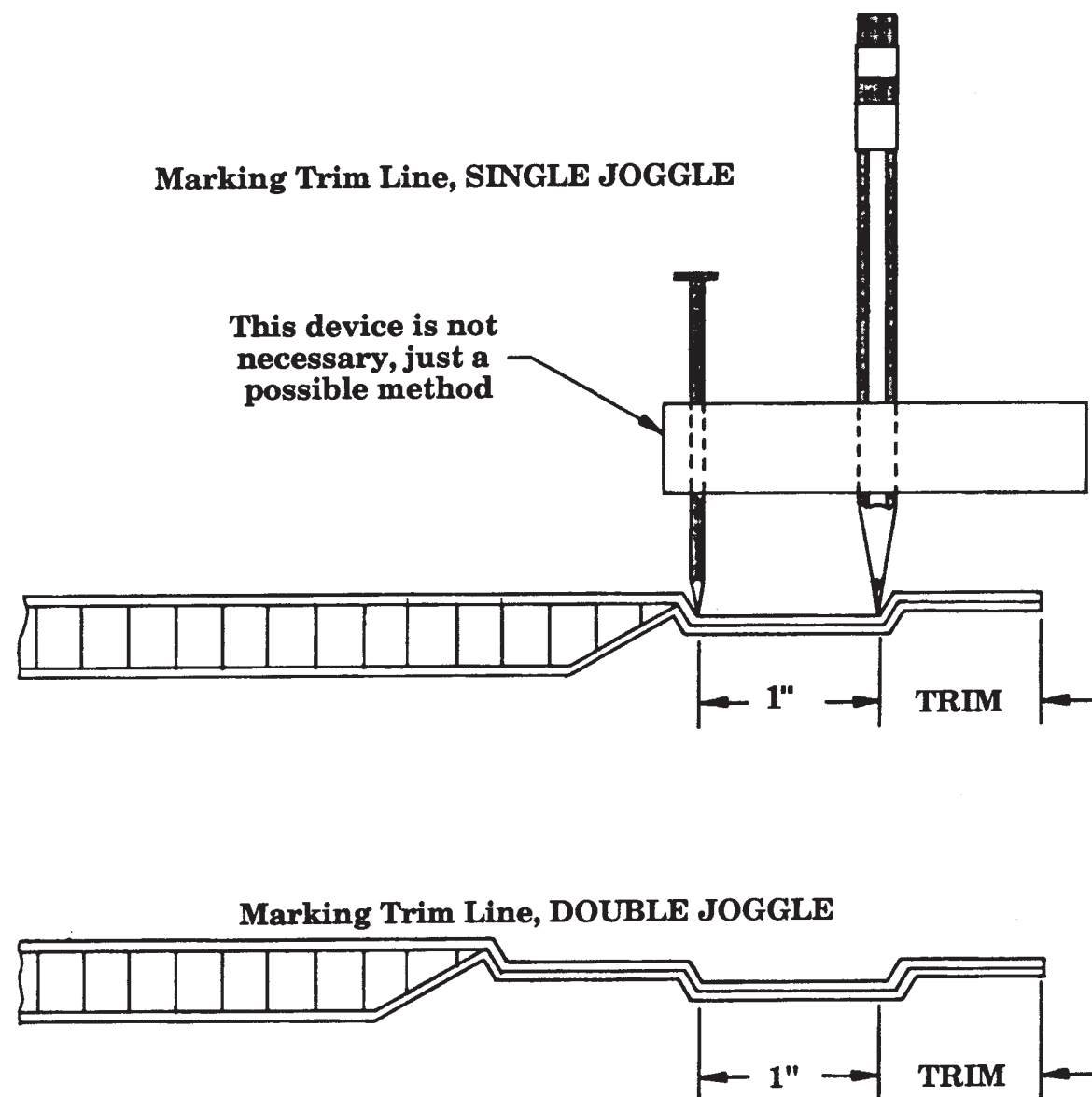
EDGES OF PARTS MAY BE SHARP. HANDLE WITH CARE, USE GLOVES OR FILE/SAND OFF SHARP EDGES.



## K. Trimming Procedure

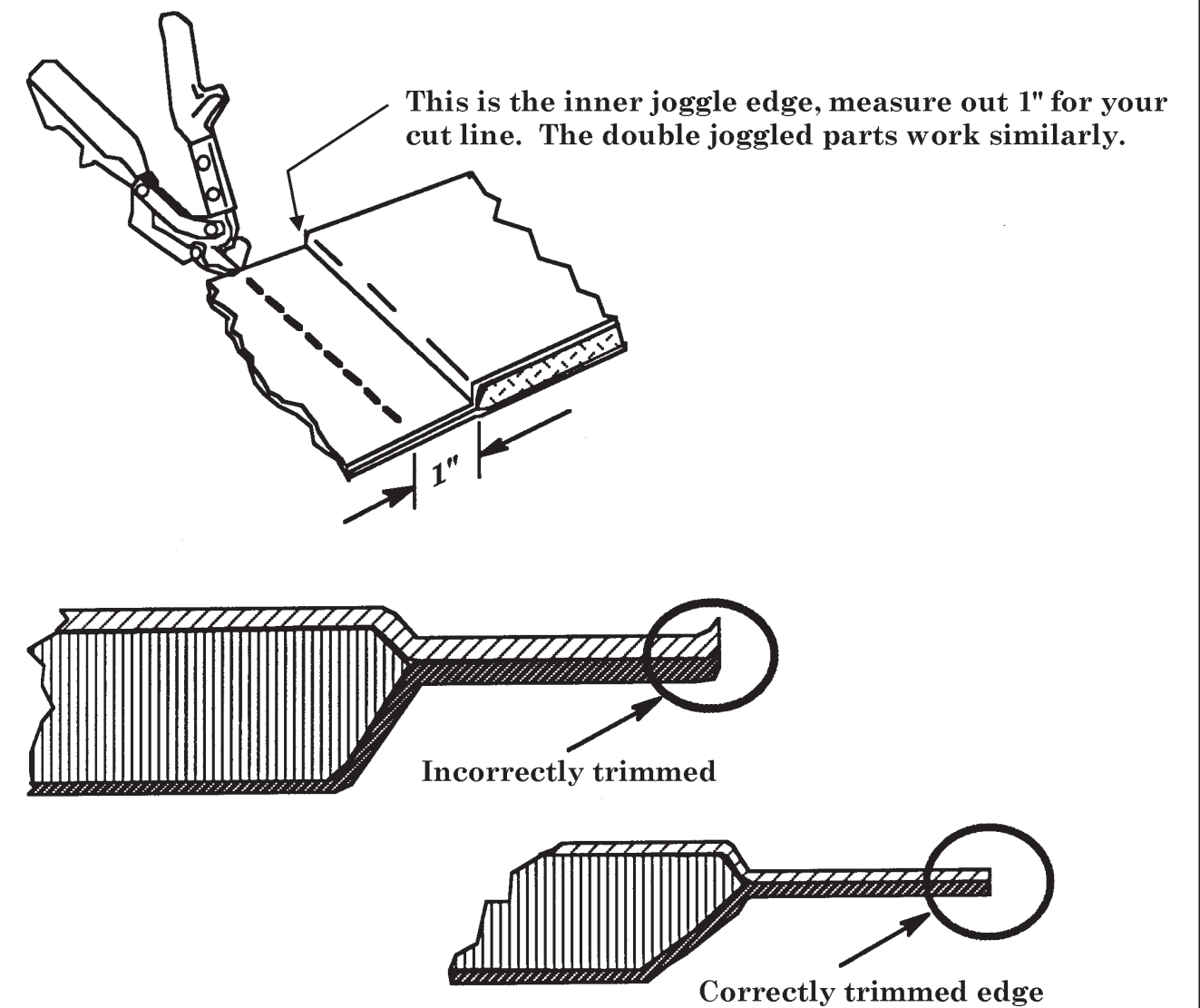
1. Place the fuselage on a convenient working surface. Mark a line on all joggle surfaces as shown in figure 1:K:1. A marking tool can be made from a piece of wood, a nail and a pencil. Make sure the nail tip is well rounded and has no sharp edges which could damage the glass fibers during use. On double joggled surfaces, mark a line as shown in figure 1:K:1.

Trimming Procedure  
Fig. 1:K:1



2. Using the shears, cut along the lines. Refer to Figure 1:K:2 for proper appearance of the edge after trimming. If necessary, trim additional material to obtain correct edge shape. Some sanding may be useful to complete the trim and smooth the edge.
3. Repeat this trimming procedure for all joggles.

Shearing Joggle  
Fig. 1:K:2



## L. Drilling Alignment Holes

### 1. Equipment required:

Electric drill  
1/8" Drill bit

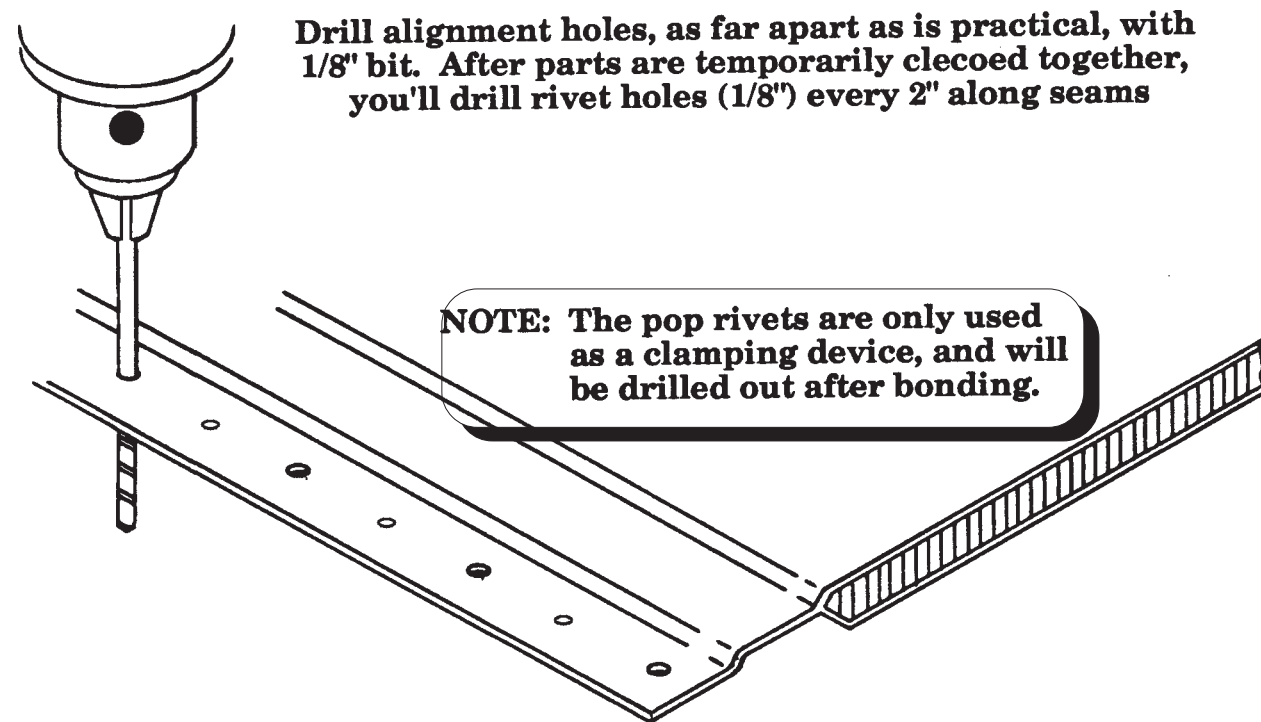
### 2. Procedure

To obtain proper overlap alignment during assembly, holes are drilled for screws or clecoes, which are placed in these holes to hold the parts in proper alignment during cure time.

Using a 1/8" drill bit, drill alignment holes in the two parts to be joined (See Fig. 1-27).

Place screws or clecoes in the alignment holes, and drill the rivet holes every 2" in-between alignment holes.

Drilling Alignment Holes  
Fig. 1:L:1



## M. Removing the Protective Coating - Peelply

### 1. Description of Parts

Molded parts are shipped with a protective coating of "peelply" material on their inner surfaces. This material will interfere with bonding and must be removed. The peelply usually sticks out from the edge of a part in at least one area and looks like white cloth. Where the peelply meets and lays on the part surface it becomes transparent.

### WARNING:

**ALL PEELPLY MUST BE REMOVED FROM BOND AREAS TO OBTAIN GOOD BONDS. BONDING OR LAYING FIBERGLASS OVER PEELPLY COULD RESULT IN STRUCTURAL FAILURE.**

Most of the peelply has already been removed from your pre-molded parts, but some may remain.

Peelply is removed by hand. It can require considerable force to pull the peelply off in some places. As it is pulled off, it usually tears off in odd shaped pieces. Use a utility knife to pick up a new edge when necessary. Use care not to cut into the glass of the parts.

The white cotton strips running in irregular directions on the surface of the peelply are required by the manufacturing process. These will come off with the peelply but more pulling force will be required.

NOTE: Although removing peelply looks simple, it can cause serious injury if your hand slips and scrapes a sharp edge. This has happened to us here at Lancair and it is not at all fun. **Please be careful.** The peelply can be removed from parts at this time. However, it does provide some protection and may be left on until those parts are needed for assembly. **At that time it MUST be removed.**



It takes practice to drill a close tolerance hole in aluminum and fiberglass. We're not all precision machinists here at the shop, but through trial and error we've come up with some drill combinations that work well for various size screws and rivets.

First a note about tolerances. When a bolt is holding a bracket tight against a bulkhead, rib, firewall etc., you needn't drill a .001" tolerance hole, because the bolt's clamping action will keep the bracket from wearing the bolt hole larger. This applies to rod end bearings and bellcrank bearings that are mounted tight with elastic locknuts. In this case, the slop in the bearings are not dependent on the tolerance of the holes.

Here is a list of drills we commonly use for various bolts and rivets:

-AN 426 rivets are .097" diameter, use #40 drill.

-1/8" rivets are .125" diameter, use 1/8" or #30 (.1285") drills.

-#6 screws are .137", drill a sloppy #29 (.136) hole or a tight #28 (.1405").

-#8 screws are .161", #20 (.161") and #21 (.159") both work well.

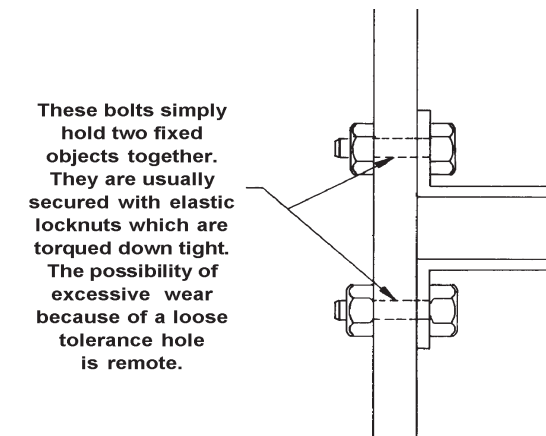
-3/16" (AN3) bolts can use, in addition to the obvious 3/16" drill, a #13 hole with reaming to get a tight fit, (See above section when and where this is necessary). A #12 hole is sometimes too sloppy but can be used for unimportant, quick and dirty holes.

-1/4" (AN4) bolts use 1/4" drill, of course. Also handy are lettered drills, like "E" (.250") or D (.246") with a reamer.

When drilling, creep up on your final drill size. If you want a tight AN4 hole and simply use a 1/4" drill first, the hole will be loose and usually triangular shaped. Try drilling a 3/16" hole first, then 7/32", then 1/4". The extra one minute spent changing drills is well worth it, especially if you're drilling a hole that needs a tight tolerance (See above).

### Bolt Holes Not Requiring Tight Tolerance

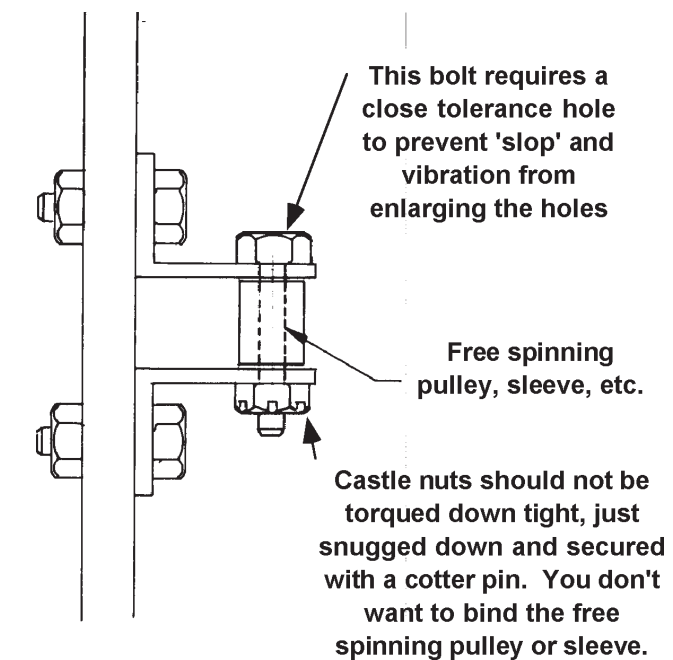
Fig. 1:N:1



One the other hand, bolt holes that require close tolerance are those in which the bolt can rotate freely. When a castle nut and cotter pin are called for, it means the nut and bolt will not be tightened against a fixed object but will allow the object to float between the brackets. A loose tolerance bolt hole will allow the bolt to vibrate and slowly enlarge the hole.

### Bolt Holes Requiring Tight Tolerance

Fig. 1:N:2



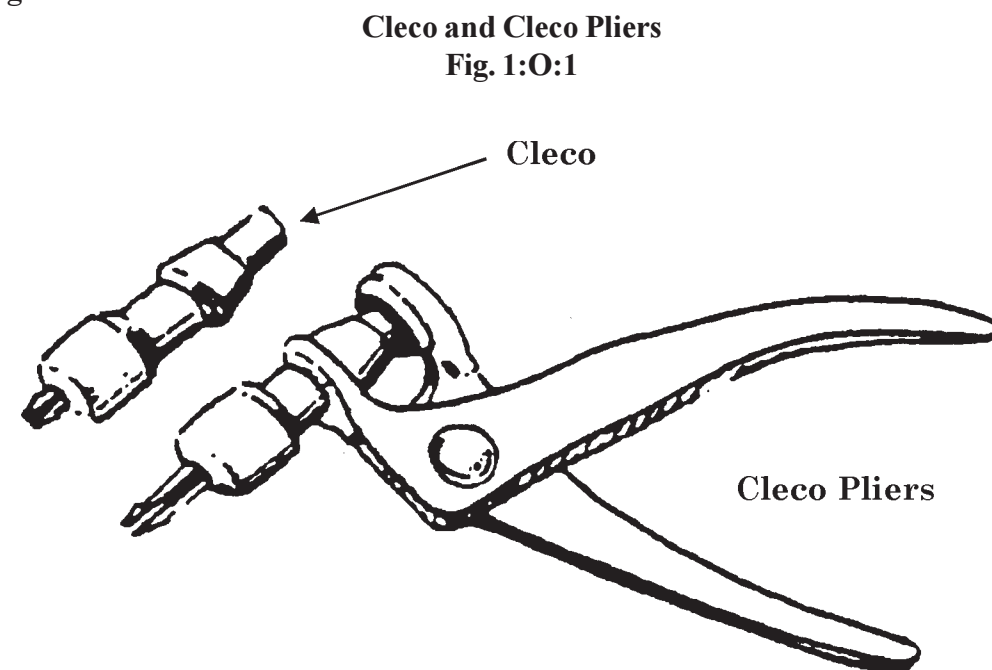
## N. Fastening Parts Together

1. When parts are to be fastened together using epoxy or structural adhesive, they must be held tightly in position until the bonding material has set. Several methods are available, but pop rivets remain the best way to be sure of a proper bond. Typically, the bonding sequence is:  
The parts are prepared for bonding:
  - a. peelply is removed
  - b. Joggled surfaces are trimmed
  - c. Alignment holes are drilled
  - d. Sheet metal screws or clecoes\* (Fig. 1:O:1.) are installed into these holes to hold the parts in alignment while holes are drilled about every 2" from pop rivets.

\*Clecoes™ are a sheet metal fastening device used extensively in the aircraft industry (refer to Fig. 1:O:1). A special pair of pliers (cleco tool) is used. The tip of the cleco is inserted into the alignment hole. When the pliers are released, the cleco locks itself into the holes, tightly holding the parts together. Clecoes and cleco pliers are available from aircraft supply stores or catalogs (ours included). Surplus clecoes are inexpensive, and only about 15 are needed for the construction of your airplane.

### NOTE:

Either sheet metal screws or clecoes are used as fasteners. If the fastener you will use has grease, oil or other such contaminants, it must be thoroughly cleaned before use to prevent contamination of surfaces which will be bonded later. Methylene Chloride may be used as a cleaning fluid.



Squeeze the pliers and the grippers extend and come together. Insert into the hole, press parts together, and release the cleco. The grippers will spread, holding the parts together.

- e. The surfaces to be bonded must now be cleaned since they may have become contaminated during handling and storage. The screws or clecoes are removed and the surfaces to be bonded are cleaned thoroughly with wax and silicone remover, acetone or MC.

### WARNING:

**FAILURE TO FOLLOW CLEANING STEPS CAN RESULT IN EVENTUAL BOND FAILURE. EVEN SURFACES WHICH APPEAR CLEAN MUST BE CLEANED SINCE NOT ALL CONTAMINANTS ARE OBVIOUS. FOLLOW CAUTIONARY LABEL ON THE WAX AND SILICONE REMOVER CONTAINER. WAX AND SILICONE REMOVER IS FLAMMABLE AND MUST BE KEPT AWAY FROM SPARKS, HEAT AND OPEN FLAMES. HARMFUL OR FATAL IF SWALLOWED. DURING USE AND UNTIL ALL VAPORS ARE GONE: KEEP AREA WILL VENTILATED AND DO NOT SMOKE. EXTINGUISH ALL FLAMES, PILOT LIGHTS AND HEATERS. TURN OFF STOVES, ELECTRICAL TOOLS AND APPLIANCES THAT COULD ACT AS AN IGNITION SOURCE. VAPOR IS HARMFUL. AVOID BREATHING VAPORS AND USE ONLY WITH ADEQUATE VENTILATION. AVOID SKIN AND EYE CONTACT. WEAR RUBBER GLOVES OR SUITABLE PROTECTIVE SKIN BARRIER. WASH HANDS IF THEY COME IN CONTACT WITH THIS LIQUID. IF SPILLED ON CLOTHING, REMOVE AND LAUNDRER BEFORE RE-USING.**

- f. Dampen one cloth or piece of toweling well with the wax and silicone remover and wipe it along the bond surface of either part. Do not rub or scrub the surface as that may work the contaminants into the surface. Follow within seconds with a dry cloth or toweling piece to absorb the solvent and the contaminants it removes from the bonding surface.
- g. Continue that process until that seam has been cleaned. Then replace both the wetting and drying cloths with new pieces and repeat the cleaning process for the other half. It at any time the wetting or drying cloth shows any soiling or the drying cloth becomes wet, replace it immediately with a new one.
- h. If any obvious contaminants still remain, the above process may be repeated with methylene chloride.

## WARNING

FOLLOW CAUTIONARY LABELS ON THE METHYLENE CHLORIDE CONTAINER. METHYLENE CHLORIDE IS A VOLATILE SOLVENT. CAUSES IRRITATION OF THE EYES, SKIN AND RESPIRATORY TRACT. PROLONGED BREATHING OF VAPOR CAN CAUSE LOSS OF CONSCIOUSNESS. DO NOT GET IN EYES, ON SKIN, OR CLOTHING. DO NOT TAKE INTERNALLY. AVOID BREATHING OF VAPORS. WHEN HANDLING WEAR CHEMICAL SPLASH GOGGLES, PROTECTIVE CLOTHING AND SOLVENT RESISTANT GLOVES. WASH THOROUGHLY AFTER HANDLING. USE ADEQUATE VENTILATION IN WORK AREA.

- i. After the seam is cleaned, repeat the cleaning process for the other part.
- j. Using clean #80 grit abrasive paper roughen all cleaned surfaces lightly until the surface shows a fine white powder. Remove the powder with a clean cloth or clean brush.
- k. The bonding material (epoxy, epoxy/flox, epoxy/micro or structural adhesive) is prepared and applied to one or both surfaces to be bonded.

## WARNING

THE CONTAINERS USED TO MIX THE ADHESIVE MUST NOT BE WAX COATED. THE WAX COATING COULD CONTAMINATE THE ADHESIVE AND REDUCE THE BOND STRENGTH. LIKEWISE, THE MIXING CONTAINER MUST BE FREE OF DIRT, GREASE, OIL OR OTHER SIMILAR CONTAMINANTS.

## WARNING

READ THE CAUTIONARY LABEL ON THE EPOXY CANS. THIS EPOXY IS EXTREMELY IRRITATING TO THE EYES AND CAN CAUSE PERMANENT EYE DAMAGE. MAY ALSO CAUSE SKIN IRRITATION OR SENSITIZATION REACTION IN CERTAIN INDIVIDUALS. PREVENT EYE AND SKIN CONTACT WITH EPOXY MATERIALS. AVOID BREATHING VAPORS. USE ONLY IN WELL VENTILATED AREA. AVOID INHALATION OR EYE CONTACT WITH DUST FROM GRINDING OR SANDING OF CURED EPOXY. REMOVE CONTAMINATED CLOTHING AND LAUNDRER BEFORE RE-USE.

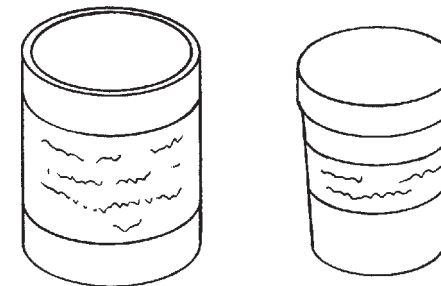
If structural adhesive is to be used, prepare it as follows:

HYSOL 9339 Epoxy can be mixed in the proper weight ratio only by using a good scale. A small calculator will help, too. IMPROPER MIXING CAN SPEED OR SLOW CURE TIME AND DECREASE ADHESIVE STRENGTH. ATTENTION TO THE MEASURING PROCESS IS IMPORTANT.

### Hysol Structural Adhesive

Fig. 1:0:2

HYSOL 9339 ADHESIVE  
Mix: 44.5 parts 9339A(blue)  
to 100 parts 9339B(White)



**Note:** [If you are using another product, make sure it is Lancair approved and that you follow the proper mixing instructions.](#)

The mixing ratio for Hysol 9339 is 100:44.5, part A to part B. The easiest way to do this is put the mixing cup on the scale and record its empty weight. Guessing at how much epoxy you will need for the job, take about 2/3's of that amount from the Part "A" can and put it in the cup, weigh, and subtract the weight of the empty cup from the new weight, giving you the weight of just the epoxy in the cup. Multiply the weight of the epoxy in the cup by 1.455. Add the weight of just the epoxy in the cup to this figure, and now add Part "B" until the cup weight is the same as your calculated figure. Maintaining nearest 1/10 oz. is plenty close enough.

a. Example:

1. Weight of empty cup: .5 oz.
2. Weight with 2/3's (estimated) of the material you'll need, Part "A": 3.7 oz.
3. Weight of Part "A": 3.2 oz
4. Multiply by mix ratio 100:44.5: x 1.4
5. Total weight of Part "A" and Part "B" needed is: 4.6 oz.
6. Add the weight of the cup back in: .5 oz.
7. The total weight, once you've added the proper amount of Part "B": 5.1 oz.
8. Add Part "B" to the cup until it weighs 5.1 oz., mix, and you're ready.

b. Mix the Hysol 9339 epoxy adhesive components as follows:

1. Read all the instructions and information on the epoxy cans. Temperature of the adhesive ingredients and the surrounding room temperature must be 60°F or more.
2. The epoxy has a working life of 2 hours at 77°F. However, at higher temperatures or with a larger batch this working life will be less. Therefore, before mixing adhesive, all necessary equipment should be ready.
3. For the same reason, it is better to mix too much adhesive than too little. If you run out and must mix a second batch, the first batch may have already begun to thicken making it difficult to compress the seam properly and possibly reducing bond strength when cured. Another reason for mixing more than you need: If you have a little left over, leave it in the corner of the cup with the mixing stick in it. Because cure time varies with temperature, by leaving a little in the cup and leaving the cup near the part you have epoxied, the cup can now be used as your test for curing. Wait at least 24 hours after joining parts. Then, before touching parts, try to move the stick around in the epoxy in the cup. If you can move it at all, your parts have not cured. Wait another 24 hours and repeat. Handling parts before cure is complete can reduce the bond strength and should be avoided.

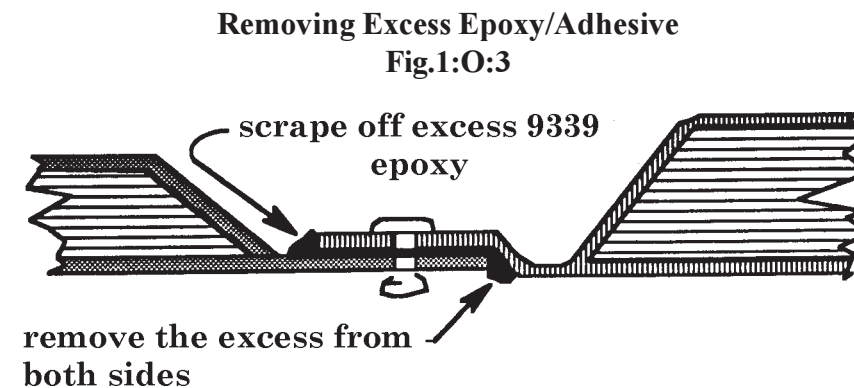
The epoxy cure time depends on the temperature during cure time. Because of the fire hazards involved with most heaters, it is not recommended to have a heater operating in the room that could cause a fire. However, getting the room nice and warm before applying adhesive, so the parts and air temperature is above 77°F, will help shorten cure times, but remember it will also shorten the pot life/working time of the adhesive.

- (a) Estimate the amount of adhesive that you will need for the first seam and measure a sufficient amount of Part "A" and "B" to make that amount.
- (b) Using a mixing stick, thoroughly mix the two parts for at least two minutes. Mix longer for larger batches. Occasionally scrape unmixed material from the sides of the cup. Uniform blue-gray color will result.
- (c) Apply the structural adhesive as follows (the following assumes the seams have been cleaned and sanded as previously described. If not, do so at this time).

1. Beginning with the seam of the first part you have chosen to start on, with a wood spatula, spread an even layer of adhesive on the overlap surface of the part. Repeat the adhesive application process on the overlap surface of the other part.
2. Overlap the two adhesive coated surfaces and align the holes in the surfaces. Insert a screw or cleco into a hole at each end of the part, or every foot along the part if it is longer than 18". Starting at either end, insert rivets into the predrilled holes and form the heads (backup washers are normally not necessary).

(d) Remove the fasteners and place rivets into those holes.

(e) While the adhesive is still soft, scrape off the excess that squeezes out (Fig. 1-32). Adhesive is much harder to remove when hardened. Use methylene chloride on a clean cloth to remove adhesive that smears on the fiberglass surface. Clean adhesive from the clecoes if any were used.



Make sure you're wearing work clothes, since the adhesive may drip on you. Also check for adhesive on hair, arms, etc., and wipe it off before it cures. A long sleeve shirt and long pants are highly recommended.

- (f) Wait at least 24 hours, then test your mixing cup residue for cure. If solidly cured, then the part should be ready to start work on once more. Drill out the rivets using a 1/8" drill, and remove any loose pieces.
- (g) Fill the rivet holes with a 50/50 mix of micro/flox, clean off any excess, let it harden, and you're done with the seam. To make things a little neater, you can put a piece of tape over the back side of the seam, covering the bottom of the rivet holes, to help contain the filler mix and make a smoother neater finish, that requires less epoxy (and adding less weight, something to think about all through the construction process).



### 3. Epoxy

(a) **Mixing epoxy:** As with the structural adhesive, you can use a scale for measuring the proper amount of laminating resin and hardener. There are also some good measuring pumps on the market that will probably pay for themselves (about \$265) since you'll waste less epoxy with them, and have less chance of spills or improper mixes. We offer one in our catalog that has performed well here in our own shop for years now.

Typically, you will be using from 1 to 6 ounces at a time.

If you prefer to use a scale instead of a dispenser, you can measure the two parts as you did for the Hysol, except use 1.44 instead of 1.445.

Another way is (Jeffco resin system used here for example purposes only. Use the appropriate ratios for your supplied system of resins.)

- (1) Place your empty cup on the scale.
- (2) Record the weight of the empty cup.
- (3) Estimate amount of epoxy you will need.
- (4) Add .25 oz of hardener (yellowish) to cup for each 1-1/4 oz you'll need.
- (5) Pour 1 oz of resin (clear) into cup for each .25 oz of hardener and mix thoroughly.

- (a) Working time can be as short as ten minutes if it is hot, so be sure everything is in place and ready to go before you begin mixing.
- (b) As with the Hysol, the surfaces must be totally free of oil, grease or other contaminants, and slightly roughened. Fasten with pop rivets, let harden, remove fasteners & fill holes.

**NOTE: USE CARE TO MIX YOUR RESINS AND ADHESIVES ACCORDING TO THE MANUFACTURER'S INSTRUCTIONS FOR THE PARTICULAR SYSTEM YOU ARE USING. THEY ARE ALL DIFFERENT. AN IMPROPER MIX RATIO COULD RESULT IN IMPROPER BONDING - OR NO BONDING AT ALL.**

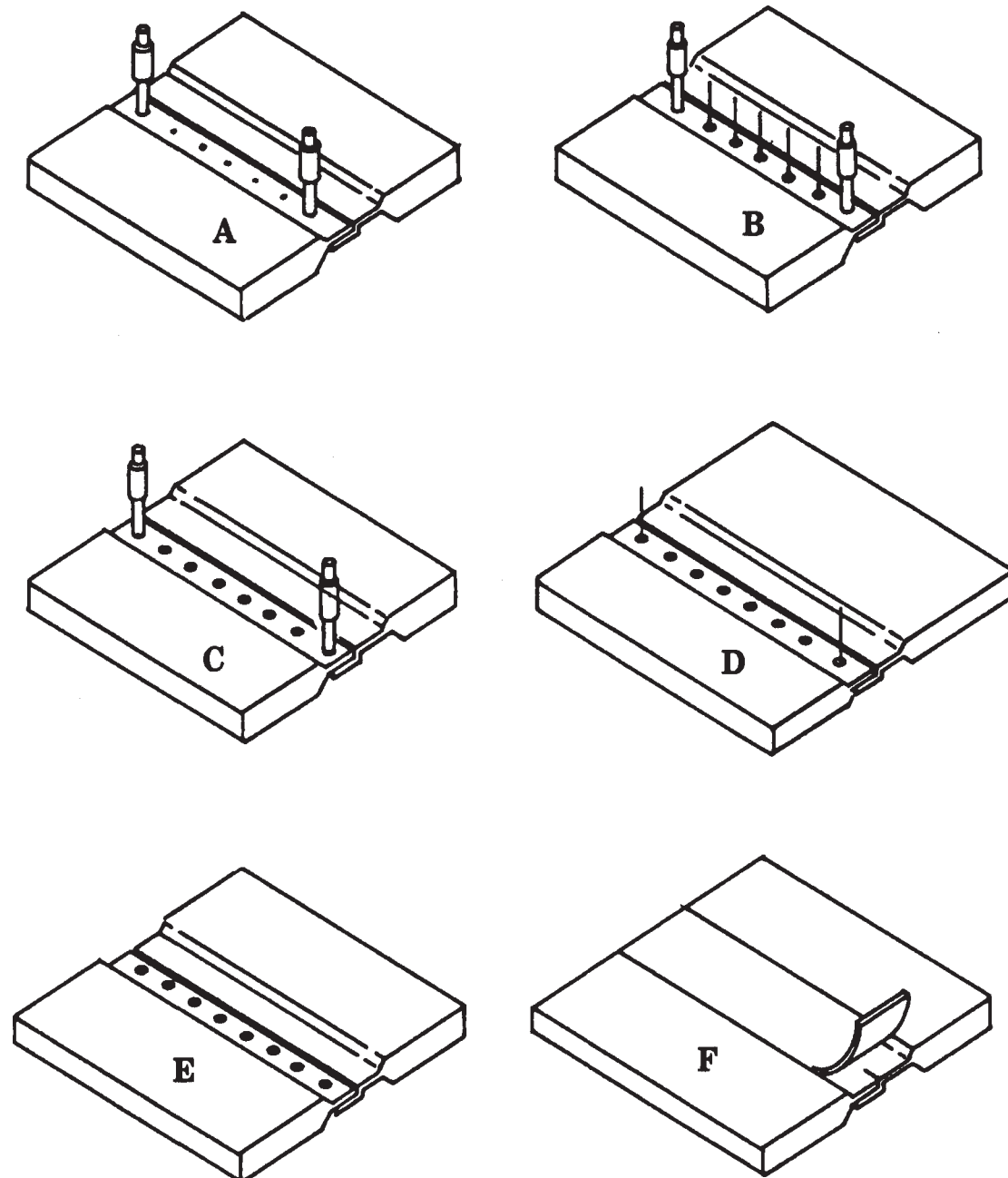
**BE CAREFUL TO PAY ATTENTION TO THE MANUFACTURER'S INSTRUCTIONS!!!**

## O. Fiberglass Strip Installation

### 1. Description

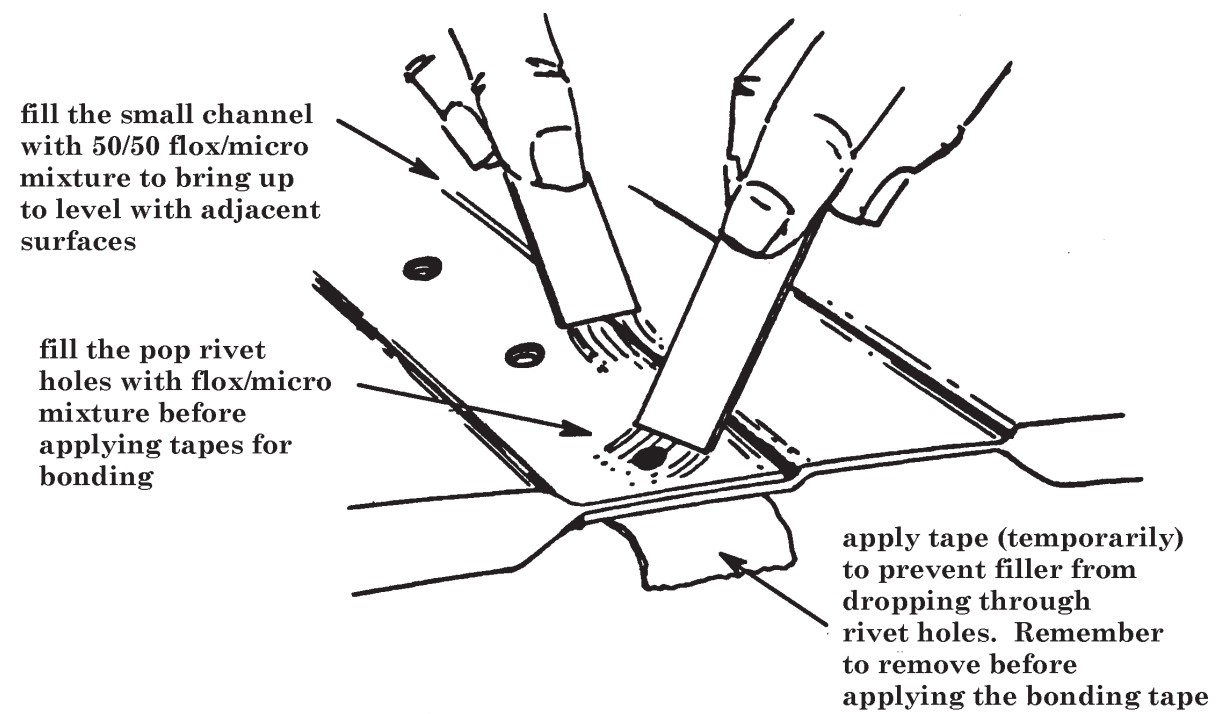
To stiffen joints and provide a double bond, fiberglass strips are laid over the bonded seams as shown in the sequence of drawings in fig. 1:P:1.

**Joining Parts  
Fig. 1:P:1**



- Fig. 1:P:1A shows the two pieces to be joined. After the adhesive has been placed along the inside of both pieces to be joined, the two clecoes were installed to hold the parts in alignment.
- Fig. 1:P:1B shows pop rivets set into the other holes drilled 1" apart for the length of the seam.
- Figure 1:P:1C shows the pop rivets after being compressed.
- In figure 1:P:1D, the two clecoes have been removed and replaced with pop rivets awaiting compression.
- Figure 1:P:1E displays the two parts, waiting patiently for the adhesive to cure.

**Preparing Seam For BID Tape**  
Fig. 1:P:2

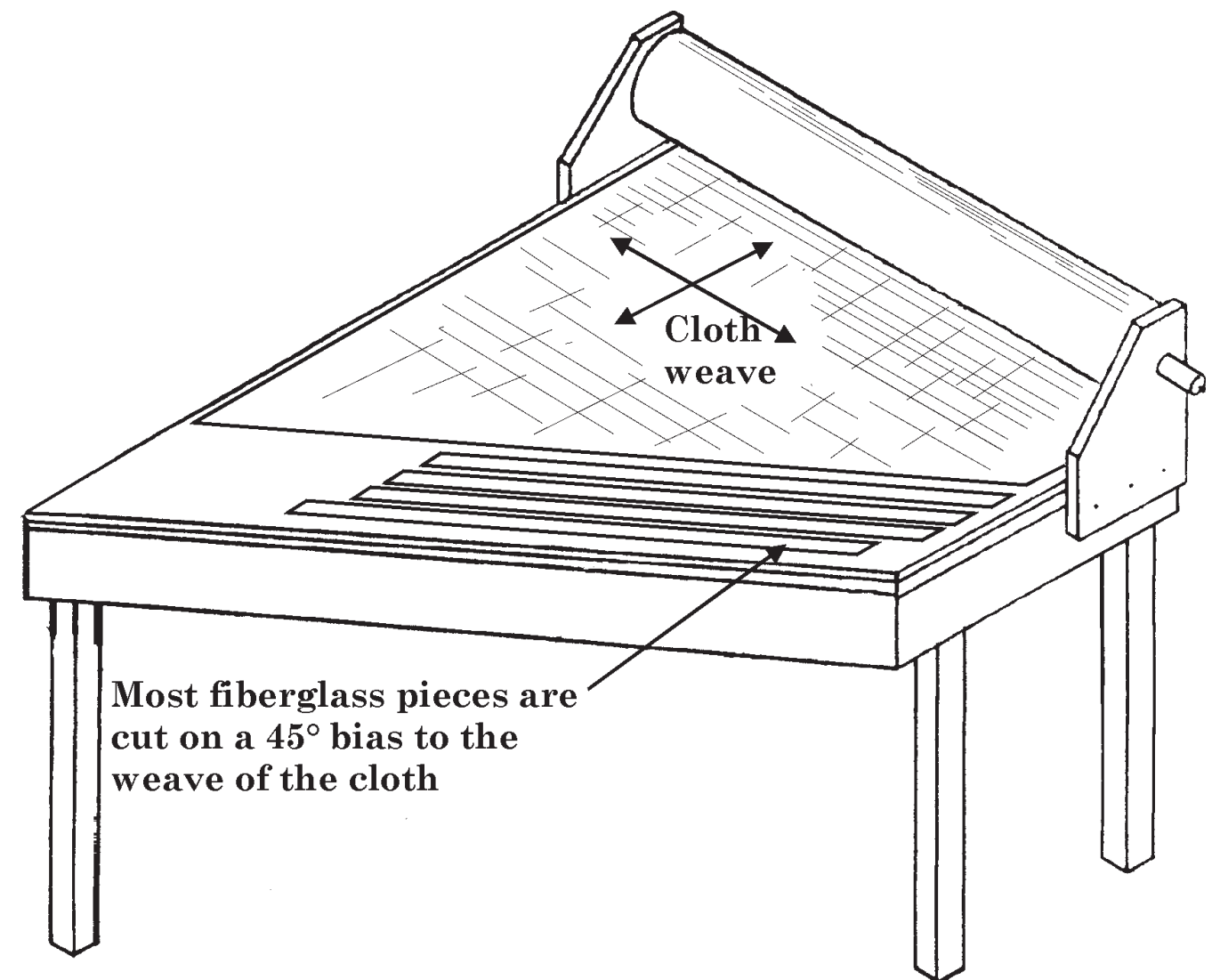


- After the adhesive has cured, the pop rivets are drilled out, the holes filled with a 50/50 mix of flox and micro (see Fig. 1:P:2) and, without a need to wait for that to cure, a bid strip is being laid into place over the top of the joggles.

## P. Cutting on the Bias

When cutting your cloth with that wonderful roller blade, please pay attention to the weave bias specified for the part you are glassing. There are very few fiberglass parts in the Lancairs that are cut on a 0° bias. Nearly every piece of fiberglass you apply will be cut on a 45° bias. The weave orientation arrows in the construction manuals are there for a reason, please use them.

**Weave Orientation**  
Fig. 1:Q:1



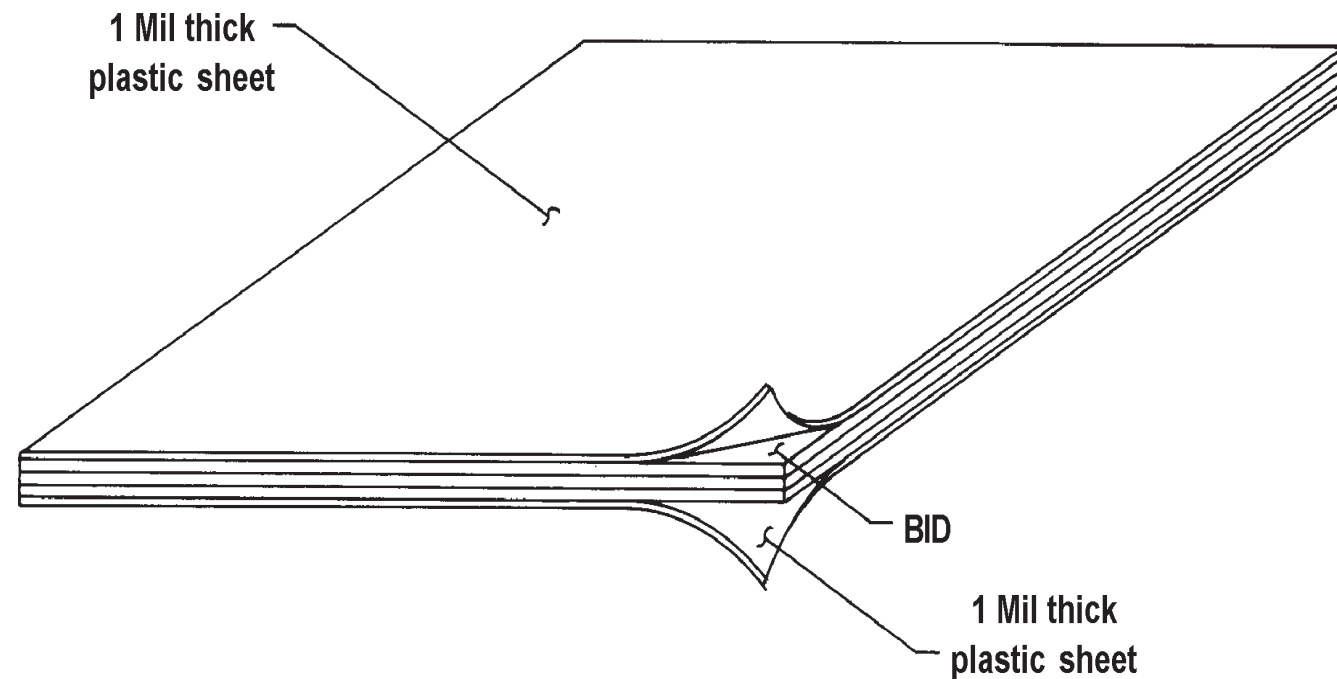
## Q. The Plastic Sandwich

This method of wetting out cloth is simple and invaluable. Many hours can be knocked off your project by using this technique.

At the hardware store, buy a few rolls of 1 mil thick plastic drop cloths. Regular household garbage bags work well when cut along the edges with a roller blade. Cut two sections of plastic bigger than the piece of fiberglass you are about to apply. Tape one piece of the plastic to your fiberglass cutting table and lay the fiberglass piece (up to 4 BID thick) on the plastic. The cutting table provides an excellent surface for this technique. Wet out the fiberglass cloth with plenty of epoxy. Gravity is your friend, it will allow the epoxy to soak down through the layers of cloth. No need to stipple the BID with a brush, just lay the other piece of plastic over the wetted out cloth and roll the air bubbles and excess epoxy out of the laminate. See the next section for more information on rollers and rolling techniques.

Plastic Sandwich Method of Wetting Cloth

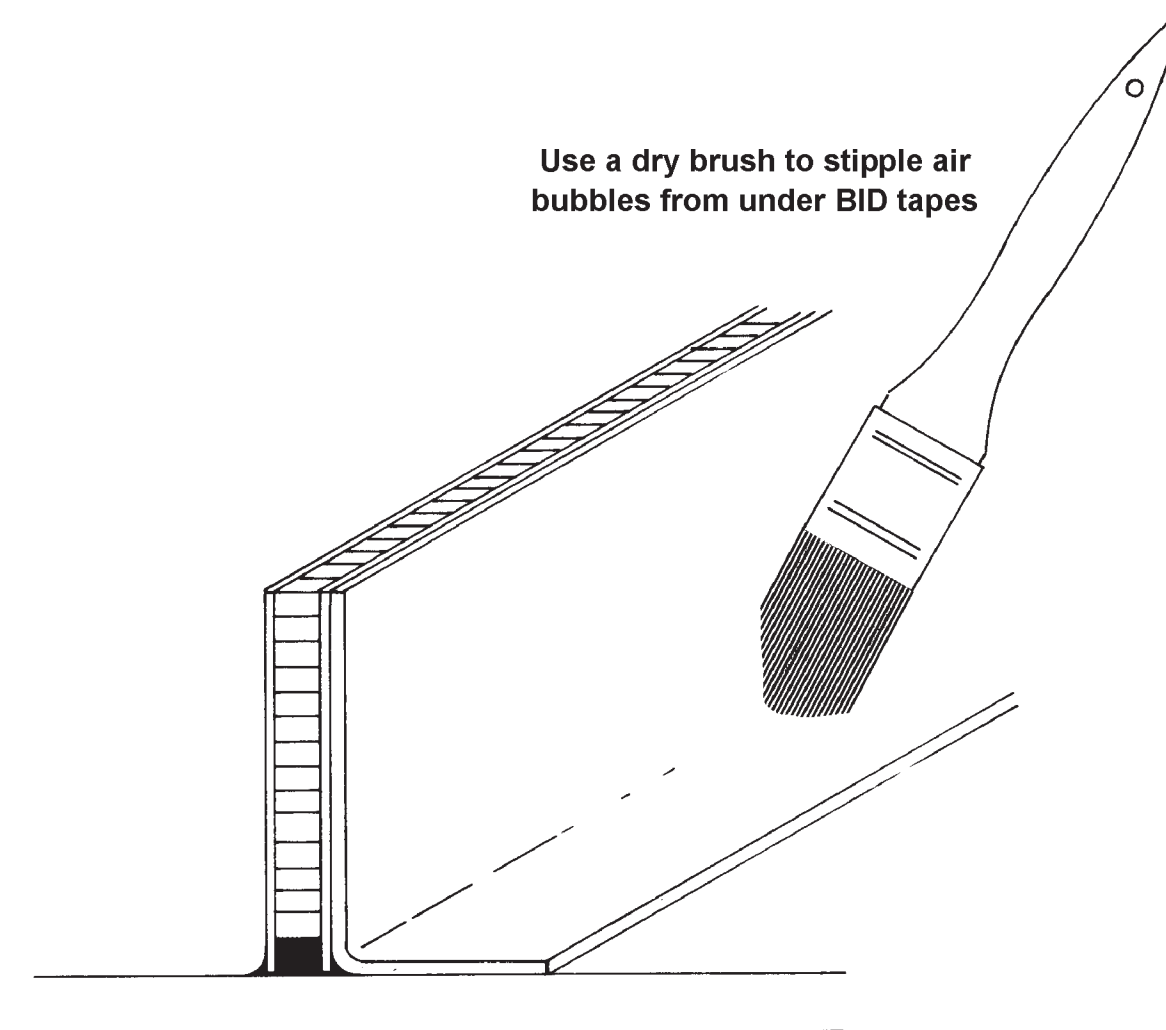
Fig. 1:R:1



Using a roller blade, cut out the shape of the laminate you need. Remove the shape. See how easy the piece is to handle with the plastic on both sides? Peel the plastic off one side of the sandwich and lay the laminate in position (of course you've already prepared the surface by sanding, cleaning, and painting on a light coat of epoxy). **DON'T APPLY THE LAMINATE WITH THE PLASTIC SIDE DOWN, STRUCTURAL INTEGRITY WILL BE COMPLETELY LOST.**

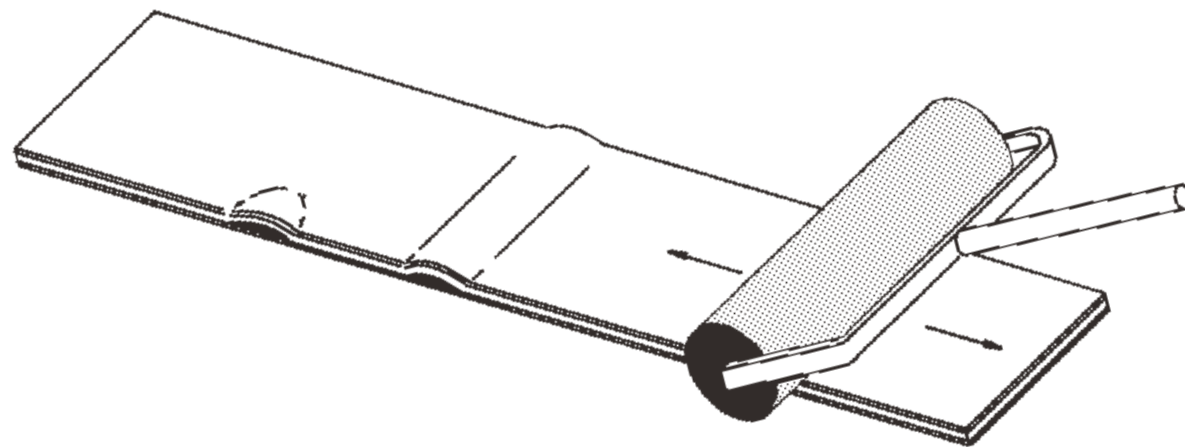
## Applying Plastic Sandwich Laminate

Fig. 1:R:2



Stipple or roll against the side of the laminate still covered by plastic to squeeze the air bubbles out from underneath. Remove the remaining piece of plastic. You should now have a bubble-free laminate with a good epoxy content. A little extra stippling might be necessary if air bubbles were formed when you removed the plastic. Easy, right?

**Using Rollers to Remove Air Bubbles  
(and Excess Epoxy)  
Fig. 1:R:3**

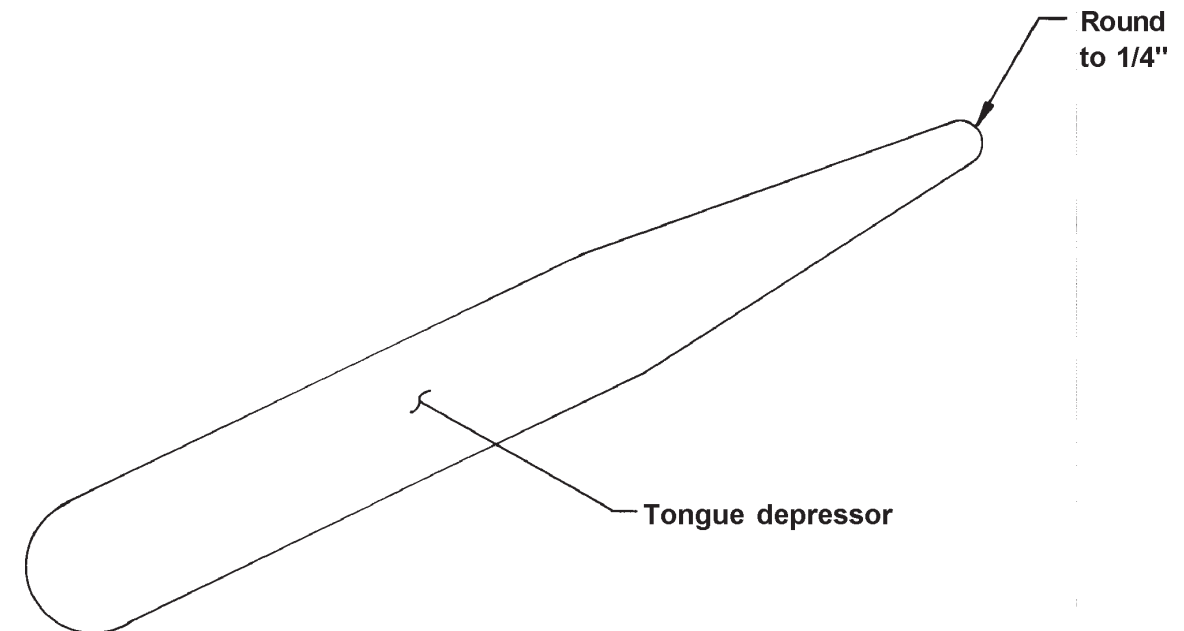


When using the plastic sandwich method of wetting out your fiberglass, simply roll out the bubbles from between the plastic and you have an air free laminate. Peel off one side of the plastic and apply the laminate to whatever you're working on. Before you peel off the second layer of plastic, use the roller to help push the air out from under the laminate.

**R. Tongue Depressors and Micro Radii**

Someone asked me recently what was the most important tool in the Lancair shop. Let me think, the milling machine, the high capacity air compressor, the super-trick mini grinder? Naw, the tongue depressor. That's the most important tool. But not just any tongue depressor, the Lancair special modified tongue depressor.

**Modified Tongue Depressor  
Fig. 1:S:1**



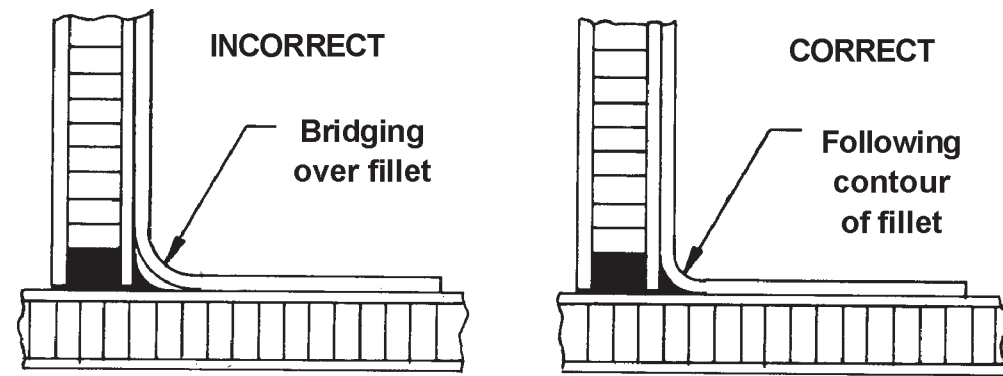
Developed in the late 1980's because of a demand for smaller microballoon radii, the Lancair tongue depressor is a necessary tool for any Lancair builder. You see, the problem with normal tongue depressors is the large radius on each end. If you were to use this radius for all your microballoon filling of joints, your Lancair will be heavier than one with proper joint radii, not by much but every pound counts, right? By sanding down the tongue depressor to a smaller radius, the micro joints on your ribs, bulkheads, etc., will look much more professional. Don't think that more micro will make the joint stronger, in fact it's just the opposite. Microballoons are not structural, so the more fiberglass tape you have bonding the actual part, the stronger the bond will be.

A word of caution. If you get carried away with smaller and smaller micro radii, the fiberglass will want to "bridge" over the microballoons, not bonding as it should. Bridging is fairly easy to detect, the air is visible under the laminate. A little practice will have your micro joints looking great.



**Bridging Fiberglass Over a Radius**

**Fig. 1:S:2.**



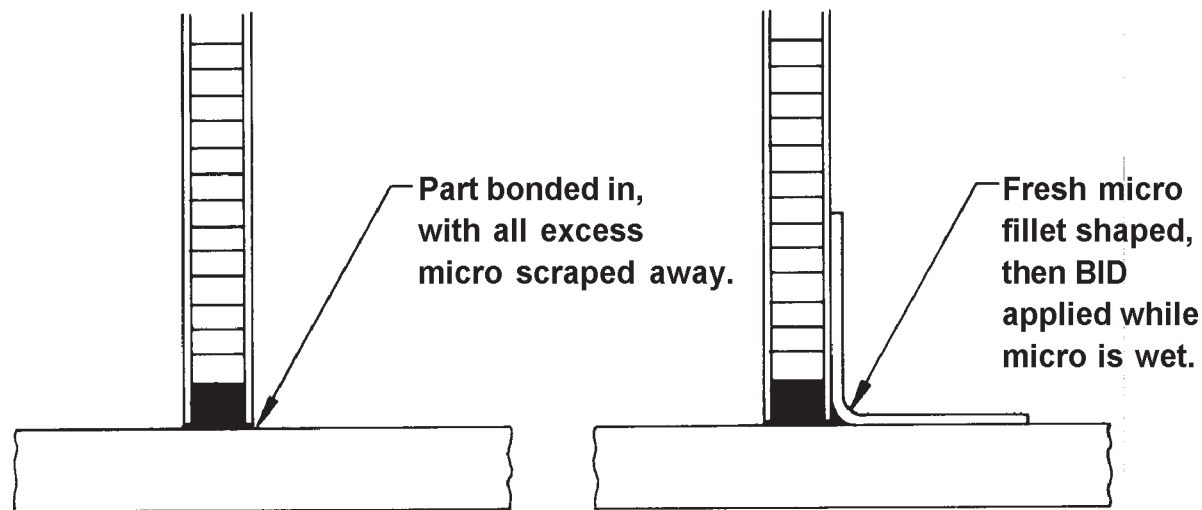
**About those Micro Radii**

The subject of how to best apply microballoon radii is a hotly debated topic around the shop (hey, we're bored sometimes, alright?). Eventually we settled on two methods:

Method #1 - Some believe that the rib/bulkhead should be bonded in and all extra micro scraped away leaving no radius. After the rib/bulkhead is cured in position, another batch of micro can be used to make the radius and the BID tapes applied while this micro is still wet. This method makes application of the micro radius easier because the part is already held firmly in position, but when pure resin is painted onto the area where the BID tapes will be applied, the micro can sag and become runny. When this condition occurs, it is easy to get air bubbles trapped underneath the BID tapes.

**Method #1 of Forming Micro Radii**

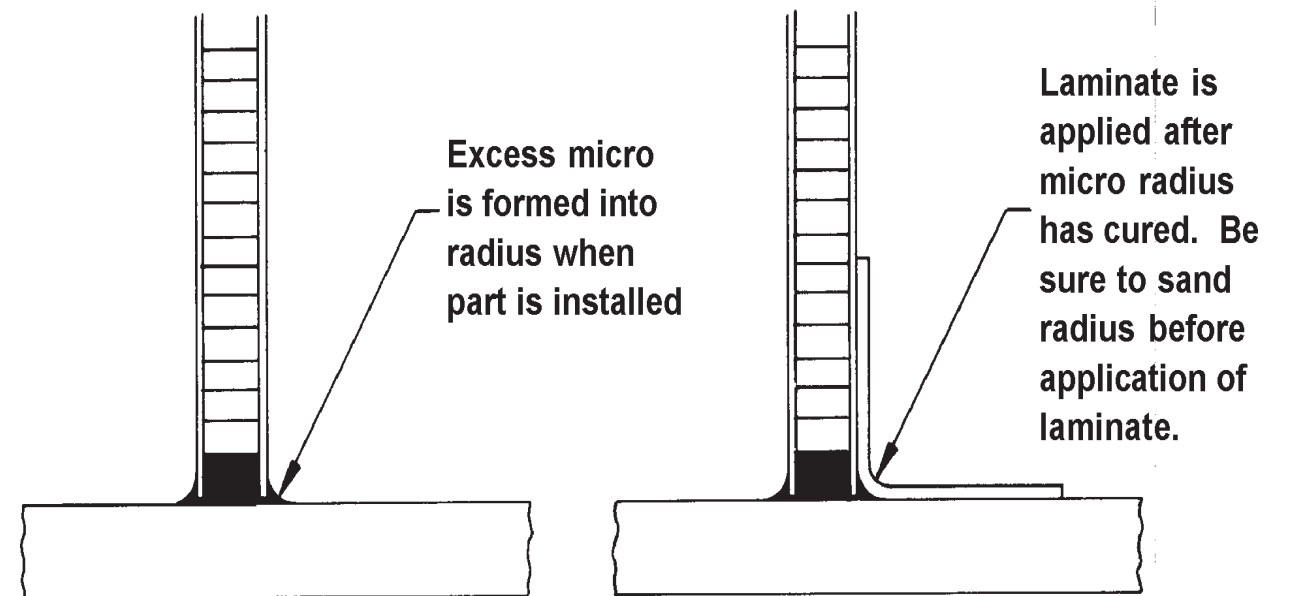
**Fig. 1:S:3**



Method #2 - Others, like myself, believe that the micro radius should be formed when the rib/bulkhead is first installed. Care must be taken to hold the rib/bulkhead in its proper position while forming the radius with your modified tongue depressor. After curing, the BID tapes can be applied over a solid micro radius. I feel this method helps eliminate air bubbles forming under the BID tapes because the resin that is used to saturate the tapes will not dissolve the micro. Plus, you can stipple the air bubbles out from under the BID tapes without destroying your beautiful radius. Be sure to sand the areas, including the micro radius, where the BID tapes will be applied.

**Method #2 of Forming Micro Radii**

**Fig. 1:S:4**

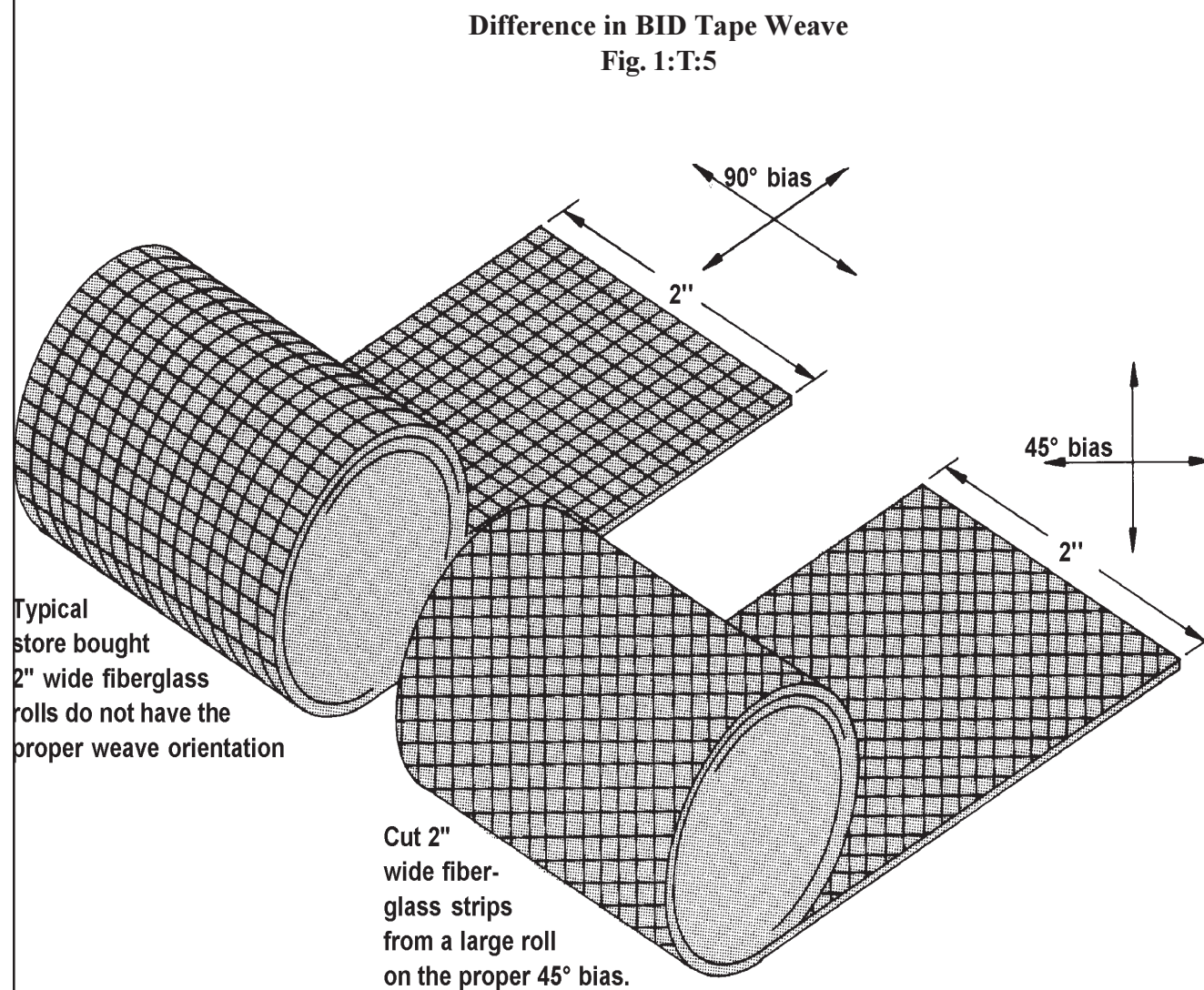


All this talk about something as simple as micro radii, you say? Well, you'll be making a lot of these in the process of building your Lancair, and paying attention to details such as this will ensure confidence and pride in your aircraft. As for which method to use for applying micro radii and BID tapes, either will work, but the second method is safer to avoid air bubbles and get a good radius.

## S. Those Annoying 2"-Wide Bid Tapes

On the subject of glassing in ribs and bulkheads, we've received a few inquiries about using 2" wide, pre-cut fiberglass tape, such as available through Aircraft Spruce, instead of cutting your own out of the 50" wide roll provided in the kit. This is fine, as long as the cloth is cut on a 45° bias. **THIS IS IMPORTANT!** If you use cloth that is cut 90°, it will only be half as strong. Most commercially available tapes are cut 90° and unsuitable for structural areas such as ribs and bulkheads.

The safe way to glass is to cut your own. At Lancair we cut 20 or 30 tapes at a time, all on a 45° bias. Then we roll the tapes up, carefully so as not to shrink or expand the 2" width, and set them aside in a clean place to use as needed. If you do buy pre-cut tapes, be very sure they have a 45° cloth weave and are of the same strength of the fiberglass.



## T. Cardboard Templates

In an early newsletter, it was suggested that the builder use cardboard to find the shape of ribs or bulkheads before cutting them out of Clark foam or prepreg. Since many of you are new builders, we thought this is worth repeating.

Simplicity and cost is why we use cardboard templates here at Lancair. The more complex the rib or bulkhead shape, the more a cardboard template will help. Plus, screwing up a piece of cardboard is much cheaper than a similar piece of prepreg.

## U. Building Light

How much resin should I put on my laminates? The worst enemy to a light, high-performance airframe is too much resin. Here at the Lancair factory, we wet out almost all our glass on 1 mil thick plastic, place another plastic sheet over the wetted cloth, and use a roller to squeeze out the excess resin (the plastic sandwich method). Use a fair amount of pressure when rolling to get a good squeezeout of resin. Not only will these BID tapes be much lighter than ones wetted out on the airframe, they will save lots of time and look very professional. And remember, when the call for BID is higher than two or three, you will save even more time (and weight) wetting the cloth out on plastic.

### 1. BID schedules

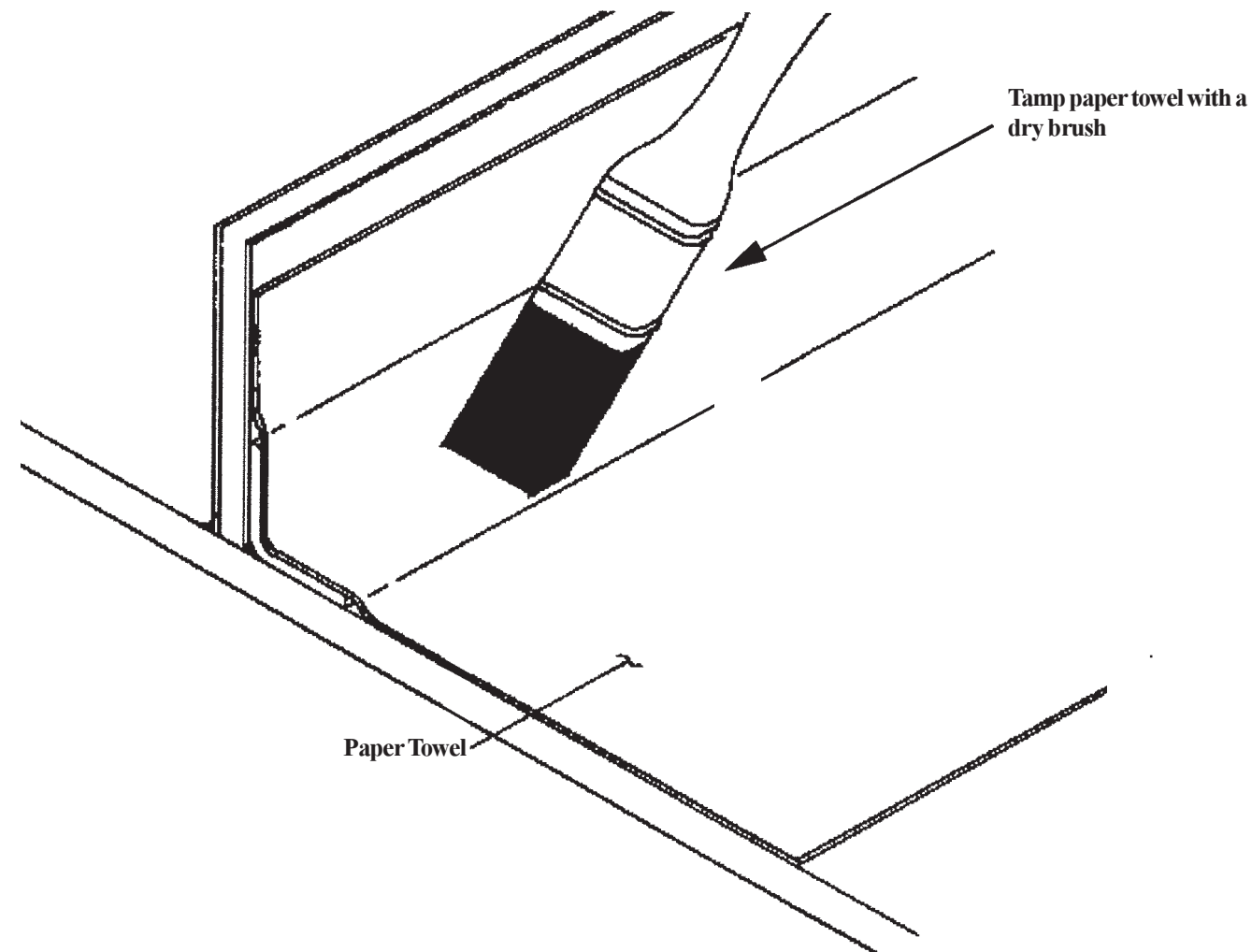
About those BID schedules, which are the number of fiberglass layers bonding a structure together. A homebuilder's natural instinct is to make his plane stronger. If the manual calls for 2 BID, three or four must be better, right? **WRONG!** If you increase the number of BID layers in your aircraft you are decreasing its strength. A heavier aircraft is quicker to build up G loads, has less payload, and is slower than the one built to spec. The Lancair was stress analyzed by Martin Hollmann, a leader in composite engineering, and fully tested. We've seen a Lancair with such a high empty weight that it is over gross as soon as the pilot steps into the cockpit, with no fuel! Think about it, and stick to the manual.

### 2. Paper towels

Enough preaching, want to save even more weight? Throw out that peel ply and use paper towels. That's right, paper towels. After pulling the plastic off a newly applied BID tape, place a paper towel directly on the wet glass and tamp it with a dry brush. The towel will soak up excess resin and the tamping will help push out those evil air bubbles. Remove the paper towels before cure.

### Soaking Out Excess Resin With Paper Towel

Fig. 1:V:1



When the towel is soaked through, pull it off and look at the results. If the towel has pulled up or distorted the glass, use a dry brush for further tamping. Does the glass still look glossy, with an uneven resin content? Well, put another paper towel on it and tamp it again. So long as you don't make the laminate look white, meaning it's too dry, there will be plenty of resin in the glass. Try it, paper towels are cheap.

## V. Building Straight

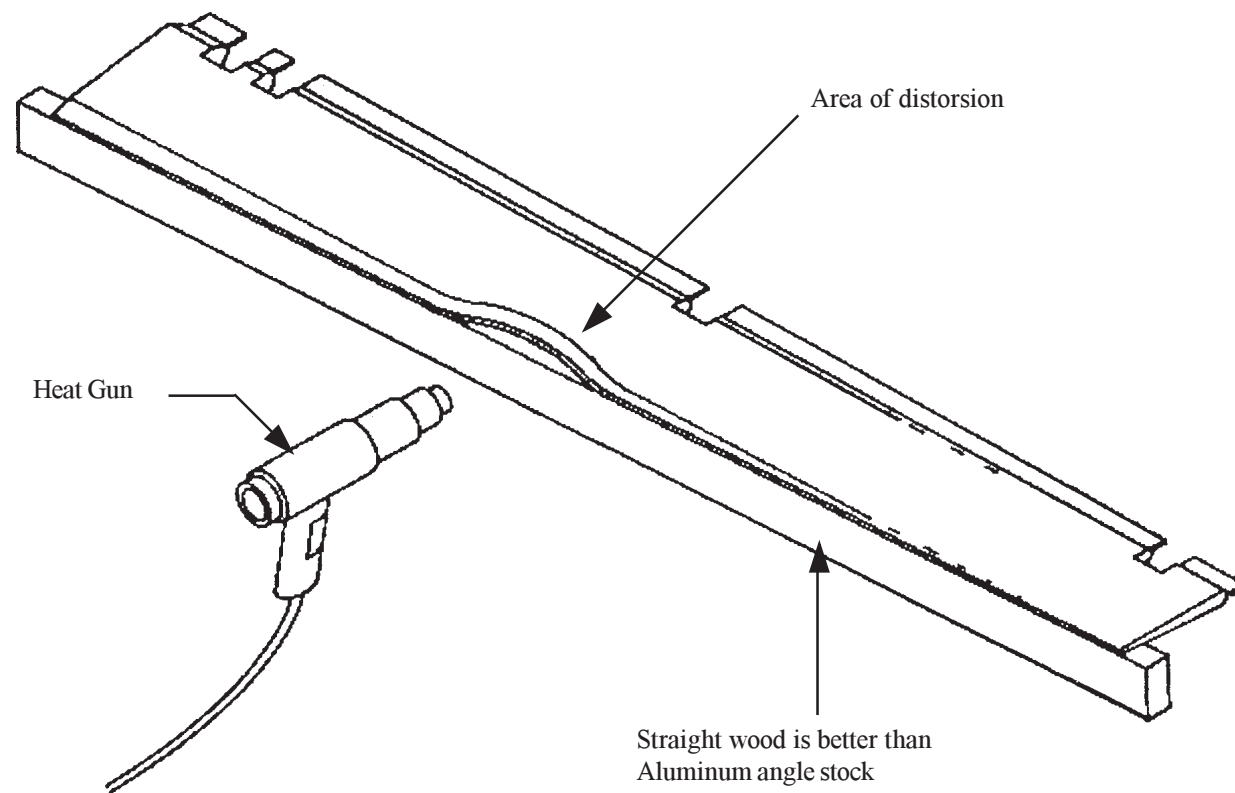
Keeping the airframe straight is also important in a good flying aircraft. Your pristine Lancair might weigh in nice, but if it corkscrews through the air in giant barrel rolls when you let go of the stick, you haven't built a straight airplane. Building your plane according to plans and following the advice given in the construction manual, your Lancair should fly straight and true (in Oz.). Back in Kansas and the rest of the world, it seems that one wing is always a tad heavy, or a trailing edge is wavy. Our prototypes never come out exactly straight and true, so we can't expect any of you builders to perform this miracle. Here's some tips that might help.

### Straight Trailing Edges

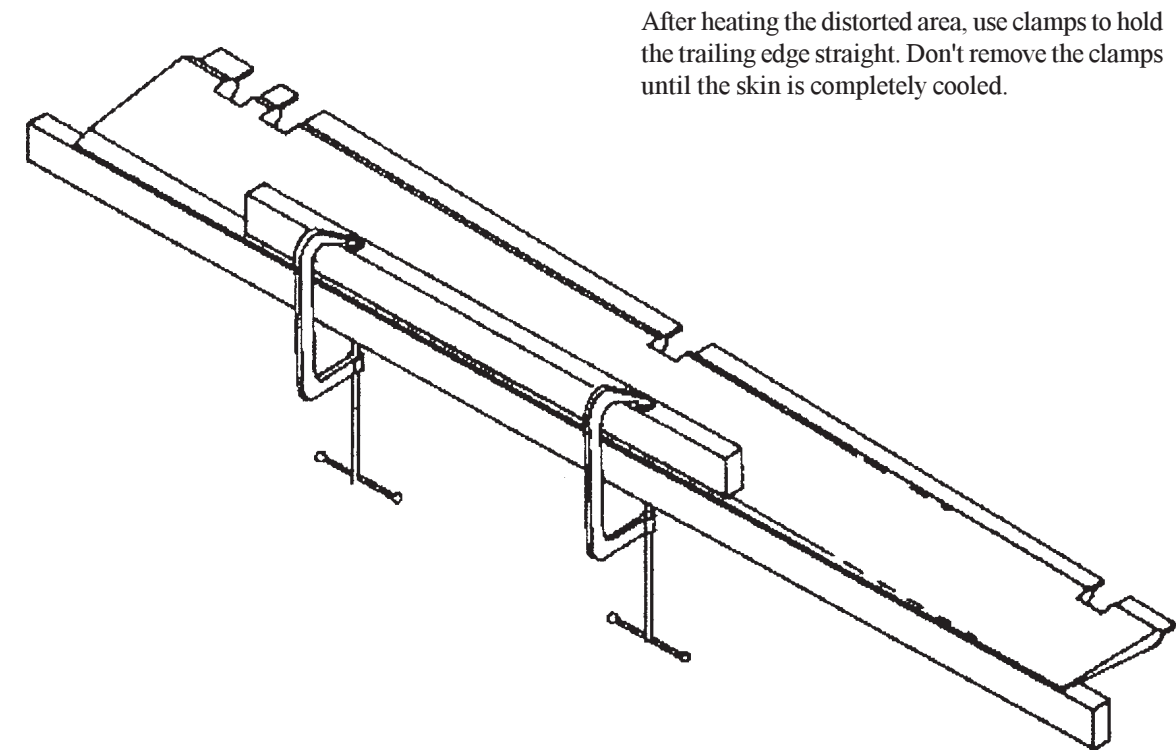
Now let's pretend that you've jigged your wings perfectly, leveled and attached the horizontal stab, and plumb bobbed the vertical stab and bonded it on. The trailing edges of your Lancair should be straight so the control surfaces can travel freely with a consistent gap. As is usually the case with the plans of all good mice or men, sometimes things aren't quite perfect.

If your wing or tail trailing edge has a slight warp in it, heat the area with a heat gun until it's just too hot to touch. Be very careful not to burn or scorch the fiberglass or carbon fiber. Try heating an extra piece of prepreg material first, just to see how much heat is required to burn it. A piece of straight wood or aluminum angle (the wood is better, because it will cool slower than the aluminum and tend to prevent re-warping the edge) can be clamped to the edge to keep it straight while cooling. Be sure to heat the angle, also. Otherwise the cold aluminum will cool the edge too quickly and the warp will remain. Heat at least an inch forward of the edge and don't discolor or burn the fiberglass (or wood). If the warp still remains, try finding a 1x2 or 2x4 board with the right curvature to warp the edge the opposite way when clamped tight. Heat the edge and let it cool with the board clamped in position. With any luck, the part will spring back nice and straight when the board is removed. See the figures on the next two pages.

Straightening Trailing Edges  
Fig. 1:W:1



Straightening Trailing Edges  
Fig. 1:W:2





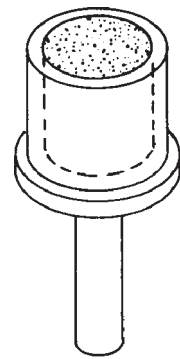
## W. Control Systems

### Pushrod Tips

- After cutting the pushrod tube to length, don't immediately rivet the rod end in position. It is better to test the pushrod in the system (flap, aileron, elevator) by temporarily securing the rod ends to the pushrod with instant glue. Use only a few drops of glue to secure the rod end or the bond may become more than temporary. Don't cover the rod end with glue then slide it into the pushrod, the bond would be impossible to break free. Once you determine the tube is the proper length, you can break the rod ends free, clean them up, and rivet them in place.
- Fill the rod ends with a 50/50 micro/flox mixture. This will allow the drill to track straight through the rod end when drilling for the rivets. The solid rod end will also prevent rivets from buckling when they are set in place.

#### Filling Rod Ends With Micro/Flox Mixture

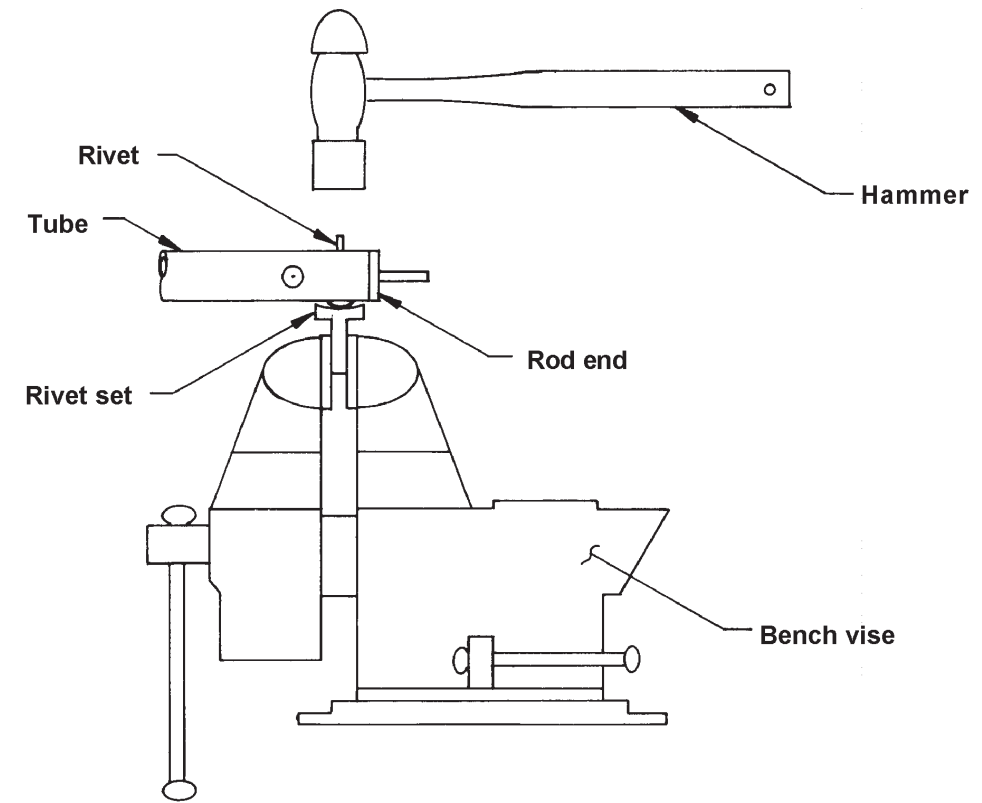
Fig. 1:X:1



- When sliding the rod ends into the pushrod tube for the last time (before riveting), coat them with Loctite™ to prevent slippage or vibration wear.
- A rivet gun is the best method of setting the rivets that secure the rod end. In a pinch, we've used a hammer to lightly tap and expand the rivets. Hit the rivet lightly and accurately to avoid mashing the rivet end to one side. A rivet squeezer is not recommended for pushrod rivets because the rivets may buckle in the center of the pushrod.
- [Make sure the distance for each rivet to the rod end is enough to prevent the rivets from interfering with each other and the threads of the rod end.](#)

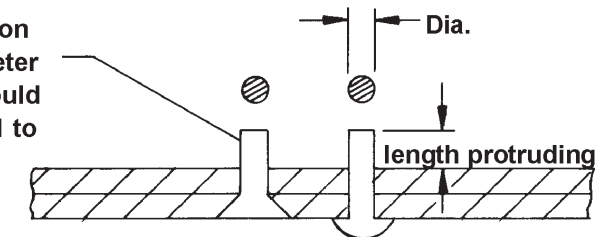
#### Setting the Rivets in the Rod End

Fig. 1:X:2



#### Rivet Rule

**RIVET RULE:**  
The correct length of protrusion is equal to 1.5 times the diameter of the rivet, i.e., a 1/8" rivet should extend 3/16" from the material to be riveted.



**1. Painting pushrods**

At Lancair we usually spray paint our pushrods with one coat of Zinc Chromate and one coat of color. Hardware store spray cans are fine for the color coat and you can choose from all kinds of nifty colors.

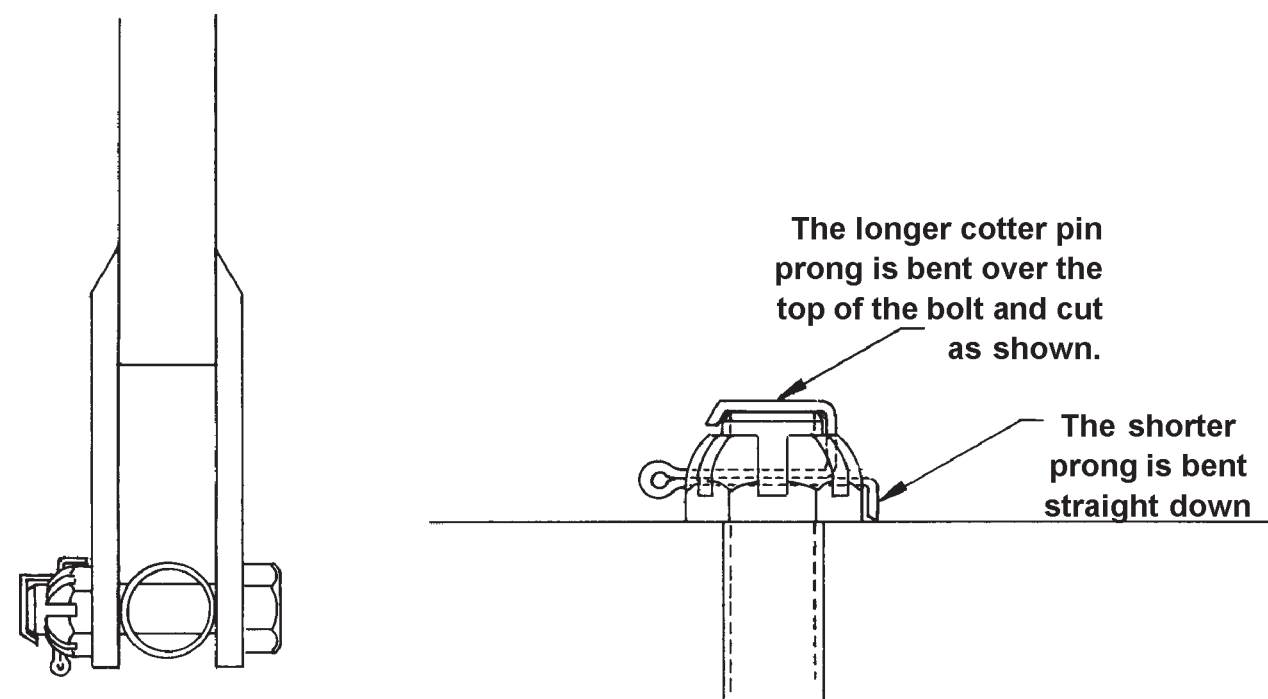
**2. Castle nuts and cotter pins**

One common error in the Lancairs we have inspected is mis-bent cotter pins and castle nuts without cotter pins.

Castle nuts are commonly called for items in the Lancair control systems. A castle nut is only used on drilled bolts and MUST be secured with a cotter pin. Castle nuts are usually snugged down, not tightened like an elastic locknut and the cotter pin will prevent the nut from loosening!

**Properly Pinned Castle Nut**

**Fig. 1:X:3**



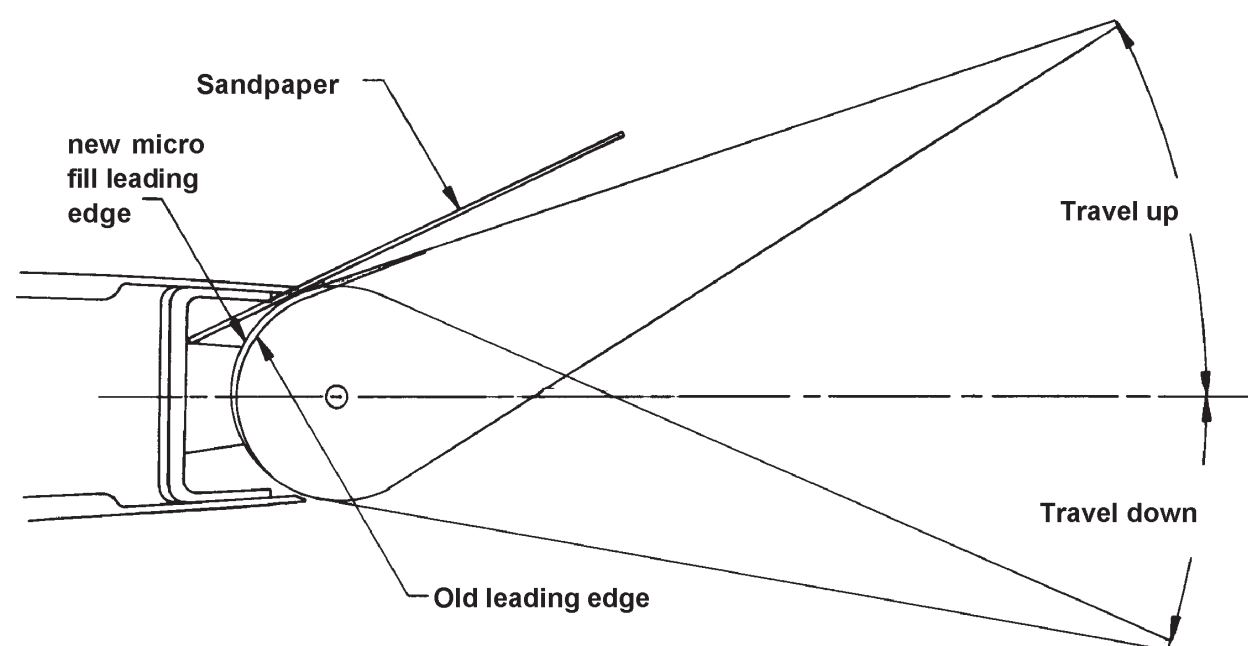
The standard method of bending and securing cotter pins is shown above. Many builders simply bend the two cotter prongs around the bolt and call it done. Without cutting the prongs to proper length, the prongs could grab a stray piece of upholstery or wire, possibly jamming the system.

**3. Control surface gaps**

If you'd like to get a closer gap on your control surfaces, try this method. No matter how good the mold, the leading edges of the elevators, ailerons, flaps, and the rudders never seem to fit the trailing edge of the wings and stabs just right. If you have this problem on your elevator, for example, mount the elevator to the horizontal stab and make sure you have at least 1/16" gap between the elevator leading edge and the stab trailing edge. Mark on the elevator where the gap is too great or fairly close and remove the elevator. Now add a micro layer, mixed thick, to the areas marked "too great" and shape a rough radius (a little sculpting skill is helpful).

**Gapping Control Surfaces**

**Fig. 1:X:4**



After the micro cures, sand it so the elevator will just fit back into the stab, and sand the stab trailing edge straight, parallel to the hingeline. Got all that? Now take one strip of sandpaper, 3M or Norton 40 grit longboard sheets work best, and run it back and forth between the elevator and the stab, sanding the micro on the elevator. Another pair of hands is very helpful in this process to hold the elevator stable while you work the sandpaper. Have your helper raise or lower the elevator slightly when you feel the resistance on the sandpaper decrease. Slowly work the elevator through its full range of travel. Now you should see a consistent gap between stab and elevator when the elevator is moved through its travel range.

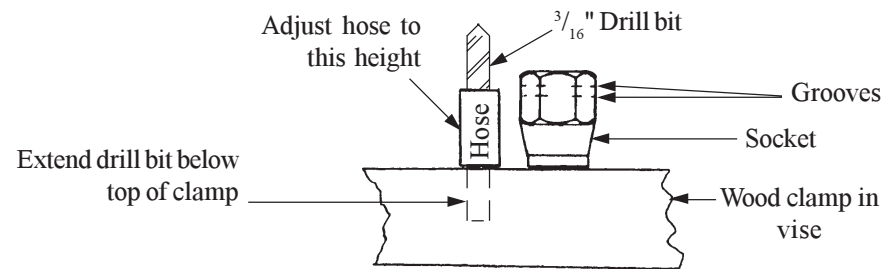
## X. Hydraulic Systems

### 1. Eastman hydraulic 3/16" hose and fittings

Construct a wood hose clamp, drill a 3/8" hole through a 1" x 2" piece of 3/4" plywood, then cut in two. Use this to clamp the hydraulic hose in a vise. The outside of the socket has two rings of small grooves in the corners of the hex.

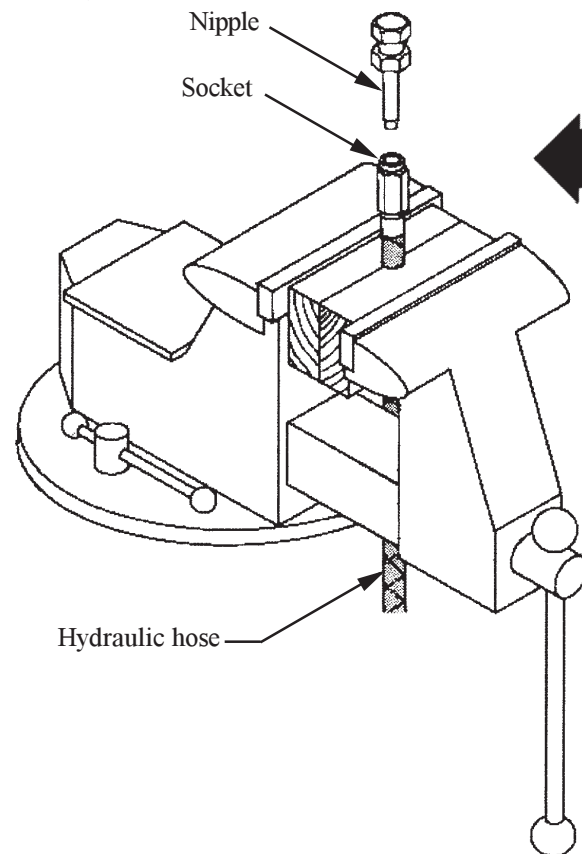
**Clamping Eastman Hose**

**Fig. 1:Y:1**



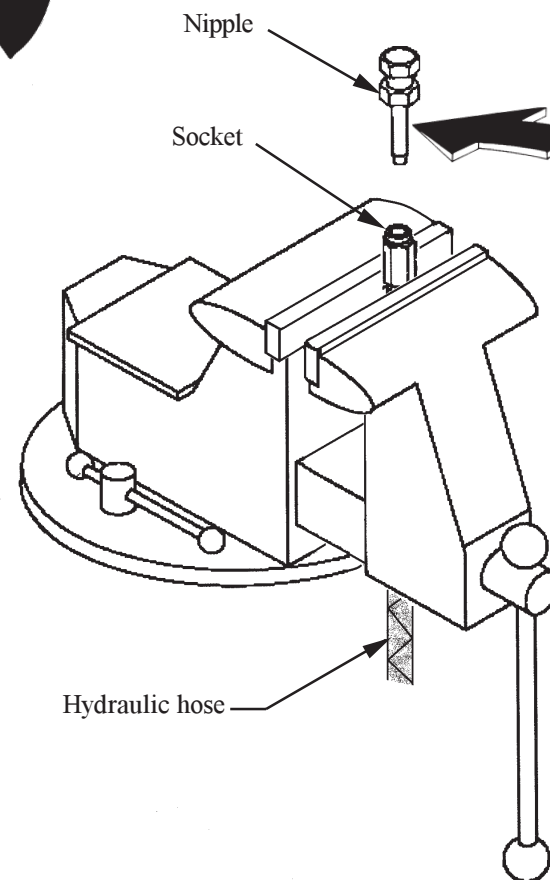
**Installing Eastman Fittings**

**Fig. 1:Y:2**



**Installing Eastman Fittings**

**Fig. 1:Y:3**



Using the two grooves on the socket as a gauge, position the end of the hose between them above the wood clamp, push the shank end of a 3/16" drill bit into hose, so it extends below the wood clamp.

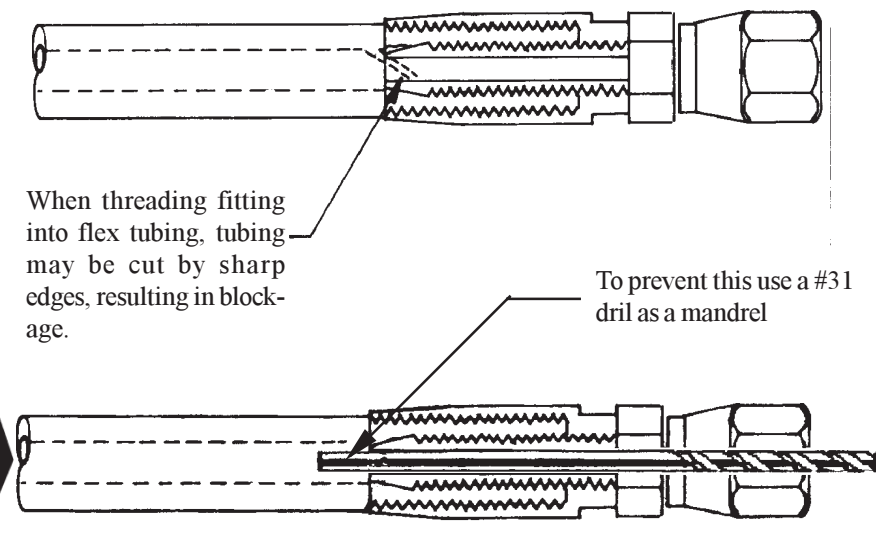
Lubricate the hose and socket with anti-seize or if available "Hoseze-oil" turn the socket counter clockwise on the hose until it touches the wood clamp. **Keep turning** don't stop and start. If hose twist kinks, or suddenly seems to be easier to turn, cut off hose and start over. (see Fig. 1:Y:2)

Remove hose and socket from wood clamp, and clamp the socket in the vise. Use the shank end of a # 31 drill bit as a mandrel, be sure that it protrudes through the hose end of the nipple. this will prevent the end of nipple from stripping material for inside of hose. (see Fig. 1:Y:3)

Lube the threads on the nipple and turn the nipple into the socket and hose. Bring the hex on the nipple into snug contact with socket but don't tighten further.

**Hose Blockage**

**Fig. 1:Y:4**

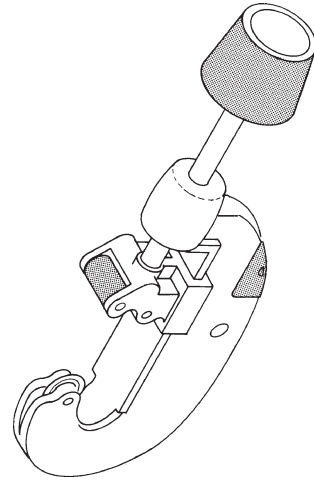


Tighten the nipple into the socket and hose, just bring it up snug to the socket don't overtighten! Remove the # 31 drill bit and blow through the line in both directions to be sure there is no flap at the end of the nipple. Clean the line with solvent.

## 2. Cutting hydraulic lines

Most Lancair hydraulic lines are made from 1/4", 5052 aluminum tubing. A tubing cutter is the standard, and best, tool for cutting the aluminum tubing to length.

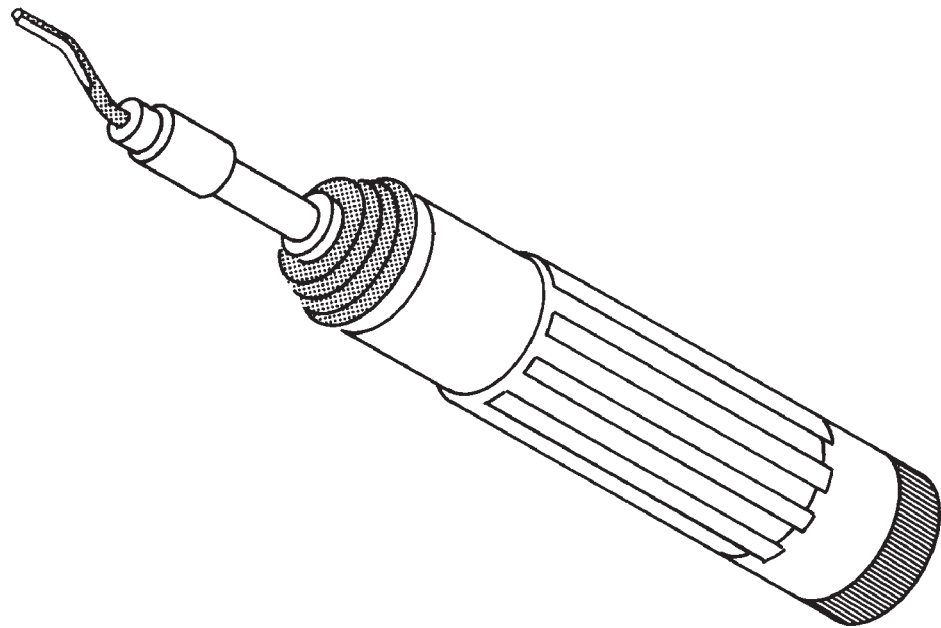
**Tubing Cutter**  
Fig. 1:Y:5



We use a small cutter because it's much easier to handle. Simply roll the cutter around the tube, tighten the handle slightly, then roll it around the tube again, etc., etc...

After every cut you must deburr the inside of the aluminum tube. A small deburring tool makes quick work of this.

**Deburring Tool**  
Fig. 1:Y:6



**WARNING:** Only deburr what is necessary to achieve a smooth edge. Excess use of a deburring tool will remove too much material and potentially weaken the subsequently flared end.

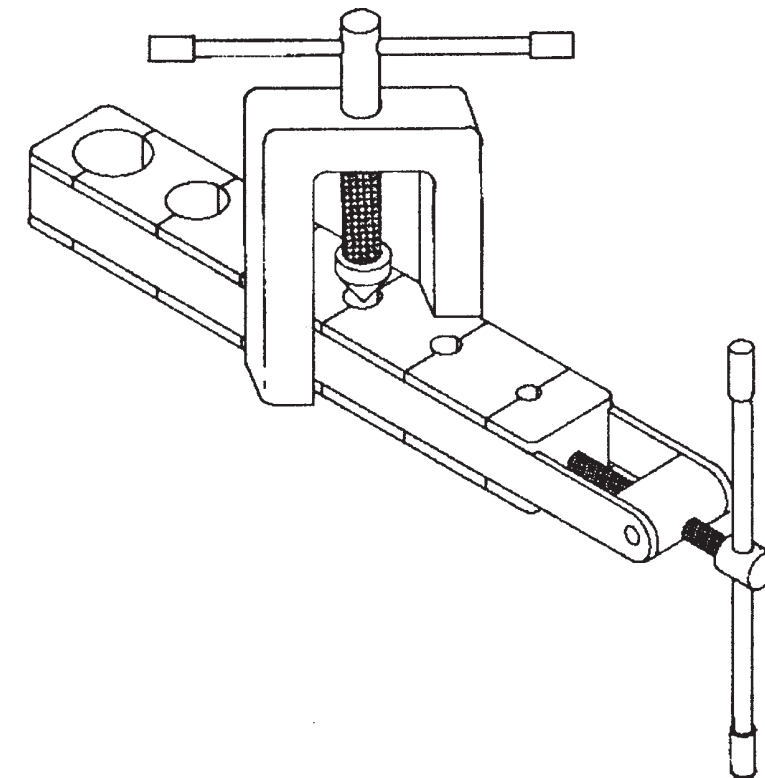
Tony Bingelis has much more information on tubing cutting and deburring in his Sportplane Builder books and Sport Aviation columns. These books are extremely helpful to the home builder. Get them and read them!

## Tube flaring

Here's another area of construction where you need a specialized tool, the flaring tool.

The tube must be deburred, as described in the previous section, in order to get a clean flare. Otherwise you could score the inside of the tube when flaring. The tube may not seal properly in this condition.

**Flaring Tool**  
Fig. 1:Y:7



We usually grease the cone shaped part of the flaring tool so it will not gouge the tube. Don't flare the tube too much, the expanding aluminum may crack. The cracks are visible if you look closely. Experiment and learn how to use your flaring tool. Again, the books by Tony Bingelis contain a lot of valuable info on these sorts of specialized jobs.



### Typical Methods for Securing Hydraulic Lines

Fig. 1:Y:8

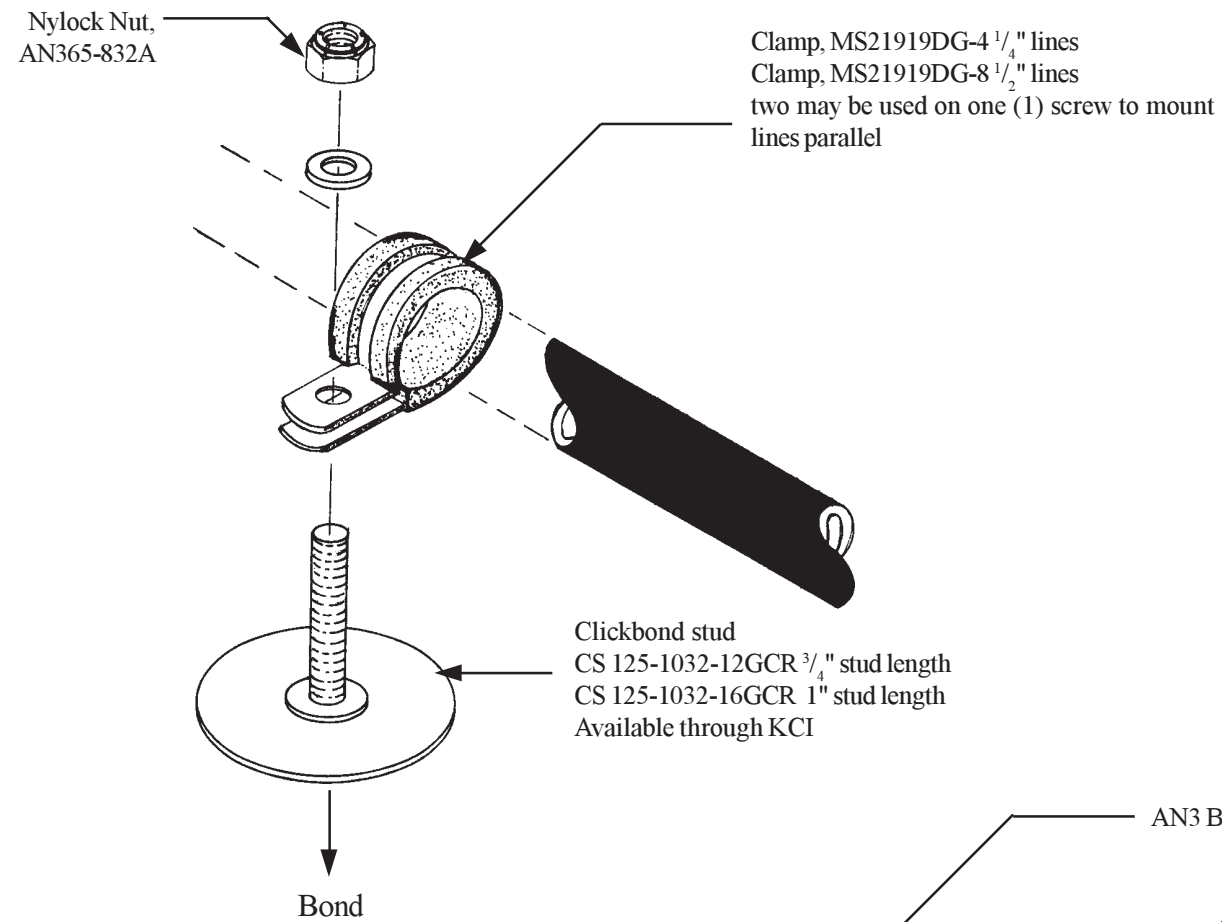


Fig. 1:Y:11

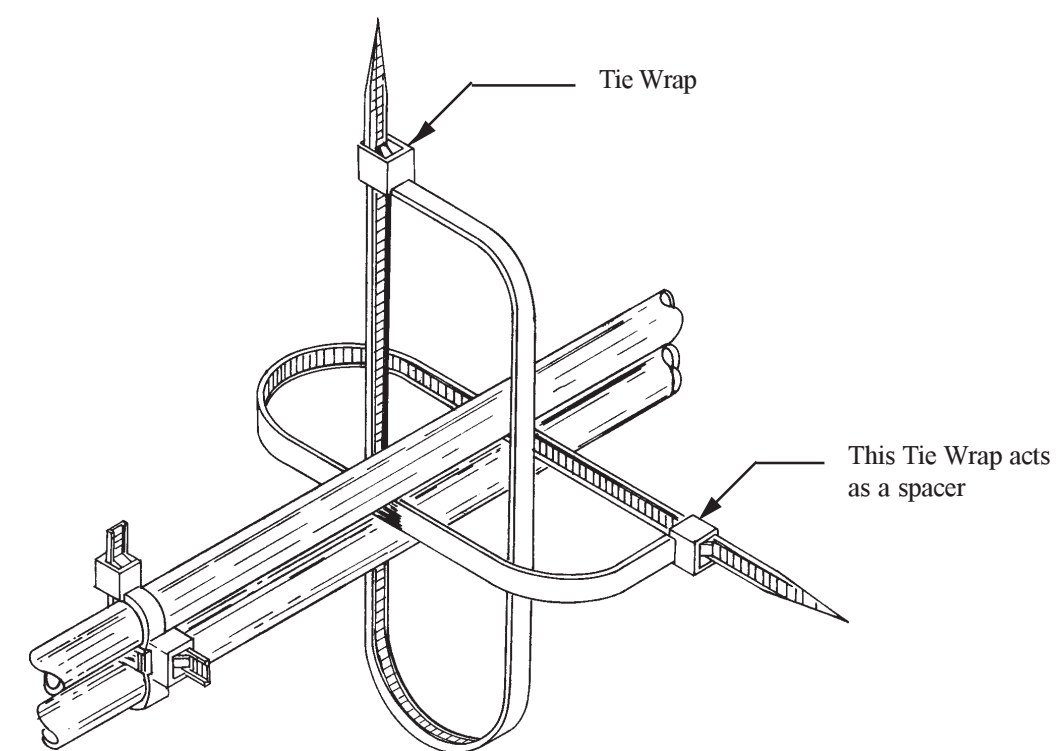
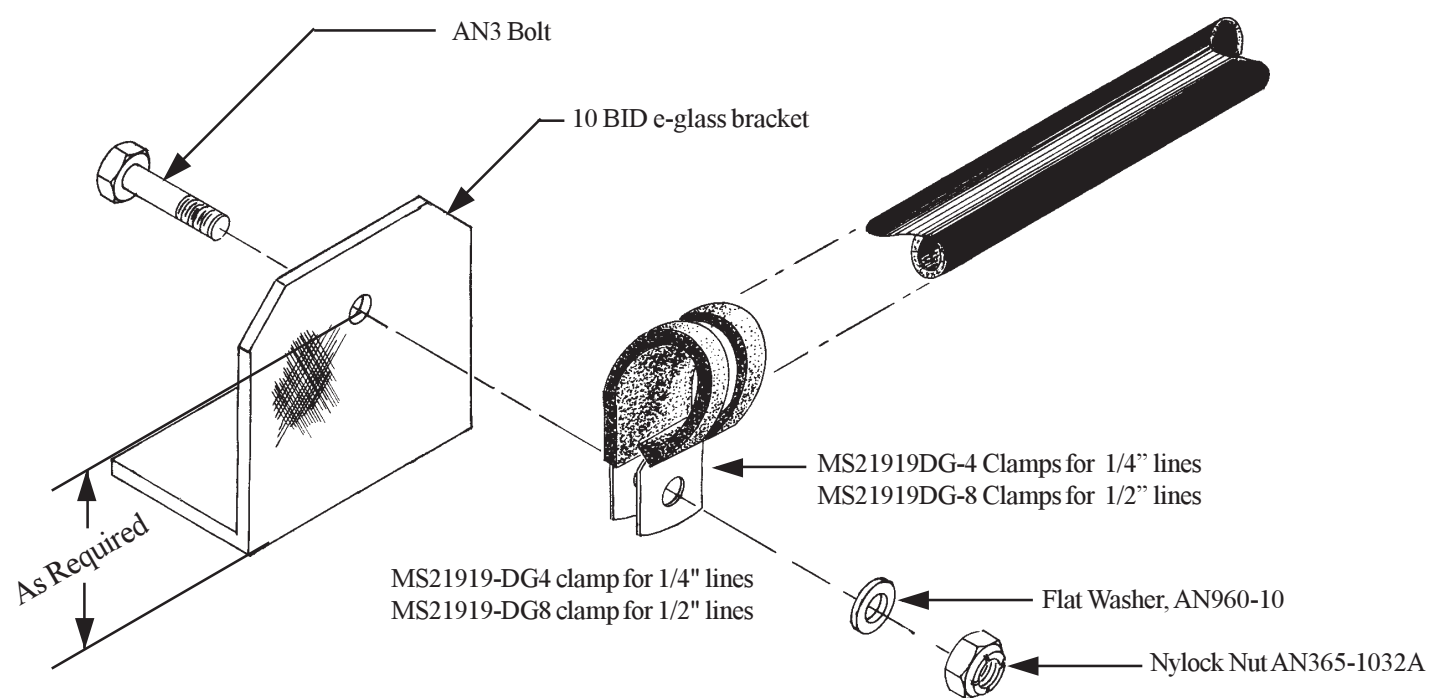


Fig. 1:Y:9



## Y. Painting

In the last year, the Lancair shop has prepared and painted Lancair prototypes. In the process, we've learned a few basic painting tips and rules you may find interesting, or even helpful.

Painting is a disgusting, dirty, tedious, boring, stressful, sometimes toxic process that you will do once and swear never to attempt again. Lock up all your weapons because with one slip of the spray gun, one little mistake, you might feel like ending it all. Bet you can't wait to get started on your paint job now, huh?

Seriously though, if you take your time and don't try to produce a flying Mona Lisa, a good looking paint job is fairly easy to produce. Here's the basic flow chart that we follow for preparation and painting of our Lancairs.

1. Clean all surfaces
2. Sand all surfaces with 80 grit
3. Prime with featherfill
4. Sand with 100 grit
5. Paint with normal primer
6. Sand down to 220 grit
7. Fill pinholes
8. Prime with normal primer
9. Sand down to 360 grit
10. Clean for color coat
11. Paint your favorite color!

Now let's get more detailed, step by step:

Step 1. Before the initial sanding of your surfaces, and before each primer and color coat, you **MUST** clean the area to remove any contaminants that would affect the paint. We use DuPont Prep-Sol cleaner for this purpose.

Step 2. After you've Prep-Soled your bare fiberglass or carbon fiber surface, scuff up the surface with 80 grit so the primer can bond properly. We use a dual action (DA) sander to make short work of this step.

Step 3. Clean your surfaces with Prep-Sol again in preparation for the first primer coat. We use the polyester based Featherfill primer as a first coat. It may sound strange, but we actually apply the Featherfill with a paint brush. We find brushing on the first coat of primer fills the pinholes much better than spraying does. Don't worry about making this first coat pretty, most all of it will be sanded off anyway.

Step 4. The goal of the Featherfill was to fill the weave of the material and the scattered pinholes. Now you can sand most of the Featherfill away with 100 grit. Use a longboard sanding block or one of the sanding blocks that use 1/2 sheet of sandpaper. If there are low spots in the surface, here is where you'll start to see them.

Step 5. Blow off the surface with an air nozzle and clean with Prep-Sol. This next coat of primer should be the same brand as your color paint. Be sure of compatibility! We've found a few really good primers. The WLS system is a great primer, we used it on the Lancair IV prototype, but the white WLS paint we applied over it isn't sticking worth a darn, especially on the leading edges (We just tell people that the paint tends to burn off during reentry into the earth's atmosphere). We just tried the Superflite primer on the 320 and we're very happy with it's application and sanding properties. Whatever brand you use, spray on a good, thick coat.

Step 6. Sand the primer smooth with 180 grit. We usually wet sand at this point, the sandpaper is much more efficient when wet. This is where many builders start to run into trouble. They begin to paint on coat after coat of primer, only to sand off each coat they apply. They complain about the huge amount of time required to get a good finish on their planes. Well of course it takes a long time if you sand off every bit of primer you put on. They might as well use watercolors, it'd come off real quick when wet sanding. Anyway, you don't have to sand all the way through the primer coat you just applied. Sand until it's smooth and that's all. On the bottom of your plane, you may not want to apply any more primer if this coat has sanded smooth without sanding through. In this case, simply switch to 320 grit and finish it off, ready for the color coat.

Step 7. This is the best time to look for pinholes in your surfaces. Use the air nozzle to blow the dust off the smoothly sanded surface and out of the pinholes. We use Evercoat polyester glazing putty to fill pinholes, chips, and other boo boos. The lacquer glazing putties tend to shrink too much with age, as does Bondo. Use a putty knife, or squeegee, to force the putty into the pinholes. Lightly re-sand the pinhole-covered areas after filling.

Step 8. Now clean all your surfaces and spray on what should be your last coat of primer. Use the same brand of primer as the previous coat. Use your judgement to decide if you need a thinner or thicker primer coat (usually this last coat is applied thinner). This primer coat should look pretty good, very evenly applied and few, if any, sandpaper scratches visible.

Step 9. Wet sand this last coat of primer with 360 grit. Some builders would cringe at this, saying that the last primer coats should be sanded down to at least 400 grit. We've found that 400 grit sands the surface just a bit too smooth, the paint doesn't have anything to grab onto. The last grit we used on the Lancair 320 repaint job was 320 grit (easy to remember, 320 on a 320) and the gray color coat did not show any scratch marks.

Step 10. This is it! Blow off and clean all your surfaces thoroughly with Prep-Sol. Fill any remaining, pesky pinholes now or forever hold your peace. Use a tack rag, available at all automotive paint stores, to remove the dust and dirt from the surfaces. Congratulations, you're ready to paint.

Step 11. The best advice we can give you about painting the color coat on your aircraft is DON'T, at least not if you don't have the proper facility, tools and training. We convinced ourselves here at Lancair that spraying the color coat on during the early dawn or dusk hours, with the pavement wetted down and no wind, would produce a lovely finish suitable for framing. It just doesn't work that way. Shooting the primer coats on in your back yard with a lousy spray gun is one thing, but getting a dust free, no runs, color coat is another. Seriously consider taking your plane to a paint shop. The Lancairs are perfectly suited for this because you can take the wings off and roll them anywhere. Having a professional shoot the color coat is not as expensive as you think IF you do all the preparation yourself. All the painter will have to do is shoot the color.

If you absolutely must spray the color on yourself, seek advice and assistance from a painter who could probably tell you ten times more than we could about painting.

Again, we're not saying this is the best, or even a standard process for finishing your Lancair, but it works for us. Sure, some of the parts may need an extra coat of primer, some edges may have to be puttied up and reprimed, but these are part of the joys of building your own plane, aren't they?

## Z. Building a Jack Stand

Jack Stand  
Fig. 1:Y:9

